United States Patent

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[33] Czechoslovakia

[31] 5354-68 and 6370-68

[54] **INVOLUTE PUMP**

15 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **418/55,** 418/56, 418/57

[51] **Int. Cl.** **F01c 1/02,** F04c 1/02, F04c 17/02

[50] **Field of Search** .... 418/19, 22, 29, 55, 56, 57; 103/130, 131, 120 C, 116 M, 216 M; 230/145, 146; 91/56; 123/8 PN

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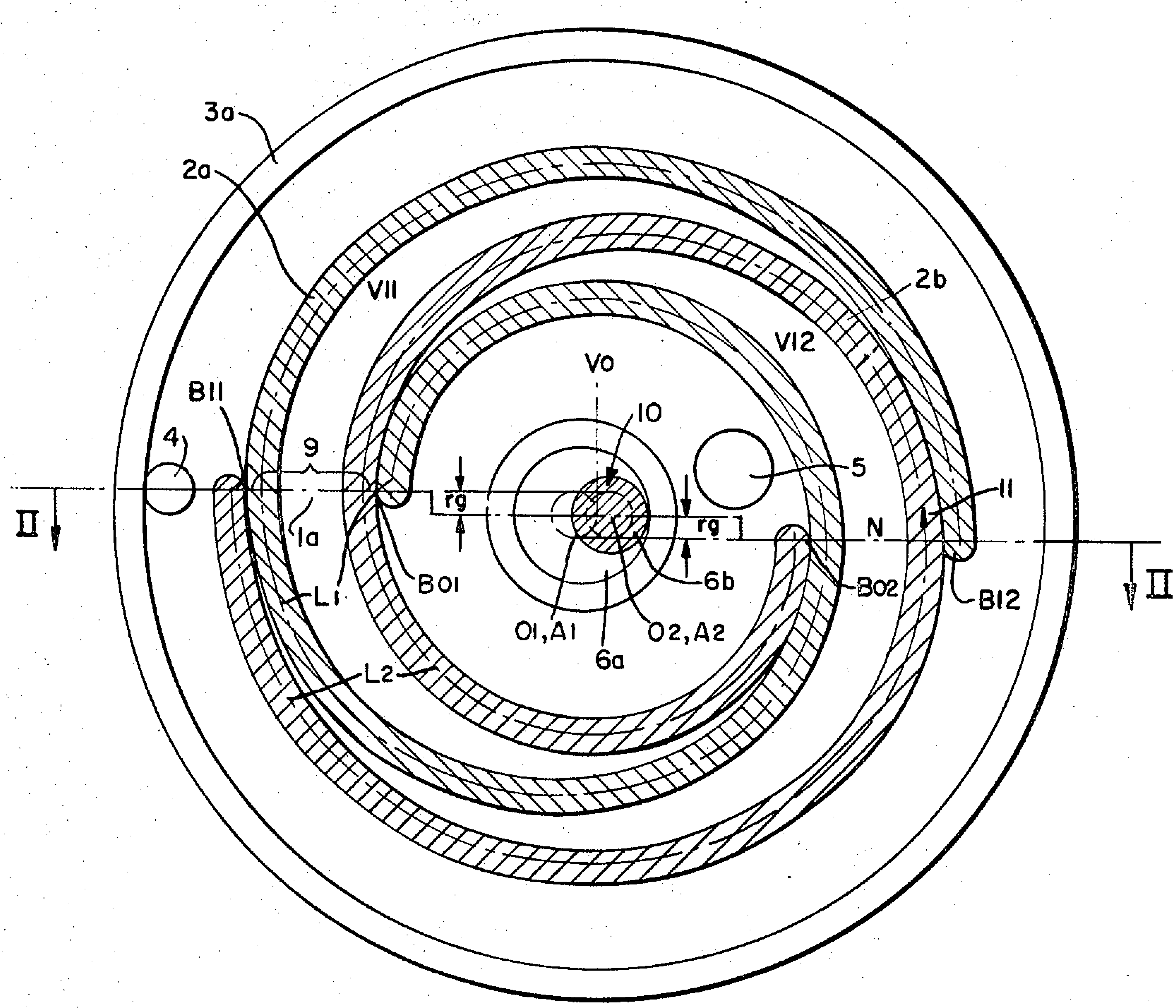
ABSTRACT: A fluid pump or motor is formed of two disks which are mounted parallel to each other and for rotation relative to each other. The opposed surfaces of the disks include substantially plane portions and projections extending from the substantially plane portions and interengaging with each other. These projections have the form of involutes of a circle of the same radius. Closed chambers are formed between the inside of one projection and the outside of another. These chambers constantly change in size during the circular movement of the disk relative to each other. By driving the disks and connecting the closed chambers to a source of fluid the device can be used as a pump; by supplying a fluid under pressure to the chambers the device can be used as a fluid motor.



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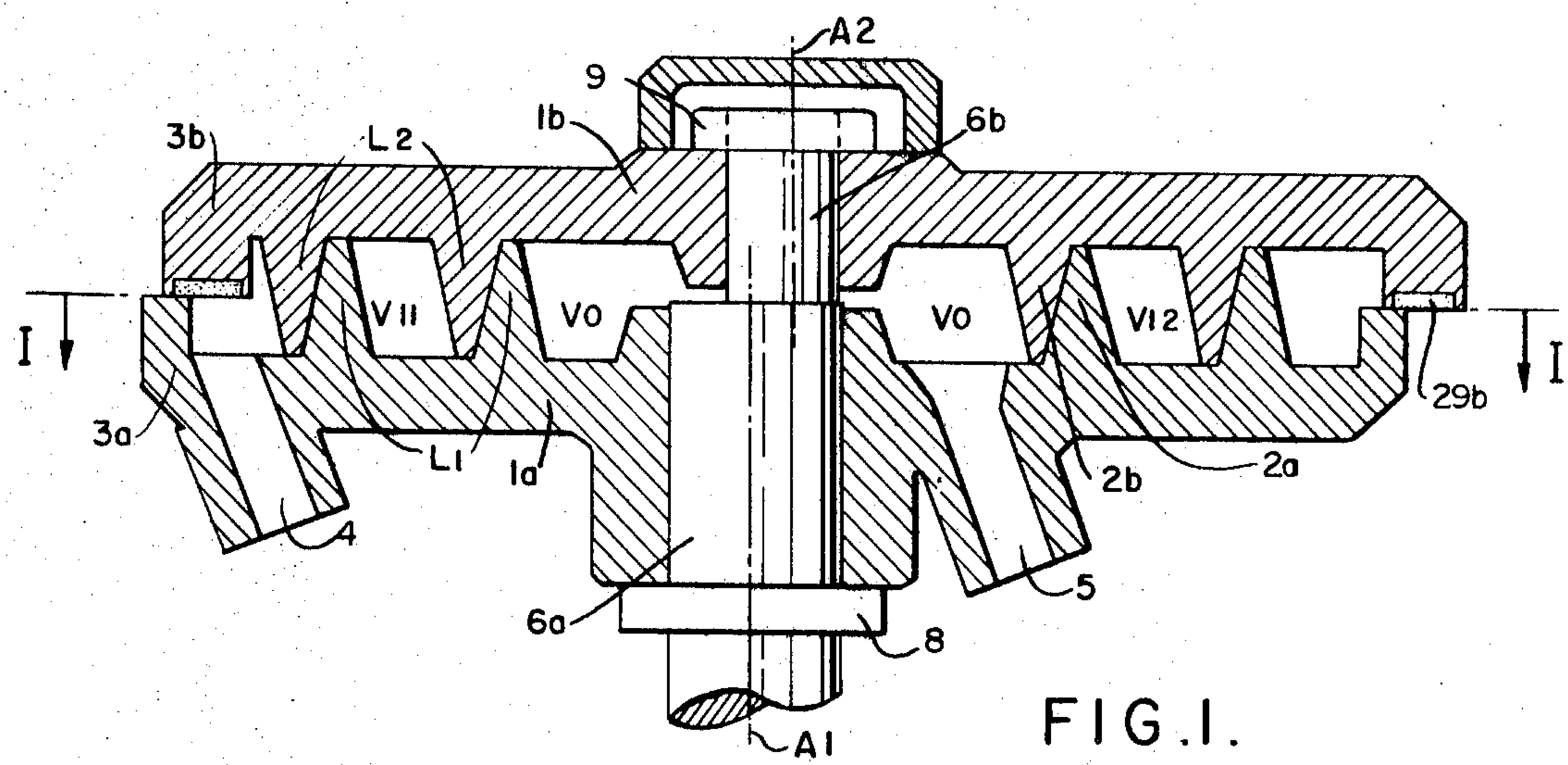

FIG.1.

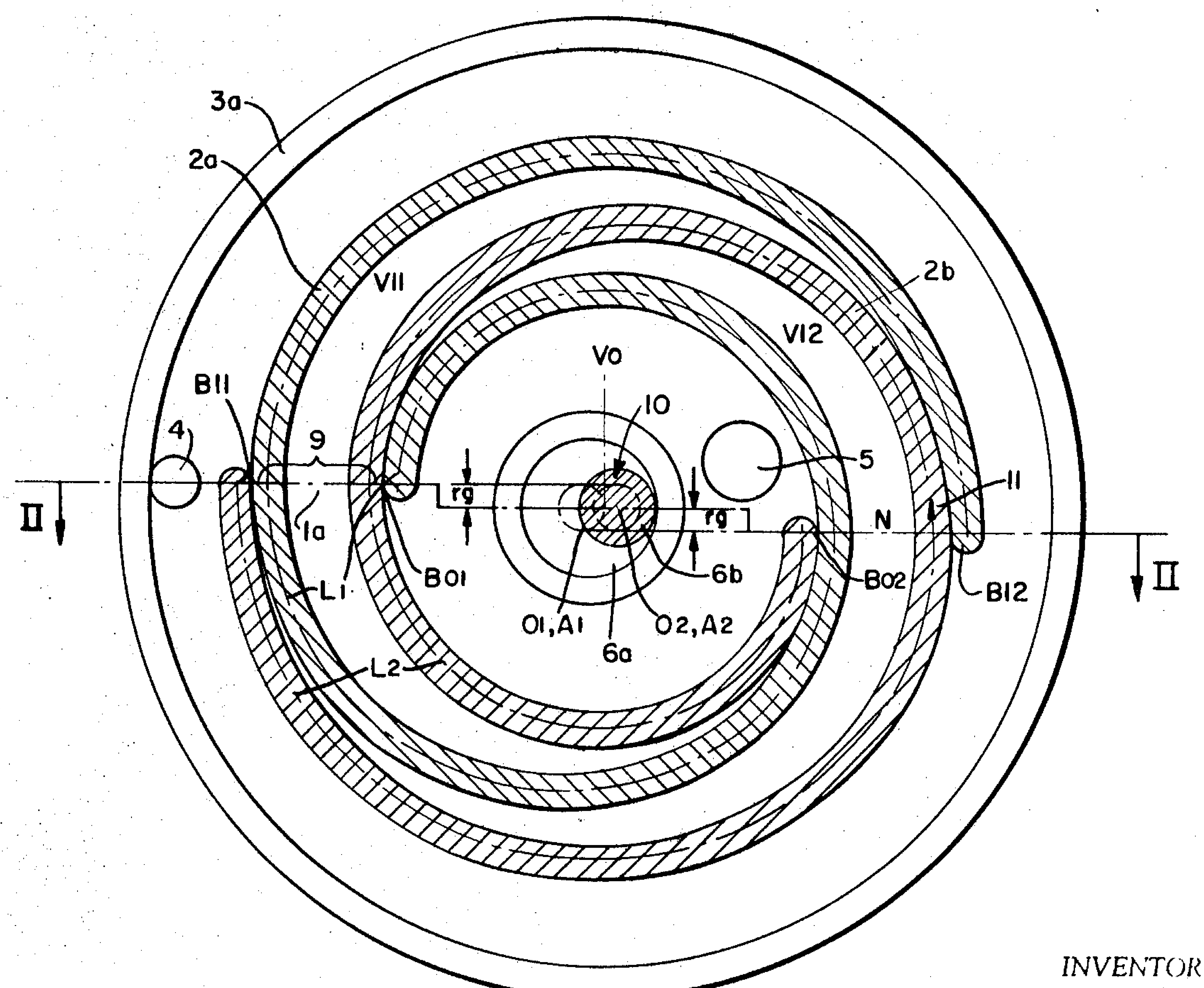

FIG.2.

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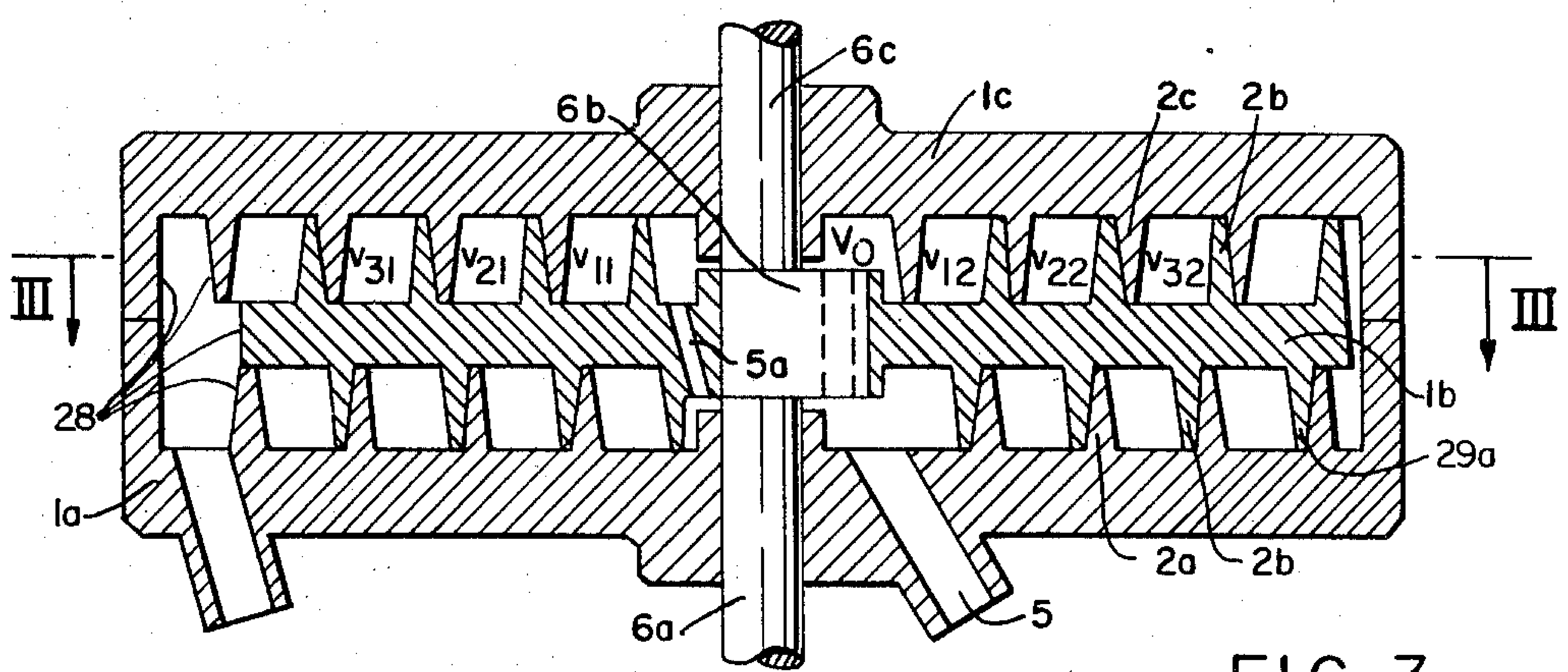

FIG. 3.

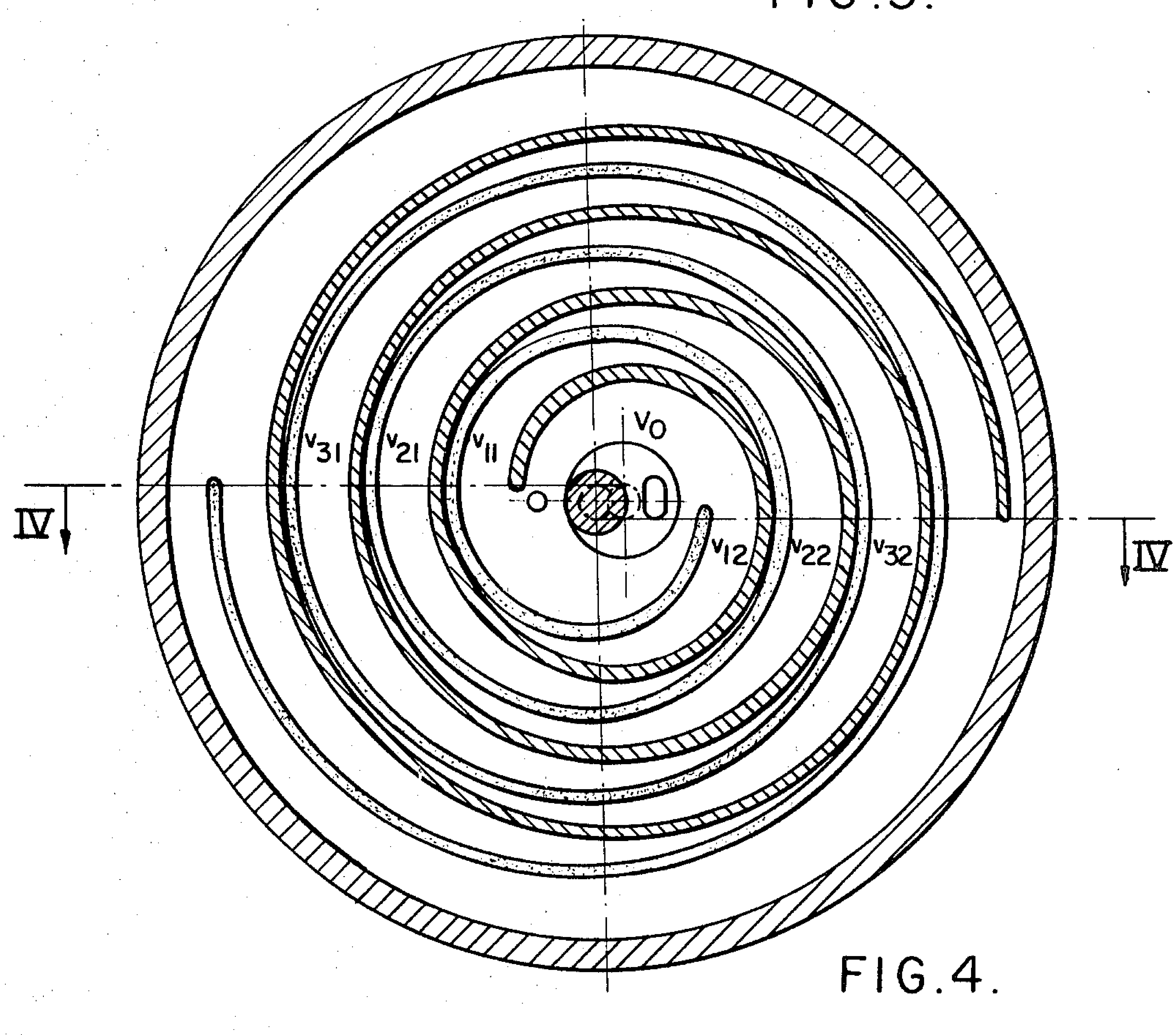

FIG. 4.

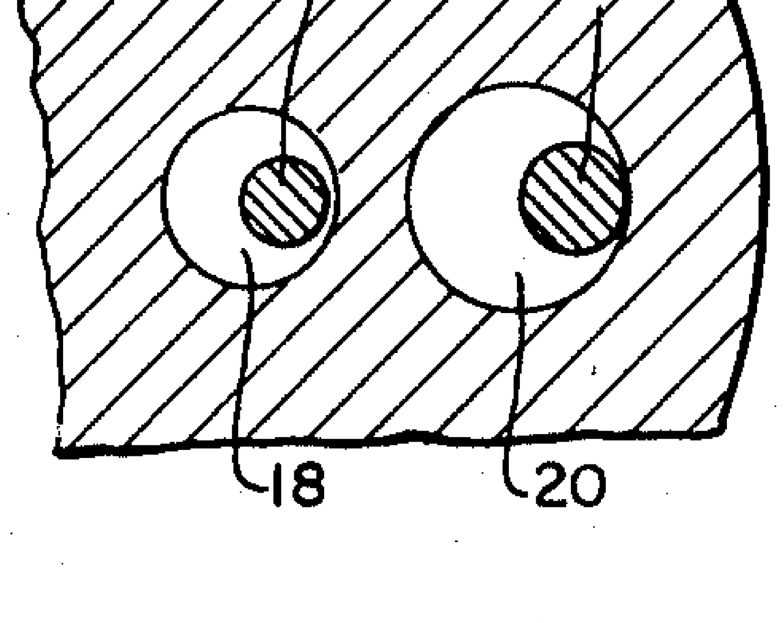

FIG. 5a.

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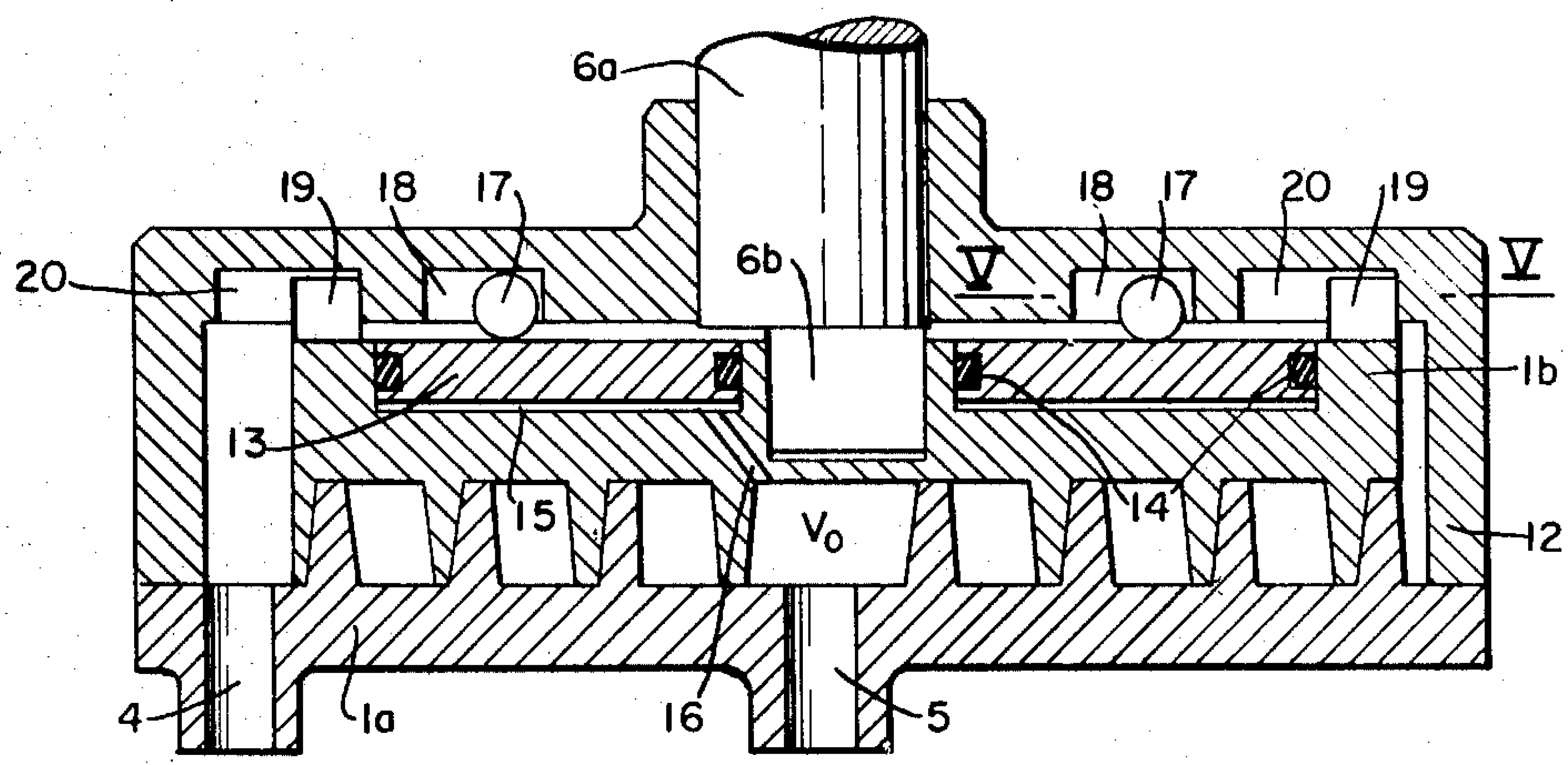

FIG. 5.

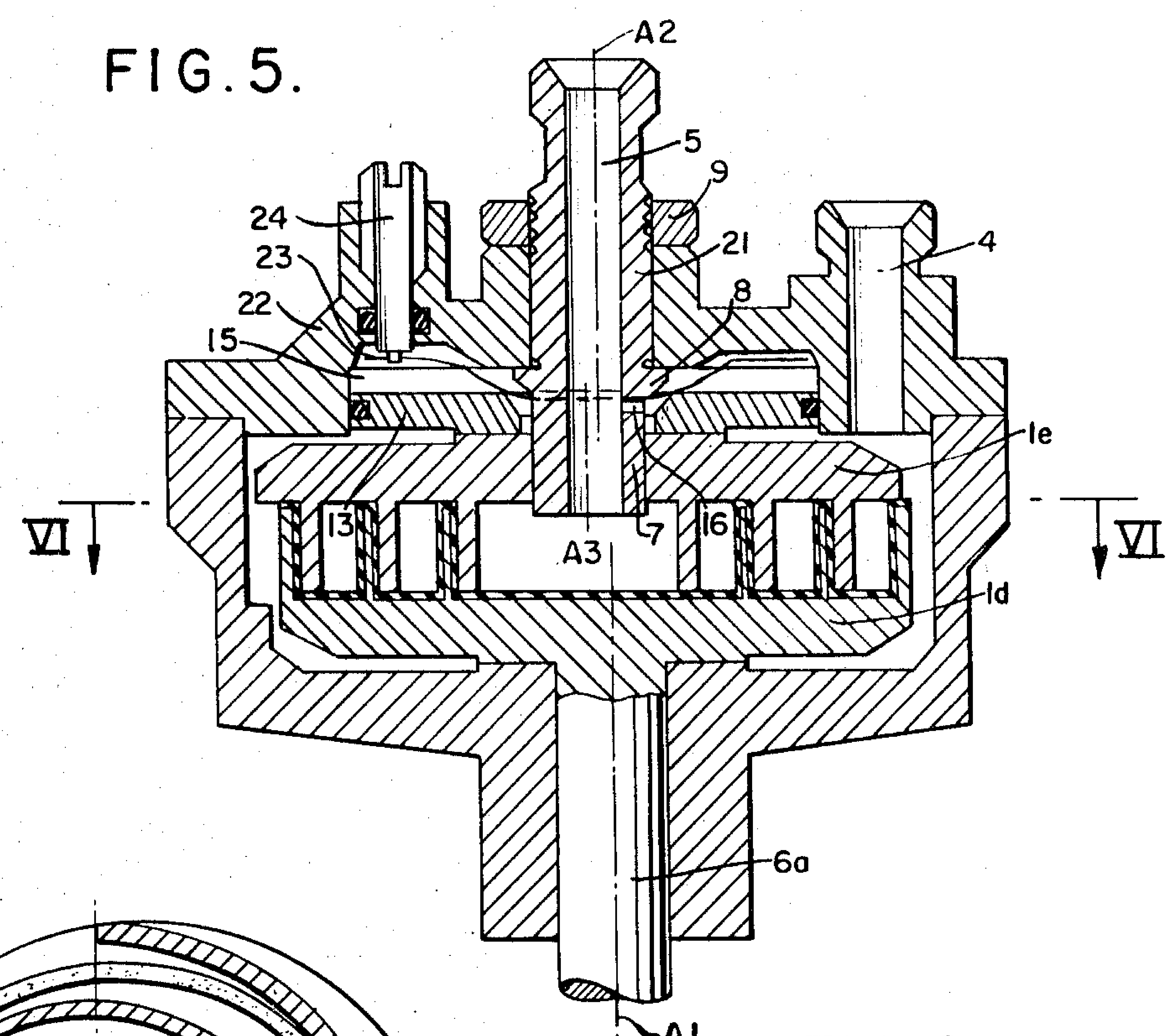

FIG. 6.

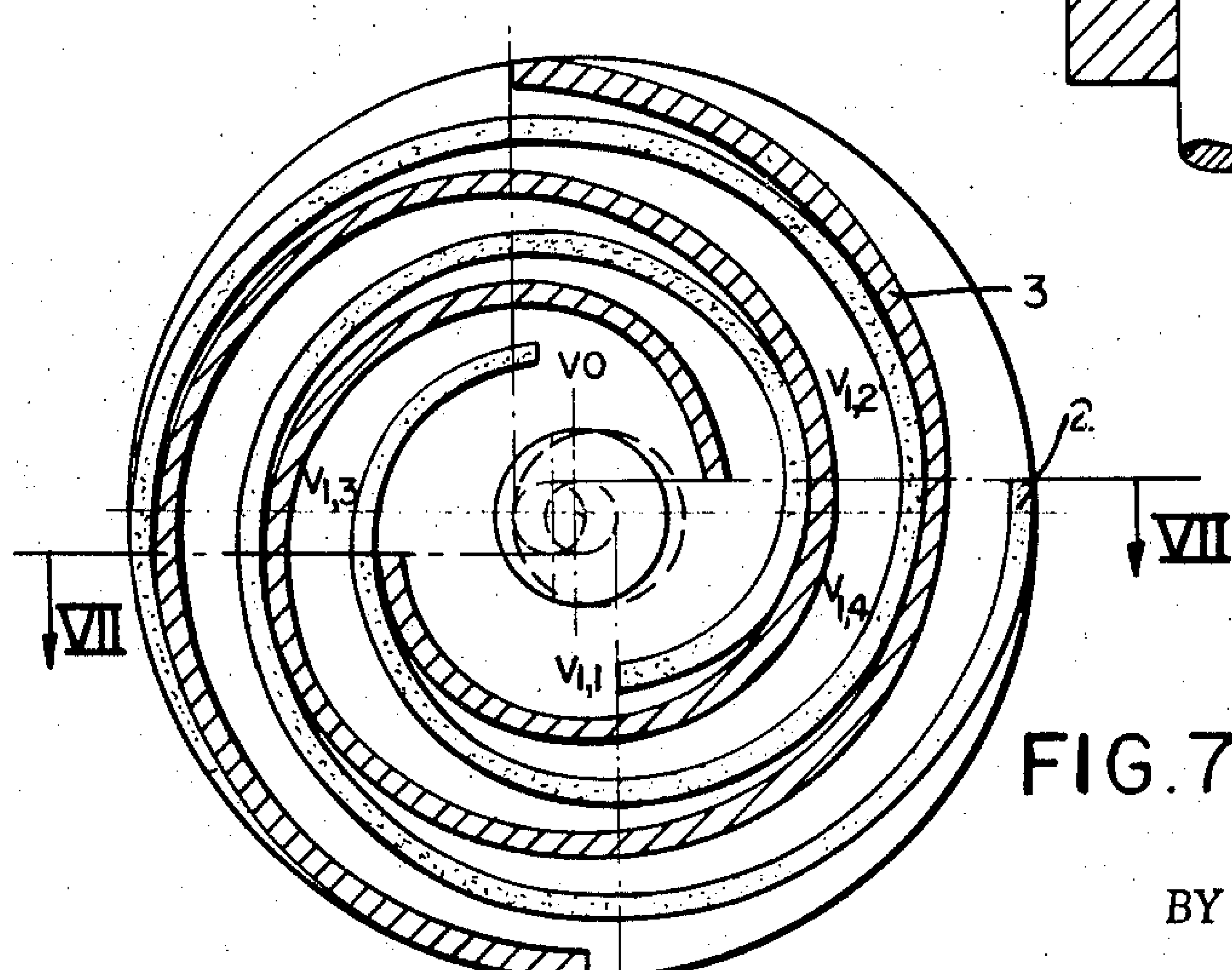

FIG. 7.

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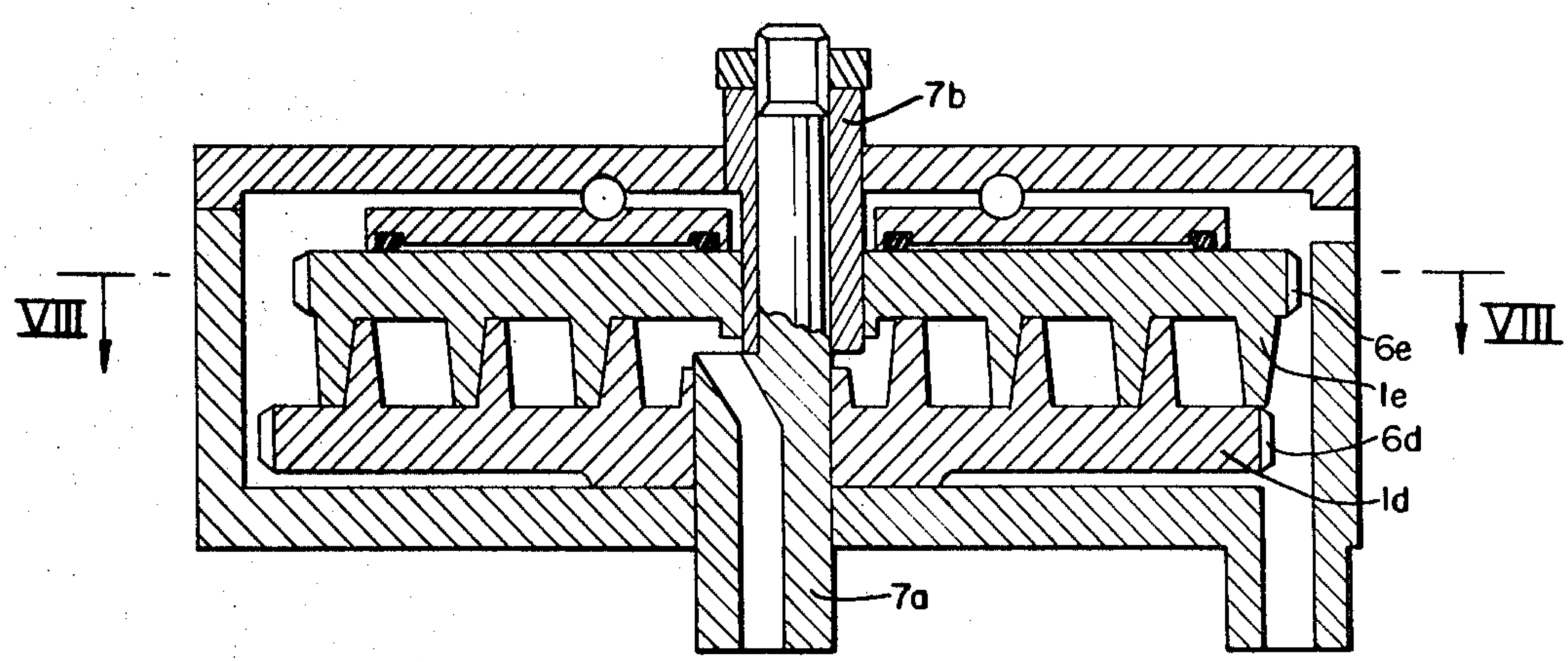

FIG. 8.

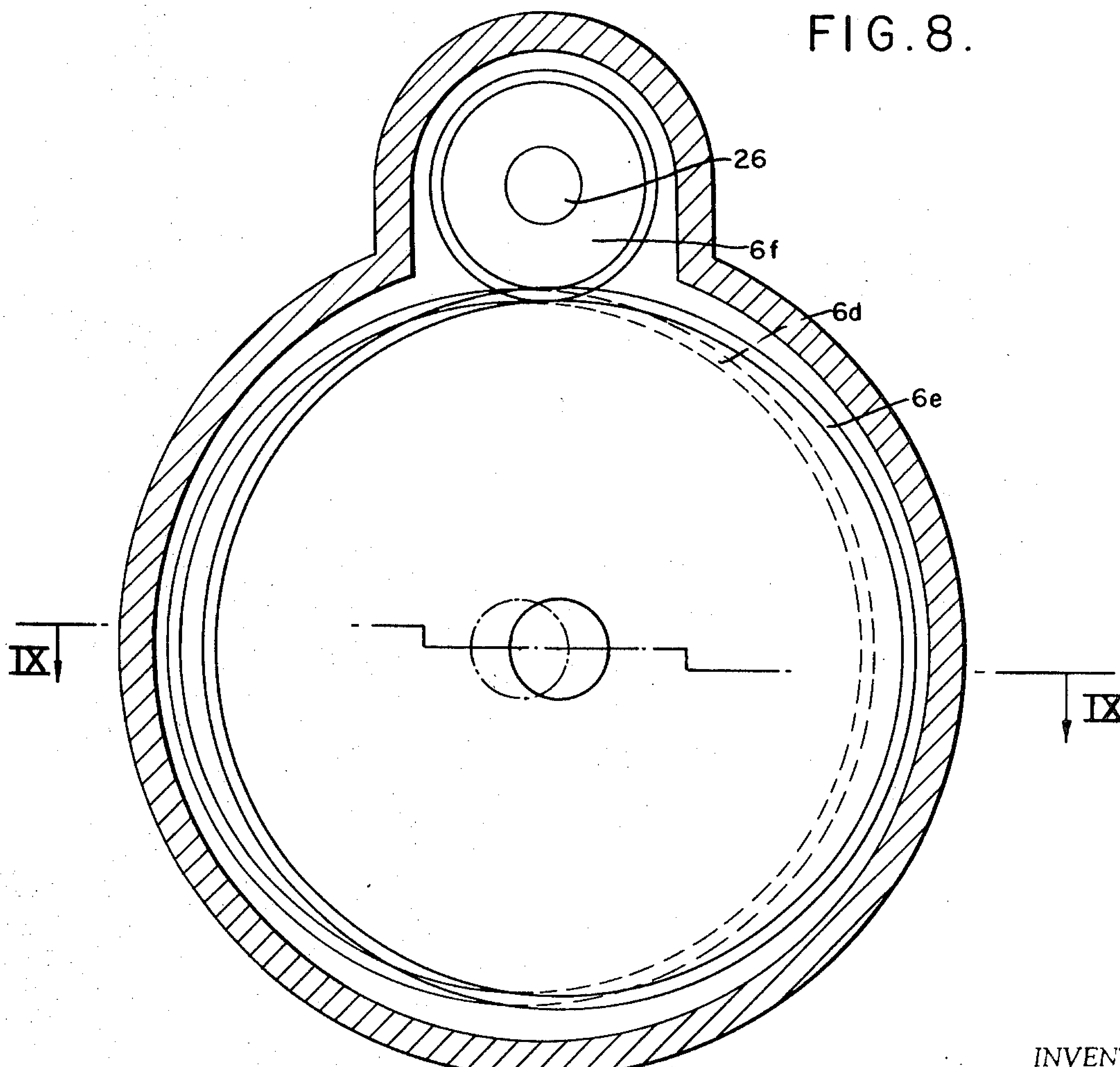

FIG. 9.

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INVOLUTE PUMP

BACKGROUND OF THE INVENTION

This invention relates to fluid motion devices, and more particularly to such a device which is particularly useful as a positive displacement pump for producing a vacuum. In REULEAUX "Theoretische Kinematik" pages 399 ff, an apparatus has become known under the name of Payton's hydrometer. This apparatus consists of a casing in which two involute circular arcs contact each other at their outside, transporting liquid by each rotation. The pumping chambers are limited by the cylindrical wall of the casing, one involute arc and the plane front and rear end walls of the casing. One of the main disadvantages in this configuration consists in the high sliding speed of the ends of the involute arcs on the casing wall.

Furthermore, different apparatus of manifold design have become known as hydroengines, pumps, pneumatic engines, compressors, ventilators or air pumps, depending on the scope and the medium to be handled. The pneumatic devices for large and medium displacement capacities at small and medium pressures are in most cases vane type, helicoid or other high speed systems, each one of which has its imperfections. Vane type compressors for example have the disadvantage of high friction, screw-type compressors are too complicated due to the many working stages required for higher pressures.

SUMMARY OF THE INVENTION

An object of the present invention was to evade the drawbacks mentioned above and to design a system simple in construction and manufacture, and precluding the disadvantages of high friction, in particular with the complicated drive gear and follower mechanisms, and high production cost.

The solution of this problem as provided by the invention consists in two plane, parallel disks **1** with interengaging projections **2**, forming the pumping chambers V, and that these projections **2** on both disks **1** with regard to the centerline L define circular involutes of the same base circle rg, and that at least one disk **1** is connected to a driver **6** for the circular translation movement of one disk **1** against the other, whereas the pumping chambers V are limited by the outside of one projection **2** and the inside of the other projection **2**. The configuration as stated in this invention in comparison to the known state of the technology offers the essential advantage that the disks do not require a special guide, but that the involute circular projections fulfill in the first place this task which in other design apparatus requires a complicated mechanism. A further considerable advantage of the design as specified in the invention consists in that the machining of the involute circular projections can be done continuously by superimposing a rotary to an advance motion. In addition it must be emphasized that the device specified in the invention allows the manufacture of volumetric displacement engines in which several involute circular projections can be arranged on one disk. This ensures a specially constant pumping effect. Also, in this arrangement the disk bearing the involute circular projections is entirely balanced. It turned out to be useful to mount the two disks rotatable on displaced shafts leading through the zero point of the involute circular projections. This makes it possible that one of the disks can be set in rotary motion by means of a driver whereas the driven disk by transfer of force via the sides of the involute circular projections sets the other disk in rotary motion of the same rotational speed and in the same sense of rotation, whereby both disks describe the relative motion in form of the circular translation.

In some cases it might be useful to drive both disks by means of suitable driving mechanisms in the same sense of rotation and with the same rotational speed. This may be achieved, for example, by providing toothed rims on the external circumference of the disks in which a common gear wheel engages. Further, it may be helpful that one disk is firmly mounted and the other disk describes the relative motion in form of circular translation by means of suitable driving mechanisms.

It proved to be convenient that the parallel guiding during the motion of circular translation is effected by the sides of the involute circular projections. In particular cases it may be useful to have the parallel guiding effected during the motion of circular translation by catches or follower elements. In view of tightness it may be of advantage that at least one disk is provided at its outer circumference with a circular projection which forms a radial seal together with the other disk. It appears furthermore useful for the continual adjustment of the radial clearance that at least one of the disks is arranged eccentrically and rotatably on the displaced shaft.

It proved to be useful that for compensating the axial pressure in the chambers formed between the disks and the involute circular projections, a ring-shaped support is placed into the side of one of the disks reverse to the side bearing the involutes, this support being placed on bearing elements arranged into the recesses of the casing and tightened by means of gasket rings, whereas the space between the ring-shaped support and the disk is connected through a pressure equalizing line with one of the chambers.

In order to compensate for the axial pressure in the chambers formed between the disks it is also possible to arrange shiftable, ring-shaped support. This support presses the two disks against each other by means of a pressure spring. It may be helpful if in such an assembly the tension of the pressure spring is adjustable by means of setscrews. It may furthermore be helpful if sealing ridges are inserted into the front ends of the involute circular projections.

The disks and the involute circular projections are normally milled from metal or cast or sintered. It might be useful, however, to coat the metallic disks and the involute circular projections with resilient material such as rubber or plastic. For instance when pumping acid-containing media or gases it may also be advisable to manufacture the disks and the involute circular projections entirely of plastic material. A convenient variation of the design specified in this invention contains between two stationary disks with involute circular projections, a mobile disk provided on both sides with involute circular projections. These projections interengage with the projections on the stationary disks, whereas the projections on one side are angularly displaced to those on the other side in order to achieve a constant displacement capacity.

It proved further to be of advantage that the involute circular projections are of trapezoidal or of rectangular section. In particular cases a different section of the projections is not excluded.

DEFINITION OF TERMS

As used in the specification and claims the following terms have the indicated meanings:

Circular translation means the movement of an object in a circular path in a single plane and without rotary movement outside of said plane.

Zero point means that point on the circumference of the base circle of an involute curve from which the curve commences.

A *fluid motion device* is a device which has the generic characteristics of a pump or a motor. Such devices normally consist of a structure having relatively moveable parts, which during their relative movement form one or more chambers whose volume varies. If such chambers are connected to a fluid supply, and if the structural parts are mechanically driven to vary the chamber size a pumping action results. On the other hand if such variable chambers are supplied with fluid under pressure either by pumping fluid into the chambers or using them as an internal combustion engine chambers the device delivers useful mechanical motion as a motor.

BRIEF DESCRIPTION OF THE DRAWINGS

Various forms of construction of the pump as stated in this invention are explained more closely hereafter with reference to the respective drawings:

FIG. 1 shows the basic principle of the device in form of a one-involute single-stage pump with one fixed and one moving disk in longitudinal section taken on line II–II of FIG. 2.

FIG. 2 shows a cross section taken on line I–I of FIG. 1

FIG. 3 shows a one-involute three-stage pump with two stationary disks and one moving disk placed in between with involute circular projections on both sides, section taken on line IV–IV of FIG. 4.

FIG. 4 shows a section taken on line III–III of FIG. 3.

FIG. 5 shows a one-involute multistage pump with one fixed and one moving disk with pressure equalizing chamber and with follower elements. FIG. 5*a*, taken on line V–V of FIG. 5, shows a follower element and one of the balls bearing the ring-shaped support.

FIG. 6 shows a two-involute single-stage pump with rotary disks, adjustable radial clearance and pressure equalizing chamber in longitudinal section taken on line VII–VII of FIG. 7.

FIG. 7 shows a cross section taken on line VI–VI of FIG. 6.

FIG. 8 shows an engine with rotary disks provided with toothed rims at their circumference where a common gear wheel engages, longitudinal section taken on line IV–IV of FIG. 9.

FIG. 9 shows a cross section taken on line VIII–VIII of FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 and 2 show the basic principle of the invention represented in a one-involute single-stage pump. This pump consists of a stationary disk **1***a* with one single involute circular projection **2***a* and one moving disk **1***b* having one single involute circular projection **2***b*. According to the representation in FIG. 1 both projections **2***a* and **2***b* have trapezoidal cross sections. The height and the side slope of which must be equal, the width of which, however, may be different. Also rectangular sections are possible, for which the same conditions apply. In the section corresponding to FIG. 2 the walls of the projections **2***a* and **2***b* and their centerlines L_1 and L_2 are circular involutes of the same base circle radius *rg* and an arc length of one and a half windings, complying with a single-stage engine. The disks **1***a* and **1***b* and the circular sealing projections **3***a* and **3***b* connected firmly to them constitute the external limitation of the engine, whereas projection **3***b* is fitted with a sealing ridge **29***b* for better tightness. This means that the only openings to the outside are the inlet aperture **4** and the outlet aperture **5** located in the fixed disk **1***a*. The drive shaft **6***a* is placed into the fixed disk **1***a*, the eccentric stud **6***b* connected firmly to it is inserted into the moving disk **1***b*. A collar **8** and a nut **9** serve for fastening of the assembly and for absorbing the axial forces. The centerline A_1 of the drive shaft **6***a* passes through the zero point 0_1 of the involute circular projection **2***a*, the centerline A_2 of the stud **6***b* through the zero point 0_2 of the involute circular projection **2***b*. As compared with the starting position, where the zero points 0_1 and 0_2 coincide and the centerlines L_1 and L_2 of the involute circular projections **2***a* and **2***b* are congruent, the two base areas of **1***a* and **1***b* are turned by 180° against each other and radially displaced by the distance 0_1 and 0_2, thus forming the joints B_{01}, B_{02} and B_{11}, B_{12} which are situated in straight lines the distance of which from zero points 0_1 and 0_2 are equal to the base circle radius *rg*. The displacement is equal to the circumference of a base circle, less half the width of the projection on one disk, less half the width of the projection on the other disk.

In this way, two closed chambers V_{11} and V_{12} are formed and the central chamber V_0. When the drive shaft **6***a* rotates in the sense of the arrow **10**, the mobile disk **1***b* performs a motion of circular translation, the chambers V_{11} and V_{12} shift toward the center and open into the central chamber V_0, as the closing joints B_{01} and B_{02} disappear. After one full circular translation, the closing joints B_{11} and B_{12} are taking the place of the previous closing joints B_{01} and B_{02}. The medium originally contained in chambers V_{11} and V_{12} was steadily transferred into chamber V_0, and new chambers V_{11} and V_{12} have formed. The swept volume therefore is equal to the sum of chamber volumes V_{11} and V_{12}.

Frictional and compressive forces produce a torque acting on the moving disk in the sense of the arrow **11**. The projection **2***b* of the moving disk **1***b* therefore leans on projection **2***a* of the stationary disk **1***a* at the contact point B_{12}, whereby reciprocal twisting of the two disks is prevented and the motion of circular translation without additional guiding mechanisms becomes possible. The restoring moment acting on contact point B_{12} is equal in any position to the normal force N occurring at this point, multiplied by the base circle radius *rg*. When during the manufacture of the pump the involute-shaped projections are produced by machining, the disk turns around the zero point of the projections. This rotary motion is superimposed by a coupled constant feed motion, perpendicular to the rotary axis. The engagement of the stationary tool is lateral to the feed direction at a distance r_g. The advance per revolution of the disk is equal to the pitch *g* of the involute-shaped projections. The relationship between base circle radius and pitch corresponds to $r_g = g/2\pi$.

FIGS. 3—4 Embodiment

The three-stage pump with axial pressure compensation according to FIGS. 3 and 4 consists of two stationary disks **1***a* and **1***c* with the pertinent involute circular projections **2***a* and **2***c*. Between the two stationary disks the moving disk **1***b* with involute circular projections **2***b* and **2***b'* is placed. All projections have several windings and, therefore, produce on both sides of the moving disk **1***b* several series-connected chambers V_0, V_{11}, V_{12}, V_{21}, V_{22} etc. The drive shaft with its ends **6***a* and **6***c* is supported by the stationary disks. On its eccentric **6***b* the moving disk **1***b* is loosely inserted. The outlet apertures **5***a* connect the upper chambers to the outlet aperture **5**. Since with multistage pumps internal compression occurs between the various chambers connected in series, liquid can only be pumped when applying special measures. When pumping gases, however, it is of advantage that several sealing points are connected in series so that only a part of the total pressure gradient will act on one sealing point. In view of the fact that the pressures prevailing on both sides of the disk provided with involutes on both sides are equal, there are no axial forces acting on this disk. These forces are directly absorbed by the stationary disks **1***a* and **1***c*. In addition it should be noticed that the upper and lower projections of the moving disk **1***b* are shifted with regard to each other by a certain degree, in order to achieve constant delivery. For better sealing, the internal metal surfaces with all pumps may be coated with a resilient material, such as rubber, or the front end faces of the projections may be provided with sealing ridges **29***a*.

FIG. 5 Embodiment

The one-involute multistage engine according to FIG. 5 consists of the stationary disk **1***a* with the pertinent involute circular projections and the inlet aperture **4** and outlet aperture **5** contained in it. Placed on top of this disk is the casing **12** in which the drive shaft **6***a* with its eccentrical stud **6***b* is located. The moving disk **1***b* is loosely placed on the eccentric stud **6***b*. On its reverse side the annular support **13** is inserted and sealed off by the gaskets **14**. The interspace between the annular support **13** and the moving disk **1***b* constitutes the pressure equalizing chamber **15**. This chamber is connected through the pressure equalizing line **16** to the central chamber V_0. The annular support **13** is again supported by the casing **12** via several balls **17** placed in cylindrical recesses **18**.

In special cases it might be useful to connect several follower pins **19** firmly to the moving disk **1***b*. The pins **19** touch at their circumference the cylindrical recesses **20** practiced into the casing **12**. The difference between the diameters of the pins **19** and the recesses **20** is equal to the diameter of circular displacement less the clearance desired between the involute circular projections. The evolvement of motion corresponds to that in FIGS. 1 and 2. The torque acting on the moving disk 1*b* due to compression and friction forces, however, is no more absorbed by the sides of the involute circular projections but by the pins 19. The effective area in the pressure equalizing chamber 15 must be large enough so that the resulting axial force is greater than that produced by the pressures in the pumping chambers.

FIG. 6—7 Embodiment

The two-involute single-stage engine with rotary plates represented in FIGS. 6 and 7 consists of the two moving disks 1*d* and 1*e* each provided with two involute circular projections of rectangular section. The disk 1*d* is firmly connected to the rotary shaft 6*a*, the disk 1*e* is loosely placed onto the eccentric stud 7 of the axle 21, whereas axle 21 and shaft 6*a* are also eccentric. By means of the collar 8 and the nut 9 the axle 21 is clamped to the casing cover 22. After loosening the nut 9 the axle 21 can be turned in itself which allows continuous adjustment of the eccentricity between the disks 1*d* and 1*e* and thus of the clearance between the involute circular projections. The annular support 13 is placed firmly on the disk 1*e* and presses the latter against the opposite disk 1*d* due to the axial forces produced by the disk spring 23 and the pressure prevailing in the pressure equalizing chamber 15. The pressure equalizing line 16 connects the pressure equalizing chamber to the outlet aperture 5. The compression force of the disk spring is adjustable by means of several setscrews 24. The inlet aperture 4 is located laterally in the casing cover 22. The outlet aperture 5 is inside the stationary axle 21.

By turning the shaft 6*a* the disk 1*a* is set in rotary motion, and by transfer of force via its projections the disk 1*b* turns in the same sense. A rotary motion is thus superimposed to the motion of circular translation corresponding to FIGS. 1 and 2. This type of drive is also possible with one-involute projections, but with two- and multi-involute projections each disk for itself is entirely balanced. The two-involute projections form four parallel chambers V_{11}, V_{12}, V_{13} and V_{14} which open against the chamber V_0 at intervals of one-fourth revolution. This ensures a more steady delivery than with one-involute engines where the two chambers open simultaneously against the central chamber V_0. The swept volume is equal to four times the content of chamber V_{14}. As compared with the starting position where the centerlines of the projections on the two disks are congruent, the angle of rotation α of the disks is after mounting equal to 180° divided by two, viz 90°, corresponding to the formula $\alpha=180/Z$, where Z is the number of involute-shaped projections per disk.

For two-involute pumps the radial displacement of the two disks, and thus the eccentricity between the centerline A_1, the shaft 6*a* and the centerline A_3 of the stud 7 is smaller than with one-involute engines, which also applies to the sliding speed of the projections of the two disks against each other.

FIGS. 8—9 Embodiment

The engine represented in FIGS. 8 and 9—if compared to that in FIGS. 6 and 7—has the particular feature that the two moving disks 1*d* and 1*e* are placed loosely on the stationary eccentric axle 7*a* and respectively on the eccentric sleeve 7*b* clamped on it. Like with the engine on FIGS. 6 and 7 the radial clearance between the projections of the two disks may be adjusted by turning the sleeve 7*b*. In addition, however, toothed rims 6*d* and 6*e* are provided on the circumference of the disks 1*d* and 1*e*, into which a common gear wheel 6*f* engages which is firmly connected to a shaft 26. The drive may be effected via the toothed rims on the two disks or from one of the two disks via the gear wheel to the other disk. Both directions of rotation are possible and delivery will be made accordingly from the outside to the inside or from the inside to the outside. In this case, the torques are transferred from one disk to the other disk via the gearing. If the radial clearance between the projections on the disks is precisely adjusted, the pump can be operated even without lubrication of the contact or closing points between the projections on the two disks.

The apparatus, subject of the invention, may furthermore be used for a delivery and/or compression of gaseous or liquid media, such as a gas compressor or a delivery pump for liquids of small and high viscosity and as a hydraulic pump. It is also suitable to be used as water, gas and steam turbine, as an internal combustion engine and as compressed air motor.

We claim:

1. A vacuum pump comprising, in combination:
   a. a support structure,
   b. a pair of disks having a surface including substantially plane portions,
   c. projections having walls extending from said plane surface portions of each disk, the centerline of the projection of each disk being an involute of a base circle of the same radius,
   d. means mounting said disks in said support structure with said planar surface portions of each disk substantially parallel and facing each other with the said walls of the projections of the two disks interengaging with each other to form closed chambers between the outside of one projection and the inside of another projection,
   e. means mounting said disks relative to one another for a circular translation movement during which said closed chambers change in size, and
   f. motion transmission means connected to one of said disks for rotating said one disk and for rotating the other of said disks only by means of force transmission through the side surfaces of said projections of said one disk, the rotation of each disk being at the same number of revolutions and in the same direction, and for guiding said disks in a circular translation with respect to one another.

2. The combination defined in claim 1 wherein said means mounting each of said disks for rotation has axes of rotation which are displaced from each other and positioned at the zero point of the involute base circle for the projections.

3. The combination defined in claim 2 wherein said interengaging walls of said projections serve as means for guiding the two disks for parallel movement during their circular translation movement.

4. The combination defined in claim 3 wherein said means for guiding said disks for parallel movement during said circular translation motion includes follower elements.

5. The combination defined in claim 4 including an axle mounted on said support means, and means rotatably mounting at least one of said disks for eccentric movement about said axle.

6. The combination defined in claim 5 wherein at least one of said disks has at its external circumference an additional circular projection which engages the other disk to form a seal preventing radial movement of fluid located between the disks.

7. The combination defined in claim 6 wherein said additional circular projection has a separate sealing element fitted on it to engage said other disk.

8. The combination defined in claim 7 including means for compensating for axial pressure within said suction chambers including an annular member positioned between one of said disks and said support means, boring means engaging said annular member and recesses formed in said support means, said annular support member and said side of the disk opposite the disk of said plane surface being shaped to form a pressure equalizing chamber, gasket means mounted between said annular member and said disk to seal said pressure equalizer chamber, and a pressure equalizing conduit means connected between said pressure equalizing chamber and one of said suction chambers formed between said disks.

9. The combination defined in claim 3 including an annular support member arranged between one of said disks and said support means, means including said annular support member forming a pressure equalization chamber having a pressure substantially equal to that within one of said suction chambers, and pressure spring means carried by said support means for moving said annular support member against one of said disks to thereby bias the planar surfaces of said disks toward each other.

10. The combination defined in claim 9 including setscrew means for adjusting the pressure exerted by said pressure spring means.

11. The combination defined in claim 9 wherein said involute projections have a rectangular cross section in a radial plane of said disk.

12. The combination defined in claim 3 including separate sealing elements mounted on the portions of said involute projections engaging the planar surface of the opposite disk.

13. The combination defined in claim 3 wherein said disks and said involute projection are made of metal and are coated with a resilient material.

14. The combination defined in claim 3 wherein said disks and said involute projections are made of plastic.

15. The combination defined in claim 3 wherein said involute projections have a trapezoidal cross section in a radial plane.