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Vulliez

[11] **3,802,809**

[45] **Apr. 9, 1974**

[54] **COMPLETELY DRY AND FLUID-TIGHT VACUUM PUMPS**

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Sept. 8, 1971 France 71.32376

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[51] **Int. Cl.** **F01c 1/02,** F04c 17/02, F04c 27/00

[58] **Field of Search** 418/5, 9, 55, 60, 88, 91, 418/104

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Assistant Examiner—John J. Vrablik
Attorney, Agent, or Firm—Young & Thompson

[57] **ABSTRACT**

A completely dry and fluid-tight vacuum pump having a cycle of circular translation movement and comprising a fixed body having a fixed disc provided on at least one of its sides with a projection in the form of a spiral, a mobile disc mounted opposite said fixed disc and also provided with at least one projection in the form of a spiral intercalated with the spiral of said fixed disc and having the same angular amplitude, a mechanism by which said mobile disc is coupled to and supported by said body, said mechanism comprising at least three crank handles having the same degree of eccentricity and coupled to each other in a synchronized manner in order to produce a movement of circular translation of said mobile disc with respect to the body during the operation of said pump, means for driving said mobile disc and for causing it to carry out said movement, the spirals of said fixed and mobile discs being spaced apart by a small constant clearance irrespective of the position of said mobile disc, and fluid-tight bellows means, the extremities of which are respectively fixed to said mobile disc and to said body, said pump being further characterized in that said mobile disc is directly coupled at its periphery to the three crank-handles, while a fixed central barrel couples said fixed disc to a fixed base of said body and is surrounded by said bellows means, one extremity of which is connected to said mobile disc and the other extremity to said base.

18 Claims, 8 Drawing Figures

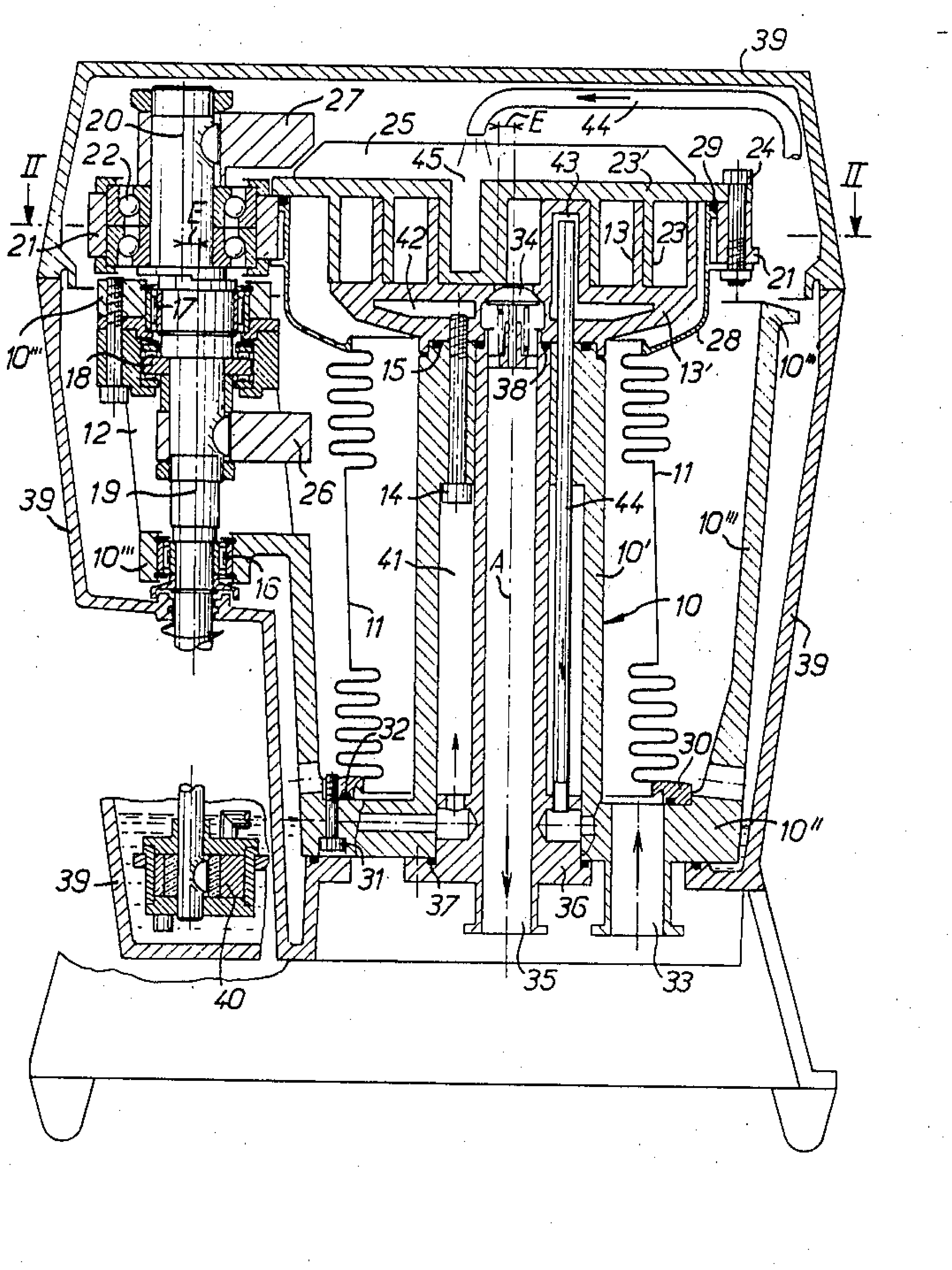

FIG. 1

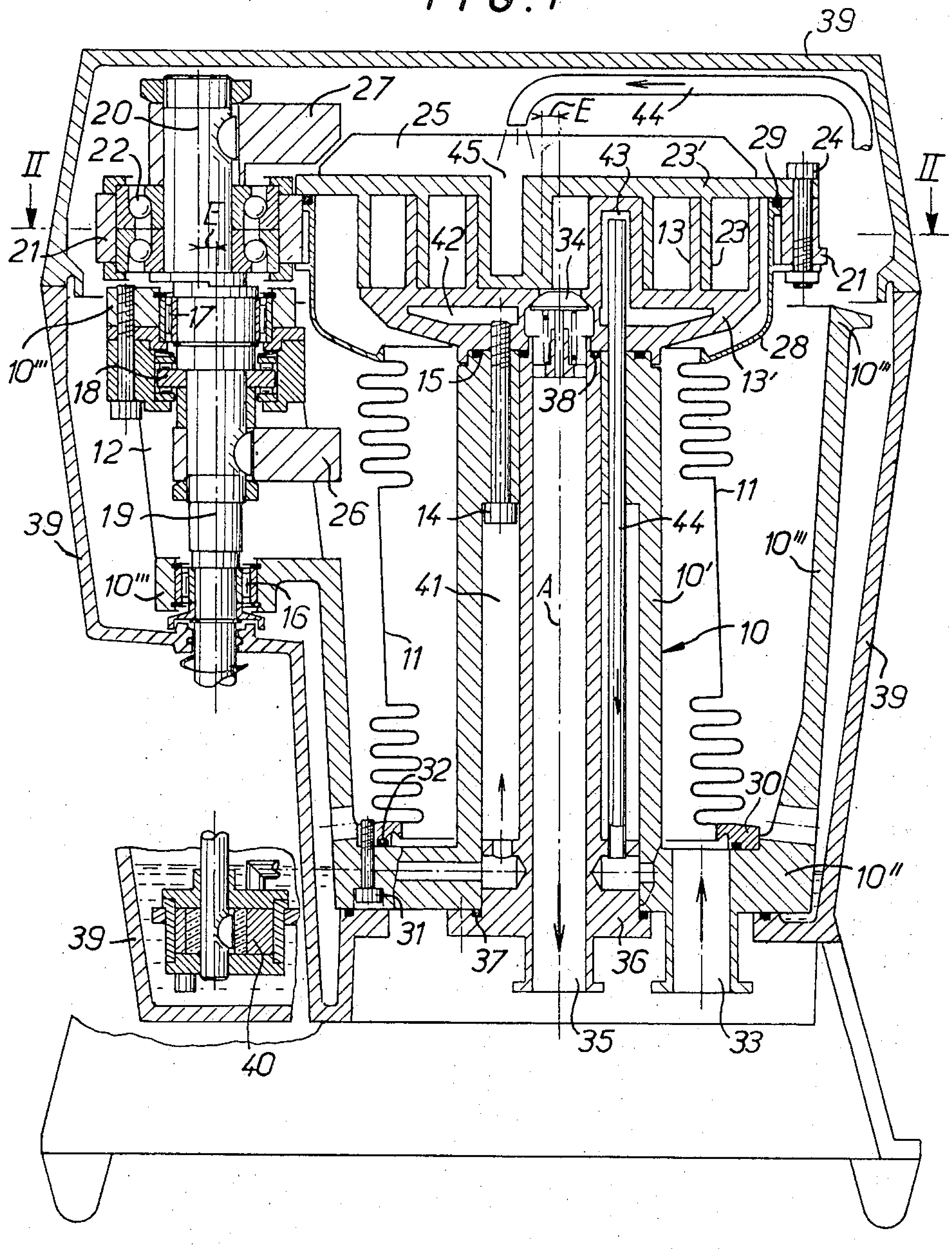
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FIG. 2

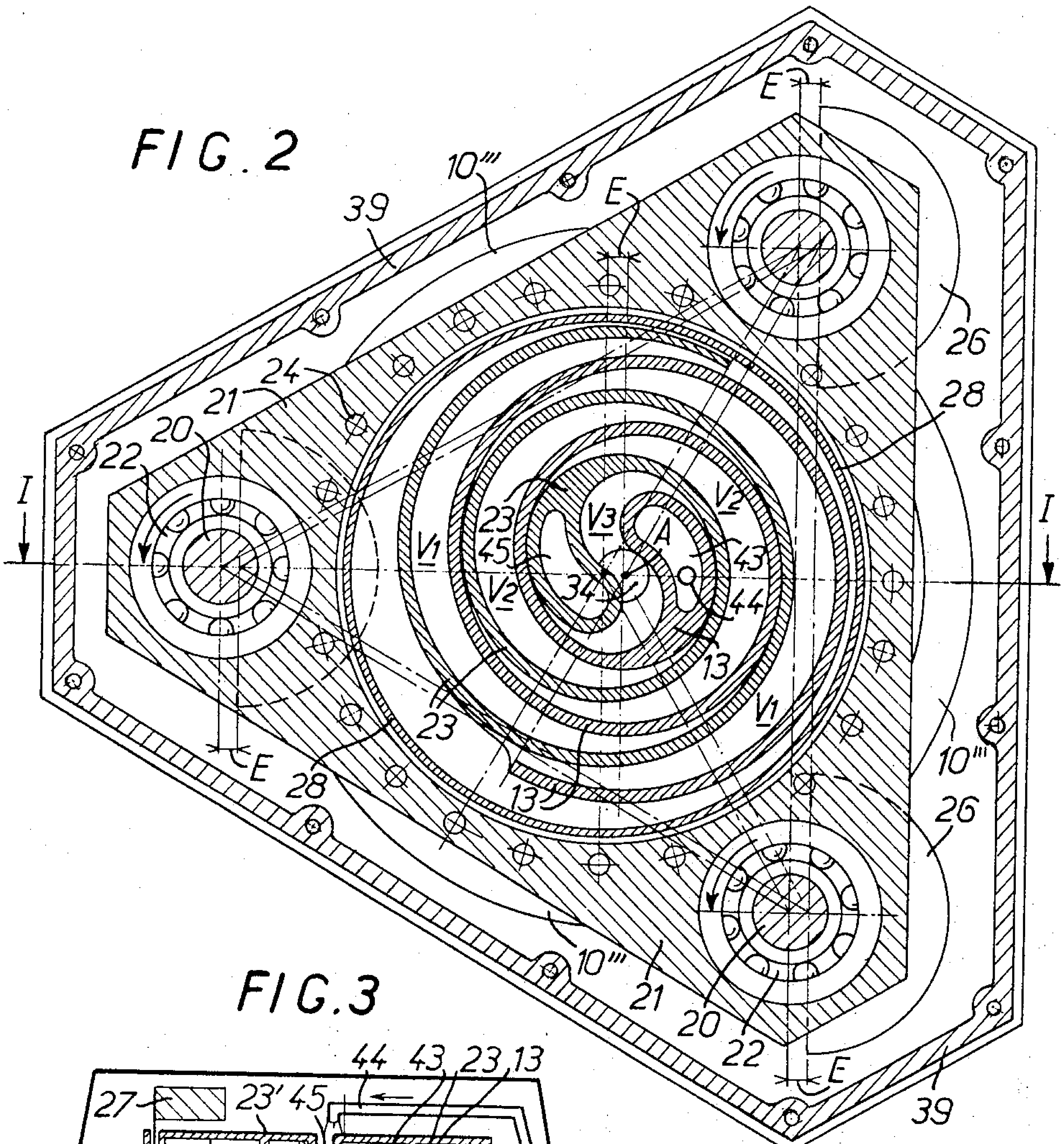
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FIG. 3

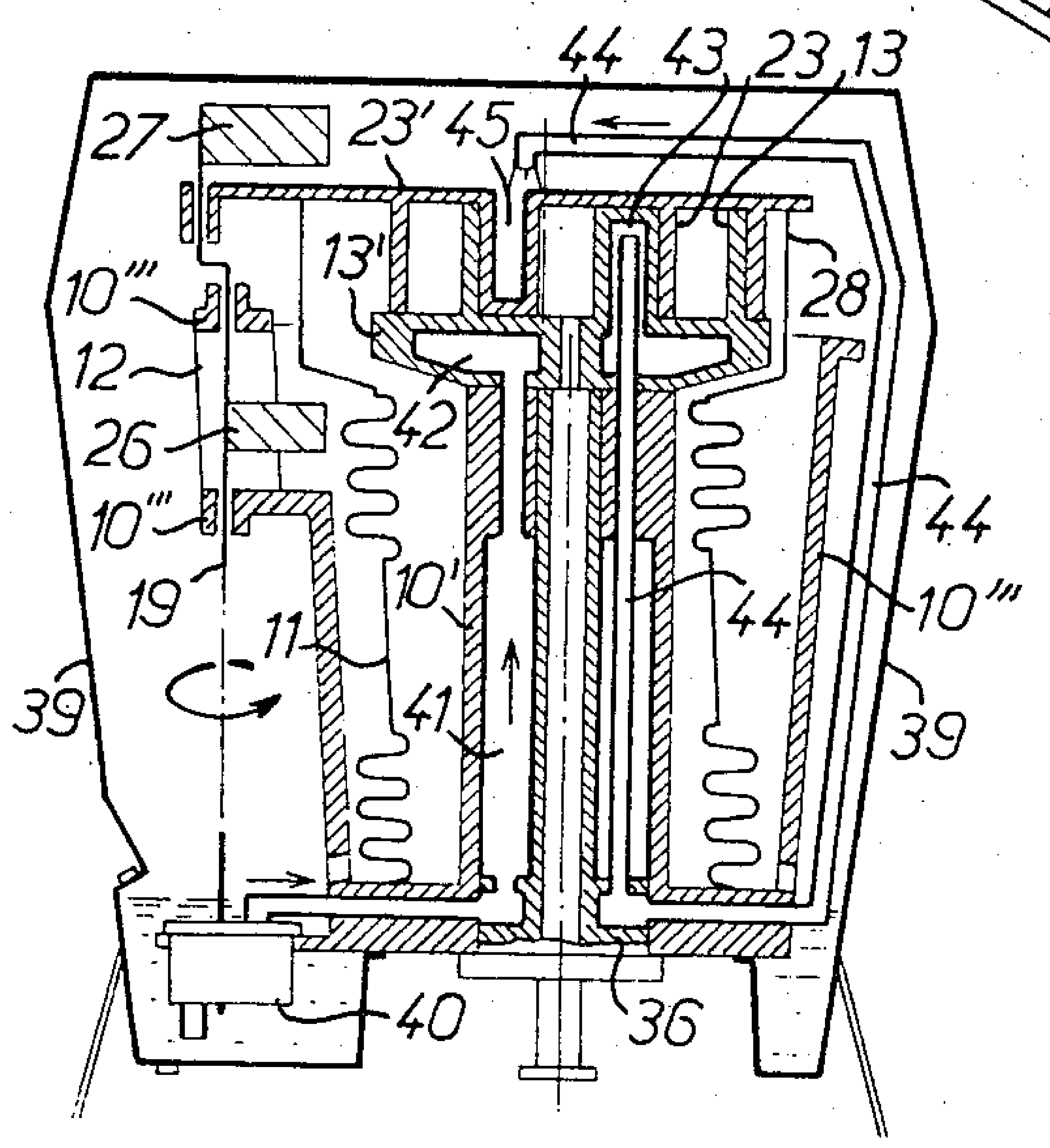
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FIG. 2a

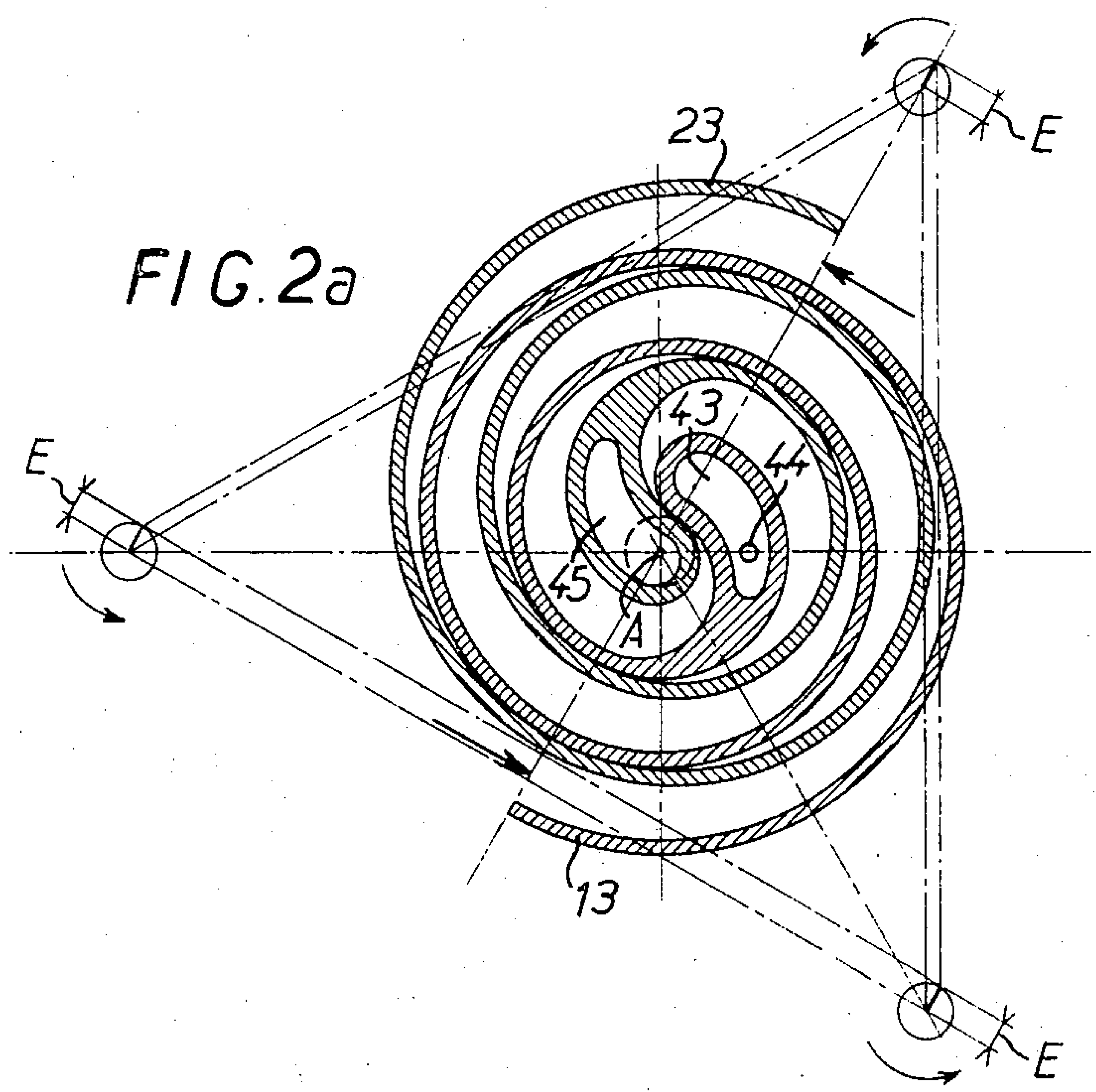


FIG. 5

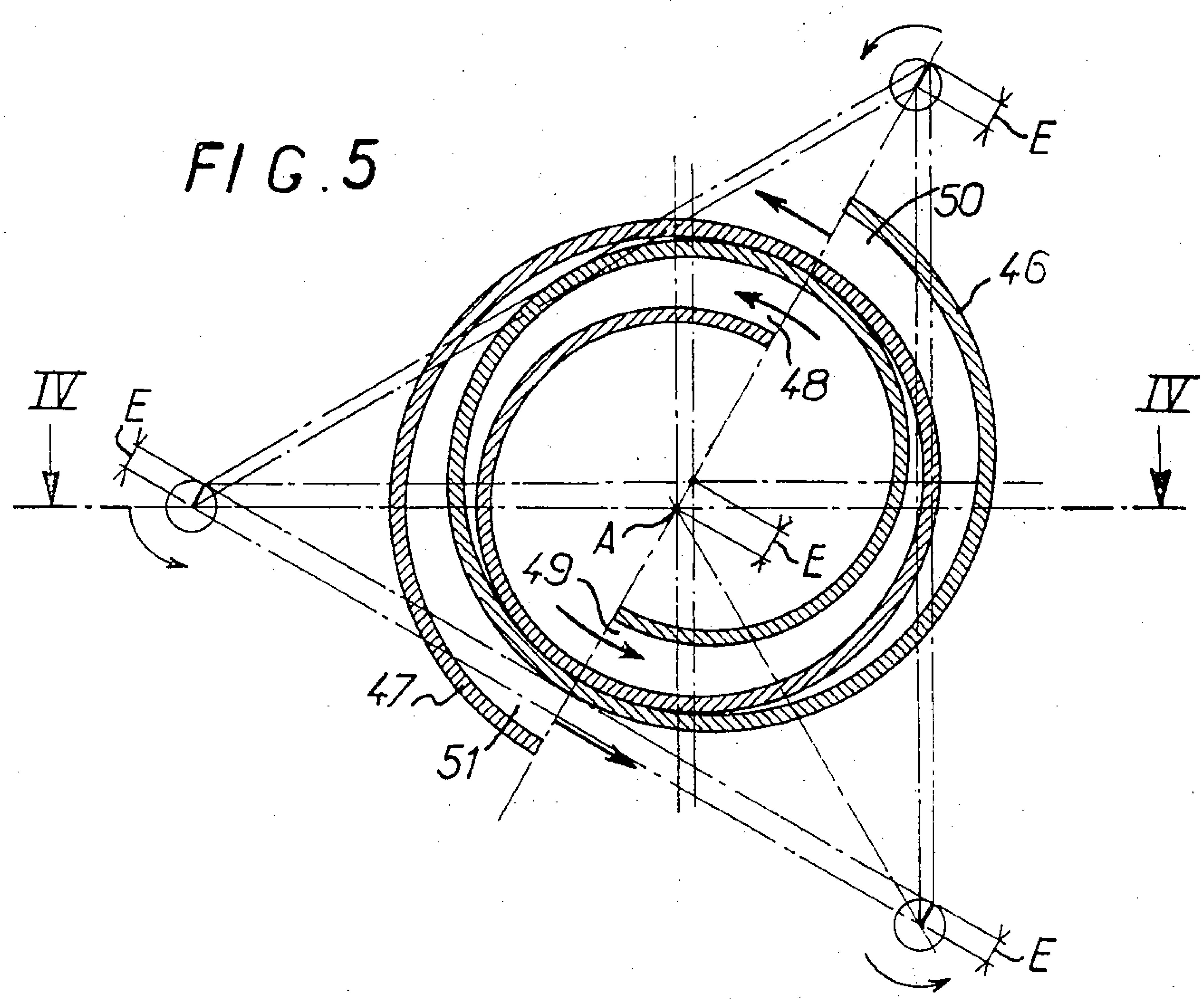
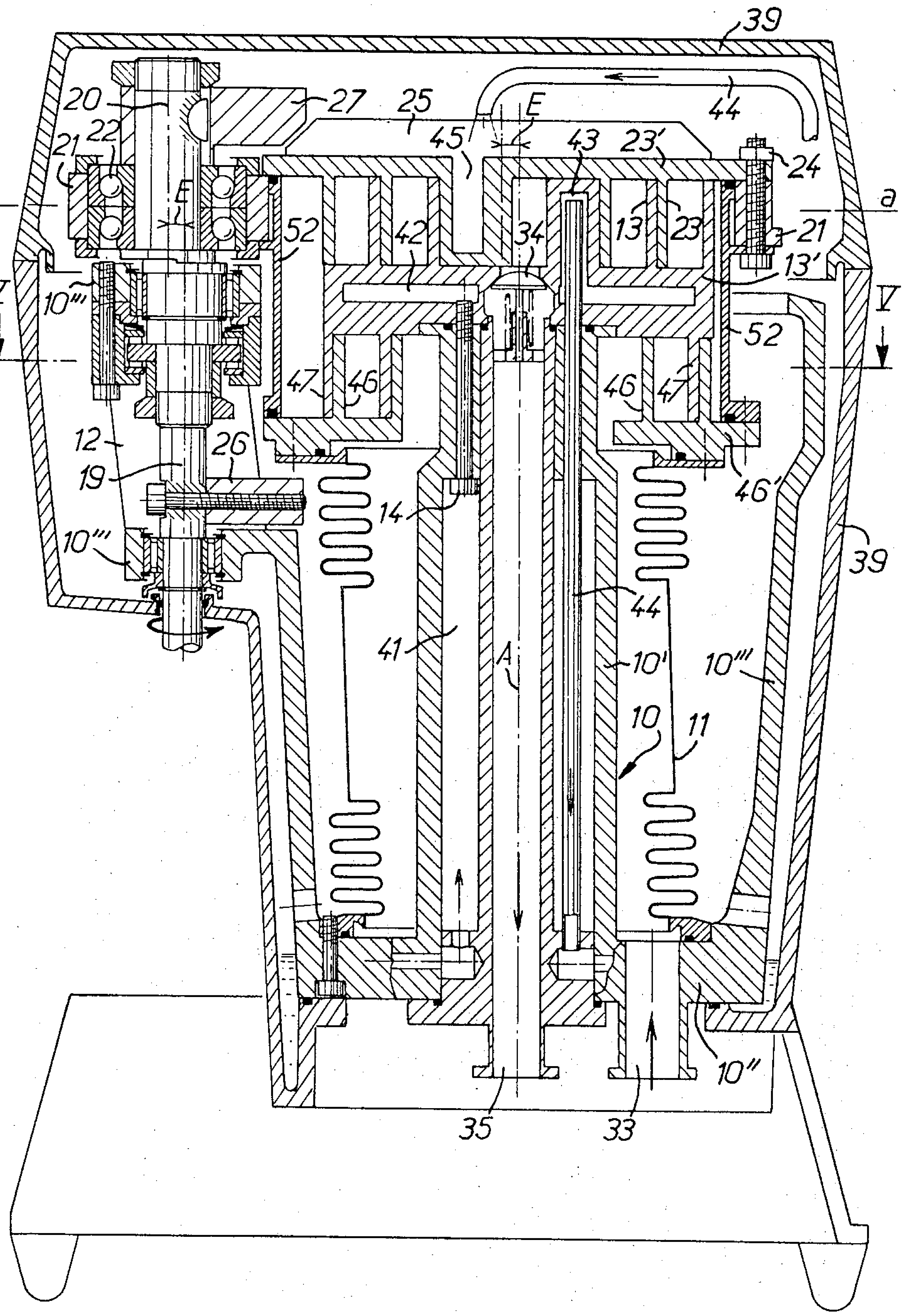


FIG. 4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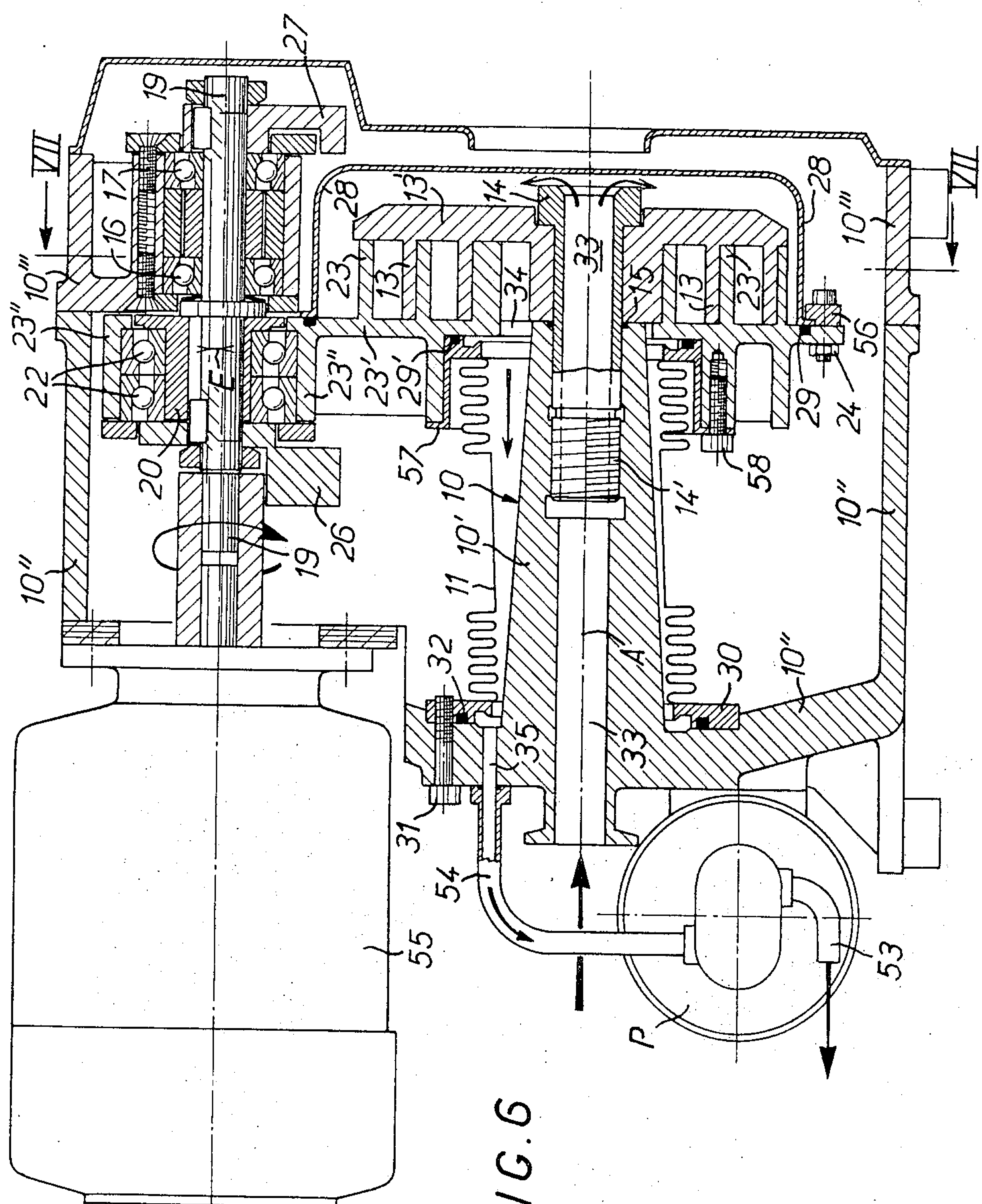
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FIG. 6

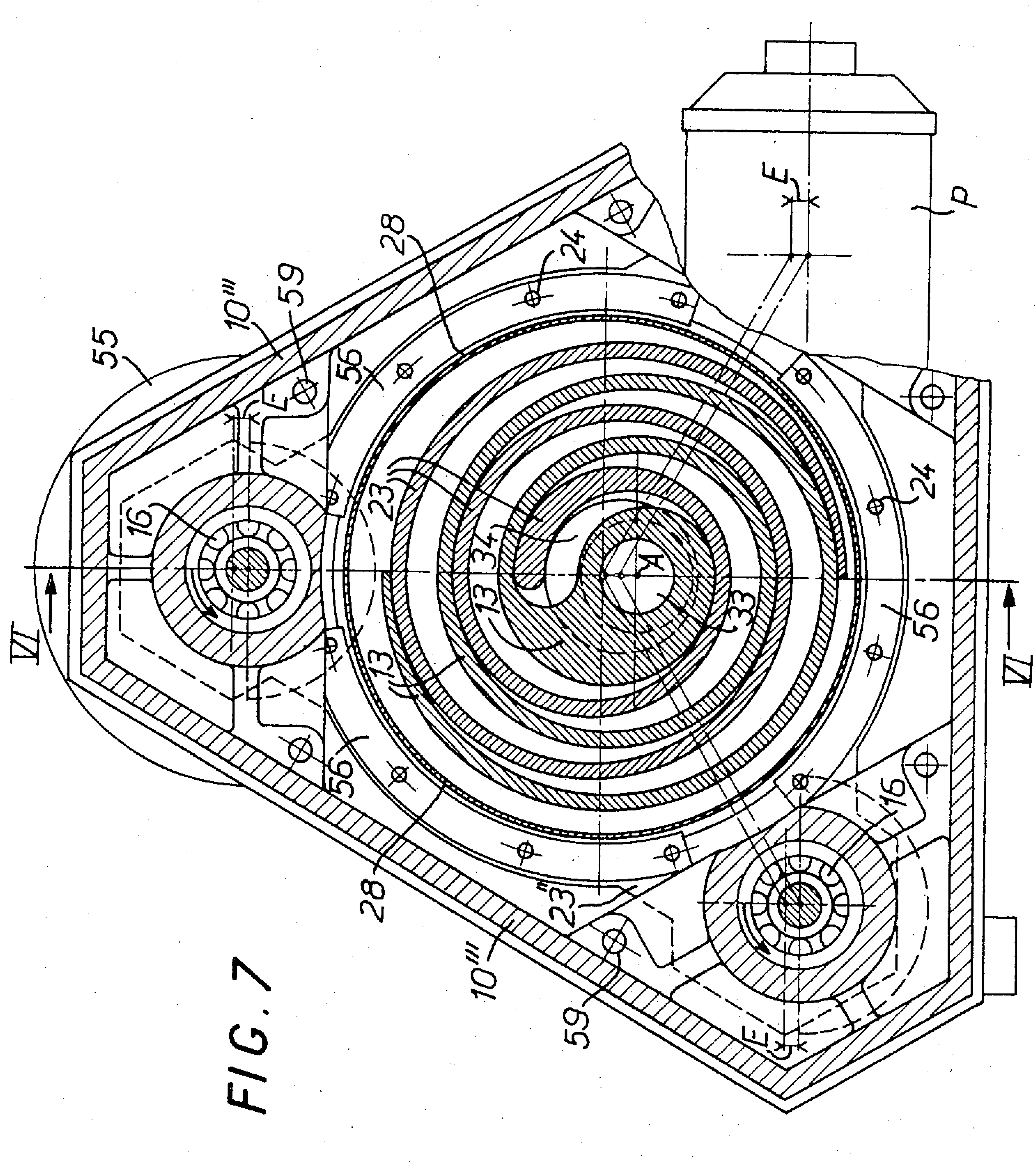

FIG. 7

COMPLETELY DRY AND FLUID-TIGHT VACUUM PUMPS

In conventional mechanical pumps utilized for obtaining a primary vacuum, such as vane pumps or oscillating piston pumps, the active pumping parts comprise friction zones which are lubricated.

Due to the existence of a film of oil between the active pumping parts, these conventional mechanical pumps attain a high compression ratio since, by permitting a rubbing action, this oil film reduces the lateral and radial leakages of fluid to be pumped, by practically eliminating all play between these same working parts. The presence of this oil also makes uniform throughout the mass of the pump the distribution of heat resulting from the pumping effect and mechanical friction, which makes it possible to prevent differential expansion which may lead to a blocking of the various parts.

The fluid-tightness of these pumps with respect to th exterior is not however complete, and the lubrication of the friction zones causes a pollution of the fluid and of the chambers to be pumped out. In spite of the expedients employed to remedy this condition, serious disadvantages result in many applications.

In order wholly to prevent these drawbacks, there have already been proposed vacuum pumps of the volumetric type, in which the working parts move with respect to each other following a precise and generated cycle of circular translation, without any friction or lubrication, and in the interior of a pumping zone, the fluid-tightness of which is complete with respect to the atmosphere and to the lubricated parts at the same time. Pumps of this kind are described in particular in French Certificate of Addition No. 93,048 of September 29, 1967 in the name of Paul Vulliez.

In order to approach the performances of conventional mechanical pumps for primary vacua, the vacuum pump described in the Certificate of Addition No. 93,048 must have:

1. An effective conformation of the active pumping parts;
2. A constant and very small lateral and radial play between the active pumping surfaces, which implies:
   - A high precision of kinematic working with the absence of any phenomena of bending or deformation due to the forces resulting from the movement and from the effects of pressure;
   - The absence of any differential expansion attributable to the temperature rise produced by the pumping and the mechanical movement, this differential expansion necessarily having the effect of modifying the relative dimensional accuracy, and in consequence the play between the active pumping surfaces.

The present invention relates to vacuum pumps of the type comprising a fixed body having an inlet and an outlet for a working fluid, a passage for the said working fluid which extends between the said inlet and the said oulet, and which is arranged in the interior of the said body, mobile means for effecting a displacement of the working fluid from the said inlet to the said oulet, a mechanism by which the said mobile means are coupled to the said body and are supported by it, the said mechanism comprising at least three crank-handles of equal eccentricity, coupled in a synchronized manner

to each other, so as to control a precise circular movement of translation of the said mobile means with respect to the said body during the operation of the pump, means for driving the said mobile means and for causing them to carry out the said movement, the said passage having walls which are shaped so as to follow the configuration of the envelope of the space swept by the said mobile means during their movement, the said mobile means and the walls closest to the said passage being separated by a small constant clearance, irrespective of the position of the said mobile means, and fluid-tight bellows means having their extremities fixed respectively to the said mobile means and to the said body in order to isolate the said passage from the atmosphere and from the lubricated mechanisms.

In vacuum pumps of this type proposed up to the present time, and especially the pump with a single mobile spiral described in the Certificate of Addition No. 93,048, it is seen that the disc of this mobile spiral is provided on its outer face with a central coupling member in the form of a barrel coupled to the three crank-handles and surrounded by the bellows, while the disc of the fixed spiral which is intercalated in the mobile spiral forms part of the fixed body.

The Applicant has discovered that this arrangement gives good results when the constant clearance provided between the spirals of the two discs is not very small, which corresponds to applications in which the value of the vacuum required from the pump is not very high. On the other hand however, an arrangement of this kind has the disadvantage of involving risk of accidental contacts when the constant clearance is made very small in order to obtain a high degree of vacuum.

The Applicant attributes this disadvantage to the fact that the movement imparted by the crank-handles to the mobile disc passes through the intermediary of a central member, which may cause a whipping action, the amplitude of which may be small at the centre but increases towards the periphery of the disc, thus involving risk of accidental contacts.

The Applicant has found that this risk may be avoided, and that it is possible to obtain greatly improved operation with a simpler and more robust construction, when the coupling member surrounded by the bellows is rigidly secured to the fixed disc and not to the mobile disc.

The present invention has for its object improvements in vacuum pumps which are completely dry and fluid-tight and which have a circular translation cycle, making it possible to obtain a simple and robust construction and also a very great precision of operation and excellent performances, and this without any risk of pollution or leakage or excessive heating, or seizure by incorrect contact, and under good conditions for the suction and delivery.

According to the invention, a vacuum pump is characterized in that the crank-handles which determine the circular translation movement and which are arranged at the periphery, directly drive the mobile disc which occupies a central position circumscribed by the said crank-handles, while the fixed disc is coupled to the fixed body by a fixed central barrel surrounded by the bellows, one extremity of which is directly or indirectly connected to the mobile disc while its other extremity is coupled to the fixed body.

This arrangement has the result of preventing in the movement transmission any central intermediate member which may be capable of generating whipping movements tending to become amplified towards the periphery. On the contrary, the high degree of accuracy which has already been achieved by the position of the crank-handles in the peripheral zone only increases when approaching the centre. There is thus obtained a very great precision of movement permitting a very small clearance to be formed between the spirals without risk of contact, and the pump is thus capable of producing a high vacuum.

More precisely, this result is obtained by the provision of a fixed body preferably made in one single piece and having its central portion surrounded by the bellows, while the peripheral portion comprises three slots arranged for the strictly accurate positioning of the shafts. This arrangement gives great rigidity to the assembly, preventing bending deformations due to the effect of pressure in the central delivery zone of the fixed spiral, and permitting a high precision of the circular translation cycle generated by the three crankshafts which thus work without any overhang, and therefore without bending deformation.

Furthermore, the fact of providing a fixed central barrel surrounded by the bellows in order to support the fixed spiral facilitates the suction and delivery conditions of the fluid to be pumped. More particularly, the suction may be effected in a simple manner in the annular space included between the fixed central barrel and the bellows which surrounds it, while a delivery conduit with its valve may readily be placed along the axis of the fixed central barrel. It will also be noted that a vertical position is favourable to the blowing-out and the expulsion of any liquid which may originate from condensable vapours in the interior of the spirals.

According to another characteristic feature of the invention, there is provided a series of arrangements permitting the elimination of any differential expansion capable of modifying the working clearances between the active parts of the pump.

To this end, the body, the active pumping members, the mechanical transmission and movement members are preferably chosen from materials which have the same coefficient of expansion and the same thermal conductivity. Also, from the time of starting-up, means for the circulation of a cooling fluid come into action in such manner that the heat produced by the pumping effect and the mechanical movement is uniformly distributed between the body, the active pumping members and the movement transmission members. Under these conditions, the working clearance of the pump remains constant both during operation and at each setting to work, even if the starting operations are carried out at different ambient temperatures.

It will be observed that in this type of pump in which the active pumping parts have no friction between each other, the quantity of heat generated remains lower than that produced by a conventional pump such as that of the vane type, in which the friction gives rise to a considerable heating effect which is added to that due to the thermo-dynamic pumping effect. For this reason, the pump according to the invention can operate at high speeds, which constitutes one of the factors in high performances.

In one form of embodiment of the invention, the mobile disc is single, that is to say it has only one spiral projection which, in co-operation with the fixed spiral projection, forms a single working pumping member.

In an alternative form of embodiment which contemplates the production of a higher vacuum, the mobile disc is provided in two parts, of which the spiral projections are placed facing each other in a spaced-apart manner, and between which is mounted the fixed disc having spiral projections on each side intended to co-operate respectively with the spiral projections of the two parts of the mobile disc so as thereby to form two active pumping members.

In this arrangement, the two spirals along which the fluid to be pumped first passes, are spirals without a central bulb in which the fluid is subjected to a centrifugal effect which improves at low pressures the vacuum production of the working assembly of the pump. These spirals are practically not subjected to any heating, as their compression ratio is only considerable at low pressures.

It will be appreciated that the construction with a fixed central barrel permits a particularly simple construction of this arrangement with two pairs of spirals rigidly fixed to the single driving system and with only one fluid-tightness bellows.

From the point of view of industrial performance obtained, it will be observed that the type of pump with a single pair of spirals is capable, when delivering directly at an atmospheric pressure of 760 torr, of producing in the case of air a limiting vacuum in the close proximity of one one-hundredth torr, measured on the McLeod gauge. Under the same conditions, the limiting vacuum reached by the type of pump having two pairs of spirals is located at a value better than one one-thousandth torr.

By way of example, and for a pump having a generated volume of 60 cu.m./hr and rotating at 1,460 r.p.m., these results are obtained with a functional clearance of the order of eight one-hundredths of a millimeter.

In another alternative form, especially for the purpose of a miniaturized construction, there is associated in a single apparatus a dry pump of conventional type, for example with a deformable diaphragm or equivalent device, and a pair of spirals with or without bulb.

The deformable diaphragm pump delivers directly at atmospheric pressure and sucks at the central delivery of the spirals, the peripheral suction of which is coupled to the chamber in which the vacuum is to be created. The work of the second active pumping member constituted by the pair of spirals sucking directly from the chamber makes it possible to improve substantially the limiting value of the vacuum in this chamber.

This result is obtained by the fact that the compression ratio, that is to say the efficiency of this pair of spirals, increases considerably from the level of the low pressures which the diaphragm pump alone can attain in producing a first preliminary vacuum of a value of a few torrs. This increase in efficiency results from the increase in the resistance to leakages across the working clearance of the apirals as and when the pressure falls.

Taking into account, on the one hand the small amount of power consumed in driving these pumps with a small generated volume, and on the other hand the large amount of work supplied by the diaphragm pump in producing the preliminary vacuum, the quantity of calories resulting from the thermo-dynamic pumping effect of the pair of spirals becomes negligible. It is thus easily possible to preserve the strict dimensions of the assembly by avoiding any differential expansion which adversely affects the operation. A single incorporated fan, directly driven by the control of the pump permits the necessary cooling to be effected and provides stabilization of the temperatures of the mechanical parts and of the internal portion of the body.

The operation without circulation of cooling liquid in contact with the spirals makes it possible to adopt arrangements in the sense of miniaturization and safety of working. In particular, the external face of the disc of the mobile spiral is directly fixed on the mobile extremity of the bellows, whereas a fluid-tightness bell is fixed on the periphery of the inner face of this same disc of the moving spiral. This bell which is not provided with a central opening, comes on top of the fixed spiral assembly which is in turn locked on the extremity of the fixed central barrel which is surrounded by the bellows.

This assembly is especially remarkable in that the expansions which could be produced by an accidental heating, act in the direction of increase in the lateral working clearances. It will in fact be understood that any expansion of the central barrel tends to move the fixed spiral away from the mobile spiral in the direction of the axis of the pump. There is thus obtained a very substantial safety in operation by virtue of this arrangement, applicable to spirals which are capable of operating without direct cooling by liquid.

It will thus be appreciated that the construction in accordance with the present alternative form of the invention provides, especially in the applications in which the utilization of the deformable diaphragm is compatible with the fluid to be pumped and the quality of the vacuum to be obtained, a simple solution of small overall size for apparatus in which the generated volume is small, that is to say is limited to about 15 cu.m./hr.

The performances obtained by this association of a diaphragm pump with one or the other type of spirals make it possible to obtain, by way of example for air, with a working clearance of the order of six one-hundredths mm. and a speed of 1,460 r.p.m. a limiting vacuum of one one-thousandth torr, measured on the McLeod gauge.

Forms of construction of the invention are described below by way of example, reference being made to the accompanying drawings, in which:

FIG. **1** is a view in vertical cross-section, taken along the line I—I of FIG. **2**, of a vacuum pump with a single pair of spirals;

FIG. **2** is a view of the same pump in horizontal cross-section taken along the line II—II of FIG. **1**, the spirals being in an instantaneous position preceding the end of the suction stage;

FIG. **2***a* is a view similar to that of FIG. **2**, but in the instantaneous position of the end of delivery and full suction:

FIG. **3** is a diagrammatic view of the same machine in which there is shown an oil circuit serving for cooling and equalizing the temperatures of the active pumping parts and for the lubrication of the movement transmission members;

FIG. **4** is a view of an alternative form of vacuum pump having two pairs of spirals, shown in vertical cross-section taken along the line IV—IV of FIG. **5**, in a different angular position;

FIG. **5** is a view in horizontal cross-section, taken along the line V—V of FIG. **4**;

FIG. **6** is a view in cross-section taken along the line VI—VI of FIG. **7** of another alternative form of vacuum pump in accordance with the invention, with one pair of spirals and a diaphragm pump;

FIG. **7** is a view of this further alternative form in cross-section, taken along the line VII—VII of FIG. **6**, the spirals being shown in the instantaneous position corresponding to the end of the suction phase and to half delivery.

In the form of embodiment shown in FIGS. **1**, **2**, **2***a* and **3**, there is seen a vacuum pump which is completely dry and fluid-tight and having a circular cycle of translation. This pump comprises a fixed body **10** having a fixed disc **13'** provided on one of its sides with a projection in the form of a spiral **13**.

A mobile disc **23'** is opposite to the fixed disc **13'**, and is also provided with a projection in the form of a spiral **23**, intercalated with the projection **13** of the fixed disc **13'** and having the same angular amplitude. A mechanism is provided for coupling the mobile disc **23'** to the body **10** and serves to support the disc. This mechanism comprises at least three crank-handles **20** having equal eccentricity E and coupled to each other in a synchronized manner so as to effect a circular movement of translation of the mobile disc **23'** with respect to the fixed body **10** during the operation of the pump.

Driving means **19** which are described later in more detail, are provided so as to drive the mobile disc **23'** and to cause it to carry out the said movement. The spirals **13** and **23** are separated by a small constant clearance which is independent of the position of the mobile disc **23'**. A fluid-tight bellows **11** has its extremities fixed respectively to the mobile disc **23'** at **28**, and to a base **10''** of the fixed body **10** at **30**.

The mobile disc **23'** is directly coupled at its periphery to the three crank-handles **20**, while a fixed central barrel **10'** couples the fixed disc **13'** to the fixed base **10''** of the fixed body **10**, and is surrounded by the bellows **11**.

The metallic bellows **11** employed in order to obtain complete fluid-tightness of the system is positively protected against any torsion force, operational or accidental, due to the kinematics of the driving system with three synchronized crank-handles **20**.

For this reason, and on condition that the rules are observed which connect the length of the bellows to the eccentricity during working, the duration of life in this member in vacuum-production applications is practically unlimited.

More particularly, the pump is of the type having a single pair of spirals **13** and **23**. It is provided with a shaft A and its fixed body **10** is made of one piece and is composed of the central portion or barrel **10'**, the base **10''** and a peripheral portion **10'''**. This latter surrounds the bellows **11** which in turn surrounds the barrel **10'**.

The peripheral portion **10'''** is provided with three openings **12** located at 120° with respect to each other. On the central barrel **10'** of the fixed body **10** there becomes centered the fixed disc **13'** powerfully locked by bolts 14 with the interposition of a static fluid-tight joint 15. The three portions of the body located in the vertical axis of the openings 12 are machined so as to receive guiding bearings 16 and 17 and an axial thrust-bearing 18, which serve to ensure the accurate positioning of each of the three shafts 19, of which the crank-handles 20 drive a transfer member 21 with an eccentricity having a value E, through the intermediary of bearings 22.

The mobile disc 23′ which carries the spiral 23 is made fixed to the transfer member 21 by a series of bolts 24. The mobile disc 23′ comprises on its upper face reinforcing ribs 25 which are intended to prevent deformation due to the effects of pressure.

On the shafts 19 are keyed balancing weights 26, and on the crank-handles 20 are provided other balancing weights 27. These various weights are calculated and positioned in such manner as to obtain a perfect static and dynamic balancing of the members having a circular translation movement.

At its upper portion, the bellows 11 is welded to a bell 28, in which the clamping by bolts 24 on the transfer member 21 compresses a static joint 29 which thus ensures fluid-tightness between this bell 28 and the mobile spiral 23.

At its lower portion, the bellows 11 is welded to an annular member 30 which is in turn clamped on the body by means of the countersunk-head bolts 31, with the interposition of a static fluid-tight joint 32.

There can be seen at 33 in FIG. 1 the suction pipe of the pump, which is rigidly fixed to the body 10 and at 35 is seen the delivery conduit which comprises a valve 34 and forms part of a member 36. This latter passes through the central barrel 10′ of the body 10 and is clamped on this barrel with the interposition of fluid-tightness joints 37 and 38, intended to prevent leakages of cooling oil towards the exterior. It will be observed that the conduit 35, the valve 34 and the member 36 are coaxial with the shaft A of the pump.

The chamber in which the vacuum is to be created is connected to the suction pipe 33 rigidly fixed to the body 10. As soon as the pump is put into service, the gaseous fluid to be pumped is subjected to the continuous and progressive effect of compression due to the displacement in a movement of circular translation of the mobile spiral 23 with respect to the fixed spiral 13. There is then created a suction of this gaseous fluid in the annular space delimited by the interior of the bellows 11 and of the bell 28 and the exterior of the central barrel of the body 10 and of the fixed spiral 13, and this is followed by a discharge of this same gaseous fluid through the valve 34 and the conduit 35.

The operation of the pair of spirals 13 and 23 is that of a multi-stage pump, and will be described in the text which follows with reference to FIGS. 2 and 2*a* which correspond to different instantaneous positions.

Each revolution of the spiral defined by an angular development of 360° corresponds to one stage of compression.

At each cycle of circular translation, the displacement of each of the separation contacts (to within the clearance) makes it possible for each stage to obtain its own progressive compression, the imprisoned volumes remaining continuously isolated from each other by as many separation barriers as there are stages in the pump.

More precisely, it can be seen from FIG. 2 that the spirals 13 and 23 are shown in a position preceding the end of the suction phase. When the position of the spirals corresponds to this end of the suction time, the two first volumes imprisoned at V1 are subjected to a first compression after a first cycle of circular translation, reducing them to the two volumes V2. After a second cycle, these latter volumes are subjected to a second compression and are combined in the same volume V3 which, during the course of the third cycle, is subjected to the effect of the final compression so as to be completely expelled (apart from the leakages) through the valve 34, the spirals being then located in the instantaneous position of the end of delivery and full suction, as shown in FIG. 2*a*.

It will be noted that the large central bulb of each spiral 13 and 23, in addition to the advantage of being provided with an external cavity 43, 45 for cooling purposes, permits by its thick shape a reduction of the radial and lateral leakages in the zone at which the compression is highest. Also, for the same eccentricity of operation E, the common volume of final compression V3 (FIG. 2) will increase in size as and when the two bulbs between which this volume is defined, are themselves larger, which especially facilitates the choice of an optimum size for the exhaust orifice 34.

It will be appreciated that the whole of the pump chamber in which the vacuum is created is completely isolated at the same time from the exterior and from a cooling and lubricating oil circuit which will be described below with reference to FIG. 3, in which the path of the oil is indicated diagrammatically.

In the bottom of an external hood 39 which encloses in an independent manner the whole of the pump, is provided an oil tank in which is immersed the pump 40 driven by one of the shafts 19.

The pulsated oil in the annular space 41 between the exterior of the member 36 and the interior of the central barrel 10′, comes into a conduit 42 formed in the disc of the fixed spiral 13 and rises into the cavity 43 provided in the central bulb of the fixed spiral 13. It escapes from there through the tube 44 and is projected into the interior of the cavity 45 provided in the central bulb of the mobile spiral 23.

By reason of the movement, after having come into contact with the outer surface of the spiral 23, the oil is powerfully projected along the hood 39. The whole of the mechanical portion becomes lubricated by projection, and the greater part of the oil streams down along the hood 39 and falls back after having been cooled into the reservoir of the pump 40.

It will be noted that when the pump is sufficiently large, the cavities 43 and 45 of the bulb can be extended into the whole or part of the development of the spirals.

It will be understood that the fact of having an intense circulation of cooling oil, especially in the cavities 43 and 45 located immediately on the outside of the central zone of the spirals, where the effect of final compression gives rise to the greatest quantity of heat, and causing this oil to circulate subsequently both in the interior of the central barrel 10′ and on the exterior of the discs 13′ and 23′ of the spirals 13 and 23 and over the whole of the body 10, results in an equalization of the temperatures in all the members of the pump located inside the non-working hood 39.

In this way, all differential expansion between these same members is avoided, which enables the same working clearance to be preserved between the spirals, under all working conditions. This result constitutes an essential factor of safety in working and ensures constant and excellent industrial performances from these machines.

The drive of the pump (not shown on the drawings) is effected either directly or indirectly by one of the three vertical shafts **19** which pass out of the hood **39**.

A second shaft **19** may actuate directly the member **40** intended to pulsate the cooling fluid. In this connection it will be noted that in the case of small pumps for which the generated volume is of the order of 10 cu.m/hr to 15 cu.m/hr, this fluid may be air driven by a centrifugal fan into sections of passage suitably formed for that purpose.

Apart from the oil which serves at the same time for cooling the spirals and for lubricating the mechanical portion, this latter being then lubricated with grease, it is possible to couple the cooling to a water intake, the mobile spiral being provided in this case on its upper face with a fluid-tight chamber connected by two flexible tubes, one to the circuit coming from the fixed spiral and the other to waste.

Reference will now be made to FIGS. **4** and **5**, in which the arrangement is similar to that which has just been described with reference to FIGS. **1** to **3**, but in which the pump is of the type having two active pumping members each provided with a pair of spirals.

More precisely, the vacuum pump shown in FIG. **4** is a machine the construction of which is similar to that of FIG. **1**, but which comprises on the one hand a first pair of spirals **46** and **47** without a central bulb (see FIG. **5**) and on the other hand a second pair of spirals **13** and **23** with a hollow central bulb towards the exterior, which is similar to the pair of spirals which have been described with reference to FIGS. **1** to **3**, and of which the view in cross-section taken along the line *a—a* of FIG. **4** corresponds to the angular position of FIG. **2**.

In the pump shown in FIGS. **4** and **5**, the primary limiting vacuum is improved by causing the fluid to be pumped to pass into the first pair of spirals **46** and **47**, which have no central bulb. Suction through the orifice **33** is effected by the internal zones **48** and **49**, and the delivery is made by the peripheral zones **50** and **51**, which both open directly into the suction zones of the two spirals **13** with bulb and **23** also with bulb, which, as in the case of FIGS. **1** and **2**, ensure directly delivery to atmospheric pressure.

The two spirals **46** and **47** have a generated volume which is chosen to be very close to that of the spirals **13** and **23**.

At the beginning of pumping, the suction volume at **33** is pulsated from the interior towards the exterior of the spirals **46** and **47** and, as in the case of the spirals **13** and **23**, with a constant separation between the enclosed volumes and the suction and delivery zones.

The identical similarity of the volumes generated by each of the pairs of spirals results in the fact that in practically the whole preliminary phase of the pumping, the compression due to the action of the spirals **46** and **47** remains extremely small and that in consequence their temperature rise is negligible.

On the other hand, as soon as the suction pressure in the zones **48** and **49** becomes small, that is to say in the vicinity of 1 torr, the efficiency of the spirals **46** and **47** begins to increase, thus enabling the whole pump assembly to reach a limiting degree of vacuum having a value better than one one-thousandth torr, this being due to the fact that the resistance to leakage across the working clearance increases considerably as and when the pressure falls.

The performances of the pump shown in FIGS. **4** and **5** are due to bringing up to speed at low pressures of the molecules of the fluid to be pumped, this bringing up to speed resulting simultaneously from the volumetric effect and the centrifugal effect produced by the movement in circular translation of the mobile spiral **46** with respect to the fixed spiral **47**.

Due to the act that their efficiency is only effective at low pressures, the two spirals **46** and **47** generate practically no heat and can give good results with a working clearance having a value greater than that of the spirals **13** and **23**.

More precisely, there can be seen in FIG. **4** the mobile spiral **23** with bulb, the movement of which in circular translation with respect to the fixed spiral **13**, is produced by the same mechanical assembly as that described with respect to FIGS. **1** and **2**.

This fixed spiral **13** belongs to a single member **13'**, in the form of a disc, in the lower part of which is machined the second fixed spiral **47** in which there is intercalated the second mobile spiral **46**. The two discs **23'** and **46'** of the mobile spirals **23** and **46** are fixed by the annular member **52** to each other, the member **52** replacing the bell **28** of FIG. **1** and being powerfully clamped simultaneously to the transfer member **21** and to the disc **46'** of the second mobile spiral **46**.

The other arrangements applied to this construction, such as cooling, static fluid-tight joints, etc., are similar to those already described with reference to FIGS. **1** and **2**.

There will be noted the advantage of simplicity achieved in this construction, in which the two pairs of spirals work by means of a single driving system and with a single fluid-tightness bellows.

Reference will now be made to FIGS. **6** and **7**, in which is shown another alternative form, concerning more particularly, but not exclusively, a miniaturized construction.

There is seen in FIGS. **6** and **7** a completely dry and fluid-tight pumping unit consisting of a diaphragm pump **P** delivering to atmosphere through the conduit **53** and taking its suction through the conduit **54** and the orifice **35** in the annular space comprised between the interior of the bellows **11** and the central barrel **10'** of the body **10**. Into this annular space opens the delivery orifice **34** of the fixed and mobile spirals **13** and **23**, in which the peripheral suction is delimited by the bell **28**. This suction is connected to the chamber to be exhausted by the conduit **33** arranged inside the central barrel **10'** and the member **14**. This latter serves to fix the fixed spiral **13** on the said central barrel **10'**.

The diaphragm pump **P**, the pumping action of which is obtained by the alternating deformation of an elastic wall subjected to an eccentric action from the driving shaft, is a dry and fluid-tight machine, of which the constructional technique is known per se and will therefore not necessitate any particular description. In its utilization in the production of vacua, its best performances are situated at a limiting pressure of the order of a few torrs.

The spirals shown at 13 and 23 in FIGS. 6 and 7 have the particular feature of possessing different bulbs. By virtue of this particular conformation, it is thus possible to adopt readily for this miniaturized construction a pair of working spirals which are practically identical with that of the spirals shown in FIGS. 1 and 2.

It can in fact be seen from FIG. 7 that at the end of the compression stage, the whole of the sucked volume, with the exception of the leakage across the working clearance, is entirely expelled through the orifice 34. By virtue of its large bulb, the fixed spiral 13 can easily be blocked with the interposition of the fluid-tight static joint 15 on the central barrel 10′ by the clamping action of the member 14 comprising a threaded portion 14′, and in which the non-threaded portion serves as a centering device on the said barrel 10′. The interior of the member 14 is hollow in the extension of the bore of the barrel 10′ in order to form the conduit 33 connecting the suction of the spirals to the chamber to be exhausted.

As already indicated above, it is possible with the same mounting to replace the two different bulb spirals 13 and 23 by two spirals without bulb and having an outline identical with that shown at 46 and 47 in FIG. 5. It will be noted that in the arrangement shown in FIGS. 6 and 7, these spirals without bulb suck-in at their periphery and deliver towards the central portion.

The bell 28 is forcibly clamped against the inner face of the disc 23′ with the interposition of the static fluid-tight joint 29, by the bolts 24 acting on the three ring segments 56. The connecting member 57 welded to the extremity of the bellows 11 is then blocked by the bolts 58 with the interposition of the fluid-tight static joint 29′, on the outer face of the disc 23′ of the mobile spiral 23. At its fixed extremity, the bellows 11 is welded to an annular member 30 which is in turn clamped on the body by the bolts 31 with the interposition of the static fluid-tight joint 32.

The disc 23′ which is of small size, comprises three extensions 23′ arranged at 120° from each other and machined in order to receive the bearings 22 in which pivot the eccentrics 20 which are rigidly fixed to the shafts 19. These three eccentrics 20 thus drive the assembly of the mobile spiral 23, 23′ and 23″ in a strictly circular translation movement following an eccentricity E.

In this construction, the absence of direct cooling of the active pumping portion formed by the spirals makes it possible to adopt arrangements tending in the direction of reduction of the dimensions and at the same time in the direction of security of working in the case of expansion due to accidental heating, and the body 10 is preferably provided in two portions in order to permit readily the assembly and adjustment of the various members.

To this end, the body 10 comprises a first member of one-piece construction, constituted by the central barrel 10′, the base and its peripheral extension 10″. A second member 10‴ adjusts itself and becomes fixed on the machined face of the peripheral portion 10″ by means of the bolts 59 (see FIG. 7).

This second portion of the body 10‴ comprises three cylindrical housings arranged ar 120° with respect to each other, machined in order to receive the bearings with oblique contacts 16 and 17 which serve simultaneously as a guide and an abutment for the strictly accurate positioning of each of the shafts 19, on which are keyed on the one hand the eccentrics 20 driving the mobile spiral 23, and on the other hand the masses 26 and 27 serving to effect the static and dynamic balancing of the moving system.

The drive may be effected as shown in FIGS. 6 and 7 by direct coupling of one of the shafts 19 to an electric motor 55. A second shaft 19 also drives directly the diaphragm pump P. At the end of the third shaft 19 there may be mounted a small built-in fan (not shown) intended to reduce and to stabilize in case of need the temperature of the mechanical portion and of the portions of the body 10″ and 10‴.

In this apparatus, valves are mounted on the suction and on the delivery of the diaphragm pump and it is possible with the mounting of the spirals 13 and 23, to provide an additional valve on the delivery 34.

These various types of completely dry and fluid-tight primary vacuum pumps according to the invention find their applications especially in nuclear construction, in the manufacture of electronic tubes and components, in the laboratories and in general in all cases where a vacuum free from all pollution is to be created with the maximum degree of safety.

What I claim is:

1. In a completely dry and fluid-tight vacuum pump having a circular translation cycle and comprising: a fixed body having a fixed disc provided on at least one of its sides with a projection in the form of a spiral, a mobile disc mounted opposite said fixed disc and also having at least one projection in the form of a spiral intercalated with the spiral of said fixed disc and having the same angular amplitude, a mechanism by which said mobile disc is connected to and supported by said body, said mechanism comprising at least three crank-handles of equal eccentricity coupled in a synchronized manner to each other in order to effect a movement of circular translation of said mobile disc with respect to the body during the operation of said pump, means for driving said mobile disc and causing it to carry out said movement, the spirals of said fixed and mobile discs being spaced apart by a small constant clearance irrespective of the position of said mobile disc, and fluid-tight bellows means, the extremities of which are respectively fixed to said mobile disc and to said body; the further characteristic features that said mobile disc is directly coupled at its periphery to the at least three crank-handles, while a fixed central barrel couples said fixed disc to a fixed base of said body and is surrounded by said bellows means, one extremity of which is connected to said mobile disc and the other extremity to said base.

2. A vacuum pump as claimed in claim 1, in which said fixed disc is located closer to said fixed base than said mobile disc.

3. A vacuum pump as claimed in claim 1, in which said fixed disc and said mobile disc are arranged with respect to each other in such manner that said mobile disc is located between said fixed disc and the fixed base.

4. A vacuum pump as claimed in claim 1, in which the mounting of said fixed spiral on said central barrel is effected in such manner that the lateral portion delimiting the thickness of said spiral is orientated so as to face said base.

5. A vacuum pump as claimed in claim **1,** in which a preliminary vacuum pump is adapted to deliver to atmosphere and has its suction located at the delivery of said pair of spirals, the suction of which is connected to the chamber in which the vacuum is to be created.

6. A vacuum pump as claimed in claim **1,** in which said pair of spirals comprises a fixed spiral with a large central bulb and a mobile spiral with a small central bulb.

7. A vacuum pump as claimed in claim **1,** in which said pair of spirals comprises a fixed spiral with a large central bulb and a mobile spiral having no central bulb.

8. A vacuum pump as claimed in claim **1,** in which said spirals are adapted to suck-in at their periphery and to deliver into their central portion.

9. A vacuum pump as claimed in claim **1,** in which the suction of said spirals is effected through the space formed in the interior of said fixed central barrel, and the delivery is effected into the annular space comprised between said fixed central barrel and the bellows means surrounding said barrel.

10. A vacuum pump as claimed in claim **1,** in which said pump has a single active pumping member with a single projection of spiral form on said fixed disc and a single spiral projection on said mobile disc.

11. A vacuum pump as claimed in claim **10,** in which said spirals are provided with a central bulb which is hollow towards the exterior.

12. A vacuum pump as claimed in claim **1,** in which said pump further comprises two active pumping members, the mobile disc being provided in two parts the spiral projections of which are disposed face to face in spaced relation and between which is arranged said fixed disc having spiral projections on each side adapted to co-operate respectively with the spiral projections of the two parts of said mobile disc, said parts being associated with said single driving mechanism while the active assembly is isolated from the atmosphere by said bellows means which are constituted by a single bellows.

13. A vacuum pump as claimed in claim **12,** in which the spirals of one of said active pumping members have no central bulb and have their suction located at their central portion, while the spirals of the other active pumping member have a central bulb which is hollow towards the exterior, and have their suction located at their periphery.

14. A vacuum pump as claimed in claim **1,** in which, for the purpose of cooling, a hood surrounds said pump in an independent manner, said hood comprising a cooling fluid reservoir from which said fluid is drawn and sent under pressure through a channel in said fixed central barrel towards a conduit formed in said fixed disc and from which said fluid passes into a cavity formed in the spiral of said fixed disc, and then passes into a conduit from which said fluid is sent into a further cavity formed in the spiral of said mobile disc.

15. A vacuum pump as claimed in claim **14,** in which each of said cooling cavities is formed by hollowed portion of said spiral, open towards the exterior.

16. A vacuum pump as claimed in claim **15,** in which said hollow portion of said spiral open towards the exterior is formed in a central bulb of said spiral.

17. A vacuum pump as claimed in claim **1,** in which the suction of said pump is adapted to communicate with the annular space comprised between said fixed central barrel and the bellows means surrounding said barrel.

18. A vacuum pump as claimed in claim **17,** in which a delivery conduit provided with a valve is disposed in the interior of said fixed central barrel.

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