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(54) **Apparatus through which a fluid can flow under counter-pressure.**

(57) An apparatus through which a fluid can flow under counter-pressure, such as a screw-type compressor, comprising at least one male and one female rotor, having on the side faces thereof enmeshing profilings, said rotors being rotatable in partially overlapping cylindrical spaces disposed within the compressor housing, while the profilings of the male rotor and of the female rotor have such a shape that when the two rotors are rolling on each other in the common area of the cylinders, the bottom and walls of the channel-shaped profiling of the female rotor are in contact with crests forming part of the profiling of the male rotor, with formation of a linear seal.

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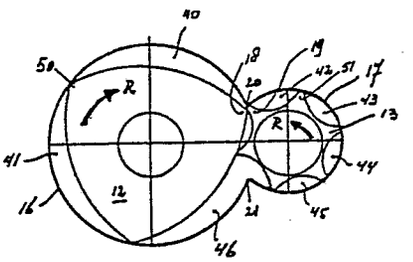


FIG. 4a

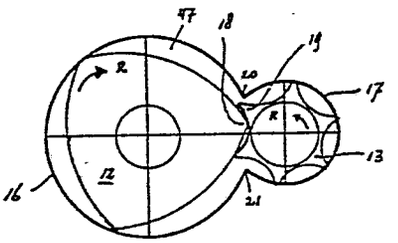


FIG. 4b

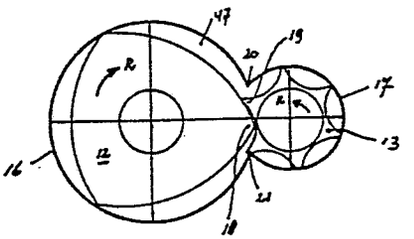


FIG. 4c

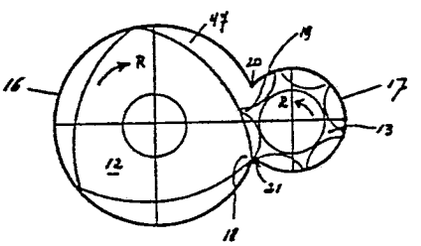


FIG. 4d

Apparatus through which a fluid can flow under counter-pressure.

The invention relates to an apparatus through which a fluid can flow under counter-pressure, comprising at least two elongate rotors arranged within the apparatus for rotation about their longitudinal axes, the external shape of said rotors being bounded by a curved side face and flat end faces, the curved side faces of the two rotors being provided with enmeshing profilings of mutually complementary shape so that one rotor can be called a male rotor and the other a female rotor, respectively of a shape allowing the transmission of the rotary movement of one of the rotors to the other rotor; a housing composed of hollow, cross-sectionally partially overlapping cylinders each containing one rotor, with the inner wall of which housing the corresponding rotors are in sealing contact with respect to the fluid through the intermediary of the associated profilings, the ends of the housing being shut off by covers, there being provided in or adjacent one of the covers means for the supply of the fluid and in or adjacent the other cover means for the discharge of the fluid.

Such an apparatus is generally known, e.g. in the form of the so-called screw-type compressors. These known screw-type compressors, however, are available in practice only in sizes with a power of over 7.5 HP (5.5 kW). The reason is the inadmissibly decreasing efficiency going with smaller sizes on account of the internal leakage occurring in such screw-type compressors of the air from the high-pressure space to the low-pressure space, in particular via the blowhole, which is produced between the grooves of the profilings of the male and the female rotor in the overlapping area of the two cylindrical spaces accommodating the respective rotors.

Attempts at limiting the internal leakage in prior art screw-type compressors via the blowhole have led to a profiling of in particular the female rotor which, seen in cross-section, requires an undercut gearing profile. As a result the manufacture of such rotors is complicated: they are to be cut on a special gear cutter, so that the manufacturing period and cost are adversely affected.

It is the object of the invention therefore to provide an apparatus of the above described type, which lacks the abovementioned drawbacks going with the prior art screw-type compressors, thus creating the possibility to make the apparatus available in sizes of an even appreciably smaller power than 7.5 HP.

According to the invention the apparatus is provided to this effect with rotors with an altered profiling, the apparatus being characterized in that the side face of the male rotor is formed from a portion of one or more helical profilings and the side face of the female rotor from one or more channel-shaped profilings, the profilings of the male rotor and of the female rotor being of such a shape that, as the two rotors are rolling on each other, in the overlapping area defined by the two points of intersection of the circular cross-sections of the cylinders, the bottom and walls of the channel-shaped profiling of the female rotor are in contact with crests forming part of the profiling of the male rotor, with formation of a linear seal.

Through the profiling of the male and female rotor according to the invention it is achieved that the chambers formed through coaction of the two rotors with the walls of each of their associated cylinders, upon in-rotation in the overlapping area, are first always combined to one closedspace of low, e.g. atmospheric pressure, which space is closed during the entire compression stage, functioning as one compression chamber, which is reduced in size during the compression stage. The invention in this respect is in contrast to the principle used in the prior art screw-type compressors, which have two separate adjacently disposed chambers whereby the fluid in the one chamber, e.g. air, has already been compressed and has a high pressure, while in the other chamber the air has to be compressed yet, so having a low, e.g. atmospheric pressure, after which both chambers in the overlapping area at a given position of the rotors relative to each other, are suddenly combined with each other to one chamber, thus discontinuing the seal and creating at this moment a reflux of fluid, e.g. air, from the high pressure compression chamber towards the low pressure chamber.

A particular embodiment of the profilings of the male and female rotor is that wherein the linear seal is a rectilinear seal. As will be explained in the following, in this case there exists the possibility to manufacture the male rotor on a conventional lathe, with the respective workpiece being set up on the lathe between two centre points which both are positioned outside the axis of the workpiece, resulting in a tumbling movement upon rotation of the workpiece, while a linear cutter feeddirection is applied. Normally, there is thus obtained in the first place the groove portion of a helical profiling with the ridge of the profiling having the shape of an elongate face of varying width, which face is curved transversely to the longitudinal direction thereof according to a circumferential portion of a circle with a diameter corresponding with the internal diameter of the corresponding cylindrical rotor housing. Through small changes in the set-up position between the two centre points located outside the axis of the workpiece, a definitive set-up position can be found, at which a profiling is obtained whose ridge-forming elongate face has a substantially constant width.

The profiling of the side face of the female rotor according to the invention is not spiral-shaped, as is the case in general with the prior art screw-type compressors, but channel-shaped and may contain a plurality of such channel-shaped grooves, in which the helical profilings of the male rotor come to perform a rolling movement.

The female rotor is often manufactured by means of a milling, whereby during the milling the workpiece can be rotated, whether or not uniformly, and a certain torsion is imparted to the channel-shaped grooves. However, manufacture of a lathe is also possible.

The male and female rotors can be advantageously applied in an apparatus according to the invention that takes the form of a screw-type compressor. When manufacturing the rotors in the above described manner, with applicaion of a simple lathe for the male rotor, the blowhole within the screw-type compressors turns out to be absent, so that economically justified screw-type compressors can be made available having a power of e.g. not over 1 HP or even smaller.

In itself, the operation of the screw-type compressor apparatus according to the invention is analogous to that of the prior art screw-

type compressors; the grooves of the two rotors rolling on each other are filled with the gas to be compressed at the moment when these rotate along the open gas inlet port. Since the profilings of the two rotors enmesh, the volumes of the gas-filled grooves become alternately smaller and larger. At the location where the grooves have the smallest volume, there is provided the gas outlet port or valve where the compressed gas can be discharged.

The required shape of the profiling of the two rotors according to the invention can also be determined by means of a computer on the basis of the theory of kinematics and the equations to be used and known per se therefrom, which provide the displacement of a point, said displacement having to comply with pre-set conditions, as a function of the time and the result being recorded on a punched tape in the form of coordinates required for the profile shape, with which in its turn a computer-controlled processor can be fed.

The apparatus according to the invention can also advantageously be designed as an engine, in particular a combustion engine, which can then be considered as an engine of the rotary cylinder type, wherein the housing, within which the rotors rotate in corresponding, overlapping cylindrical spaces, is provided at the ends thereof with a front and a back cover with a suction port or valve for the fuel mixture adjacent or in the one cover and an outlet port or valve for the waste gases adjacent or in the other cover.

Rotary combustion engines are known per se in the form of the so-called Wankel engine. In this prior art type of rotary engine a delta-shaped rotor is rotated non-centrically about a gear in a cylinder. This prior art engine is notorious for its sealing problems of the delta-shaped rotor non-centrically rotating in the cylinder, owing to which it requires machining to very close tolerances, so that manufacture requires great accuracy and is hence time-consuming and expensive.

It will be clear that, conversely, a continuously centrically rotating rotary piston is simpler to seal than a system-defined non-centrically rotating rotary piston, which first mentioned situation can actually be obtained with the apparatus according to the invention by designing same so that the male screw rotor, rotating against the female screw rotor, provides successively through rotation a compression stage,

and after combustion an exhaust stage for the waste gases.

The operation of the apparatus according to the invention when designed as a screw-type engine is analogous to that of the known two-stroke engines: the grooves of the male and female rotors rolling on each other are filled with compressible gaseous fuel at the moment of their rotation along the open inlet port.

Since the profilings of both rotors enmesh, the volumes of the gas-filled grooves become alternately smaller and larger. At the place where the grooves have the smallest volume, there is provided the explosion chamber where the compressed gas becomes ignited.

Through further rotation, after expansion, the exhaust gases are discharged through an outlet port provided in the end cover.

At higher compression pressures and with shorter rotor lengths it may be necessary to have the gases flow away via corresponding ports in a disc co-rotating at the inlet and outlet ends.

In other cases radial or combined axial-radial ports may constitute a simpler and properly functioning solution.

Since the ridges of the profilings of the rotors according to the invention, as described in the above, may be designed in such a way that they have the shape of an elongate face of a given width, the possibility is offered to recess in said ridges a sealing strip (piston ring). As a result of the centrifugal forces acting on the strip, this is pressed against the cylinder wall or the other rotor.

The apparatus according to the invention designed as screw motor may further be designed in such a way as to comprise means for driving same by means of a gas under high pressure or by means of combustion gases, originating from a combustion to be realised outside the apparatus.

Some rotors to be used in a screw-type compressor according to the invention will now be described, by way of example, with reference to the accompanying drawings, wherein

Fig. 1 is a side view of an assembly of a male and a female rotor to be applied in the known screw-type compressors;

Fig. 2 shows the assembly according to Fig. 1 on an enlarged scale and in axial view, provided within the housing in the

associated partially overlapping cylindrical spaces;

Fig. 3 is a perspective view of an assembly of a male rotor and a female rotor according to the invention; and

Fig. 4 is a diagrammatic, axial view of the assembly of the rotors according to Fig. 3, provided within their respective cylindrical spaces within the housing of an apparatus according to the invention, formed as an oil-free screw-type compressor and shown in four rotational positions of the rotors relative to each other.

At 1 in Fig. 1 is shown a known assembly of a male rotor 2 and a female rotor 3. The drive takes place via the shaft 4 of the male rotor,while through the enmeshing profilings of the two rotors, the drive of the male rotor 2 causes the female rotor 3 to be carried along in opposite rotary movement as indicated in Fig. 2 by arrows R, the male rotor 2 and the female rotor 3 being arranged within their cylindrical spaces 7, 8 which, seen in cross-section, partially overlap each other in the area indicated by the points of intersection 5 and 6 of the circular cross-sections of the spaces 7 and 8.

In the position of the two rotors as shown in Fig. 2, the pressure in the space 10 formed by the male rotor in co-action with the cylindrical house 7 is higher than in the space 11 between female rotor anf the associated housing 8 on account of the reduction in volume occurring in space 10 as a result of the profile 9, tooth-shaped in section, entering said space. (The pressure in space 11 in the position shown in Fig. 2 of the rotors is equal to that in the spaces 32, 33, 34, 35, 36 and 37 and substantailly equal to atmospheric pressure). Furthermore Fig. 2 clearly shows that at the moment when the tooth-shaped profiling 9 of the female rotor 3 beyond the point of intersection 5 rotates entirely into the overlapping area located between the points of intersection 5 and 6, there is no longer any seal between the compression space 10 and the adjoining low pressure space 11, so that the air compressed in space 10 flows partially to space 11, as indicated by the arrow B, and is compressed again. This internal leak or blowhole adversely affects the efficiency of the screw-type compressor.

The assembly according to the invention shown in Fig. 3, which is suitable for use in an oil-free compressor comprises a male rotor 12 and a female rotor 13.

The male rotor 12 is provided with three helical profilings, while in the ridges thereof there is provided a strip from a self-lubricating material, as indicated by way of example for strip 14.

The female rotor 13 is provided with six channel-shaped grooves which are slightly twisted, while here too, the ridges of the grooves contain a strip of a self-lubricating material, as indicated by way of example for strip 15.

Fig. 4 shows the male rotor 12 and the associated female rotor 13 provided in their cylindrical spaces 16 and 17 forming part of the housing of the screw-type compressor, which spaces overlap each other partially to a cross-sectionally overlapping area located between the points of intersecion 20 and 21. Fig. 4 a shows the situation wherein the crest 18 of the profiling just releases contact with the wall of the cylindrical housing 16 and rotates into the overlapping area at point of intersection 20. At that moment the sealing, as a result of the contact of the crest 18 with the wall of the cylindrical space 16, is taken over by the contact of the crest 18 with the inside of the portion 19 of the profiling of the female rotor, which portion is tooth-shaped in section.

The pressures in the spaces 40 and 41 formed through co-action of the male rotor 12 and the cylindrical housing 16 and the spaces 42, 43, 44 and 45 formed through co-action of the female rotor 13 and the cylindrical housing 17, as well as the combined space 46 are all equal and substantially equal to atmospheric pressure.

At the above indicated moment, shown in Fig. 4 a, when the crest 18 of the profiling of the male rotor sealingly contacts the crest 19 of the female rotor, beyond the intersection 20, when both rotate simultaneously into the overlapping area, the spaces 40 and 42, wherein no compression took place yet, and wherein therefore mutually equal pressures prevail, are combined to one common space which subsequently, upon further rotation of the rotors 12 and 13 to successive positions as shown in Fig. 4 b and Fig. 4 c, compression

space, which is increasingly reduced in volume, as shown in Fig. 4 through rotation towards each other of the crest 50 of the male rotor and the crest 51 of the female rotor, as viewed in cross-section. The gas outlet port is disposed at the location where the compression space 47 has the smallest volume.

At the moment (fig. 4 d), when the crest 18 leaves the overlapping area and rotates again into the cylindrical space 16, the sealing contact of the crest 18 is again taken over by the inner wall of the cylindrical space 16.

Naturally, modifications may be applied in the apparatus as discussed in the above and shown in the drawings without departing from the scope of the invention.

CLAIMS

1. Apparatus through which a fluid can flow under counter-pressure, comprising at least two elongate rotors arranged within the apparatus for rotation about their longitudinal axes, the external shape of said rotors being bounded by a curved side face and flat end faces, the curved side faces of the two rotors being provided with enmeshing profilings of mutually complementary shape, so that one rotor can be called a male rotor and the other a female rotor, respectively of a shape allowing the transmission of the rotary movement of one of the rotors to the other rotor; as well as a housing composed of hollow, cross-sectionally partially overlapping cylinders each containing one rotor, with the inner wall of which housing the corresponding rotors are in sealing contact with respect to the fluid through the intermediary of the associated profilings the ends of the housing being shut off by covers, there being provided in or adjacent one of the covers means for the supply of the fluid and in or adjacent the other cover means for the discharge of the fluid, characterised in that the side face of the male rotor is formed from a portion of one or more helical profilings and the side face of the female rotor from one or more channel-shaped profilings, the profilings of the male rotor and of the female rotor being of such a shape that as the two rotors are rolling on each other, in the overlapping area defined by the two points of intersection of the circular cross-sections of the cylinders, the bottom and walls of the channel-shaped profiling of the female rotor and in contact with crests forming part of the profiling of the male rotor, with formation of a linear seal.

2. Apparatus according to claim 1, characterised in that the linear seal is a rectilinear seal.

3. Apparatus according to claims 1-2, characterised in that the crest of the one or more helical profilings is a curved elongate face.

4. Apparatus according to claim 3, characterised in that the elongate face has a variable width.

5. Apparatus according to claim 3, characterised in that the elongate face has a constant width in the longitudinal direction thereof.

6. Apparatus according to claims 1-5, characterised in that in case of an oil-free embodiment of the apparatus, the sealing areas of the profilings of the male and/or female rotor are provided with strips of self-lubricating material and/or of material having extra sealing properties.

7. Apparatus according to claims 1-6, characterised in that it is designed as a screw-type compressor.

8. Apparatus according to claims 1-6, characterised in that it is designed as a motor.

9. Apparatus according to claim 8, characterised in that the motor is a combustion engine.

10. Apparatus according to claim 8, characterised in that the motor comprises provisions for driving same by means of a gas under high pressure or by means of combustion gases originating from a combustion to be realised outside the apparatus.

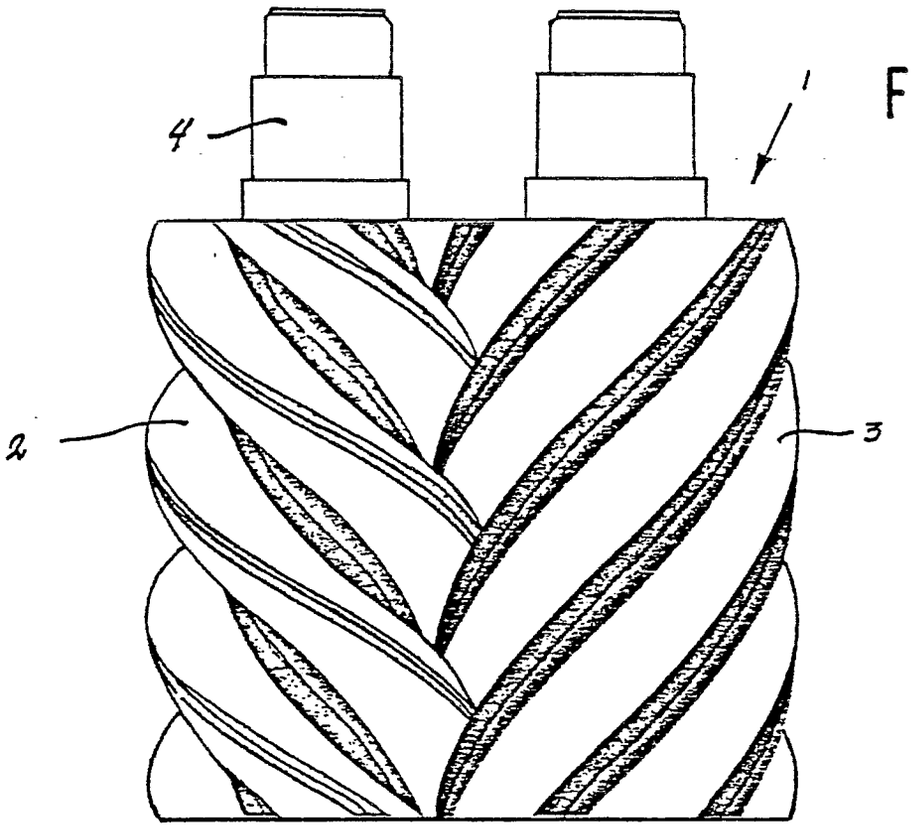


FIG. 1

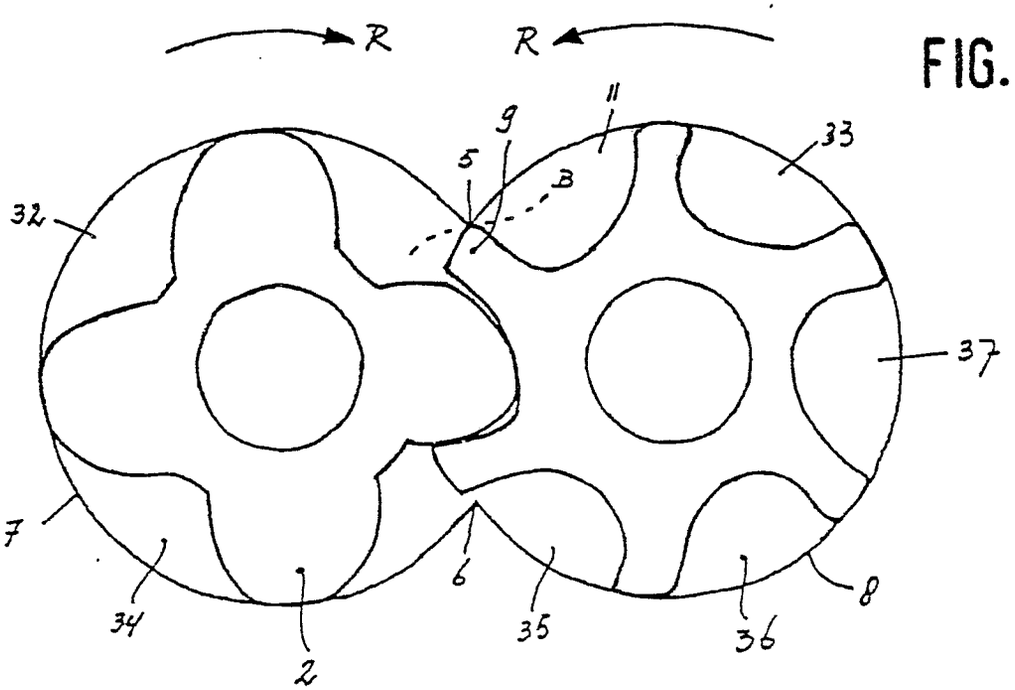
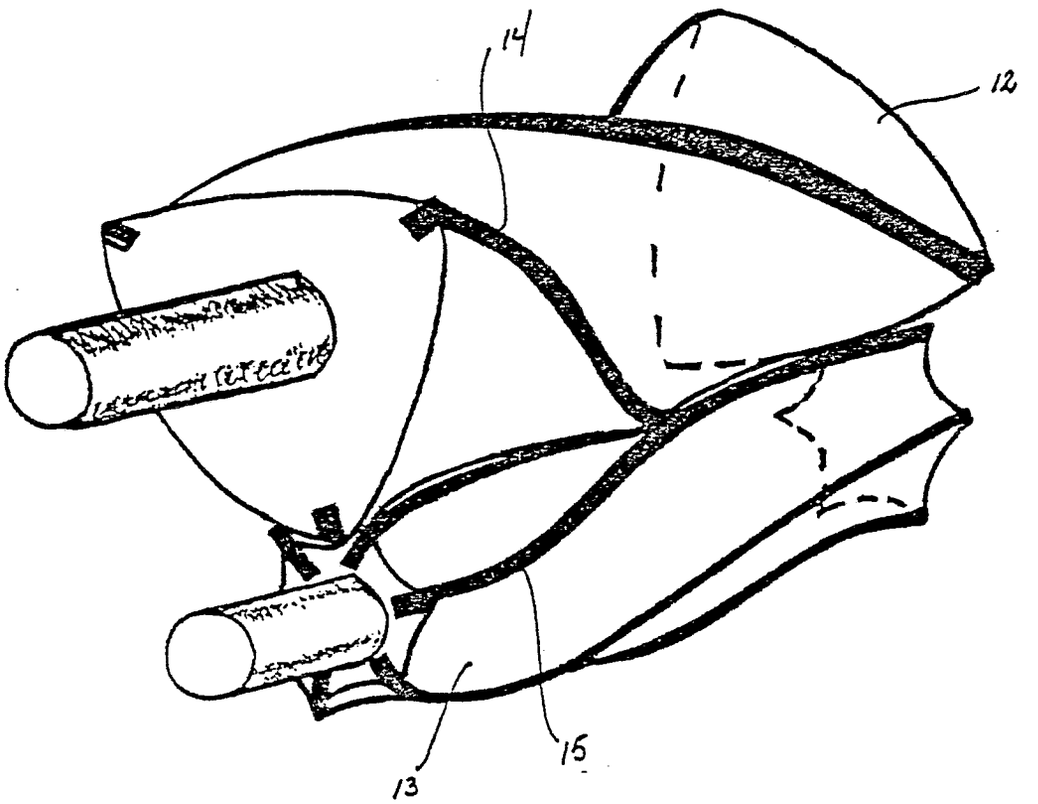


FIG. 2

FIG. 3



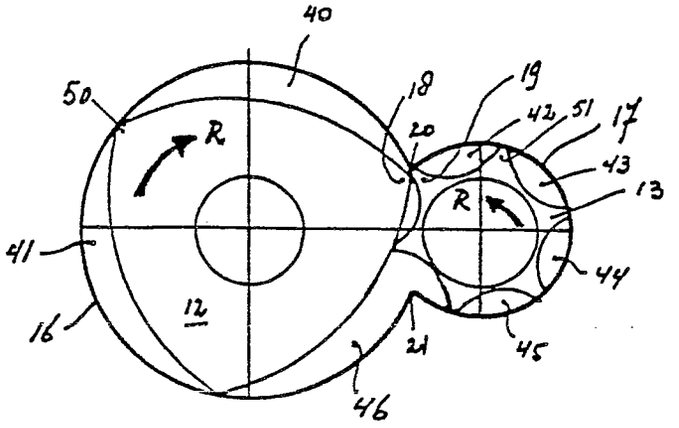


FIG. 4a

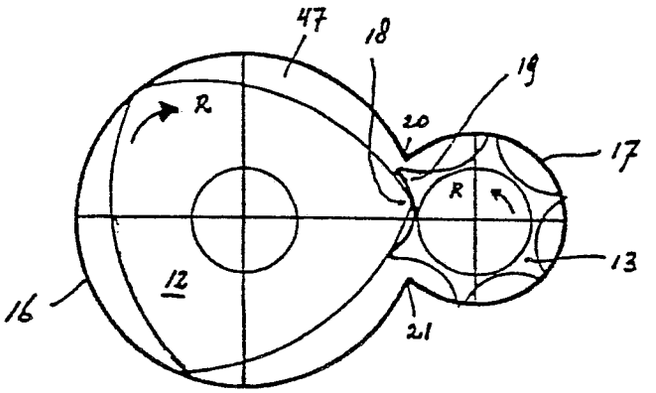


FIG. 4b

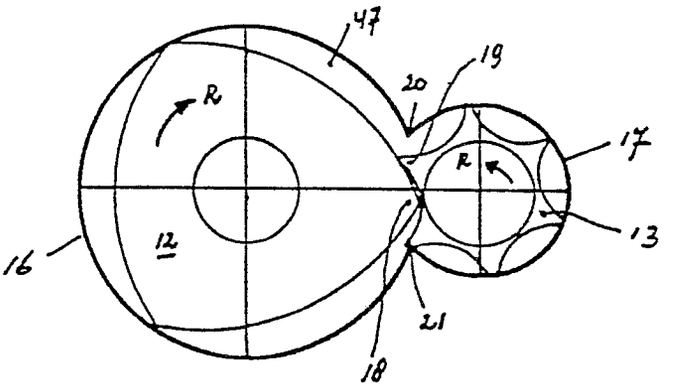


FIG. 4c

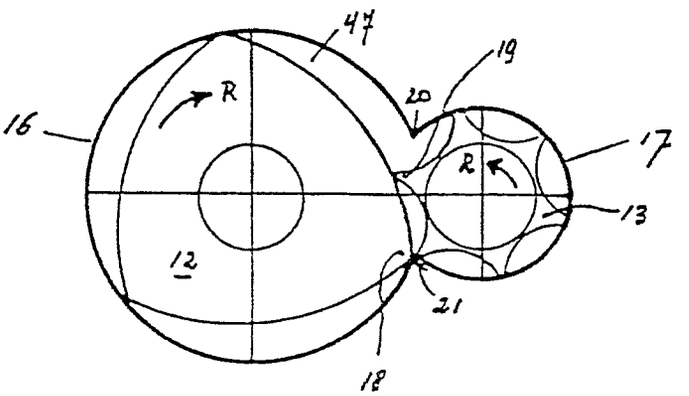


FIG. 4d