April 1, 1958 J. W. MARSHALL 2,828,695

ROTARY MACHINE

Filed Jan. 31, 1955 8 Sheets-Sheet 1

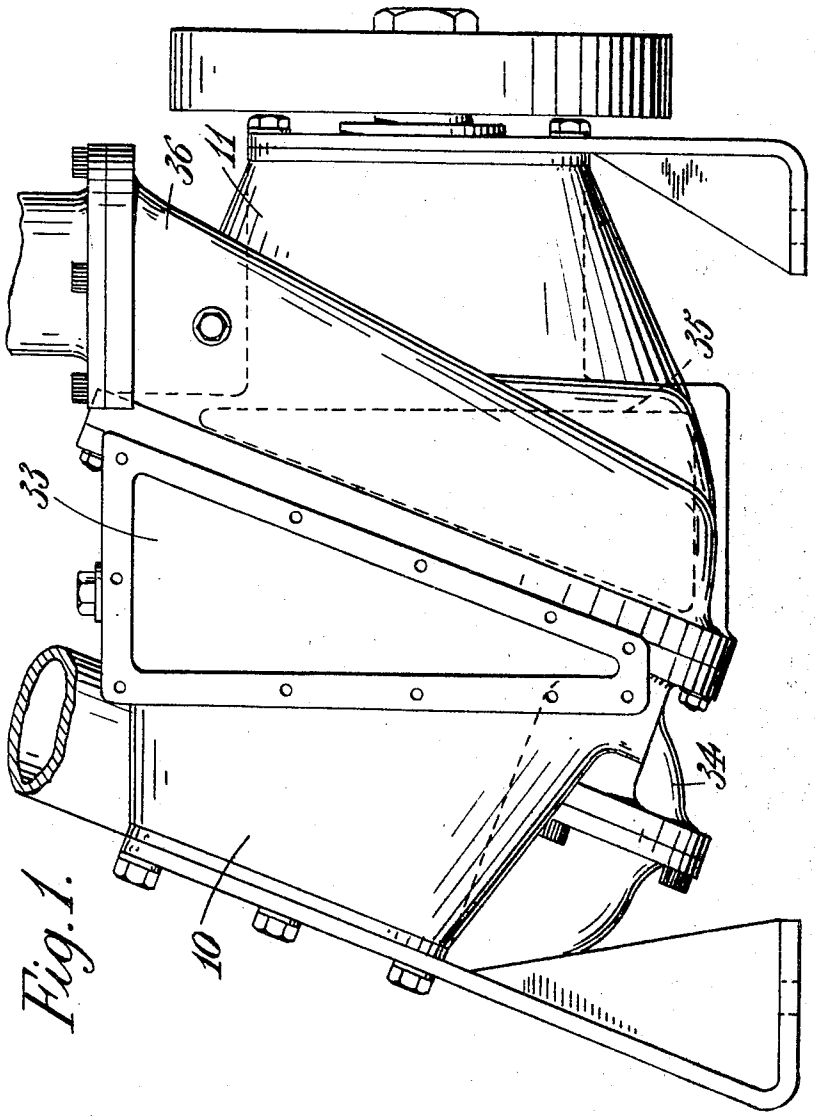


Fig. 1.

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ROTARY MACHINE

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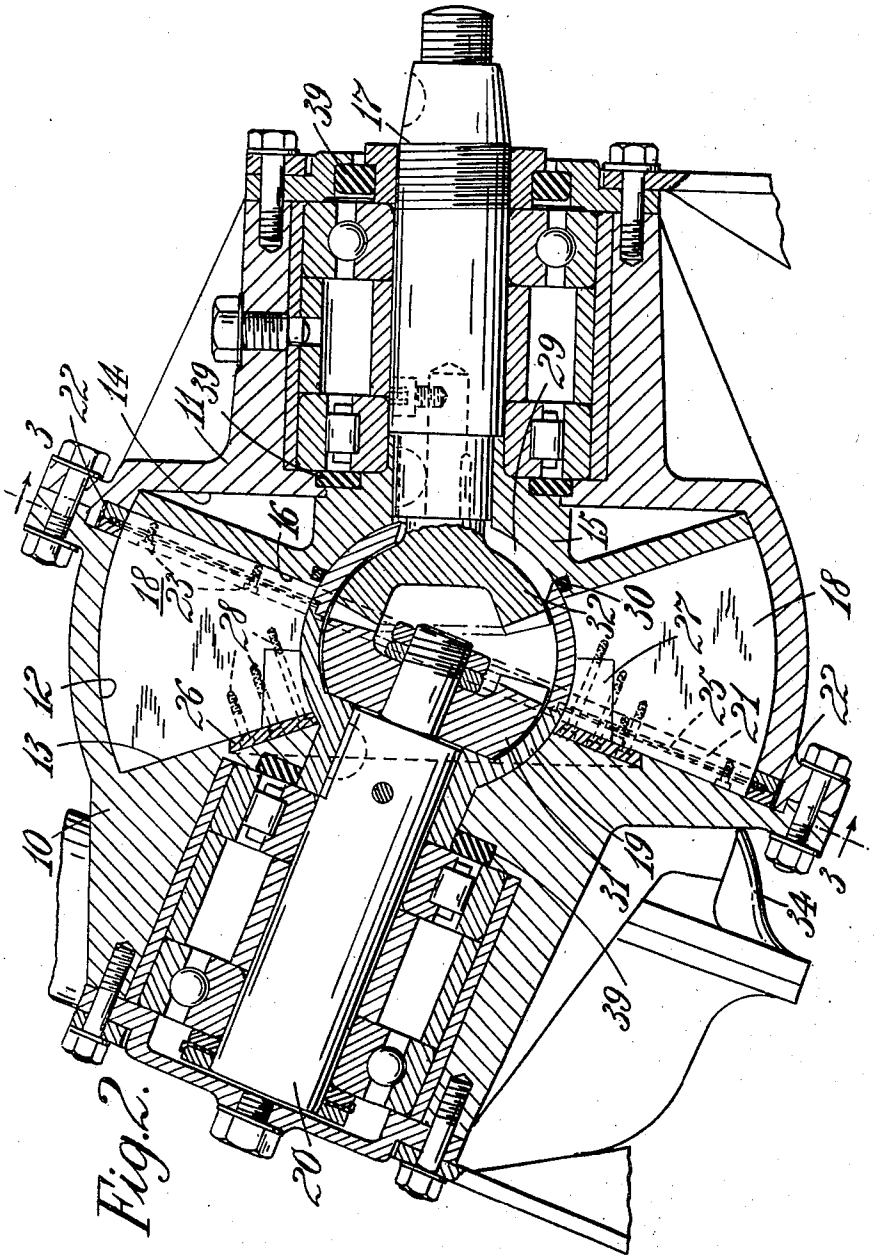


Fig. 2.

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ROTARY MACHINE

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Fig. 3.

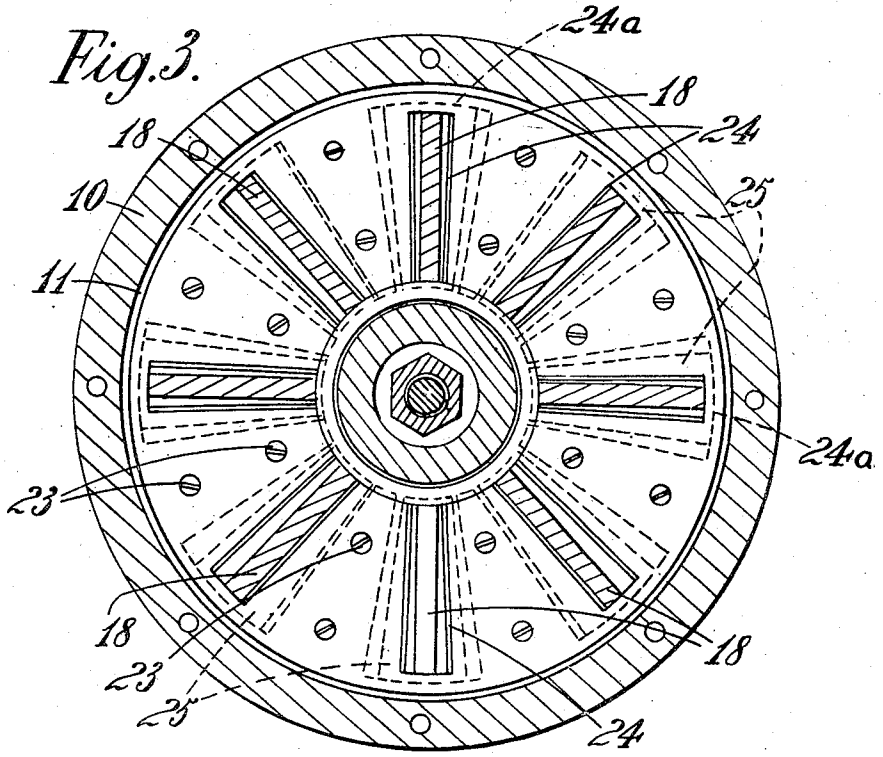
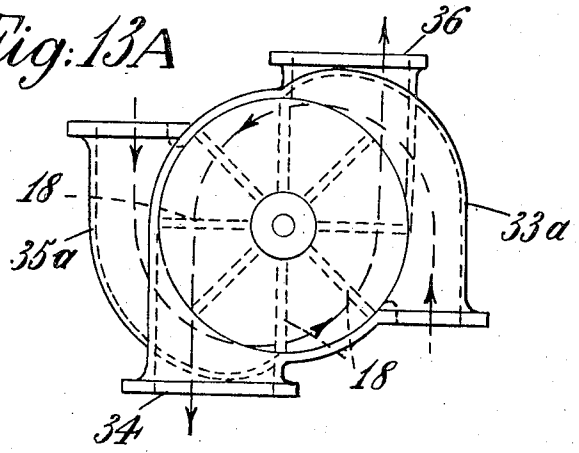


Fig. 13A



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Fig.4.

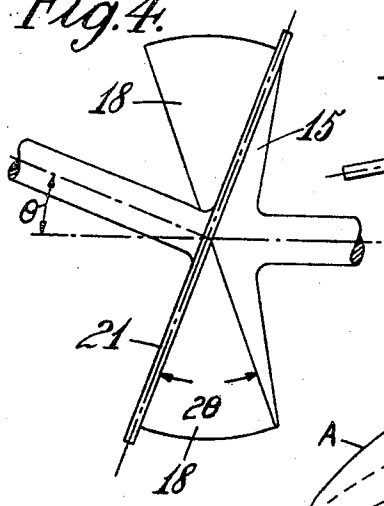


Fig.5.

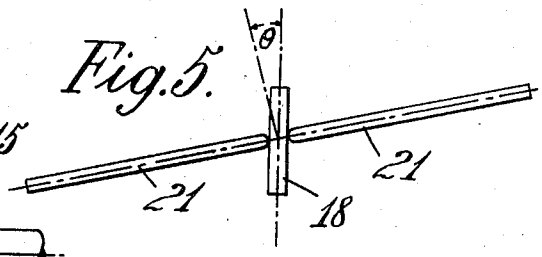


Fig.6.

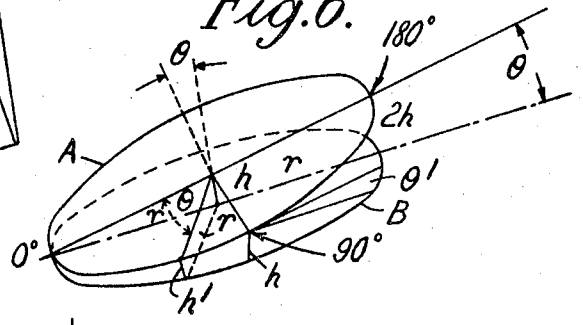


Fig.7

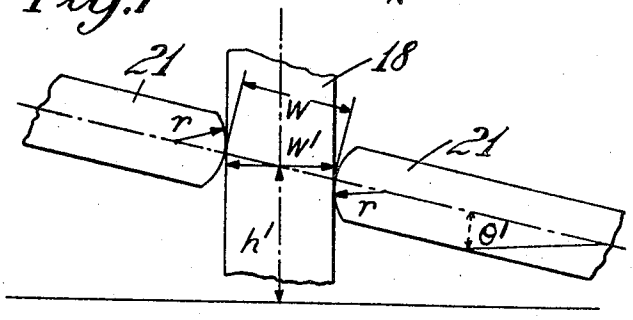
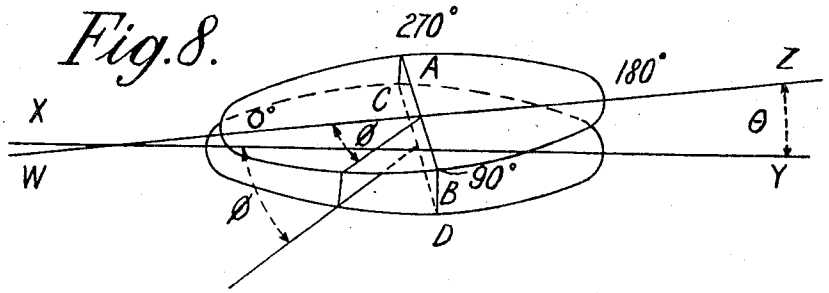


Fig.8.



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Fig. 9. Fig. 10. Fig. 11. Fig. 12.

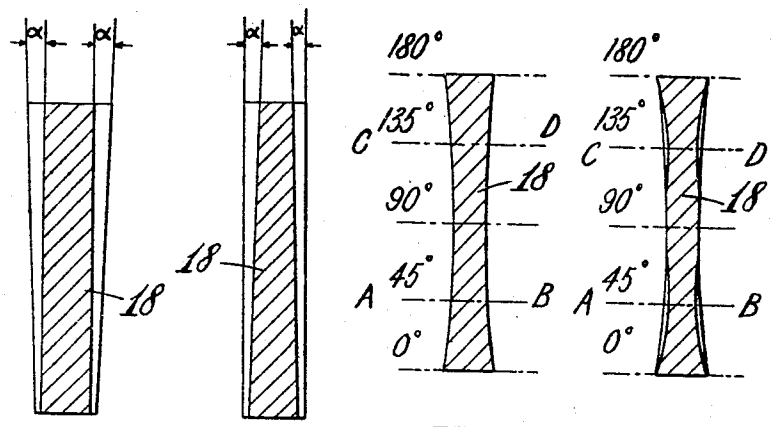


Fig. 15.

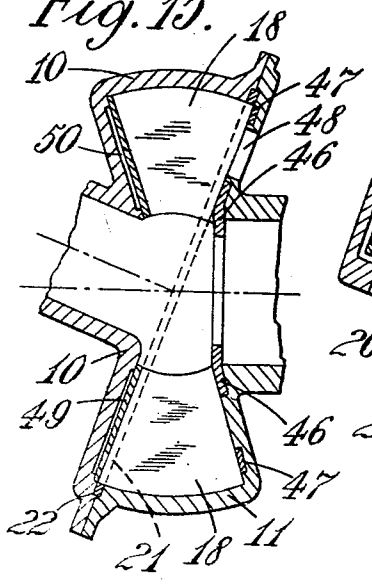
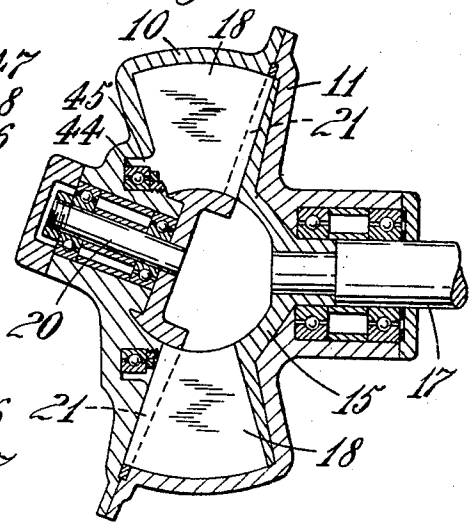


Fig. 16.



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Fig. 17.

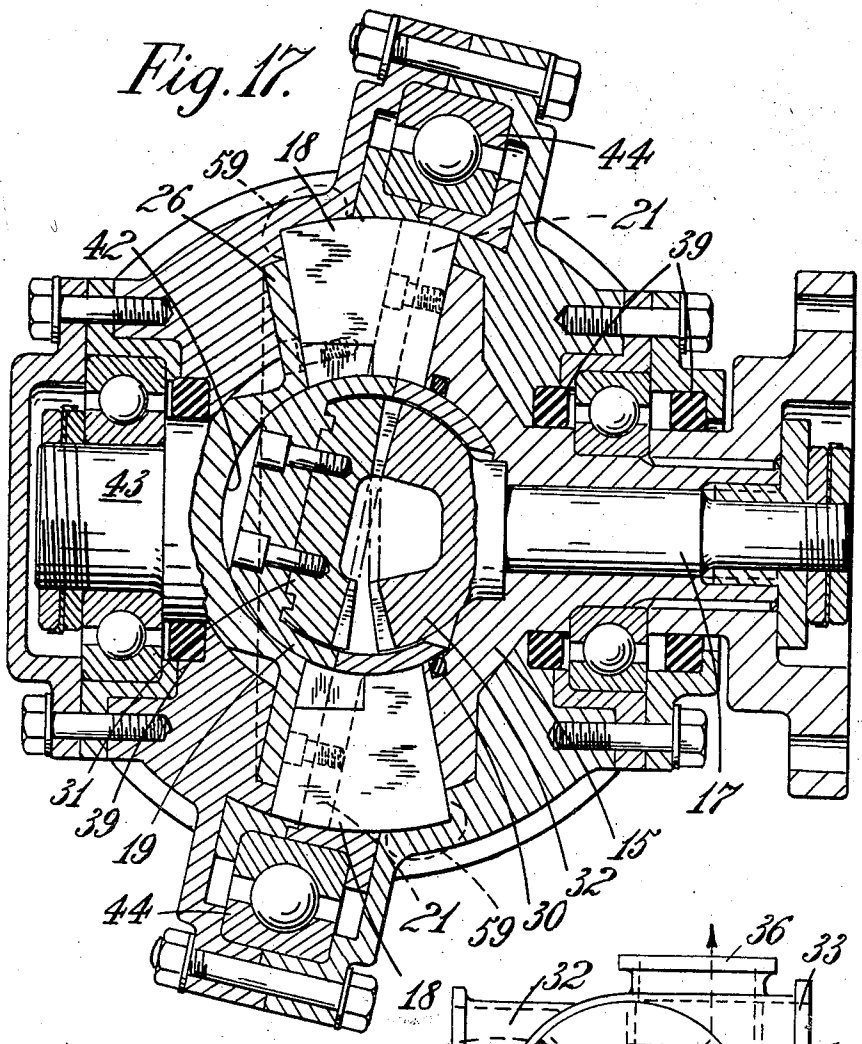
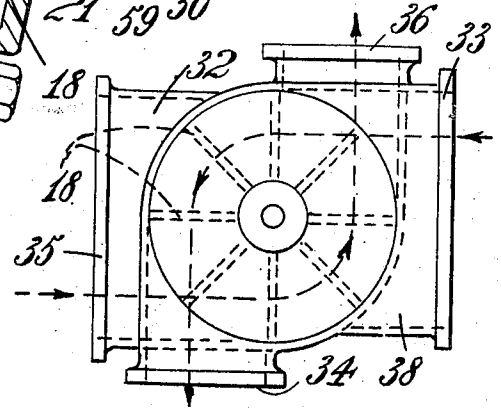


Fig. 13.



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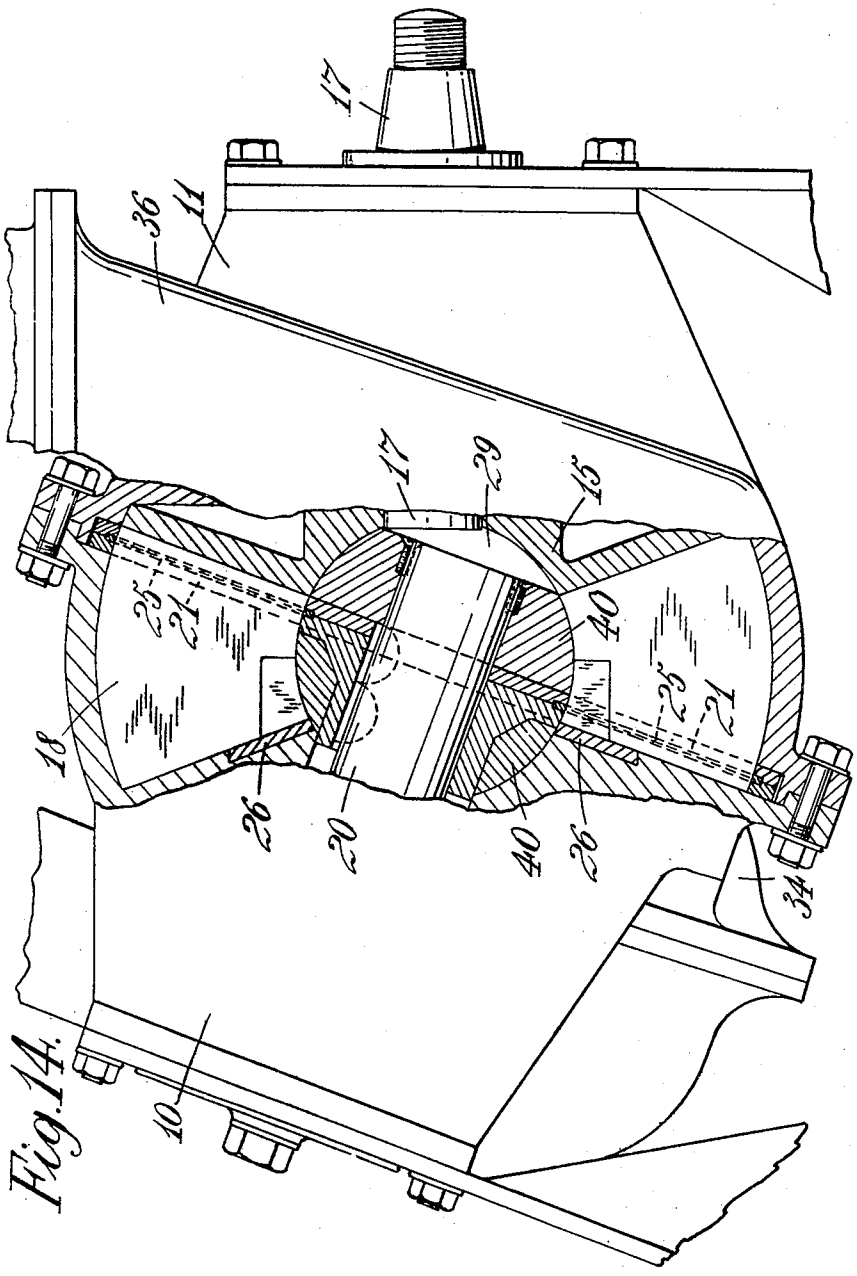


Fig. 14.

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Fig. 18.

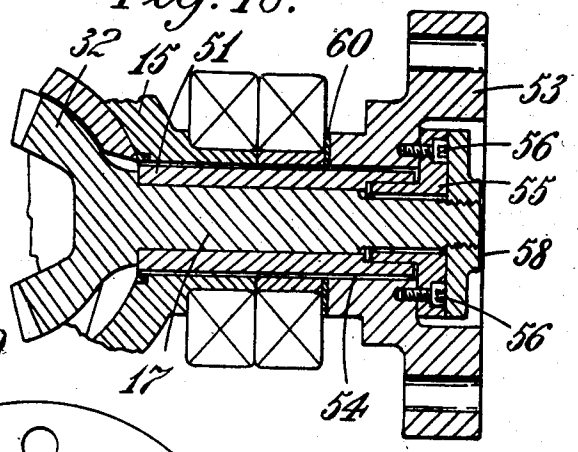


Fig. 19.

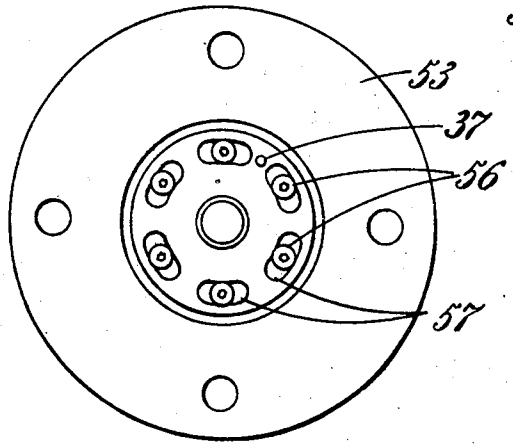
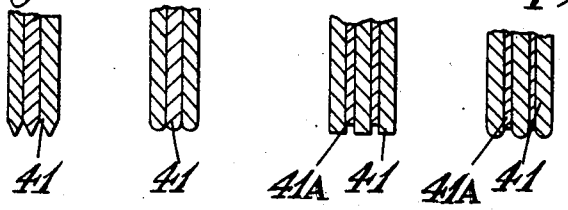


Fig. 24.



Fig. 20. Fig. 21. Fig. 22. Fig. 23.



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United States Patent Office 2,828,695 Patented Apr. 1, 1958

2,828,695

ROTARY MACHINE

John Wilmott Marshall, Weybridge, England

Application January 31, 1955, Serial No. 485,255

Claims priority, application Great Britain February 4, 1954

21 Claims. (Cl. 103—117)

This invention relates to rotary machines and in particular to rotary pumps and rotary engines, such as compressors and blowers, hydraulic and fluid pumps, steam engines, hot air engines, compressed air engines, internal and external combustion engines, rotary heat exchangers and air pre-heaters.

It is an object of the invention to provide an effective rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

It is a feature of the invention that there may be provided a plurality of shutter members oscillatably carried by the disc, each shutter member extending across one of said slots in close contact with the disc and having itself a radial slot of less width than the blade slot and accommodating the blade with a close fit, each blade having its opposite faces concave in cross-section, whereby the lateral and angular displacements of the blades with respect to the shutters which occur during rotation are permitted while the close fit of the blades within the shutter member slots is maintained. The shutter members may be omitted and it is then preferred to taper the blades or the slots in the manner hereinafter described. In some cases flat blades may be used instead of concave blades. Even when shutters are used it may be advantageous to taper the slots in the disc.

The aforesaid driving connection may comprise the slot walls or abutments on the disc engageable by the blades or the shutter members. Alternatively the connection may comprise a constant velocity coupling (e. g. a gear connection), in which case it is preferred to provide means outside the casing for adjusting the coupling.

The invention is also concerned with the arrangement of the aforesaid ports.

Shroud means may be provided extending around and secured in sealing relationship to at least part of the radially-extending edges of the blades, which shroud means fit closely against the interior of the casing. The shroud means may take various forms as described hereinafter.

The invention also provides means for assembling a hollow hub on the disc within part-circular recesses at the radially inner ends of the blades.

A peripheral bearing may be provided for the disc. Alternatively the blades may be supported on both sides by bearings (e. g. by a shaft attached to the rotor and by a bearing carried by the blades). These arrangements increase the stability of the rotary parts.

Preferably, if shutters are used they comprise a plurality of superimposed and relatively movable thin plates.

There follows a description, by way of example, of a number of constructions of compressor in accordance with the invention, reference being made to the accompanying drawings, in which,

Figure 1 is an elevation of a compressor casing, interior parts of the compressor not being shown;

Figure 2 is a sectional elevation of the compressor of Figure 1;

Figure 3 is a cross-sectional view on the line 3—3 of Figure 2;

Figures 4 to 12 are diagrammatic representations of parts of the compressor;

Figure 13 is a diagrammatic representation of the inlet and outlet ports of the compressor of Figures 1, 2 and 3;

Figure 13A is a diagrammatic representation showing modified inlet ports;

Figure 14 is an elevation, partly in section, of a modified compressor;

Figure 15 is a diagrammatic sectional view of a compressor having different forms of shrouds on the blades;

Figures 16 and 17 are diagrammatic sectional views of two further constructions of compressor;

Figure 18 is a sectional view of a detail of a compressor employing gearing;

Figure 19 is an end view of the detail of Figure 17;

Figures 20, 21, 22, 23 and 24 are cross-sectional views of different forms of shutter edges.

The compressor shown in Figures 1, 2 and 3 has a casing in two parts 10, 11 which are bolted together. The peripheral wall 12 of the interior of the casing is in the form of the equatorial zone of a sphere. One end wall 13 of the interior of the casing is of frusto-conical form while the other end wall 14 is flat (or if desired may be frusto-conical). A rotor 15 within the casing has a shroud part with a frusto-conical face 16 symmetrical with the end wall 13, and is fixed to a shaft 17 journalled in suitable bearings in the casing part 11. Made in one piece with the rotor 15 are eight equally-spaced radial blades 18 of sector shape. Alternatively the blades may be separate and secured to the rotor. The radially inner edges of the blades 18 are arcuate so as to fit around a hollow spherical hub 19 fixed to a shaft 20 journalled in suitable bearings in the casing part 10. Carried by the hub 19 is a disc 21 in line contact with the end wall 13 and the face 16 and its periphery fits into an annular groove 22 in the casing part 11. The disc 21 is in two halves connected together by screws 23, the hub 19 being in two parts each of which carries one half of the disc. In the disc 21 are eight equally-spaced radial slots 24 and a recess 24a is provided between the two halves of the disc 21 around each slot 24. Fitting within each recess 24a is a sector-shaped shutter 25 provided with a radial slot for passage of a blade 18. Each recess 24a is of greater width than its shutter 25 so that the shutter can oscillate therein

in a circumferential direction. A shroud **26** of frusto-conical shape is carried by the blades **18** on the opposite side to the rotor **15** and fits within an annular recess in the end wall **13**. In order that the spherical hub **19** may be inserted between the arcuate radially-inner ends of the blades **18**, the shroud **26** is connected to the blades through segments **27** of the same thickness as the blades, which segments fit into cut-outs in the ends of the blades. After insertion of the hub **19** between the blades, the segments **27** and the shroud **26** are fixed to the blades by screws **28**. The segments may be made in one piece with the shroud or may be separate parts. The hollow hub **19** is received with a suitable running clearance in a part-spherical recess **29** in the rotor **15**, a circular seal **30** in an annular groove in the rotor **15** being provided between the two members. Within the hollow hub **19** and fixed to the shaft **20** is a spiral bevel gear **31** meshing with a spiral bevel gear **32**, also within the hollow hub **19**, which gear **32** is fixed to the shaft **17**. Thus, when a drive is applied to the shaft **17**, the blades **18** being either fixed to the rotor **15** or an integral part thereof are caused to rotate, and the disc **21** being driven through the gears **31** and **32**, rotates with equal and constant velocity to the rotor **15**. The volume swept by the blades on each side of the disc varies from minimum volume to maximum volume in half a revolution, and from maximum volume to minimum volume in completing the revolution. The casing part **10** is provided with an inlet **33** and an outlet **34** communicating with the casing interior on one side of the disc **21** and the casing part **11** is provided with an inlet **35** and an outlet **36** communicating with the casing interior on the other side of the disc **21**. The inlets **33** and **35** being of triangular peripheral shape extend into the casing interior so that gaseous fluid can be drawn into the casing interior as the swept volume increases from minimum to maximum on each side of the disc. The outlets **34** and **36** communicate with the casing interior at or immediately before the line contact of the position of minimum volume on each side of the blade.

It is necessary that the edges of the blades **18** shall fit with as small a running clearance as possible against the peripheral wall **12**, the end wall **13** and the hub **19**. The rotor **15** should also fit with the smallest possible running clearance against the peripheral wall **12** and the hub **19** (the seal **30** being provided to minimize leakage of fluid between the rotor and the hub). To prevent or minimize leakage of fluid from the casing interior seals **39** are provided at appropriate positions between stationary and moving parts of the compressor. The periphery of the disc **21** should fit with the smallest running clearance possible into its groove **22** to minimize leakage from one side of the disc to the other. It is also necessary to minimize leakage of fluid from one side of the disc to the other where the blades pass. For this purpose the shutters **25** are provided and a particular formation of the blades **18** and the slots **24** in the disc is adopted.

In order that the formation of the blades **18** and the slots **24** may be fully understood, an arrangement is described below in which, for simplicity of explanation, only two blades **18** are provided on the rotor **15** and no shutters **25** are provided.

The axes of rotation of the rotor **15** and the disc **21** are inclined to each other at an angle θ (a suitable value for θ is 20°) and intersect in the central plane of the disc so that the blades pass centrally through the slots. In the position of Figure 4 the blades are at right-angles to the disc and have their edges in the slots, but after rotation through 90° to the position of Figure 5, the blades are at an angle θ to the disc and lie half-way through the slots. Thus, if the blade is parallel-sided as shown in Figure 5, and if the slot is of such a width as to give only a very small working clearance in the position of Figure 5, then in the position of Figure 4, there will be a substantial gap between the blade and the slot walls, resulting in considerable leakage. The gerater the angle θ, the greater will be the leakage.

Referring to Figures 4 to 7:

The radius of the impeller disc B=r

The angle of inclination=θ

The angle of cant of the disc A in relation to impeller disc B will be referred to as=θ^1

The height of the blade measured from the impeller disc B to the centre of the disc element A will be referred to as h.

The angle of rotation=ϕ

The height of the blade at the periphery of the discs at angle of rotation ϕ will be referred to as h^1

Then the height will be:

0 at 0° of rotation

h at 90° of rotation

$2h$ at 180° of rotation

The angle of cant θ^1 at any angle of rotation is governed by the pure trigonometrical formula:

Formula 1.—$\text{Sin}\theta^1=\sin\theta\times\sin\phi$ or $\cos\theta^1=\sqrt{1-(\sin^2\theta\sin^2\phi)}$

Where

θ^1=angle of cant.

θ=angle of inclination.

ϕ=angle of rotation.

The calculation of the height h' for any design and size of unit and for any degree of rotation ϕ is expressed by the following formula:

Formula 2.—$h'=r\tan\theta(1-\cos\phi)$ or $r\tan\theta(1+\cos\phi)$ depending on whether 0° in Figure 6 is referred to as the point of contact of the two discs or is at the position of maximum distance i. e. 0° or 180°.

Where

r=radius of the impeller disc B.

θ=angle of inclination.

ϕ=angle of rotation.

It is now proposed to give the exact width of any blade at any angle of cant θ^1 so that the blade shall completely fill the slot aperture without leakage being allowed at any position of that blade.

$$W'=W\cos\theta^1+2r(\cos\theta^1-1)$$

Formula 3.—$W'=W\cos\theta^1+2r(\cos\theta^1-1)$

Where

W'=width of blade desired at the height h' already ascertained from Formula 2 and at the same angle of cant

W=maximum width of the slot

r=radius of the two slot arcs

$\text{Cos}\,\theta^1=\sqrt{1-(\sin^2\theta\sin^2\phi)}$

From these three formulae it is possible to design a blade which will improve the efficiency of the machine.

The transverse cross-section of the blade will be double concave as shown in Figure 11. The angles indicated in that figure are values of ϕ of rotation.

In addition to the displacement of the blade discussed above, a further displacement (also depending in extent on the value of θ) occurs at positions between 0° and 90° of rotation, 90° and 180°, 180° and 270°, and 270° and 360°, and allowance should preferably be made for this further displacement.

Referring to Figures 8 to 12:

In Figure 8 two flat discs of equal diameter are inclined to one another at an angle θ and so positioned that the axis AB of the top inclined disc lies vertically above the axis CD of the lower disc. This means that a vertical blade positioned on the axis CD on the lower disc would then pass through the upper axis AB. If this blade is then rotated to the XY axis position it will again pass

through the WZ axis of the upper disc. However, at intermediate points of rotation this vertical blade will not pass through the corresponding axis on the upper disc. If ϕ is the angle of rotation on the lower disc ϕ^1 is the relative angle of rotation of the upper disc and the angle of inclination θ governs the disparity between these two angles. The larger the angle ϕ the greater will be this relative disparity.

The first requirement is to find the position of rotation where a vertical blade on the lower disc radially disposed to the centre of that disc produces the maximum displacement with reference to its corresponding axis on the upper disc.

This position is obtained from the formula:

ϕ produces a maximum displacement$=\tan \phi\sqrt{\sec \theta}$

It is then necessary to calculate the difference between ϕ and ϕ^1 and we will call this angle α.

Then:

$$\sin \alpha = \frac{\sin \phi(\sec \theta - I)}{\sqrt{(\sec^2 \theta + \tan^2 \phi)}}$$

When

$\theta = 20°$
$\phi = 45° 34'$
$\alpha = 1° 48'$

From these formulae it is clear that the slots in the inclined disc member must be designed for the worst position i. e. $\phi = 45° 54'$ when $\theta = 20°$.

Each slot must therefore be the width of the blade plus the running clearance, say .002", at its inner end and its sides must be declined at an angle of 2α.

In the case where $\theta = 20°$, $2\alpha = 3° 36'$

Figures 9 and 10 show the shape of the slot when

(*a*) The blade is rectangular cross section,
(*b*) When the blade is tapered cross section.

It is desirable to produce a shape of blade and slot which gives maximum sealing and the closest running clearances at all positions of rotation and particularly at the 90° and 270° positions of rotation because this is where compression pressures reach a maximum in those pumps having a built in pressure ratio of the order of 3:1.

It has already been described above how to profile a blade to give optimum sealing at 0°, 90°, 180° and 270° given a parallel sided rectangular slot but we now find that the slot must either be of tapered form or if the slot is parallel, the blade must be tapered to enable the two members to rotate and co-operate with one another at 45°, 135°, 225° and 315°.

The optimum shape of blade and slot is therefore a combination of a concave profiled blade superimposed on a tapered blade section.

Thus the taper shown in Figure 10 is superimposed on the profiled blade shown in Figure 11 along the axes AB and CD where ϕ produces a maximum displacement and consequently where the slot width is controlled from. This is shown in Figure 12.

Leakage of air will still occur at the tapered portions of the blade i. e. along the axes AB and CD, i. e., reaching a maximum at 45°, 135°, 225° and 315° of rotation but the blade will seal at 0°, 90°, 180° and 270°.

Alternatively, the same result can be achieved by tapering the blade at 0°, 90° and 180° (see Figure 11) and having the blade parallel along the axes AB and CD. In this case the slot will be of tapered form.

In the construction of compressor shown in Figures 1, 2 and 3, the blades 18 have their opposite faces suitably concave in cross-section as shown diagrammatically in Figure 11. The blades pass closely through the aforesaid shutters 25, and the shutters can oscillate to permit the above-mentioned further displacement of the blades at positions of rotation between 0°, 90°, 180°, 270° and 360°. Thus, neither the blades nor the slots in the shutters are tapered. The shutters fit closely within the disc 21 and in order that the disc shall mask the shutters to the greatest possible extent, the slots 24 in the disc are tapered as aforesaid so that at the position of the maximum aforesaid further displacement which is depicted in Figure 3, each blade lies closely against one wall of its slot 24. This arrangement has been found to give very effective sealing of one side of the disc from the other.

The inlets 33 and 35 being of triangular and peripheral shape extend into the casing interior as illustrated diagrammatically in Figure 13 and the openings are on opposite sides of the line of contact of the disc 21 with the end wall 13 and the face 16. Simple inlet openings (preferably peripheral) may alternatively be provided, but in that case unnecessary work must be done in creating a vacuum as the blades move from the positions of minimum swept volume to the positions of maximum swept volume, adjacent to which the inlet openings would be disposed. The arrangement shown in Figure 13 permits entry of fluid as soon as possible after the line of contact and during a substantial part of the movement (preferably at least 150–160° of rotation) between the positions of minimum and maximum swept volume. Figure 13A shows an alternative construction with peripherally-extending inlets 33A and 35A in which the inlets are of volute form to assist in the intake of fluid. The outlets 34 and 36 open peripherally into the casing interior on opposite sides of the aforesaid line of contact of the disc adjacent the positions of minimum swept volume. The outlets may open into the casing interior in an axial direction but this necessitates the omission of the shrouds for the blades or the provision of ports through the shrouds, resulting in substantial clearance volume which receives compressed fluid and returns it to the suction side of the compressor. With a peripheral opening it may be preferable, in order to prevent fluid trapping and baffling, to extend the outlet openings for a short distance round the axial end of the casing interior, the shrouds being of less diameter than those ends (e. g. as shrouds in Figure 17) to permit the passage of fluid to the axial portion of the outlet openings. Figure 17 illustrates diagrammatically by broken line 59 the cross-sectional shape of such part-peripheral part-axial openings.

The shroud 26 of Figure 17 may be enlarged to fit against the peripheral wall (or to have a clearance when a part-axial part-peripheral outlet opening is used). A fully-shrouded blade assembly (i. e. one in which the whole of the straight edges of the blades are shrouded) has the advantage of avoiding leakage of fluid at the point of running clearance between each blade 18 and the casing wall 13.

Figure 14 illustrates a modification of the compressor in which no gear connection is provided between the two shafts 17 and 20. The shaft 20 has fixed thereto a solid spherical hub 40. The hub is made in one piece, to facilitate accuracy of shaping, which is divided as shown and attached to the disc 21. Alternatively the two halves of the disc 21 may have solid spherical hubs 40 instead of the hollow hubs 19 shown in Figure 2. The blades drive the disc through the shutters and for this reason the oscillating shutters are arranged to abut the disc or members (preferably resilient members e. g. springs or elastomeric material such as neoprene) attached thereto, so as to transmit the drive.

The shutters 25 may be of solid sheet material but preferably they are formed of a plurality (conveniently three) of thin plates 41 (see Figures 20 to 24), pressed out of sheet (e. g. 1/32 inch thick) and assembled to the required thickness. The slot edges in the shutters may be arcuate, flat or knife-edged, but in order to improve the sealing a labyrinth effect is preferred as shown in Figures 20 to 23, which illustrate constructions giving a triple line seal. In Figures 22 and 23, thin spacing plates

41A are provided between the plates 41. The thin plates 41 of each shutter can slide relatively to one another so that each plate remains in contact with the blade during angular displacement of the blade relative to the shutter. The use of a plurality of thin plates facilitates manufacture of the accurately-dimensioned shutters.

Figure 17 shows another construction of compressor in which the axes of rotation of the disc and the blades are inclined at an angle less than in the constructions of Figures 1, 2, 3 and 14 (suitably at an angle of between 10° and 12°). The compressor is intended to be run at a higher speed than the constructions previously described. Since, owing to the smaller angle between the axes, less displacement of the blades occurs, no shutters are provided but the blades are preferably concave (but may be concave and tapering or they maybe flat) and the slots in the disc are tapered as aforesaid. The spherical hub 19 is not carried by a shaft but is received with a suitable running clearance in a spherical recess 42 in a rotor carrying the shroud 26 and having a shaft 43 journalled in suitable bearings. Since the blade assembly is supported on both sides, more compact bearings can be used while maintaining or improving stability. The disc 21 is provided with a peripheral bearing 44, which restrains the periphery of the disc from lateral movement or distortion. The shaft 17 is connected to the spherical hub 19 through gears 31 and 32 as hereinbefore set out. In larger sizes of compressor a peripheral bearing cannot be used owing to size restrictions, in which case the disc and the hub 19 would be carried by a shaft in a similar manner to that shown in Figure 2.

Figure 16 shows a compressor in which a bearing 44 in the casing part 10 is carried by lugs 45 on the blades 18 so that the blade assembly is supported at one side by the shaft 17 and at the other side by the bearing 44. The bearing 44 must be suitably sealed. An advantage of this arrangement is that closer clearances can be used without danger of seizure.

Instead of the comparatively heavy shrouds used in the constructions described hereinbefore, two thin shroud rings 46 and 47 may be provided as shown on the right of Figure 15, which figure also shows the casing part 11 raised to fill the gap between the rings 46 and 47, and an axially-directed outlet port 48. The chief functions of a shroud or shroud rings are to support the blades to prevent deflection thereof and to prevent leakage. An axially-directed port has the advantage that oil loss is reduced as compared with a peripheral port, through which oil is liable to be flung. Figure 15 also illustrates on the left a single thin shroud 49. The shroud would be suitably apertured if axial ports are used. Suitably a thin shroud 49 is provided on each side of the blades, or rings 46 and 47 are provided on each side. A recess 50 may be provided for passage of cooling fluid behind the shroud, or each shroud ring. An important advantage of the shroud rings or thin shroud is that axial ports can be used without having substantial clearance volume which would occur with a thick shroud.

Where a gear connection is provided between the disc and the blades it is advantageous to provide means for adjusting the connection as shown in Figures 18 and 19. The shaft 17 is slidably mounted within a hollow shaft 51. The hollow shaft 51 is splined to the rotor 15 and within the hub of a driving flange 53, splines 54 connecting these parts for rotation together. A tubular flanged member 55 is splined or keyed to the shaft 17 and is connected by screws 56 to the driving flange 53. The tubular flanged member 55 has slots 57 accommodating the screws 56, whereby the relative angular position of the shafts 17 and 51 can be adjusted, thereby effecting relative rotation between the blades and the disc. A locking nut 58 (omitted in Figure 19) is also provided, and a dowel 37 fixes the parts in the required position. A shim or shims 60 is or are provided so that on removal thereof the two gears can be moved towards one another to remove backlash or take up wear.

It will be understood that instead of a gear connection, any other suitable form of constant velocity coupling may be used and that means may be provided for adjusting the coupling in the same manner as the gears.

The constructions hereinbefore described may be used as blowers or pumps by suitable modification of the inlet and outlet openings where necessary. Also they may be operated as motors or engines (e. g. by supplying fluid through the aforesaid outlets and exhausting fluid from the aforesaid inlets). They may be used as internal-combustion engines by igniting a mixture of fuel and air within the casing at a suitable position. Where a hot fluid is on one side of the disc, a cooler fluid may pass on the other side of the disc so that the apparatus acts as a heat exchanger or air pre-heater. Where one half of the apparatus acts as an engine or a motor in such a case the other half may act as a pump or compressor.

Although the machines described hereinbefore have eight blades, it may be preferably (especially with a casing of larger diameter) to use more blades. In some cases less than eight blades may be used (e. g. in small machines).

I claim:

1. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, a plurality of shutter members oscillatably carried by the disc, each shutter member extending across one of said slots in close contact with the disc and having itself a radial slot of less width than the blade slot and accommodating a blade with a close fit, and each blade having its opposite faces concave in cross-section, whereby the lateral and angular displacements of the blades with respect to the shutter members which occur during rotation are permitted while the close fit of the blades within the shutter member slots is maintained, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

2. A rotary machine as claimed in claim 1 in which the driving connection comprises abutments on the disc engageable by the shutter members.

3. A rotary machine as claimed in claim 2 in which the abutments are resilient.

4. A rotary machine as claimed in claim 1 in which the driving connection comprises a constant velocity coupling.

5. A rotary machine as claimed in claim 4 in which the constant velocity coupling comprises a gear connection.

6. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the

casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, each blade having its opposite faces concave in cross-section and each blade having zones extending along its length and tapering in a radially outwards direction, whereby the lateral and angular displacements of the blades with respect to the disc which occur during rotation are permitted while the close fit of the blades within the slots is maintained, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

7. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly- directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, each blade having its opposite faces concave in cross-section and each slot widening as it extends radially outwards, whereby the lateral and angular displacements of the blades with respect to the disc which occur during rotation are permitted while the close fit of the blades within the slots is maintained, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

8. A rotary compressor comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, inlet ports opening through the peripheral wall of the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and outlet ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume, said inlet ports opening through the peripheral wall of the casing interior for more than half of the distance from the position of maximum swept volume to the position of minimum swept volume.

9. A rotary compressor comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, inlet ports opening through the peripheral wall of the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and outlet ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume, said outlet ports opening through the peripheral wall of the casing interior.

10. A rotary compressor as claimed in claim 9 in which the outlet ports also open into the casing interior in an axial direction.

11. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on

opposite sides of the disc adjacent the positions of minimum swept volume, said driving connection comprising a constant velocity coupling having one part connected to the disc and another part connected to the blades, adjusting means being provided outside said casing for changing the angular relatonship between the last said part and the blades.

12. A rotary machine as claimed in claim 11 in which said coupling parts comprise meshing gears.

13. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, annular shroud means extending around and secured in sealing relationship to at least part of the radially-extending edges of the blades, which shroud means fit closely against the interior of the casing, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

14. A rotary machine as claimed in claim 13 in which the shroud means comprise rings extending around radially inner and outer portions of said radially-extending edges of the blades.

15. A rotary machine as claimed in claim 14 in which the wall of the casing interior between said rings is raised to fit against the blades and is apertured to provide a port.

16. A rotary machine as claimed in claim 13 in which the shroud means cover at least substantially the whole of at least one radially-extending edge of each blade.

17. A rotary machine as claimed in claim 16 in which the shroud means comprises thin sheet material.

18. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, a spherical hub member fixed centrally to said disc, which hub member fits with a close running clearance in part-circular depressions in the radially-inner ends of the blades, a shroud ring covering at least the radially-inner portion of an edge of each blade, segment pieces connecting the ring to the blades, each segment piece being of the same thickness as its blade and providing said radially-inner portion of an edge of the blade and the adjacent part of the part-circular depression, whereby the hub member can be inserted between the blades and thereafter the segment pieces and the shroud ring can be attached, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

19. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, each blade having its opposite faces concave in cross-section and each blade and its slot being in tapering relationship, whereby the lateral and angular displacements of the blades with respect to the disc which occur during rotation are permitted while substantial leakage of fluid between the blades and the slot walls is prevented, an annular bearing between the periphery of the disc and the casing, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

20. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, a plurality of shutter members oscillatably carried by the disc and each comprising a plurality of superimposed thin plates slidable over one another, each shutter member extending across one of said slots and having itself a radial slot accommodating a blade with a close fit, whereby the lateral and angular displacements of the blades with respect to the shutter members which occur during rotation are permitted while the close fit of the blades within the shutter member slots is maintained, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a mini-

mum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

21. A rotary machine comprising a casing having an interior of circular cross-section, a rotor mounted in the casing, the rotor and the casing interior defining a space having a peripheral wall in the form of the equatorial zone of a hollow sphere and side walls in the form of inwardly-directed truncated cones whose bases are in contact with the edges of the peripheral wall, a plurality of fixed radial blades carried by the rotor, which blades divide the space in the interior of the casing into a plurality of separate compartments, a disc rotatable within the casing and having a plurality of radial slots through each of which a blade passes, the axes of rotation of the disc and the rotor being inclined to each other and intersecting in the central plane of the disc and the disc being substantially in line contact with each side wall and dividing the interior of the casing into two separate parts, a plurality of shutter members oscillatably carried by the disc, the shutter members being separately mounted and separately oscillatable on the disc, and each shutter member extending across one of said slots in close contact with the disc and having itself a radial slot of less width than the blade slot and accommodating a blade with a close fit, a driving connection between the blades and the disc, whereby the blades and the disc rotate simultaneously and the volume swept by the blades on each side of the disc varies from a minimum to a maximum during one half-revolution and from a maximum to a minimum during the subsequent half-revolution, ports opening into the casing interior on opposite sides of the disc adjacent the positions of maximum swept volume and ports opening into the casing interior on opposite sides of the disc adjacent the positions of minimum swept volume.

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