Sept. 13, 1949. H. R. NILSSON 2,481,527

ROTARY MULTIPLE HELICAL ROTOR MACHINE

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Fig. 1.

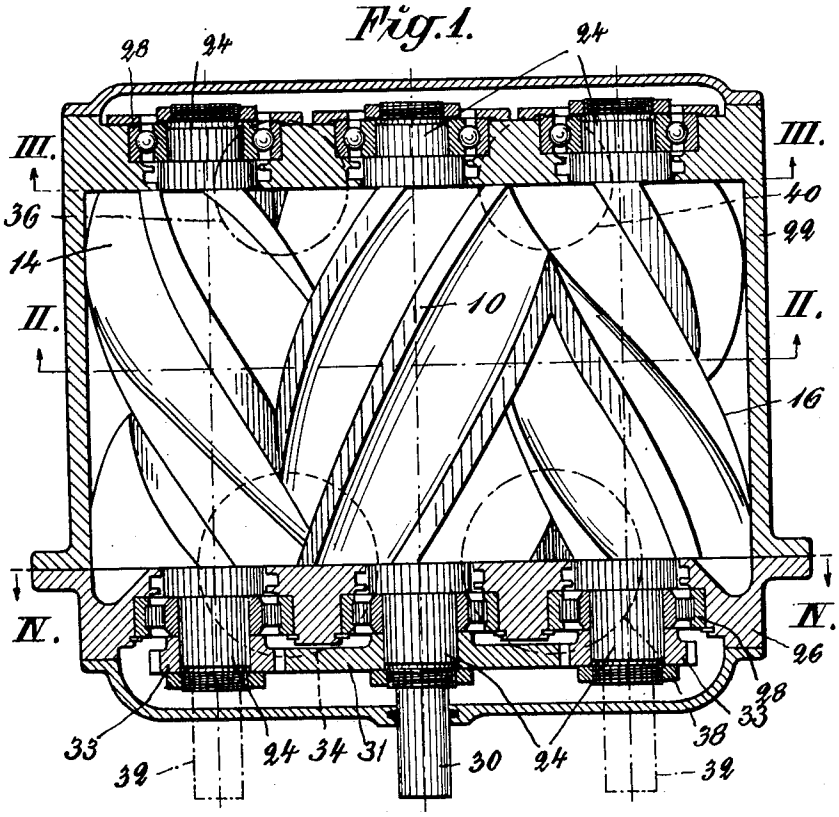
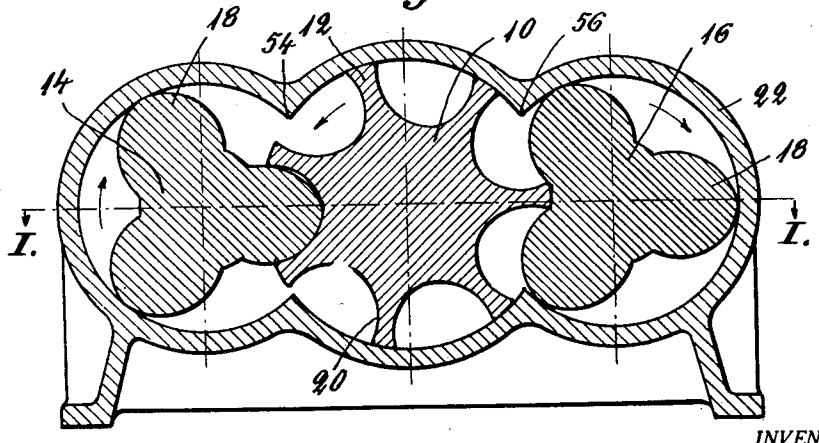


Fig. 2.



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Fig. 3.

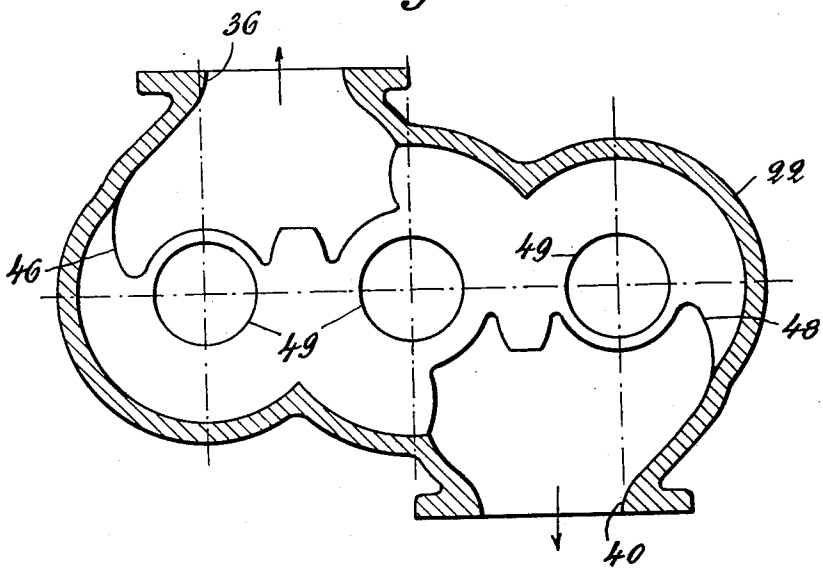
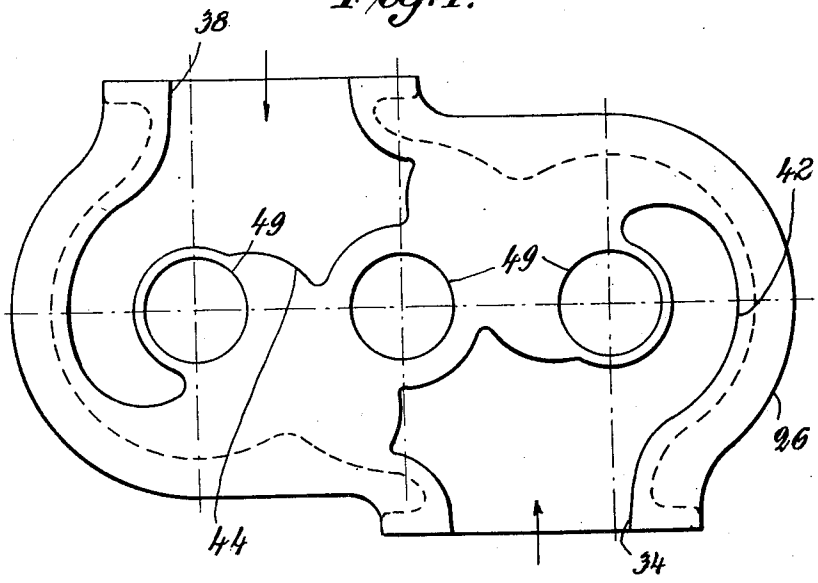


Fig. 4.



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ROTARY MULTIPLE HELICAL ROTOR MACHINE

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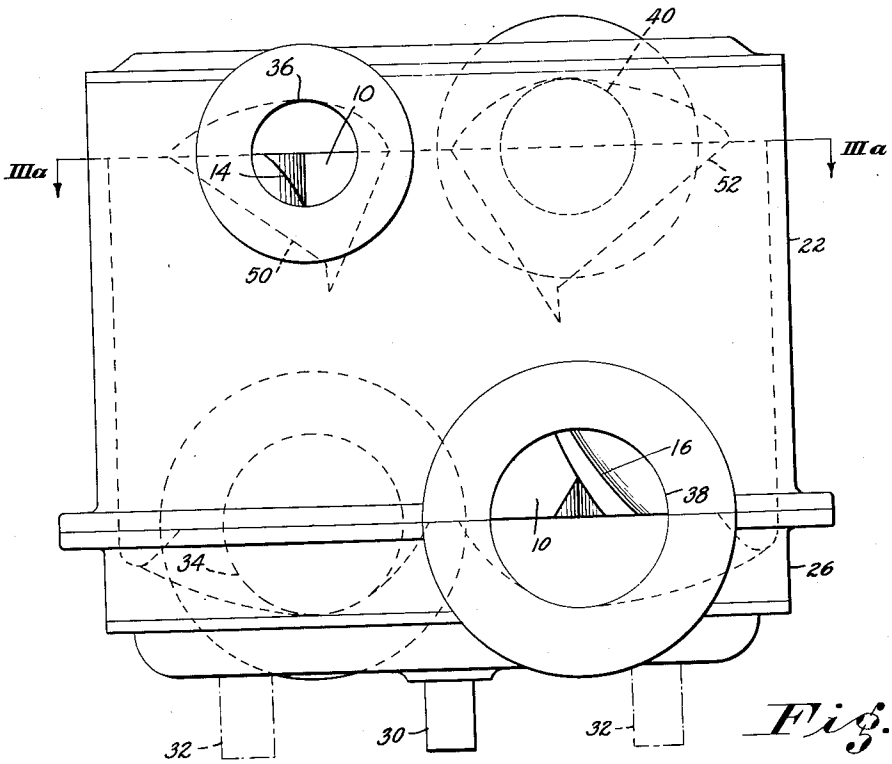


Fig. 3a

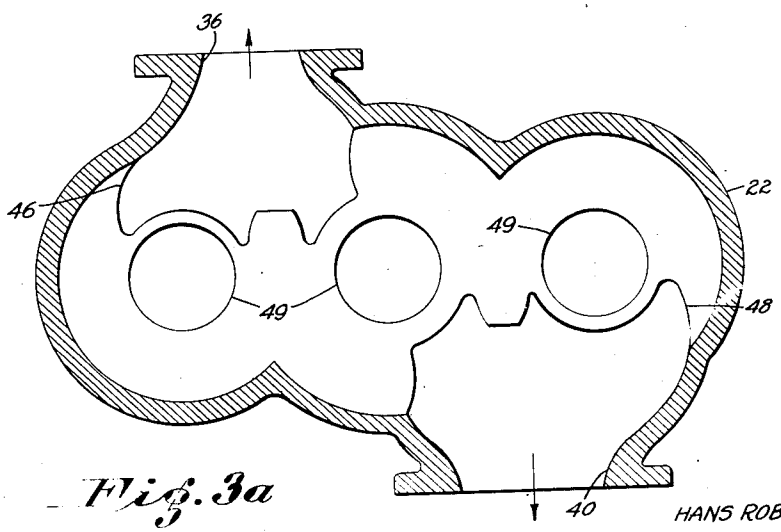


Fig. 3a

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ROTARY MULTIPLE HELICAL ROTOR MACHINE

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Fig. 5.

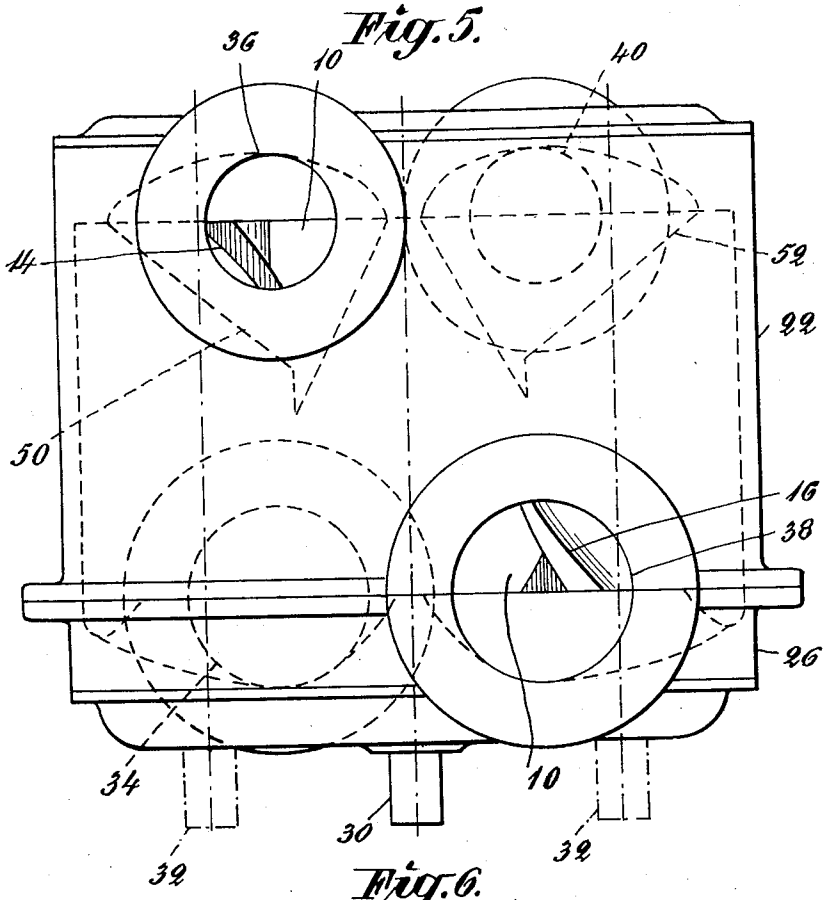
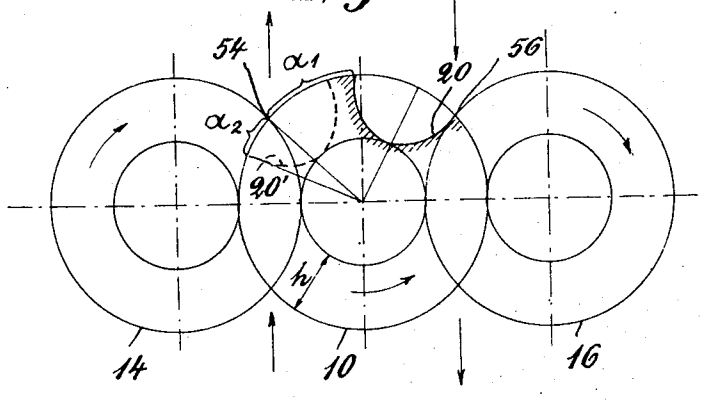


Fig. 6.



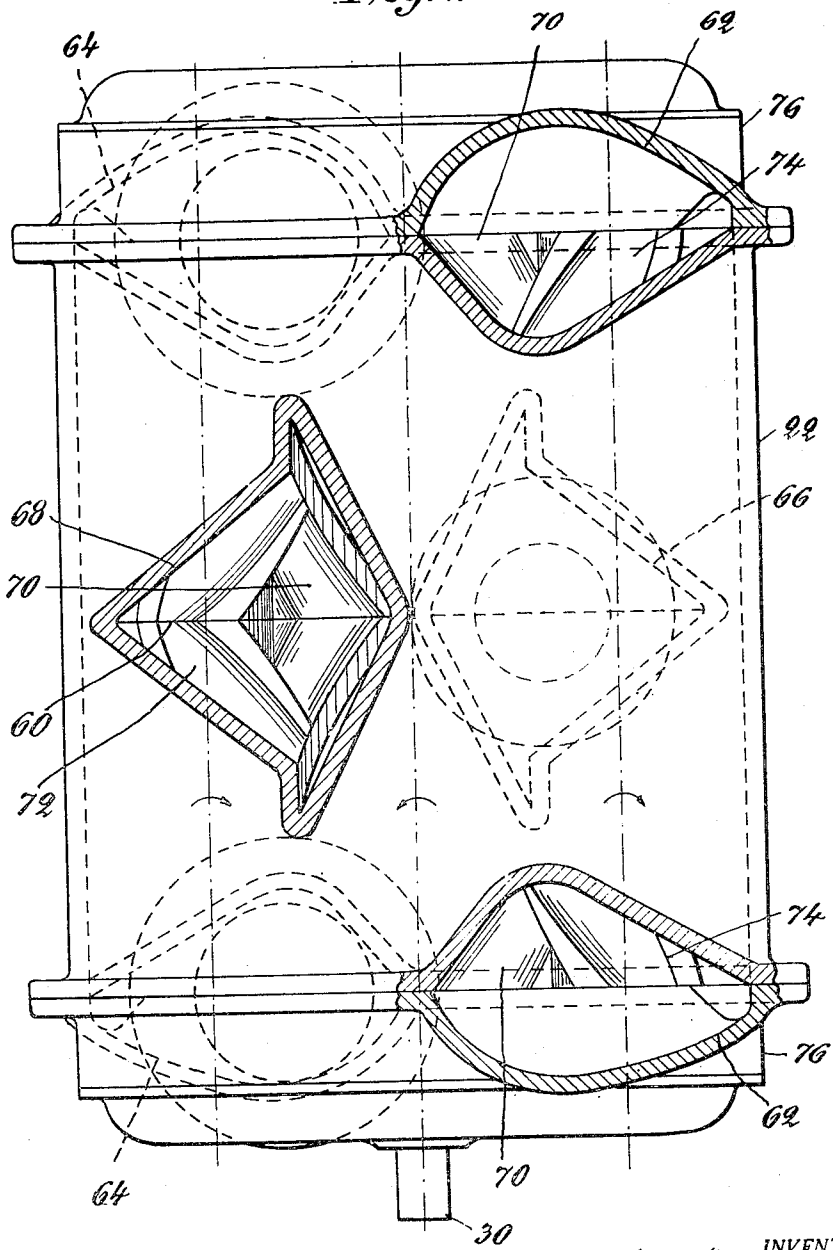
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Fig. 7.



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Patented Sept. 13, 1949 2,481,527

UNITED STATES PATENT OFFICE

2,481,527

ROTARY MULTIPLE HELICAL ROTOR MACHINE

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Application September 29, 1944, Serial No. 556,458
In Sweden June 29, 1944

11 Claims. (Cl. 230—143)

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The present invention relates to rotary machines or devices of the kind providing working spaces or chambers between intermeshing rotors of the screw wheel type mounted in a suitable casing. Such machines may be employed as compressors to compress a gaseous fluid, or as engines generating power by the expansion of such fluid. More particularly, the invention relates to devies of the kind described, in which the spiral lobes and grooves of the rotors are provided with pitches related to the length of the rotors such that the lobes do not extend around a complete convolution of the rotor, such, for example, as devices of the kind disclosed in U. S. Patent No. 2,174,522.

With respect to the capacity of the rotary machine, the depth of the grooves between the lobes should be as great as possible. In consideration of the dynamic and volumetric losses of the machine, it will not be found possible at a certain depth of the grooves to dimension the rotors solely from the point of view of the strength thereof. In practice, therefore, the external diameter of the rotors will depend on the number of lobes. This, in turn, involves that the rotors having concave grooves, "female rotors," with a small number of lobes, for instance three lobes, may be too weak to resist the pressure of the operative fluid acting in a radial direction on the same upon operation of the machine. Considering the strength of material, one may therefore be compelled to increase the number of lobes, although in the known constructions of the type in question this will have an unfavourable effect on the properties of the machine in other respects. The invention departs from this construction, less favourable as it is per se, to provide a rotary machine, in which the drawback in question is eliminated, and which has a larger capacity with a simultaneous reduction of the losses. This is accomplished due to the factor, among others, that the number of lobes of a primary rotor is larger than that of two or more secondary rotors intermeshing therewith, and that each pair of intermeshing rotors have an inlet and an outlet for the operating fluid. A further feature of the invention is to provide a rotary machine having smaller dimensions for a certain capacity than the known constructions, and contributing to this is the circumstance that the rotors can be operated at a greater speed. By the fact that the central rotor has two or more lobe grooves, which are active at the same time, the transport paths of the operating medium and the dynamic losses as well as the losses through leakage become smaller.

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The invention also permits the advantage of compressing an operating medium in one and the same machine to two or more different pressures.

Further objects and advantages of the invention will be apparent from the following description considered in connection with the accompanying drawings which form a part of this specification, and of which:

Fig. 1 is a horizontal longitudinal section on the line I—I of Fig. 2 through a compressor constructed according to the invention.

Fig. 2 is a cross section on the line II—II of Fig. 1.

Fig. 3 is a cross section on line III—III of Fig. 1.

Fig. 3*a* is a view similar to Fig. 3 showing a modification of outlet porting and taken on line III*a*—III*a* of Fig. 5.

Fig. 4 shows an end cover pertaining to the compressor casing, said cover being viewed in projection on the line IV—IV of Fig. 1.

Fig. 5 is an external view of the compressor viewed from above.

Fig. 5*a* is a view similar to Fig. 5 showing the outlet port modification of Fig. 3*a*.

Fig. 6 shows diagrammatically a cross section of the rotors of the compressor.

Fig. 7 shows another embodiment of a compressor according to the invention, the same being viewed from above with certain parts cut away.

In the embodiment according to Figs. 1–6, 10 designates a central or primary rotor or rotor with undercut concave lobes 12, said rotor in the present case intermeshing with two laterally disposed or secondary rotor or screws 14, 16 with convex lobes 18. The number of secondary rotors may be more than two, however. The central rotor 10 preferably has at least 6, in the present case 7 lobes separated by grooves 20. In the embodiment disclosed, the secondary rotors 14, 16 have three lobes 18, although the number of lobes may be greater. The number of lobes of the rotor 10 is preferably double that of the rotors 14, 16, or even larger. The shape of the lobes 12, 18 and of the grooves 20 has been described more in detail in the above-mentioned patent, to which reference may be had for such description. The lobe sides of the mutually similar secondary rotors 18 thus preferably have the shape of circular arcs as well as of epicycloids determined and generated by the outer edge of the grooves of the primary rotor cooperating with the respective lobe sides. The grooves 20 are formed in a corresponding way, so that the best possible packing effect is obtained between the rotors. The rotors

10, 14, 16 are preferably cylindrical in shape, and their lobes extend at an oblique angle, as will be seen particularly from Fig. 1, and as will be explained more fully in the following.

The rotors are enclosed within a housing or casing 22 with a small space packing clearance. At their end portions they are formed or connected with journals 24 engaging holes 49 (Figs. 3 and 4) in the casing or in the cover 26 thereof, said journals being supported in bearings 28. In Fig. 1, the primary rotor has a portion 30 projecting from the casing, over which portion the driving torque is transferred from a driving member, such as a motor, and over gear wheels 31, 33, to the secondary rotors. However, the one or the other of the secondary rotors may instead be the driving one by being formed with journals projecting from the casing, as indicated by dash and dot lines 32 in Fig. 1. The choice of the different modes of operating to be used depends on the speed of the driving motor, inasmuch as the secondary rotors run faster than does the primary rotor.

The primary rotor 10 and the secondary rotor 14, on the one hand, and the primary rotor 10 and the secondary rotor 18, on the other hand, each have their inlet and outlet, the connecting sockets of which on the casing 22 are denoted by 34, 36 and 38, 40, respectively. The two inlets 34, 38 are located toward the same end wall of the compressor casing, but on opposite sides thereof. This also holds true in respect of the outlets 36, 40, which are located at the other end wall of the compressor casing. The compression of the gaseous medium takes place in the working chambers formed by the screws, which chambers are limited radially outwards by the casing 22 and toward the ends by the plane end walls of this casing. To provide for favourable conditions of flow, the inlet port 34 merges into a recess 42 in the cover 26, the shape of which at the inner wall of the cover corresponds to that of the working chamber between the screws 10 and 14 at the moment when the inflow of the gaseous medium is terminated. The inlet port 38 merges into a recess 44 of the same shape in the cover 26. Preferably the admission of the gas may also take place radially, as will appear from Fig. 5, where portions of the rotors 10, 16 are visible directly below the pipe socket 38. On the outlet side of the compressor, the end wall of the casing is also provided with recesses 46, 48, the contour of which corresponds to that of the working chambers formed by the respective spiral grooves of the pairs of rotors 10, 14 and 10, 16, respectively, so that a communication with the outlet sockets is obtained which is favourable from the point of view of flow, when the compression against the end wall has reached the desired value. The compressed gas also escapes radially through openings 50 and 52, respectively, the contour of which corresponds at least approximately to the packing line between the lobes of a pair of rotors.

In the operation of the compressor, working chambers separated from each other will be formed between the lobes and the casing including the end walls thereof, in which chambers the compression of the gas is effected. Thus, for instance, the gaseous medium admitted through the inlet 38 passes between the intermeshing lobes of the rotors 10 and 16 to the outlet 40. A portion of this medium passes, however, through chambers limited by the primary rotor 10 and the secondary rotor 14 and the cylindrical portion of the casing located between the edges 54 and 56. This portion of the operating medium escapes through the outlet 36. In the same way, the gas admitted through the inlet 34 is divided into two parts, one of which escapes through the outlet 36 and the other through the outlet 40. The two inlets 34, 38 and/or the two outlets 36, 40 may be connected with each other, so that the compressor will have a common inlet conduit and outlet conduit, respectively.

In accordance with one aspect of the invention, the compressor may be used where compression to two different final pressures is desirable. In order to do this the outlet openings or ports may be made of different size so that the fluid compressed in different series of chambers within the compressor and delivered through the ports will be compressed to different final pressures. Such a construction is illustrated in Figs. 3*a* and 5*a*, which show a form of compressor which in all respects is like that shown in Figs. 1–5 and in which the parts are correspondingly numbered, except that in the modified construction the ports openings 46 and 50 communicating with the outlet 36 are smaller than the port openings 48 and 52 leading to the outlet 40, so that the fluid compressed in the chambers discharging to outlet 36 is compressed to higher final pressure than that discharged through the outlet 40.

It is of material importance that the angular extent or compass angle of the lobes on the primary rotor 10 be properly adapted relatively to the enclosing angle of the casing between the edges 54, 56. In Fig. 6 a groove 20 is shown with full lines, which is situated at that end of the rotor 10 which is adjacent to the viewer and which, during the rotation of the rotor, has been brought into such a position that the rear edge thereof has just reached the edge 56 of the casing. In order not to have an open passage between the inlet on the one side and the outlet on the other side of the screw 10, the pitch of the groove 20 must be below a value such that its end edge on the rear side of the screw has not reached the point 54, which corresponds to a compass angle α for the lobe according to Fig. 6. Actually, however, one may operate with overlapping by a certain angle α_2, so that the rear edge of the lobe will be in the position indicated by 20^1 in Fig. 6. Such overlapping, which always results in the fact that during the rotation of the rotors their spaces always communicate at the same time with an inlet and outlet for a certain moment of time, can be utilized without difficulty for the reason that the ratio of compression as well as the area of overflow at the inlet are small in the beginning, besides which the pressure wave proceeding through the working chamber from the outlet toward the inlet does not reach the inlet, before the latter is closed.

With a depth of lobe $h=0.25$ times the external diameter of the secondary rotors and with 3 lobes on these rotors and with 6 lobes on the primary rotor, the groove of the latter will have a compass angle $\alpha_1=48°$ or thereabout and a compass angle $\alpha_1+\alpha_2$ with overlapping as aforesaid$=58°$ or thereabout. With an increased number of lobes on the primary rotor the value of these angles is augmented. Thus the compass angles α_1 and $\alpha_1+\alpha_2$, respectively, may amount to about 66° and 75°, respectively, with 8 lobes on the central screw.

It will be seen from the above that the angular extension of the lobes between the end planes is less than 360°, and from this it follows that the

rotors will be subjected to radially directed forces upon operation of the compressor, said forces being, according to the invention, controlled in a favourable manner from the point of view of construction and operation.

The embodiment according to Fig. 7 differs from the preceding substantially only in that the rotors are doubleended, that is to say, each rotor is composed of two rotor portions according to the preceding figures, with their lobes directed in opposite directions and meeting at the center on the line 60. Thus the compressor will have two outlets or two inlets at each end wall. In the present case, the compressor has two inlets 62 located on the one (upper) side of the compressor and two inlets 64 located on the opposite (lower) side thereof. The outlets are located at the center of the compressor, so that the inlets 62 correspond to an outlet 66 on the lower side of the compressor, while the inlet 64 corresponds to an outlet 68 on the upper side thereof. In this embodiment, too, the gas admitted through an inlet is divided into two parts so as to be conveyed to both outlets. The respective inlets and outlets have, as in the preceding case, a shape corresponding to that of the rotor grooves, when the latter are closed and opened. In Fig. 7, the outlet sockets have been cut away from the inlets 62 and the outlet 68 visible on the upper side. Therefore, the primary rotor 70 and the secondary rotors 72, 74 are visible through these openings. Otherwise, all of the rotors have the shape above described save for the fact that they are each built from two rotor portions with lobes extending mutually against one another. As will appear from the figure, the compressor according to this embodiment has two head covers 76.

While the device has hereinbefore been described in its operation as a compressor, it may also be employed as a motor, in which case the ports hereinbefore referred to as inlet ports would operate as outlet ports and the ports described as outlet ports would operate as inlet ports for the admission of the motive fluid. In either case, however, the relation of pressures as between the two series or groups of ports will be the same. In other words, one series or group of ports will always act as high pressure ports for the admission or discharge of high pressure fluid while the other set will always operate to either induct or discharge low pressure fluid. The terms "high pressure" and "low pressure" are of course relative to each other.

What I claim is:

1. A rotary device comprising casing structure having inlet and outlet ports, and a plurality of rotors mounted to rotate in said structure, said rotors having helical lobes and grooves having less than 360° compass angle along the portion of the rotor between the transverse planes of the inlet and outlet ports respectively and comprising a primary rotor and a plurality of secondary rotors, the lobes of certain of said rotors having generally convex profiles and the lobes of certain other of said rotors having generally concave profiles and each of said secondary rotors intermeshing with the primary rotor to provide working chambers each including communicating groove portions of two intermeshing rotors and varying in volume as the rotors rotate, each secondary rotor intermeshing with said primary rotor to provide a series of said chambers separate from the chambers provided between the primary rotor and any other of the secondary rotors.

2. A rotary device comprising casing structure having inlet and outlet ports, and a plurality of rotors mounted to rotate in said structure, said rotors having helical lobes and grooves having less than 360° compass angle along the portion of the rotor between the transverse planes of the inlet and outlet ports respectively and comprising a primary rotor and a plurality of secondary rotors, the lobes of certain of said rotors having generally convex profiles and the lobes of certain other of said rotors having generally concave profiles and each of said secondary rotors intermeshing with the primary rotor to provide working chambers each including communicating groove portions of two intermeshing rotors and varying in volume as the rotors rotate, each secondary rotor intermeshing with said primary rotor to provide a series of said chambers separate from the chambers provided between the primary rotor and any other of the secondary rotors, said ports including a plurality of separate high pressure ports peripherally spaced around said primary rotor, each of said high pressure ports being located to communicate with a different series of said chambers.

3. A rotary device comprising casing structure having inlet and outlet ports, and a plurality of rotors mounted to rotate in said structure, said rotors having helical lobes and grooves having less than 360° compass angle along the portion of the rotor between the transverse planes of the inlet and outlet ports respectively and comprising a primary rotor and a plurality of secondary rotors, the lobes of certain of said rotors having generally convex profiles and the lobes of certain other of said rotors having generally concave profiles and each of said secondary rotors intermeshing with the primary rotor to provide working chambers each including communicating groove portions of two intermeshing rotors and varying in volume as the rotors rotate, each secondary rotor intermeshing with said primary rotor to provide a series of said chambers separate from the chambers provided between the primary rotor and any other of the secondary rotors, said ports including a plurality of separate low pressure ports peripherally spaced around said primary rotor and located so that each of said low pressure ports communicates with rotor grooves forming portions of the working chambers of two separate series of chambers.

4. A rotary device comprising casing structure having inlet and outlet ports, and a plurality of rotors mounted to rotate in said structure, said rotors having helical lobes and grooves having less than 360° compass angle along the portion of the rotor between the transverse planes of the inlet and outlet ports respectively and comprising a primary rotor and a plurality of secondary rotors, the lobes of certain of said rotors having generally convex profiles and the lobes of certain other of said rotors having generally concave profiles and each of said secondary rotors intermeshing with the primary rotor to provide working chambers each including communicating groove portions of two intermeshing rotors and varying in volume as the rotors rotate, each secondary rotor intermeshing with said primary rotor to provide a series of said chambers separate from the chambers provided between the primary rotor and any other of the secondary rotors, said ports including a plurality of separate high pressure ports peripherally spaced around said primary rotor and a plurality of separate low pressure ports peripherally spaced around said primary rotor and axially offset from the high

pressure ports, said high pressure ports being peripherally located relative to each other and said low pressure ports being located relative to each other and to the high pressure ports so that each series of said chambers communicates with a different one of the high pressure ports and the grooves forming each series of chambers communicate with two of said low pressure ports.

5. A rotary device comprising casing structure having inlet and outlet ports, and a plurality of rotors mounted to rotate in said structure, said rotors having helical lobes and grooves having less than 360° compass angle along the portion of the rotor between the transverse planes of the inlet and outlet ports respectively and comprising a primary rotor and a plurality of secondary rotors, the lobes of certain of said rotors having generally convex profiles and the lobes of certain other of said rotors having generally concave profiles and each of said secondary rotors intermeshing with the primary rotor to provide working chambers each including communicating groove portions of two intermeshing rotors and varying in volume as the rotors rotate, each secondary rotor intermeshing with said primary rotor to provide a series of said chambers separate from the chambers provided between the primary rotor and any other of the secondary rotors, said ports including a plurality of separate high pressure ports peripherally spaced around said primary rotor, each of said high pressure ports being located to communicate respectively with a different one of said series of chambers and said high pressure ports including ports of different area to provide for communication respectively with chambers of different volume in different ones of said series of chambers.

6. A device as set forth in claim 1 in which the grooves in the primary rotor are substantially entirely inside the pitch circle of the rotor and the lobes of the secondary rotors are substantially entirely outside the pitch circles of the secondary rotors.

7. A device as set forth in claim 1 in which the primary rotor is provided with a greater number of grooves and lobes than the number in any one of the secondary rotors, the grooves in the primary rotor being substantially entirely inside the pitch circle of the rotor and the lobes of the secondary rotors being substantially entirely outside the pitch circles of the secondary rotors.

8. A device as set forth in claim 1 in which the working chambers are defined in part by an end wall of said casing structure.

9. A device as set forth in claim 1 in which each of said rotors comprises two parts having oppositely inclined lobes and grooves and in which said working chambers are each formed by communicating groove portions of each part of each of the two rotors cooperating to provide the chamber.

10. A rotary device comprising casing structure having a plurality of inlet ports and a plurality of outlet ports axially offset with respect to the inlet ports, a plurality of rotors mounted to rotate in said structure, said rotors having helical lobes and grooves having less than 360° compass angle along the portion of the rotor between the transverse planes of the inlet and outlet ports respectively and comprising a primary rotor and a plurality of secondary rotors, the lobes of certain of said rotors having generally convex profiles and the lobes of certain other of said rotors having generally concave profiles and each of said secondary rotors intermeshing with the primary rotor to provide working chambers, each of said chambers including communicating groove portions of two intermeshing rotors and varying in volume as the rotors rotate, said secondary rotors having lobes the pitch angle of which provides a compass angle of the lobe along the length of the rotor between an inlet port and an outlet port of less than 360° and the lobes of the secondary rotors having pitch angles appropriate to provide intermeshing relation with the primary rotor, each secondary rotor intermeshing with said primary rotor to provide a series of said chambers separate from the chambers provided between the primary rotor and any other of the secondary rotors.

11. A rotary device comprising casing structure having inlet and outlet ports, and a plurality of rotors mounted to rotate in said structure, said rotors having helical lobes and grooves having less than 360° compass angle along the portion of the rotor between the transverse planes of the inlet and outlet ports respectively and comprising a primary rotor having lobes of generally concave profile and a plurality of secondary rotors peripherally spaced around said primary rotor and having lobes of generally convex profile, each of said secondary rotors intermeshing with the primary rotor to provide working chambers each including communicating groove portions of two intermeshing rotors and varying in volume as the rotors rotate, each groove of said primary rotor cooperating successively during one revolution of the primary rotor with a groove of each of the secondary rotors to provide a plurality of different and separate working chambers communicating with different ports.

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