

Jan. 31, 1967

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3,301,232

ROTARY VANE MACHINE

Filed July 30, 1963

5 Sheets-Sheet 1

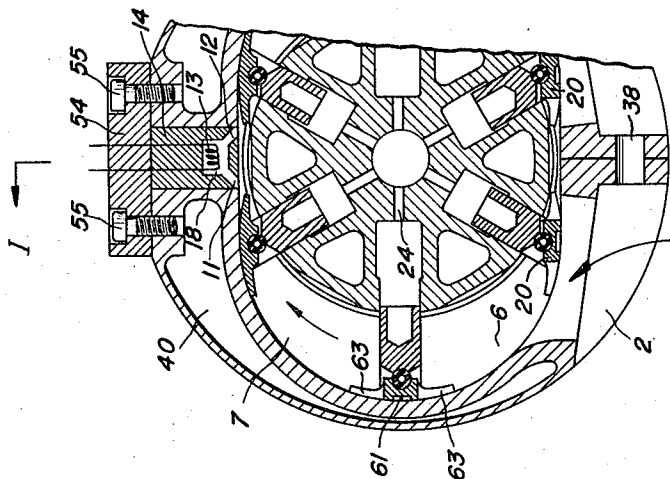
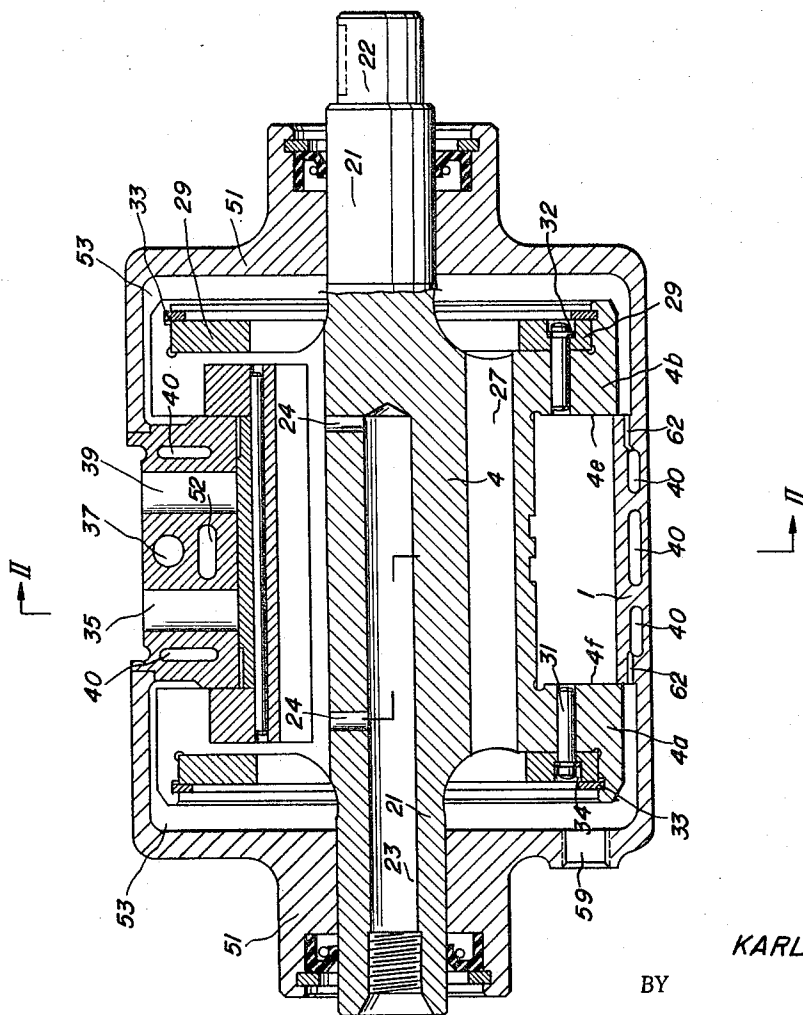


Fig. 2

Fig. 1



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Fig. 4

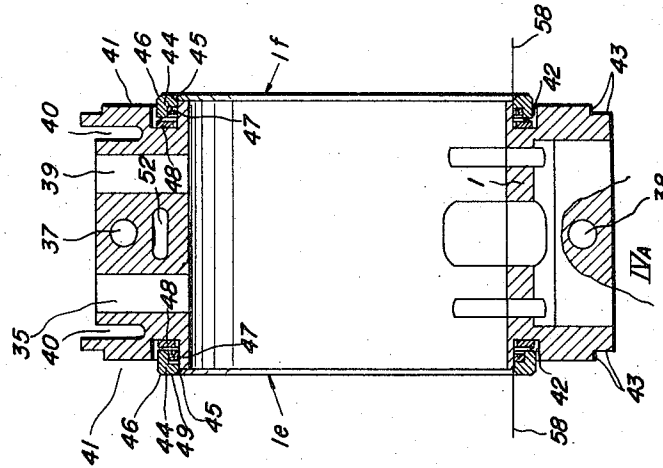
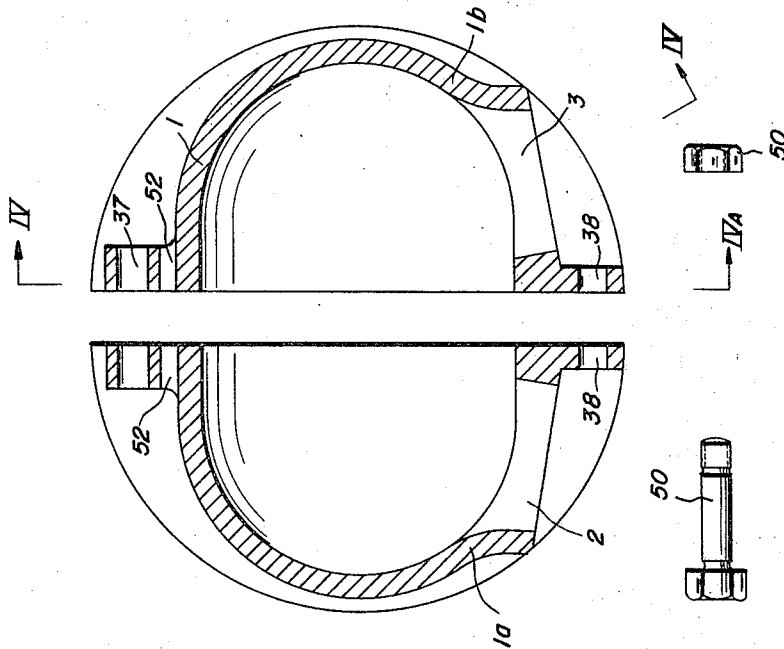


Fig. 3



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Fig. 6

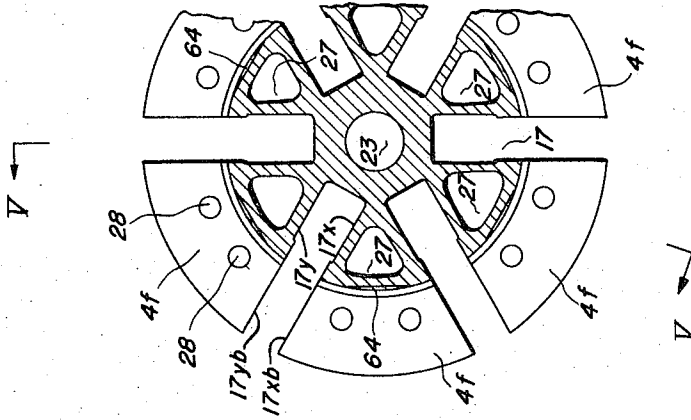


Fig. 5

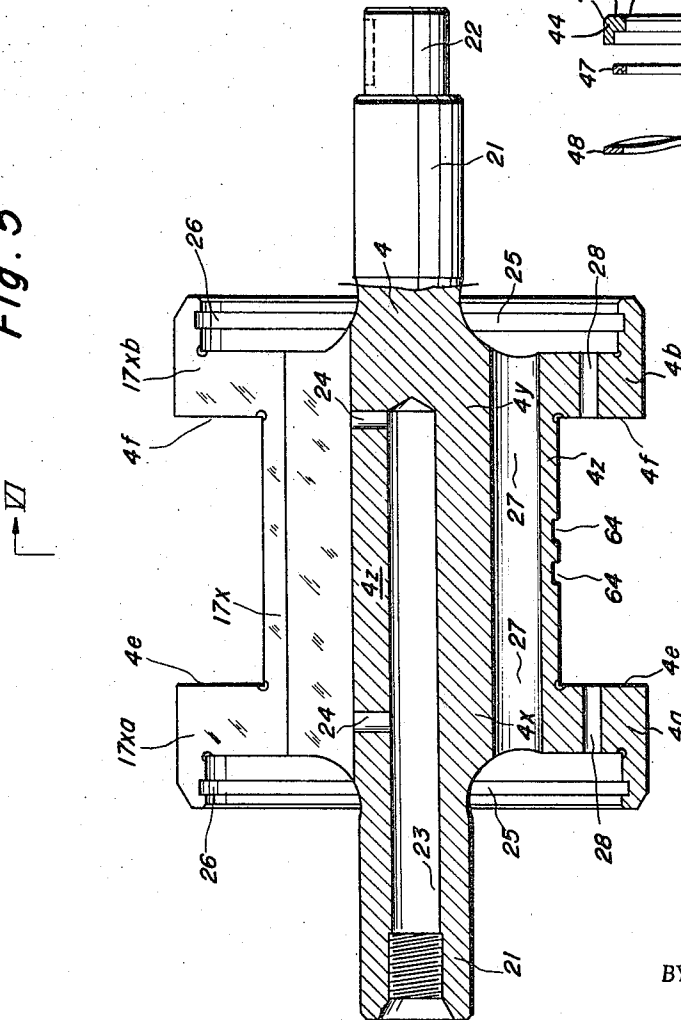
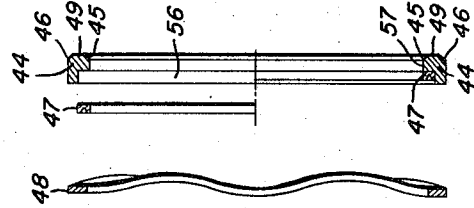


Fig. 8



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Fig. 11

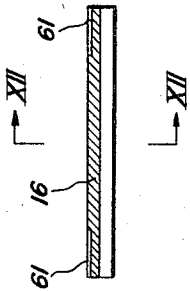


Fig. 13

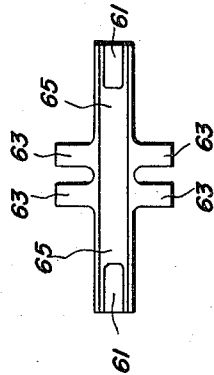


Fig. 10

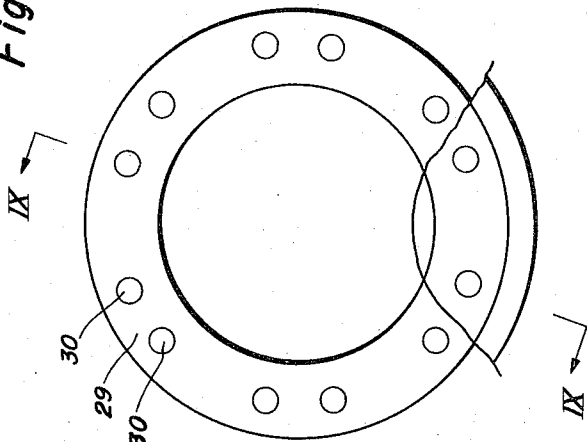


Fig. 9

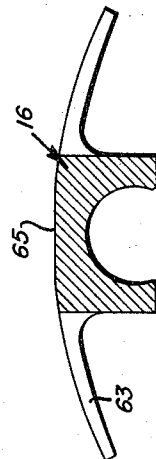
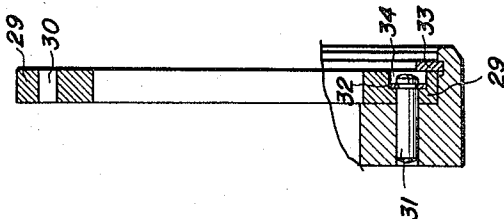


Fig. 12

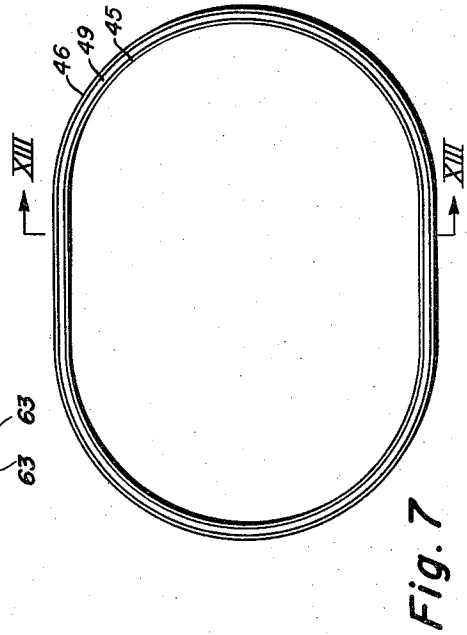


Fig. 7

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Fig. 15

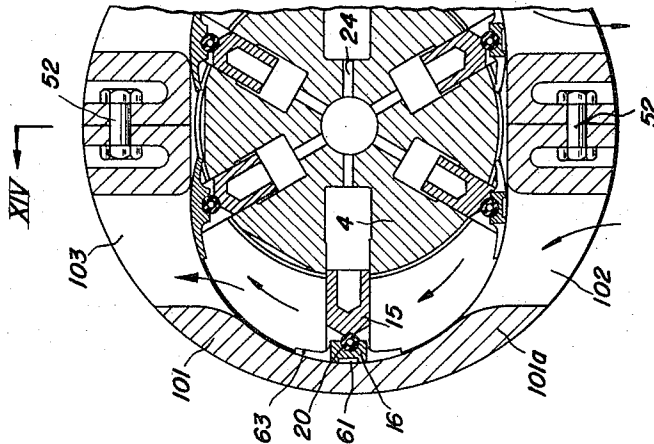
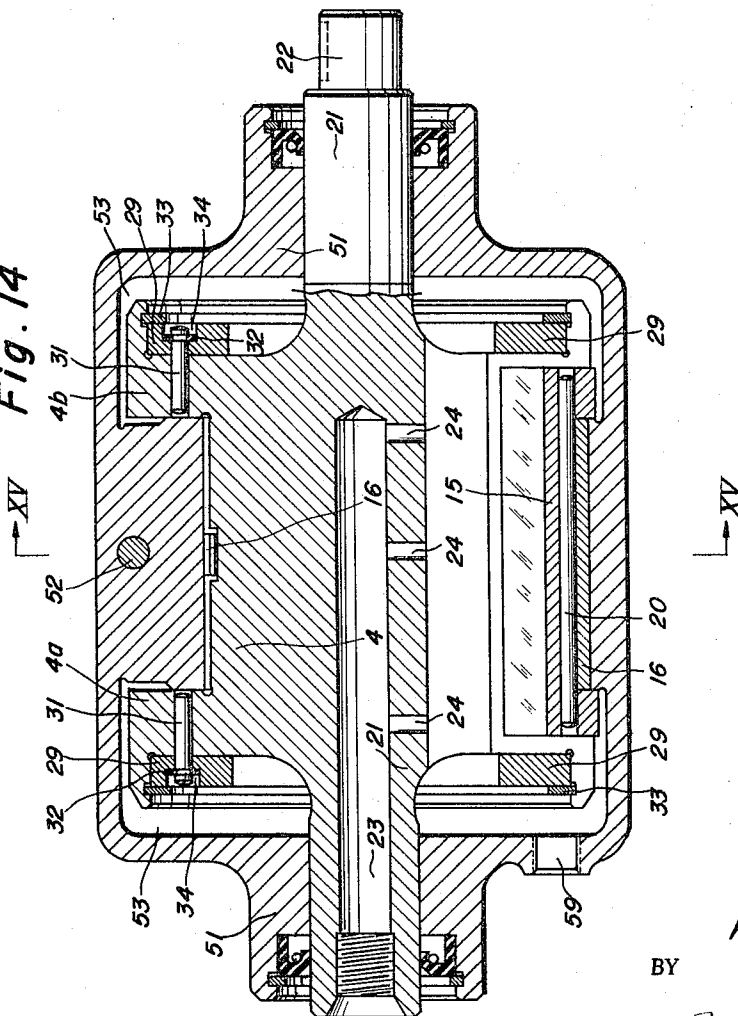


Fig. 14



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ROTARY VANE MACHINE

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Filed July 30, 1963, Ser. No. 298,726

Claims priority, application Germany, Aug. 6, 1962,
E 23,335

8 Claims. (Cl. 123—16)

The present invention relates to a rotary vane machine and especially to a rotary vane combustion engine of the type comprising a stationary housing with compression and releasing chambers therein which are defined by vanes with or without vane skids and by rotor side walls, inner surfaces of the housing and outer surfaces of a rotor which is rotatably mounted in the housing. The invention also relates to a rotary vane machine of a type which is operated by means of a fluid or gas in the vane cells between the housing, the rotor, the vanes, and the rotor side walls.

Rotary vane combustion engines or rotary vane machines of the above-mentioned type are already known in the art. All of these prior engines and machines have, however, the great disadvantages that they are of a very complicated construction and can therefore be produced only with great difficulty and at a high expense, that their work chambers or cells are very difficult to seal relative to each other, and that they are unstable because the rotor or rotors of any of these engines are divided into two or more parts.

It is an object of the present invention to provide a rotary vane combustion engine or rotary vane machine of the above-mentioned type which overcomes the above-mentioned disadvantages and is of a simple and inexpensive construction which may be manufactured at a relatively low cost.

According to the invention, this object is attained by providing a rotor which is preferably mounted centrally within the housing and consists together with its rotor side walls of a single piece of material. Another important feature of the invention is the fact that the stationary housing is made of two parts which are divided in the radial direction and are fitted between the rotor side walls and around the rotor. After being installed, the housing is clamped together by suitable means, for example, bolts, so that thereafter it is equivalent to a stable one-piece housing.

Another feature of the invention is the fact that the engine does not require any lateral hoods or the like for closing the rotor side walls.

Another feature of the invention consists in the provision of engine stabilizing rings.

A further important feature of the invention consists in providing at least a partial sealing of the clearances in the rotor slot and between the rotor side walls and the housing by means of lubricants, especially oil. In this connection it is another feature of the invention that the spaces between the rotor and the lateral hoods of the housing are filled with a lubricant.

Another feature of the invention consists in the fact that the sealing and lubricating media are supplied or drawn-in through the rotor. If, however, the sealing and/or lubricating medium is supplied under pressure, it is possible according to the invention to attain a stronger cooling effect if the speed of flow of the respective medium is increased.

The invention further provides a new sealing system between the housing and the rotor side walls which is preferably composed of plates or parts thereof and of strips or the like which are, for example, inserted into the housing from the side and may be pressed against the

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rotor side walls. The sealing elements are then preferably designed so as to be movable axially relative to the housing and to form stationary sealing means together with the housing.

A further feature of the invention consists in the employment of the centrifugal force of the lubricating and/or sealing medium for the purpose of cleaning the work chambers of the lubricant and/or carbon residues and for the purpose of lubricating and sealing the sealing gaps.

Further features of the invention consist in the novel provision of ignition means and/or induction channels and/or exhaust channels and/or cooling agent areas, cooling ribs and/or cooling chambers in a housing which consists of at least two parts.

Still another feature of the invention consists in designing the housing parts and the lateral hoods of the housing which form or support the bearings so as to be integral with the housing so that an outer body will be attained which is radially divided into at least two parts forming or containing the housing and bearing elements and which are clamped together by suitable means in a manner so as to be equivalent to a one-piece body.

The features of the invention as mentioned above and as will become apparent from the following detailed description thereof and the accompanying drawings may be applied in internal combustion engines either individually or in any suitable combination. Most of these features are intended for permitting rotary vane combustion engines to be produced very easily, at a low cost, of a very rugged construction and capable of producing very high pressures, and of a tightly sealing construction so as to operate at a high total efficiency for a long period of time and at a low expense.

The invention may also be applied at least partly in rotary vane machines other than combustion engines, for example, in rotary vane pumps, compressors or fluid or gas-driven machines such as, for example, hydraulic or pneumatic pumps or motors.

In the drawings,

FIGURE 1 shows a longitudinal section of an internal combustion engine according to the invention;

FIGURE 2 shows a cross section which is taken along line II—II of FIGURE 1;

FIGURE 3 shows a longitudinal section of the housing which is taken along line III—III of FIGURE 2;

FIGURE 4 shows a cross section which is taken along line IV—IV of FIGURE 3;

FIGURE 5 shows a longitudinal section of a rotor according to the invention;

FIGURE 6 shows a cross section which is taken along line VI—VI of FIGURE 5;

FIGURE 7 shows a detail view of a sealing element;

FIGURE 8 shows a cross section which is taken along line VIII—VIII of FIGURE 7;

FIGURE 9 shows a longitudinal section of a rotor stabilizing ring according to the invention;

FIGURE 10 shows a cross section which is taken along line X—X of FIGURE 9;

FIGURE 11 shows a longitudinal section of a vane skid;

FIGURE 12 shows a cross section which is taken along line XII—XII of FIGURE 11;

FIGURE 13 shows a plan view of the vane skid according to FIGURE 11;

FIGURE 14 shows a longitudinal section of another rotary vane machine according to the invention; while

FIGURE 15 shows a cross section which is taken along line XV—XV of FIGURE 14.

As illustrated particularly in FIGURE 2, a gas, for example, a combustible mixture of fuel and air, may be

drawn in or fed to the working chamber 6 in housing 1, through the intake channel 2. The direction of flow of the gases and the direction of rotation of the rotor 4 is indicated by arrows. Rotor 4 and its rotor side walls 4a and 4b are provided with substantially radial slots 17 in which, when rotor 4 rotates, the vanes 15 can slide outwardly and inwardly in radial or substantially radial directions. The working chambers as indicated, for example, at 6, 7, 8, 9, and 10 are formed between the inner surface or surfaces of housing 1, the rotor side walls 4a and 4b, the rotor 4, and the vanes 15, and—if provided—also the vane skids 16. During the rotation of rotor 4, the working medium, for example, the combustible mixture, which is drawn in or fed to the working chamber 6 is compressed, for example, when the working chamber 6 is located in and passes through the position of chamber 7 or a position between the chambers 7 and 8. The minimum volume and thus the maximum compression of the working gas is attained when the respective working chamber is in the position of chamber 8 in FIGURE 2. The gas or combustible mixture then enters through channel 11 into the ignition chamber 18 in which it is ignited, for example, by the ignition means 13. The flame then passes through channel 12 into the working chamber 8 and ignites the compressed working gas therein. The particular arrangement of the channels 11 and 12 and the ignition chamber 18 is to be regarded merely as an example as it may be modified considerably. The ignition chamber 18 together with the working chamber may, for example, also form a single continuous chamber. After the fuel mixture has been ignited in the working chamber 8, the pressure increases considerably in this chamber. In the meantime, the rotor continues to rotate and the working chamber proceeds to a position between those as indicated at 8 and 9. During the further rotation, when the working chamber is in the position of chamber 9 and between chambers 9 and 10, the working gases expand and deliver energy to the rotor and by means of the rotor produce a torque. After reaching the position of the largest chamber volume, the gases are discharged from the respective working chamber in the position 10 through the exhaust channel 3. The gas forces acting upon the vane or vanes at the expansion or "releaser" side of the engine are greater than those acting thereon at the compression side. The rotor is thereby kept in rotation and a load may be applied on the shaft.

During the continuous rotation of the rotor, the different functions as described above are repeated periodically at each revolution in accordance with the number of working chambers which are provided in the rotor. If a large number of chambers are provided, the ignition means may become superfluous, namely, when the combustion has once been started and the combustion flame passes, for example, through a connecting ignition chamber 18 or through ignition channels 11 and 12 from one working chamber in front to the next working chamber at the rear thereof when the chambers are in the vicinity of the position of chamber 8. The principles of operation of such a combustion engine insofar as they have been described above are already known in the prior art.

The very extensive attempts which have been made in the past to design a combustion engine of the above-mentioned type which is really successful and economical in actual practice have been blocked by serious difficulties. Especially the cost of production of such combustion engines has been too high or the sealing action in the sealing gaps was insufficient, or heat deformations resulted in seizing or jamming between the relatively movable surfaces and parts, for example, between stationary and rotating parts.

According to the present invention it has now been recognized that these disadvantages are especially due to the fact that the rotors of the conventional type are not of a sufficiently solid construction and that therefore the different parts became bent which increased the jamming

of these parts. It is therefore the basic concept of the invention that in order to produce a rotary vane combustion engine which is really useful and economical, it is necessary to design the rotor in a manner so as to be of a very high stability and simplicity of construction. In order to attain this object, the rotor of the rotary vane combustion engine according to the invention is made integral of a single piece of material. The simplicity of this rotor will become especially apparent from FIGURES 5 and 6. As shown in these drawings, the rotor 4 is provided with six radial slots 17. Depending upon the desired construction, it is, however, also possible to provide the rotor with any other number of slots 17, for example, with 3 to 21 slots. These slots 17 may also be designed so as not to extend exactly radially, but at a small angle to the radial direction. Rotor 4 consists of the central part 4z, and the two opposite axial extensions 4x and 4y with the rotor side walls 4a and 4b thereon which project radially from these axial extensions beyond the diameter of the central rotor part 4z. The rotor side walls 4a and 4b are provided with inner sealing surfaces 4e and 4f which extend radially and vertically to the rotor axis. The rotor slots are extended in the axial direction through the rotor side walls 4a and 4b and form the slot parts 17a and 17b in the rotor side walls. Slots 17 are provided with the slot walls 17x and 17y which are extended into the rotor side walls 4a and 4b and form surfaces which are rigid in the tangential direction and preferably are plane. The parts of the slot walls in the rotor side walls 4a and 4b are identified in the drawings at 17xa, 17xb and 17ya, 17yb. One or both slot walls 17x and 17y serve as sliding and sealing surfaces for the plane bearing surfaces of vanes 15 and the axial extensions 17a and 17b thereof. Vanes 15, the pivot pins 17 of the vane skids which are mounted therein, and the vane skids 16 themselves, as well as the sealing means between the vanes 15, pivot pins 20 and vane skids 16 are of the type as disclosed in my Australian Patent No. 237,220. According to the present invention, the rotor is provided with a central bore 23 and connecting bores 24. The central bore 23 extends axially at least in one direction to the outside of the rotor. The connecting bores 24 connect the central bore 23 with the rotor slots 17 or also with the cooling channels 27 or also with the outer parts of the rotor side walls 4a or 4b. The particular arrangement of the connecting bores 24 depends upon the particular constructive design of the rotor. In the embodiment according to FIGURES 5 and 6 they are arranged in such a manner that they extend radially from the central bore 23 through the rotor web into the respective rotor slot 17. The number of these connecting bores 24 also depends upon the particular design of the rotor. Finally, rotor 4 together with the trunnions 21 are preferably made of one piece of material and the trunnions 21 preferably extend in both axial directions beyond the rotor and its side walls. It is also of advantage to make the drive shaft 22 integral with the rotor at least at one end thereof.

Another feature of the invention consists in the provision of the cooling channels 27 which extend axially through the rotor and rotor side walls, that is, through the parts 4z, 4b and 4a, 4x and 4y. These cooling channels may, however, also be modified so as to extend merely axially into the rotor without passing axially therethrough. Finally, the cooling channels 27 as shown in FIGURES 5 and 6 are not directly connected with the rotor slots, but only communicate therewith outwardly around the rotor. Although not illustrated in the drawings, it is, however, also possible according to the invention to provide direct connecting bores or direct connecting channels through the rotor webs between the cooling channels 27 and the rotor slots 17. In accordance with the desired design, it is further possible to provide such channels or bores in the central rotor part 4z, in the axial rotor extensions 4y or 4x or in the rotor side walls 4a or 4b. The advantage of the inventive arrangement of such bores or channels is

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that a cooling and/or lubricating medium which is supplied through the central rotor bore 23 or through other bores or channels can lubricate, seal, or cool directly or indirectly all important points in, on, or around the rotor. Such a medium passing into the central bore 23 may according to the invention also pass into the rotor slots 17, flow around the rotor side walls, pass through the cooling channels 27, and finally into the balancing areas in the vane skids, as disclosed in the mentioned Australian patent. It may also pass into the rotor bearings. These inventive effects are possible especially because the rotor according to the invention may have axially open rotor slots 17 which do not have to be closed radially or axially toward the outside in the rotor side walls 4a and 4b. A rotor as illustrated in FIGURES 5 and 6 would be able to carry out its required functions completely and reliably because it is very solid, is provided with an extensive communicating cooling system, and may be produced at a very low cost. For very high pressures it is, however, possible according to the invention, to provide the rotor with special stabilizing rings. For this purpose, the rotor side walls 4a and 4b are provided with bores 28 which extend axially from the outside into or through the rotor side walls, depending upon the particular desired construction. The number of these bores 28 is also optional. In order to illustrate the stabilization of the rotor more clearly, the stabilizing ring 29 is shown in FIGURES 9 and 10. This stabilizing ring 29 is provided with bores 30 which correspond to the bores 28 and are disposed therein so as to extend coaxially to the associated supporting bores 28 in the associated rotor side wall. In order to simplify the construction it is also possible first to mount the stabilizing ring 29 on the associated rotor side wall 4a or 4b and thereafter to bore and/or ream the bores 30 of the same diameter in one operation through the stabilizing ring 29 and the respective rotor side wall 4a or 4b. In this manner it is possible to produce the mentioned bores 28 and 30 very inexpensively and to coincide very accurately. Set pins 31 are then fitted or pressed into the associated bores 30 and 28. The seat 25 for the stabilizing ring may be cut very simply axially from the outside into the respective rotor side wall 4a or 4b. Toward the outside of this seat 25 a radial groove 26 may be provided in the rotor side wall 4a or 4b for receiving a spring ring or the like. As illustrated at the lower part of FIGURES 9 and 10, the stabilizing ring 29 may then be fitted into the seat 25 of the respective rotor side wall 4a or 4b and thereafter the required number of set pins 31 may be fitted into the corresponding bores 30 and 28. A spring ring 33 or other suitable means may then be installed in order to prevent the stabilizing ring 29 from falling out of the respective rotor side wall and/or to prevent the set pins 31 from falling out of their bores. Finally, additional means may be provided to prevent the set pins 31 from slipping through the rotor side wall toward the inside into the working chamber or into the housing. This may be prevented very easily by providing the bores 30 from the outside with an enlarged recess 34 for receiving a spring ring 32 or the like which is mounted in a groove in the set pin 31. After being installed in this manner, all of the stabilizing elements in the rotor 4 are securely locked and the rotor is stabilized so that no slot wall 17x or 17y can yield in a tangential direction even under high pressures.

In FIGURES 3 and 4 the central part of the housing is illustrated in two parts. Since the rotor is made of one piece in order to possess the required stability and rigidity and to insure that the slot walls will be of the required precision, while the central encasing ring of housing 1 must be fitted with its axial end surfaces 1e and 1f between the inner sealing surfaces 4e and 4f of the rotor side walls 4a and 4b, it is obviously impossible to make the housing of one piece. According to the invention, the encasing ring of the housing is therefore radially divided into two parts and in a manner so that its stability will not be diminished and so as to permit

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it to be easily manufactured and installed even though it contains the channels and ignition means as are required in the housing of an internal combustion engine of a stationary type. According to the invention, the housing is preferably divided in such a manner that the compression chambers and the expansion chambers are respectively formed in a single integral element. The casing ring or central housing therefore preferably consists of two identical halves 1a and 1b. FIGURE 3 shows the manner in which these two halves 1a and 1b of the housing are divided. The housing part 1a contains the intake channel or channels 2, while the housing part 1b contains the exhaust channel or channels 2. Both housing parts 1a and 1b are provided with corresponding coaxial bores 37 and 38 of the same diameter into which bolts may be fitted which may then be tightened, for example, by nuts 50 so as to clamp the two housing parts 1a and 1b so securely together as if the housing was one integral element. Due to this housing construction, the separate housing parts may be applied radially from the outside around the rotor and may thereafter be connected and tightened to each other. The axial end walls 1e and 1f of the housing 1 will then fit into the inner sealing surfaces 4e and 4f of the rotor until the two housing parts 1a and 1b engage properly with each other and are then rigidly secured to each other by the bolts 50. The division of the housing along a plane which extends substantially centrally between the intake and exhaust channels and also extends in the high-pressure zone between the compression side and the expansion side has not only the advantage that it is easy to provide the necessary parts for the bores 37 and 38 and to provide these bores in a position so as to be easily accessible from the outside for fitting the bolts 50 therein, but that the interior surfaces of the housing along which the vanes 15 or vane skids 16 slide will then form an uninterrupted closed compression half and an uninterrupted closed expansion half. If in addition the interior surfaces of the central housing are made at least partly of a constant radius, it is very easily possible by means of the vane skid arrangement as disclosed in my mentioned Australian patent to attain a perfect sealing effect of the working chambers within the main compression zone and also within the main expansion zone.

The two-part central housing 1 according to the invention which may be very accurately combined and easily assembled and disassembled has the further advantage that it may be provided with adequate cooling channels 40 and flange seats 43 for mounting the lateral caps or hoods 51 of the housing thereon. The cooling chambers 40 may start, for example, only at a short distance from the intake channel 2 and extend all around the housing 1, that is, around the housing parts 1a and 1b, to a point shortly in front of the exhaust channel 3. They may in this manner encompass the ignition chambers 35 and 39 so that the latter will be cooled especially effectively, and the parts and materials will thus be separated by the cooling chambers 40 in the vicinity of the ignition chambers from the axial end walls of the housing 1. By making the cooling channels of adequate dimensions and by additionally providing cooling ribs or the like, it is possible to attain that in the vicinity of the ignition chambers 35, 39 the velocity of flow of the cooling medium will be especially high or that it will flow along large cooling surfaces and will therefore cool this zone very intensively. It is also possible and of advantage to provide in both housing parts 1a and 1b one or more special cooling channels 52 in the immediate vicinity of the inner wall of the housing between this wall and the bore 37. This permits a very intensive cooling of the inner wall of the housing and the points around the ignition chambers 35 and 39. According to the invention, such cooling channels 52 are preferably provided in both housing parts 1a and 1b. Finally, central housing 1 may be provided with seat surfaces 43 for centering and/or car-

rying the bearing-supporting or bearing-forming lateral hoods 51 of the housing. These lateral hoods or caps form the bearings for the rotor 4 and seal the rotor shafts axially toward the outside. In this manner inner chambers 53 are formed in the housing hoods between the rotor parts and the housing parts or housing hoods. These chambers 53 have the inventive advantage that they may be supplied with the same lubricant and/or sealing medium and/or cooling medium which also enters into or passes through the chambers in rotor 4. This construction constitutes an important feature of the invention as it permits an inexpensive production of the engine, an effective cooling of its parts, a reduction in heat deformations of the different parts, and an effective lubrication and sealing of the gaps in the engine. According to a further embodiment of the invention which is not particularly illustrated in the drawings, it is also possible to design the housing 1 and the lateral housing hoods 51 so as to form a single two-part body. The line of separation would then be the same as that of the housing parts 1a and 1b, but these parts would be extended in the axial direction to form lateral hood portions corresponding to hoods 51. If desired, these hood portions may then be provided with special bores into which the axially extending bolts may be inserted. In this event, the entire housing would only consist of two parts, namely, housing part 1a together with a portion (51a, not shown) on each axial end and housing portion (51b, not shown) with a part 51b on each axial end similar to the embodiment of FIGS. 14 and 15.

In the ignition chambers 35 and/or 39 ignition means of a conventional type may be provided, for example, spark plugs or glow plugs. According to the invention, several such ignition chambers may be provided in the housing. They may be axially offset to each other or they may be peripherally offset to each other so as to be located ahead or behind each other. For example, it would be possible to provide one ignition chamber in the housing part 1a, and a second or several others in the housing part 1b, so that one ignition chamber lies before the dividing line as seen in the direction of rotation, and another or several others lie behind the dividing line. In the particular embodiment as shown in the drawings, however, the ignition chambers are arranged so as to project from the dividing line into both housing parts 1a and 1b. Special sealing elements or plastic gaskets may be employed between the ignition chambers and the ignition means therein or the housings or supports of the ignition means.

The parts as previously described with reference to the drawings may already form a good combustion engine of a simple type of construction. However, apart from the elements as described, such an engine may be provided with additional improvements, for example, on the housing. Thus, for example, the housing 1 may be provided in both axial end surfaces 1e and 1f with special sealing chamber channels 42, as shown particularly in FIG. 4. The axial end surfaces of housing 1 radially outside of the mentioned channels 42 may also be set back so as no longer to engage directly with the inner sealing surfaces 4e and 4f of the rotor side walls 4a and 4b but to be separated therefrom by a gap. This has the advantage that there will be less friction and that seizing between the axial end walls 1e and 1f of the housing and the inner sealing surfaces 4e and 4f of the rotor side walls 4a and 4b will be prevented.

According to the invention the sealing chamber channels 42 may be provided with sealing elements for sealing the gap between the axial end walls 1e and 1f of the housing and the inner sealing flanges 4e and 4f of the rotor side walls 4a and 4b.

In order to illustrate the different forms of construction more clearly, the ignition means are indicated in FIGURE 2 in principle. In FIGURE 1, however, the ignition means are not illustrated in order to show more

clearly that the ignition chambers 35, 39 may be designed in a manner so as to form simple slots or bores in which the housings 54 for the ignition means may be inserted from the outside and may be secured, for example, by bolts 55.

In order to indicate different manners of construction, housing 1 is also shown in FIGURES 1 and 2 without the sealing chamber channels 42. In the detail view of housing 1, as shown in FIGURES 3 and 4, however, the sealing chamber channel 42 is shown in the housing. Depending upon the particular type of construction of the engine, it is therefore possible to employ either a housing 1 as shown in FIGURES 1 and 2 or a housing 1 as shown in FIGURES 3 and 4.

An especially simple and reliable type of sealing element which may be inserted into the sealing chamber channels 42, that is, one of many types which may be employed, is illustrated particularly in FIGURES 7 and 8. The sealing element according to these drawings consists of a compression spring 48 of a molded shape, a plastic sealing ring 47, and the actual floating sealing ring 44. All three parts are inserted into the respective channel 42, that is, at first the compression spring 48 and then the floating sealing ring 44 together with the plastic sealing ring 47 which is inserted into the annular groove 56. Sealing ring 44 may be applied with its inner sealing surface 57 around the sealing chamber surface 58 radially within the respective channel 42 and in sealing engagement therewith. In such a case, the plastic sealing ring 47 is superfluous. However, it is then necessary to fit the floating sealing ring 44 relative to the housing 1 so as to remain slidable in the axial direction.

In actual practice, however, certain heat deformations may occur on the housing 1 which might impair the axial moveability of the floating sealing ring 44. The production of such accurate sealing surfaces 57 and 58 is also expensive. This expense may be reduced and the danger that the axial moveability of the floating sealing ring 44 may be impaired may be prevented if the sealing ring 44 is provided with an annular groove 56 into which the plastic sealing ring 47 is inserted. This plastic sealing ring 47 may be formed by a round cord of a plastic and preferably heat-resistant material, it may, however, also be of a V-shaped cross section and be provided with sealing lips which effect the sealing action between the floating sealing ring 44 and the adjacent sealing chamber surface 58. If the adjacent chamber 53 of the housing hood contains a sealing, lubricating, and/or cooling medium, this medium may enter radially outside of the floating sealing ring 44 at the rear side thereof into the respective sealing chamber channel 42, and may act from the rear upon the latter and press the same axially from the outside against the inner sealing surfaces 4e and 4f of the rotor side wall 4a and 4b. This results in a sealing surface or a number of sealing surfaces between the end surface 49 on the floating sealing ring 44 and the mentioned adjacent inner sealing surface 4e or 4f of the respective rotor side wall. The individual working chambers are thus sealed perfectly radially toward the outside relative to the inside 53 of the housing hood. Such sealing elements are preferably provided on both axial ends of the housing 1. If the end sealing surface 49 of the floating sealing ring would be plane in radial directions, it might occur that the pressure forces on the ring 44 become instable in the axial direction. In order to prevent this, it is advisable to bevel the end sealing surface radially toward the outside and inside so that the beveled surfaces 45 and 46 are formed. As the result of this, a certain amount of cooling, sealing, and/or lubricating medium will enter between the inner sealing surfaces 4e and 4f of the rotor side walls 4a and 4b and the end sealing surfaces 49 of the floating sealing ring 44 from the adjacent interior 53 of the housing hood, and at the same time also a little working gas may also enter from the respective adjacent working chamber 6, 7, 8,

9, or 10. Since at least some of the mentioned working chambers are under a low pressure, it is possible by controlling the pressure in the adjacent chamber 53 of the housing hood to attain that the pressure upon the floating sealing ring 44 will be stronger in the axial direction toward the outside than axially toward the inside if the resultant is formed over all of the parts of the floating sealing ring 44. Locally limited reverse pressure conditions are then overcome by the total resultant, and if the ring is made of the proper dimensions and the pressures are also not excessive, the ring will be pressed only lightly against the adjacent rotor side wall 4a or 4b so that under any operative conditions the sealing effect between the end sealing surface 49 and the adjacent inner sealing surface 4e or 4f on the adjacent rotor side wall 4a or 4b will be maintained and insured. The compression spring 48 may initiate or support the pressing effect as long as there is no pressure in the chambers 53 in the housing hood. Of course, the sealing elements may also be made of other cross-sectional shapes than those illustrated in the drawings. It is also possible to make the sealing elements of several parts. This would be absolutely required in order to permit the installation of the parts in the sealing chamber channel 42 when the housing 1 does not have any removable parts radially outside of channel 42. The division of the sealing elements is not illustrated in the drawings since there are so many possibilities of friction thereon. After being divided, the sealing elements may again be combined by connecting elements, not shown. The floating sealing ring 44 together with its auxiliary elements may also be employed in machines with lateral rotor hoods, as disclosed, for example, in the British Patent No. 744,446, and they may be fitted into these lateral rotor hoods or be slidable thereon.

By means of the present invention the principles of the operation of a combustion engine with a stationary housing as described at the beginning are modified by additional effects, especially as follows:

a. When rotor 4 rotates, the centrifugal force of the medium becomes effective in the connecting bores 24 so that the medium is thrown radially outwards. This centrifugal action results in a reduced pressure or a vacuum in the central rotor bore 23 which, in turn, causes the entry of new medium into the central bore 23 so that a continuous flow of a gaseous or fluid medium occurs into the central rotor bore 23 and then through the connecting bores 24. This flow then continues into the gaps between vanes 15 and the rotor slots 17 and also axially at one or both sides out of the rotor slots 17 and into one, both or more chambers 53 in the housing hoods. From these chambers the flow of medium may continue through the cooling channels 27 in rotor 4 and through cooling spaces or channels in the rotor side walls 4a and/or 4b. Finally, the flow of medium may also pass into the sealing chamber channels 42 of housing 1 in which it may carry out the functions as already described. Furthermore, it may pass into the gaps between the axial vane extensions and the slots in the rotor side walls 17a and 17b, and it may also enter into the sealing gap between the axial end surfaces of the vane skids 16 and the inner sealing surfaces on the radial extensions of the axial vane extensions, as disclosed in my Australian patent previously referred to, and finally also into the radial balancing areas in the vane skids 16, as likewise disclosed in this Australian patent. Finally, it may escape from the housing through the return-flow bore or the return connection 59. In this manner an automatically operative flow of medium is formed which is produced by centrifugal force and the simplest possible means, and which flow passes through practically all chambers and spaces, except the working chambers themselves, and is regenerated continuously by a fresh supply of medium. The medium may consist of air if the engine operates in the free atmosphere, or it may be

a fluid such as, for example, water, oil, or the like, if the central rotor bore 23 is connected to a container holding such a fluid. Depending upon the particular construction of the engine, this flow of medium may then be employed to cool the various parts and/or to seal or lubricate the sealing gaps in the engine.

b. If a forced feed of medium under pressure, for example, by means of a preliminary pump, is connected to the central rotor bore 23, or if the medium is fed under pressure by other means into the central rotor bore 23, the entire engine may receive a forced flow of medium under pressure which passes through, engages with, or affects all chambers and spaces in the manner as already described. The force of this preliminary pressure may be of great influence upon the effects of the flow of medium. The preliminary pressure may, for example, be made slightly higher than the maximum pressure in the working chambers. In this event, a continuous flow of medium, although in small quantities, occurs into the working chambers through the sealing gaps. If oil is employed as the medium, a continuous flow of small quantities of oil will thus be attained into the working chambers which fills out the sealing gaps continuously and absolutely prevents the entry of working gases into these gaps.

It is also possible to make the preliminary pressure substantially equal to the medium gas pressure in the working chambers. In such a case, the gas penetrates into the sealing gaps adjacent to the working chambers containing a higher pressure, while the flow of medium escapes from these gaps. In the gaps adjacent to the zones of the working chambers containing a lower pressure, however, the flow of medium penetrates into the sealing gaps, while the working gas is displaced from the sealing gap or gaps back into the working chamber. It is thus possible, especially when employing oil as a medium, to attain that the exact amount of oil will always be present in the sealing gaps which is necessary for sealing them. Finally, it is possible to provide oil discharge grooves 60 in the inner surface of the housing for discharging the excess oil from the working chambers. For regulating the pressure of the flow of medium, it is advisable to provide a control valve, for example, a high-pressure relief valve, at a point behind the return bore 59.

A further advantage of the medium flow according to the invention is that large quantities of medium may be pumped or fed through the rotor bore 23 so that a very strong cooling effect will be attained which may be increased in accordance with the rate of flow. This greater quantity of medium may at the same time produce a continuous supply of fresh lubricant to the sealing gaps. By supplying adequate quantities of medium, it is possible to cool the revolving rotor so extensively that heat deformations thereon will be almost entirely prevented. It is further possible to conduct a separate current of cooling medium around the housing which may flow through the cooling channels 40 and 52. The return bore 59 may, however, also be closed and the medium of the main current of medium may be passed from the chambers 53 in the housing hoods through bores or channels 62 into the cooling channels or cooling chambers 40, 52 and through the latter, and then finally, after the medium has passed through the largest part of housing 1, out of the mentioned cooling chambers through outlet bores or outlet connections, not shown, or through a pressure control valve behind these chambers. In the manner as above described it is thus possible by means of a single current of medium to cool, lubricate, or seal all cooling chambers, sealing gaps and lubricating slots, as well as the bearings, as may be desired in accordance with the particular engine construction. The system of the flow of medium according to the invention permits the volume of the flow of medium through the engine as well as the pressure of the medium therein to be varied so that the

system may be adapted to any requirements which may occur in actual practice.

Finally, the vane skids 16 which are known from my mentioned Australian patent may be equipped with stabilizing arms 63 as shown in FIGS. 11 to 13. They may also be provided with the radial balancing areas 61 to carry out the functions as also disclosed in the mentioned Australian patent. The stabilizing arms 63 have the advantage that they have outer surfaces which have the same radius as the surface of the compressor and expander housing parts. They therefore engage fully the inner surface of housing 1 when they pass through the respective compressor and expansion chambers. If the entire vane skid 16 would be equipped with such stabilizing arms 63, the space required by it would have to be taken from the rotor diameter which would result in increased tangential loads upon the vanes. According to the invention, it is therefore advisable to mount only one, two, or a few stabilizing arms 63 in both tangential directions on the vane skid 16. In the axial direction, however, these stabilizing arms only need to be narrow since even narrow stabilizing arms 63 may produce the stabilizing effect which would prevent the skid 16 from tilting tangentially.

FIGURES 11 to 13 also indicate that the central web of vane skid 16 is provided on its radially outward surface with a plane surface 65 which is adapted to engage tightly upon the inner surface of the housing at the plane connecting points of the inner housing surfaces between the arcuate surface parts thereof. If the mentioned connecting surfaces between the cylindrical inner surfaces in the compressor and releaser parts are not plane, the surface 65 is made accordingly of a different shape so as to correspond to the connecting surfaces in the housing and to engage tightly therewith.

FIGURES 14 and 15 illustrate a rotary vane machine with a double diametrical action, especially for fluid operation. This machine is equipped with a rotor and rotor stabilizing means according to the invention and its housing 101 is also divided into two parts which are secured to each other by bolts 52. When the rotor revolves in the clockwise direction, the working medium is supplied to the machine through the two diametrically opposite feed channels 102 and it is subsequently discharged through the discharge channels 103 which are likewise located diametrically opposite to each other. The rotary vane machine may operate either as a compressor or as a pump or as a motor. Especially it may be used as a fluid pump or fluid motor, in which case the sealing gaps are lubricated and sealed with fluid and, because of the double diametrical arrangement of the feed and discharge lines, the rotor will be radially completely balanced, provided that it has an even number of vanes. According to the invention, the entire housing including hood-shaped end portions is divided into two parts in such a manner that each housing portion 101a and 101b of the central housing part is provided with a feed channel 102 and a discharge channel 103. The dividing line of housing 101 and the position of bolts 52 is arranged according to the invention so that the feed and discharge channels 102 and 103 are not interrupted by the dividing surface of the two housing parts. Another important advantage of the invention is that the revolution of the rotor produces centrifugal forces which also become active in the medium which is taken along by the rotor. Lubricants, for example, which might have passed into the working chambers are conducted by the centrifugal force into the gaps between the stationary housing and the rotating rotor side walls 4a and 4b where they support the sealing and lubricating effects. The centrifugal force as described also acts upon combustion residues, such as carbon residues, impurities, etc., and it may be utilized for removing these impurities from the working chambers through cleaning channels, not shown, which are pro-

vided in the direction of the centrifugal force in stationary or rotating parts of the machine.

The bearing surfaces of the vanes, especially also the axial vane extensions in the rotor side walls may also be provided with smaller grooves, recesses, and the like which, due to pressure or the centrifugal force become partly or entirely filled with sealing and/or lubricating medium and thereby effect a better lubrication, sealing, or hydrodynamic support of the vanes in the slots of the rotor side walls. All of these means individually or combined, will increase the reliability of operation of the machine at a very low cost and also result in a high output of the machine at a high static stability despite its small size.

The foregoing description of a few examples of the many possibilities in which the invention may be applied is merely intended to explain the basic principles and features of the invention and some of the preferred embodiments thereof, but it is to be understood that the invention is in no way limited to the details of such embodiments, but is capable of numerous modifications within the scope of the appended claims.

Having thus fully disclosed my invention, what I claim is:

1. A rotary vane machine comprising a stationary housing, a rotor in said housing comprising a central rotor part and two rotor side walls axially at both sides of said central part and radially projecting therefrom, said rotor side walls having opposite inner sealing surfaces adjacent to said central part, said housing having an encasing ring part with axially outer end surfaces fitted between the sealing surfaces of said rotor side walls, said rotor having substantially radial slots, vanes slidably mounted in said slots, said central rotor part together with said rotor side walls and said encasing ring part defining a working space, said working space being divided by said vanes into a plurality of individual working chambers, said housing having housing hoods spaced from and enclosing said rotor side walls to form end chambers separate from said working chambers, said end chambers formed axially outside of said rotor side walls, channel means for supplying a flowing cooling medium to said end chambers, and including first channels extending substantially axially through said rotor and opening at the axial ends of the same for connecting said two end chambers with each other, and second channels supplying said medium to said first channels intermediate the ends thereof.

2. A rotary vane machine as defined in claim 1 in combination with annular sealing means for sealing the gaps between said sealing surfaces and said end surfaces operatively associated with said sealing surfaces, said sealing means comprising an annular sealing groove in one of said associated surfaces and a sealing ring inserted in said sealing groove.

3. A rotary vane machine as defined in claim 1, in which said second channels include a central longitudinal channel extending axially at least to one end of said rotor shaft, and transverse channels branching from said central channel and terminating in the areas limited by said rotor including said vane slots, and adapted to supply a pressure medium through said central longitudinal channel and said transverse channels to said areas.

4. A rotary vane machine according to claim 1 wherein said radial rotor slots extend in axial direction through said rotor side walls and have open ends at the outer faces of the same for communicating with said end chambers, and means for feeding an auxiliary medium to said second channels.

5. A rotary vane machine comprising a rotor having a central rotor part, two rotor side walls projecting radially beyond said central part, and a rotor shaft extending axially beyond said rotor side walls, said rotor having substantially radial slots extending in axial direction through said rotor side walls and having open ends at the outer

faces of the same, vanes slidably mounted in said slots, a housing enclosing said rotor, means for rotatably mounting said rotor in said housing, said housing having a central encasing ring part engaging radially inwardly between said rotor side walls and two end caps axially closing said housing and having bearings for said shaft, said vanes being adapted to slide along said encasing ring part during the rotation of said rotor, said housing including said ring part and said end caps being divided into two shell-like parts having a dividing plane extending substantially through the axis of said rotor, said end caps being spaced from and enclosing said rotor side walls to form end chambers separate from said working chambers and communicating with said open ends of said slots; said rotor having a first channel extending in axial direction through said rotor and opening at the axial ends of the same for connecting said end chambers, a second channel extending in axial direction into said rotor for supplying a fluid, and third channels connecting said second channel with said rotor slots so that said fluid is supplied to the same and through said open ends to said end chambers.

6. A rotary vane machine comprising a rotor having a central rotor part and rotor side walls axially on both sides of and directly connected to said central part and projecting radially outwards therefrom, said central rotor part and said rotor side walls forming one integral element, said rotor having substantially radial slots extending axially therethrough at least up to one end of said rotor and adapted to receive vanes slidable in said slots, so that web-shaped rotor parts remain on said rotor end between the adjacent slots, and at least one stabilizing ring on said rotor end for bracing said web-shaped rotor parts against each other, at least one of said rotor side walls having an annular recess open axially toward the outside and adapted to receive said stabilizing ring, and means for centering and fixing said stabilizing ring in said annular recess.

7. A rotary vane machine comprising casing means; a rotor means rotatably mounted in said casing means and having rotor side walls on the axial ends of a rotor central portion, said rotor side walls extending radially beyond said rotor central portion for partially embracing corresponding plane end faces of said casing means; vane means provided in substantially radial slots in said rotor means for periodically moving radially inwards and outwards therein and sliding along the inner face of said casing means during operation of the machine for dividing a working chamber which is formed between said casing means and rotor means into a plurality of separated intervane spaces; said casing means including a plurality of separate housing portions which abut in a radial plane and enclose said working chamber, said housing portions having radial end faces at the axial ends thereof which are partially in sealing engagement with confronting inner faces of the rotor side walls, said housing portions having inner face portions of part-cylindrical configuration; passage means extending into said working chamber for passing fluid into or out of said intervane spaces during operation of the machine; at least one of said vane means being provided with a longitudinal seat; a pivotable member mounted in said seat; a slide member carried by said pivotable member for sliding with its outer face along said inner face of said casing means in sealing engagement for sealing one of the intervane spaces relatively against another of the inter-

vane spaces, said outer face of said slide member having a central portion of a first radius and having therefrom peripherally extending forward and backward portions of part cylindrical configuration of a second radius corresponding substantially to the radius of the part cylindrical configuration of said inner face portions of said housing portions.

8. A rotary vane machine comprising casing means, a rotor means rotatably mounted in said casing means and having a central portion and rotor side walls on the axial ends of said rotor central portion, said rotor side walls extending radially beyond said rotor central portion for partially embracing respective plane end faces of said casing means; vane means provided in substantially radial slots in said rotor means for periodically moving radially inwards and outwards therein and sliding along the inner face of said casing means during operation of the machine for dividing the working chamber which is formed between said casing means and rotor means into a plurality of separated intervane spaces; said casing means including a plurality of separate housing portions which are abutting each other with radial plane connecting faces while said plurality of housing portions encloses said working chamber and has radial end faces at each of its axial ends which are partially in sealing engagement with the innermost faces of said rotor side walls; and passage means extending to said working chamber for passing fluid to or from said intervane spaces and to said substantially radial slots, said slots extending axially through said rotor central portion and through said rotor side wall means and having open ends at the outer faces of the same, said casing means forming end chambers with the axial ends of said side wall means, said end chambers communicating with said slots; and said rotor having channels for supplying a fluid to the radially inner portions of said rotor slots intermediate the open ends of the same, and other axially extending channel means for connecting said end chambers.

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