April 21, 1964 J. CIRILLO 3,129,875

ROTARY GAS COMPRESSOR

Filed Feb. 20, 1962

FIG. 1

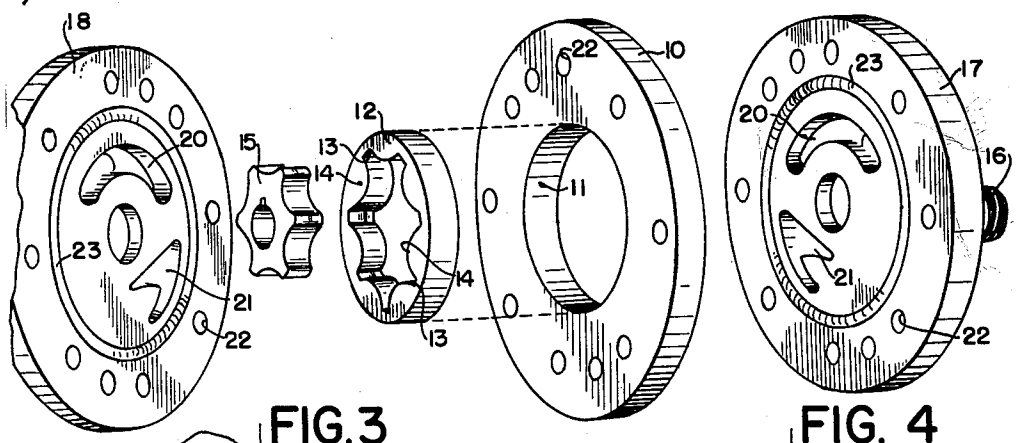


FIG. 3

FIG. 4

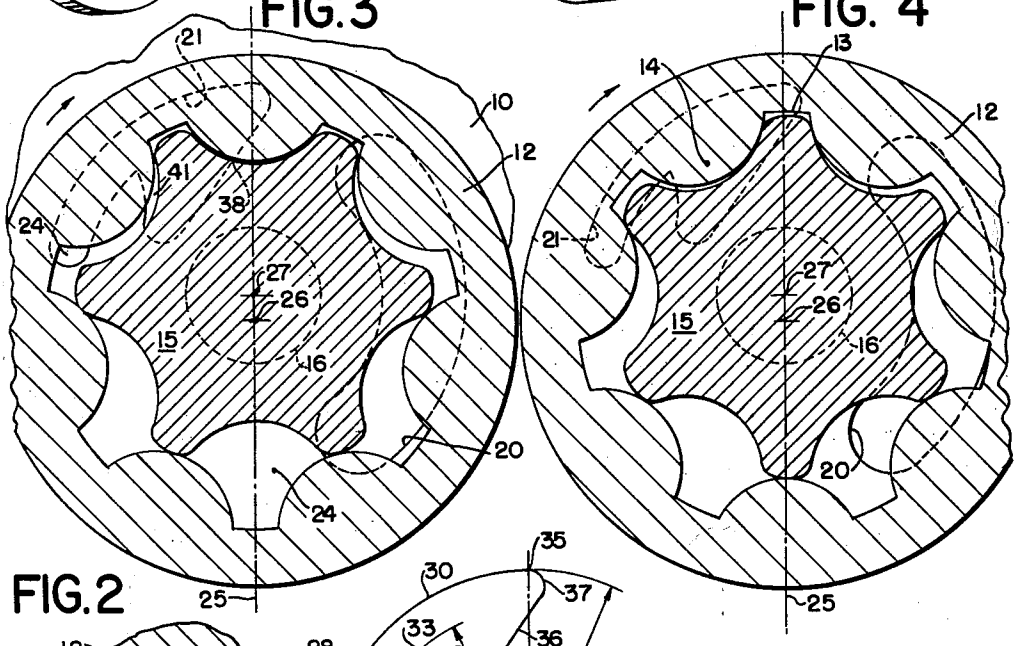
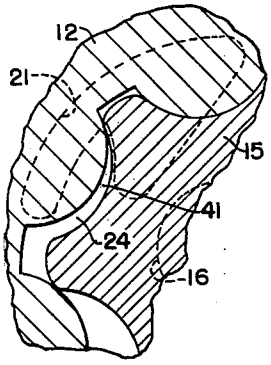


FIG. 2



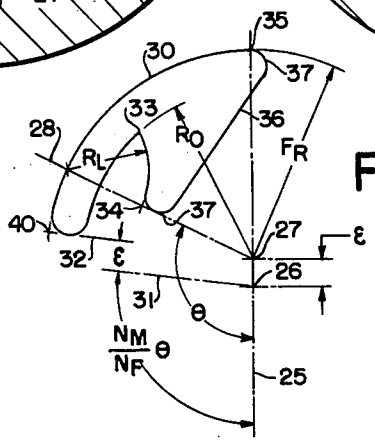


FIG. 5

INVENTOR.
JOHN CIRILLO

BY Darby & Darby

ATTORNEYS

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ROTARY GAS COMPRESSOR

John Cirillo, Kings Park, N.Y., assignor to Fairchild Stratos Corporation, Hagerstown, Md., a corporation of Maryland

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The present invention relates to rotary gas compressors and particularly to a "Gerotor" type pump utilized for compressing gas. The "Gerotor" pump is basically an internal gear type positive displacement pump having two rotors or gears, one of which is within and eccentric to the other, the rotors having tooth divisions, with contours on each outlined by the tooth form of the other at regular angular motion and the outer rotor having one tooth division more than the inner rotor. In the past, such pumps have been used for the pumping of liquids only, since in the form in which heretofore constructed, they could not serve to compress gases efficiently.

In my present invention the "Gerotor" is adapted to the compressing of gases by modifying the size and shape of the discharge port. Thus as the lobe space between the two rotors of the pump diminishes the gas is retained therein and compressed, being discharged when and only when the desired pressure, in terms of the compression ratio, has been attained. This is accomplished by so locating, dimensioning and shaping the port as to cause the discharge to be immediate once the desired compression ratio has been reached. This modification of the "Gerotor" type pump not only produces an efficient gas compressor, but also retains the advantage of extremely small size thus producing a compressor which is particularly adapted for airborne usage.

Furthermore, as has been indicated, the gas compressor may be assembled from readily available parts, that is, the normal internally toothed and externally toothed internal gear arrangement of the usual "Gerotor" pump, the only modification necessary being in the formation of the discharge port or ports.

It is an object of the invention to provide a gas compressor which is generally similar to the "Gerotor" type of internal gear positive displacement pump.

It is another object of the invention to provide such a gas compressor in which a desired compressor ratio may be obtained by simply designing the discharge port or ports to produce that desired compression ratio assuring that there will be no leakage into the discharge ports prior to the time that the desired pressure has been attained and that once that pressure has been attained the discharge from the tooth spaces will be substantially instantaneous.

Other objects and features of the invention will be apparent when the following description is considered in connection with the annexed drawings, in which,

FIGURE 1 is an exploded view of a "Gerotor" type positive displacement pump having discharge ports in accordance with my invention thereby converting the said pump into a gas compressor;

FIGURE 2 is a fragmentary cross-sectional view of the male and female rotors of the pump showing the relative position of the two parts just prior to the time of discharge of the compressed gas into the discharge port or ports;

FIGURE 3 is a transverse cross-sectional view of the assembled device of FIGURE 1 showing the position of the male and female rotors at the moment when the space between a pair of the male and female rotors has just been filled with gas and compression is started. This view also shows gas being discharged from the reduced space between other lobes of the male and female rotor into the discharge passageway;

FIGURE 4 is a view similar to FIGURE 3 but showing the rotors further advanced to the point where discharge of the compressed gas has been substantially completed; and

FIGURE 5 is a diagram showing the mode of designing the discharge ports as functions of the rotor geometry and the desired compression ratio.

Referring now to the drawings and particularly to FIGURE 1, there is shown therein a housing member **10** which has a bore **11** therein which bore is eccentric to the outer periphery of the member **10**. Mounted in the bore **11** is a female rotor **12**, having in the particular instance shown, seven teeth **13** and a corresponding number of lobes **14**.

Mounted within the female rotor **12** is a male rotor **15** which rotor is keyed to a shaft **16**, the shaft being mounted concentrically with respect to the housing end members **17** and **18**. These housing end members are normally of the same diameter and configuration as the housing member **10** and serve to seal the rotors **12** and **15** from atmosphere.

The male rotor **15** in the usual manner has one less tooth than the female rotor **12** thus in the particular instance having six teeth. Each end plate or housing member **17** and **18** is provided with an inlet port **20** of the usual kidney shape common in "Gerotor" pumps and is additionally supplied with a discharge port **21** which discharge port is of such a size and so shaped that it provides substantially instantaneous discharge of the compressed gas once the desired compression ratio has been attained, while assuring that there will be no leakage of gas from the compression chamber to the discharge port until that compression ratio has been attained.

As is usual, the housing member **10** and end plates **17** and **18** are provided with aligned apertures **22** through which bolts are passed, the nuts placed thereon then serving to draw the ports tightly together and to bring the sealing gasket **23**, inserted in a groove in each end plate **17** or **18**, into engagement with the respective flat facing surface of housing member **10** thereby sealing the unit.

As has been indicated, the design of the discharge port or ports (it being only necessary that a single port in one of the end plates be utilized, but preferable that each end plate have such ports) is the essence of my invention and makes it possible to utilize a unit which heretofore has been widely and favorably known as a liquid pump only, as a gas compressor. The method of laying out this port is shown particularly in FIGURE 5 which figure shows the various rotor radii and relates these dimensions to a particular position of the rotors in which a lobe space has just been filled, this same relationship being shown in FIGURE 3.

Referring now to FIGURE 3, the space **24** between rotors **12** and **15** is the space which has just been filled with gas which has been supplied through the inlet port **20**. The center line designated **25** is the line which passes through the center of lobe or tooth space **24**, through the center **26** of the female rotor and through the center **27** of the male rotor. This center line and these centers have been given the same reference characters in FIGURE 5. With this position of the rotors as a starting point, the angle θ is laid off about the center **27** thus making it possible to draw a radial line **28** from that center outwardly and intersecting the arc **30** which is an arc of the root circumference of the female rotor, the radius of which root circle has been designated F_R. The angle θ is the angle at which the desired compression ratio is attained which can be determined experimentally or by calculating the decrease in the space between the rotor lobes as the male rotor is driven and the female rotor driven by it.

The distance between the centers **26** and **27** is the eccentricity of the female rotor relative to the true center represented by the center of the male rotor and of the shaft **16**. This distance has been designated on the drawing as ϵ. The ratio of the number of lobes of the male rotor (N_M) to the number of lobes of the female rotor (N_F) is multiplied by θ thus giving an angle always smaller than θ. This second angle

$$\frac{N_M}{N_F}\theta$$

is laid out about the center **26** and a radial line **31** drawn. Thereafter a line **32** is drawn parallel to, above and spaced from the line **31** by the distance ϵ. The boundary of the discharge port extends inwardly along the line **32** until that line intersects an arc struck about the center **27** with the outer radius of the male lobe (R_O) as its radius.

Next an arc of radius R_L, equal to the lobe radius of the the male rotor, is struck from the point at which arc **30** intersects line **28**. An intersection of this arc with the arc of radius R_O determines the point **33** in the port outline. The arc of radius R_L terminates where that arc intersects the radial line **28** thus determining the point **34** of the lobe outline. From point **34** the lobe outline extends to the point **35** which point is a point on the circumference F_R 180° removed in the direction of rotation from the filled lobe space.

As shown in the drawings, the line **36** connecting points **34** and **35** does so by means of fillet curves **37**. This, however, is not essential although it is desirable for ease in manufacture. Also, although the line **36** is shown as straight, this is not necessary it being essential only that the connection between points **34** and **35** extend through the point such as that indicated at **38** (FIG. 3) at which the male and female rotor lobes are in substantially complete engagement.

From the point **35** the port outline extends in a direction counter to the indicated direction of rotation to the point **40** which point is that at which the description of the discharge port outline started. Again for ease of manufacturing fillet curves are supplied at the corners so that at the lower end of the discharge port, as seen in FIGURES 2 through 5, is not square, but is rounded off.

Referring now particularly to FIGURE 2, it will be seen that during the rotation from the position shown in FIGURE 3, to that shown in FIGURE 2, the space **24** between lobes of the male and female rotors has been diminished and in the particular showing of FIGURE 3 the volumetric capacity of the lobe space has been decreased to produce the desired compression ratio. It will be noticed that the upper tail-like portion **41** conforms to the arc R_L of the discharge port, but that no discharge has yet been permitted to occur.

Referring now to FIGURE 3, it will be noted that in that figure the space **24** between the respective lobes is in communication with the discharge port not only at its end, but also at the opposite end where the tail portion **41** occurs.

Referring now to FIGURE 4, it will be seen that at this point the lobe bearing the compressed gas is still in communication with the discharge port throughout a major portion of its remaining area. Thus the gas compressed in the lobe space is virtually instantaneously discharged once the rotors have reached the desired position corresponding to the desired compression ratio, but due to the shape of the port no discharge occurs in advance of attaining that compression ratio.

It is desirable that the gas to be compressed have a small amount of lubrication such as oil in suspension therein in order to aid in sealing the device.

It will be obvious from the foregoing discussion that the exact shape and size of the port depends solely upon the geometry of the mating rotors and the desired compression ratio and that therefore although the axact shape and size of the port will vary, there will be a single shape and size used with a particular pair of rotors to achieve a particular desired compression ratio.

It will also be obvious that the male rotor may be operated on an eccentric portion of a shaft supported in the same manner as is the shaft **16** and the female rotor mounted in a bore concentric to the shaft **16** and thus eccentric as respects the center of the male rotor.

As indicated hereinabove, the extreme radially outward and radially inward boundaries of the discharge port need not be exactly where defined above, since radially outward movement of the circle arc of the female rotor radius would cause that boundary to coincide with a solid portion of the rotor and would not alter the effective discharge port area and, in a like manner, movement of the boundary defined by line **36**, while keeping all portions of the line or curve within the boundaries of the male rotor, would not affect the effective discharge port area.

While I have described a preferred embodiment of the invention, it will be understood that I wish to be limited not by the foregoing description, but solely by the claims granted to me.

1. In a "Gerotor" compressor of the type having a lobed female rotor, a lobed male rotor having one less lobe than said female rotor, a housing member having a bore in which said female rotor is rotatably mounted, closure members at the sides of said housing member, said closure members carrying a shaft on which said male rotor is mounted, said bore and said male rotor shaft mounting being eccentric with respect to each other, the center of one of said rotors being concentric to said shaft and the center of the other rotor being eccentric to said shaft, all lobes of one of said rotors being in sealing contact with the lobes of the other of said rotors at least one of said closure members having an inlet port of usual kidney shape; the improvement which comprises providing a discharge port in at least one of said closure members which is substantially the projection of a figure bounded by a line extending from a point lying on a circle arc having the root radius of said female rotor, laid off about a center coinciding with the center of the concentrically mounted rotor, said point being removed in the direction of rotation from a diameter extending through the center of the male and female rotor lobe space which is filled at the start of compression, and through the centers of said male and female rotors at that position, by an arc comprising the arc subtended by an angle measured about the center of said eccentrically mounted rotor which angle is equal to the ratio of the number of lobes in the male rotor to the number of lobes in the female rotor multiplied by the angle measured about the center of the concentrically mounted rotor at which the desired compression ratio occurs, and the arc of said root radius circle subtended by a chord equal to the eccentric distance; thence inwardly along a line parallel to the radial line defining said first mentioned angle to a point on a second circle arc having a radius equal to the outer radius of the male rotor, said arc being struck about the center of the concentrically mounted rotor; thence in the direction of rotation along said second circle arc to a point at which that arc is intersected by an arc of the male rotor lobe radius struck from the point on said first circle arc angularly spaced from said center line by said desired compression ratio angle; thence along said male rotor lobe radius arc in a direction generally counter to the direction of rotation to the intersection of said arc with the radial line extending to the center of said concentrically mounted rotor from the point from which said arc was struck; thence through a point at which the female lobe and male lobe space are in substantially complete engagement to a point on said first circle arc removed substantially 180° in the direction of rotation from the center line of said filled

rotor lobes; and thence along said first circle arc to the place of beginning.

2. In a "Gerotor" compressor of the type having a lobed female rotor, a lobed male rotor having one less lobe than said female rotor, a housing member having a bore in which said female rotor is rotatably mounted, closure members at the sides of said housing members, said closure members carrying a rotatable shaft on which said male member is fixed, said bore being eccentric with respect to said male rotor shaft, the center of one of said rotors being concentric to said shaft and the center of the other rotor being eccentric to said shaft, all lobes of one of said rotors being in sealing contact with the lobes of the other of said rotors at least one of said closure members having an inlet port of usual kidney shape; the improvement which comprises providing a discharge port in at least one of said closure members which is substantially the projection of a figure bounded by a line extending from a point lying on a circle arc having the root radius of said female rotor, laid off about the center of the male rotor, said point being removed in the direction of rotation from a diameter extending through the center of the male and female rotor lobe space which is filled at the start of compression, and through the centers of said male and female rotors at that position, by an arc comprising the arc subtended by a first angle measured about the center of said female rotor which first angle is equal to the ratio of the number of lobes in the male rotor to the number of lobes in the female rotor multiplied by a second angle measured about the center of the male rotor at which the desired compression ratio occurs, and the arc of said root radius circle subtended by a chord equal to the eccentric distance; thence inwardly along a line parallel to the radial line defining said first mentioned angle to a point on a second circle arc having a radius equal to the outer radius of the male rotor, said arc being struck about the center of the male rotor; thence in the direction of rotation along said second circle arc to a point at which that arc is intersected by an arc of the male rotor lobe radius struck from the point on said first circle arc angularly spaced from said center line by said desired compression ratio angle; thence along said male rotor lobe radius arc in a direction generally counter to the direction of rotation to the intersection of said arc with the radial line extending to the center of said male rotor from the point from which said arc was struck; thence through a point at which the female lobe and male lobe space are in substantially complete engagement to a point on said first circle arc removed substantially 180° in the direction of rotation from the center line of said filled rotor lobes; and thence along said first circle arc to the place of beginning.

3. In a "Gerotor" compressor of the type having a lobed female rotor, a lobed male rotor having one less lobe than said female rotor, a housing member having a bore in which said female rotor is rotatably mounted, closure members at the sides of said housing members, said closure members carrying a shaft on which said male member is mounted, said bore and said male rotor shaft mounting being eccentric with respect to each other, all lobes of said male rotor being in sealing contact with lobes of said female rotor at least one of said closure members having an inlet port of usual kidney shape; the improvement which comprises providing a discharge port in at least one of said closure members which is substantially the projection of a figure bounded by a line extending from a point lying on a circle arc having the root radius of said female rotor, laid off about a center coinciding with the center of the concentrically mounted rotor, said point being removed in the direction of rotation from a diameter extending through the center of the male and female rotor lobe space which is filled at the start of compression, and through the centers of said male and female rotors at that position, by an arc

comprising the arc subtended by an angle

$$\frac{N_M}{N_F}\theta$$

measured about the center of said eccentrically mounted rotor wherein θ is the angle measured about the center of the concentrically mounted rotor from said diameter to the point at which the desired compression ratio occurs, N_M is the number of lobes of the male rotor and N_F is the number of lobes of the female rotor, and the arc of said root radius circle subtended by a chord equal to the eccentric distance; thence inwardly along a line parallel to the radial line defining said angle

$$\frac{N_M}{N_F}\theta$$

to a point on a second circle arc having a radius equal to the outer radius of the male rotor, said arc being struck about the center of the concentrically mounted rotor; thence in the direction of rotation along said second circle arc to a point at which that arc is intersected by an arc of the male rotor lobe radius struck from the point on said first circle arc angularly spaced from said center line by said angle θ; thence along said male rotor lobe radius arc in a direction generally counter to the direction of rotation to the intersection of said arc with the radial line extending to the center of said concentrically mounted rotor from the point from which said arc was struck; thence through a point at which the female lobe and male lobe space are in substantially complete engagement to a point on said first circle arc removed substantially 180° in the direction of rotation from the center line of said filled rotor lobes; and thence along said first circle arc to the place of beginning.

4. In a "Gerotor" compressor of the type having a lobed female rotor, a lobed male rotor having one less lobe than said female rotor, a housing member having a bore in which said female rotor is rotatably mounted, closure members at the sides of said housing members, said closure members carrying a rotatable shaft on which said male member is fixed, said bore being eccentric with respect to said male rotor shaft, all lobes of said male rotor being in sealing contact with lobes of said female rotor at least one of said closure members having an inlet port of usual kidney shape; the improvement which comprises providing a discharge port in at least one of said closure members which is substantially the projection of a figure bounded by a line extending from a point lying on circle arc having the root radius of said female rotor, laid off about the center of the male rotor, said point being removed in the direction of rotation from a diameter extending through the center of the male and female rotor lobe space which is filled at the start of compression, and through the centers of said male and female rotors at that position, by an arc comprising the arc subtended by an angle

$$\frac{N_M}{N_F}\theta$$

measured about the center of said female rotor wherein θ is the angle measured about the center of the male rotor from said diameter to the point at which the desired compression ratio occurs, N_M is the number of lobes of the male rotor and N_F is the number of lobes of the female rotor, and the arc of said root radius circle subtended by a chord equal to the eccentric distance; thence inwardly along a line parallel to the radial line defining said angle

$$\frac{N_M}{N_F}\theta$$

to a point on a second circle arc having a radius equal to the outer radius of the male rotor, said arc being struck about the center of the male rotor; thence in the direction of rotation along said second circle arc to a point at

which that arc is intersected by an arc of the male rotor lobe radius struck from the point on said first circle arc angularly spaced from said center line by said angle θ; thence along said male rotor lobe radius arc in a direction generally counter to the direction of rotation to the intersection of said arc with the radial line extending to the center of said male rotor from the point from which said arc was struck; thence through a point at which the female lobe and male lobe space are in substantially complete engagement to a point on said first circle arc removed substantially 180° in the direction

of rotation from the center line of said filled rotor lobes; and thence along said first circle arc to the place of beginning.

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