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ROTARY ENGINE

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3 Sheets-Sheet 1

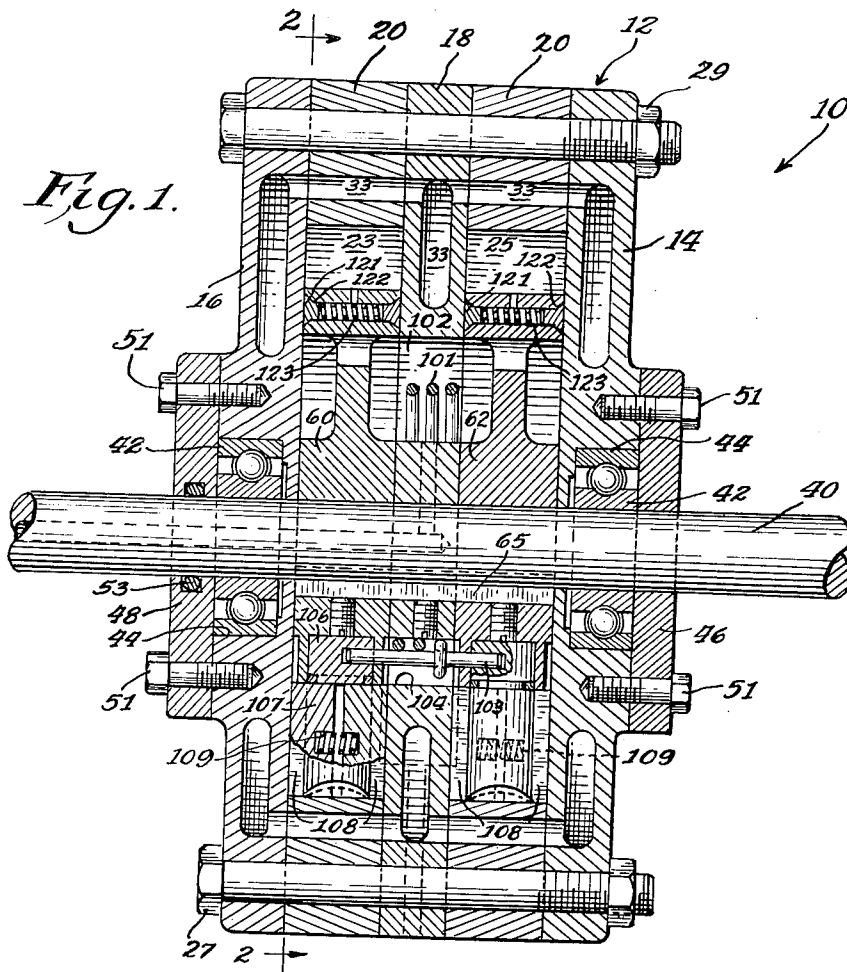


Fig. 1.

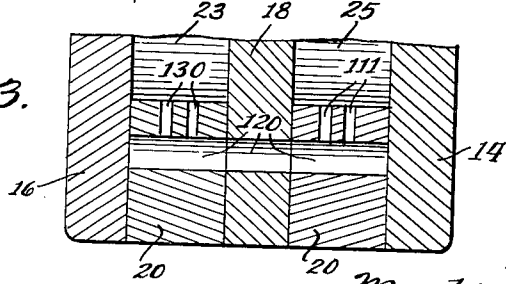


Fig. 3.

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Fig. 2.

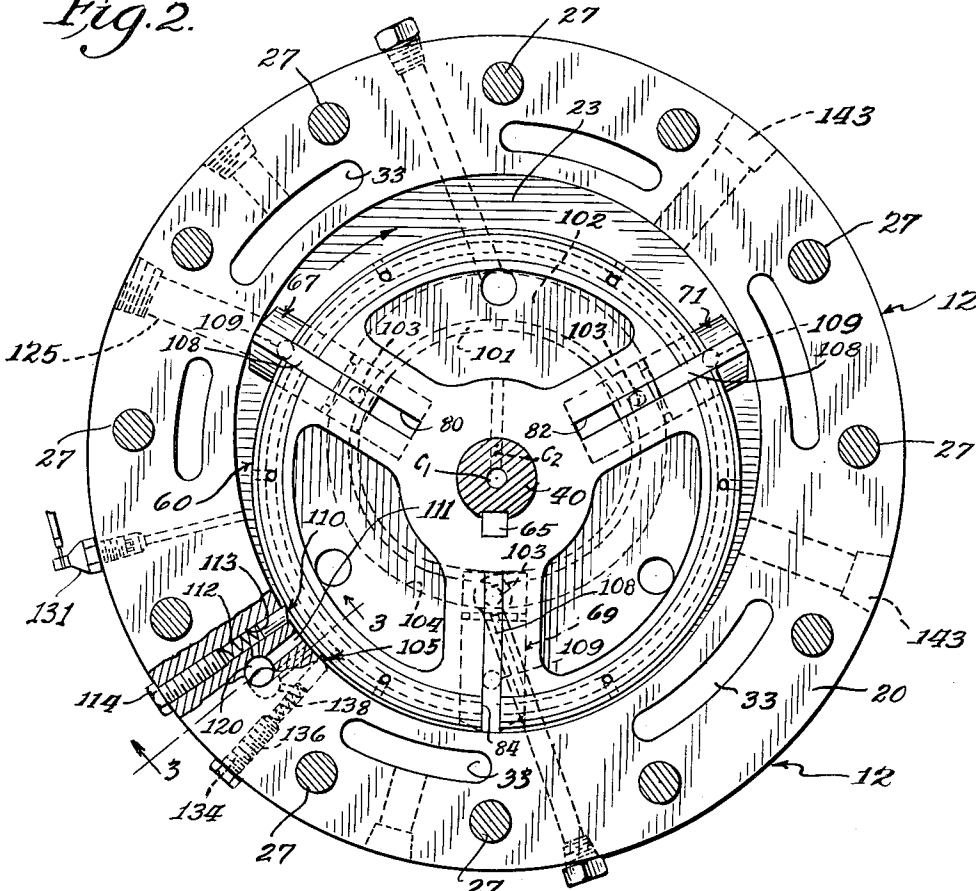
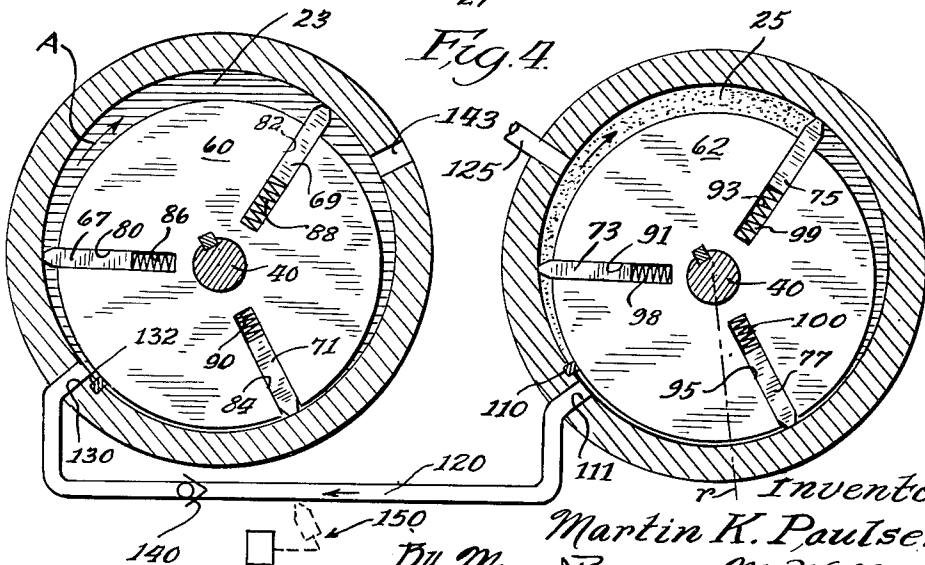


Fig. 4.



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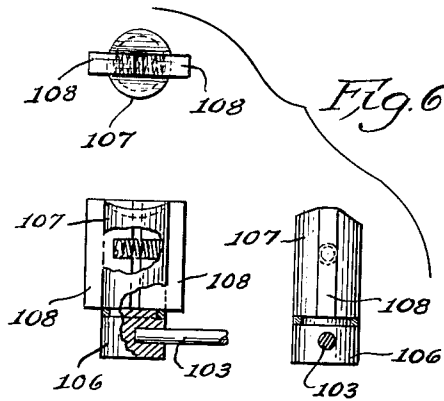
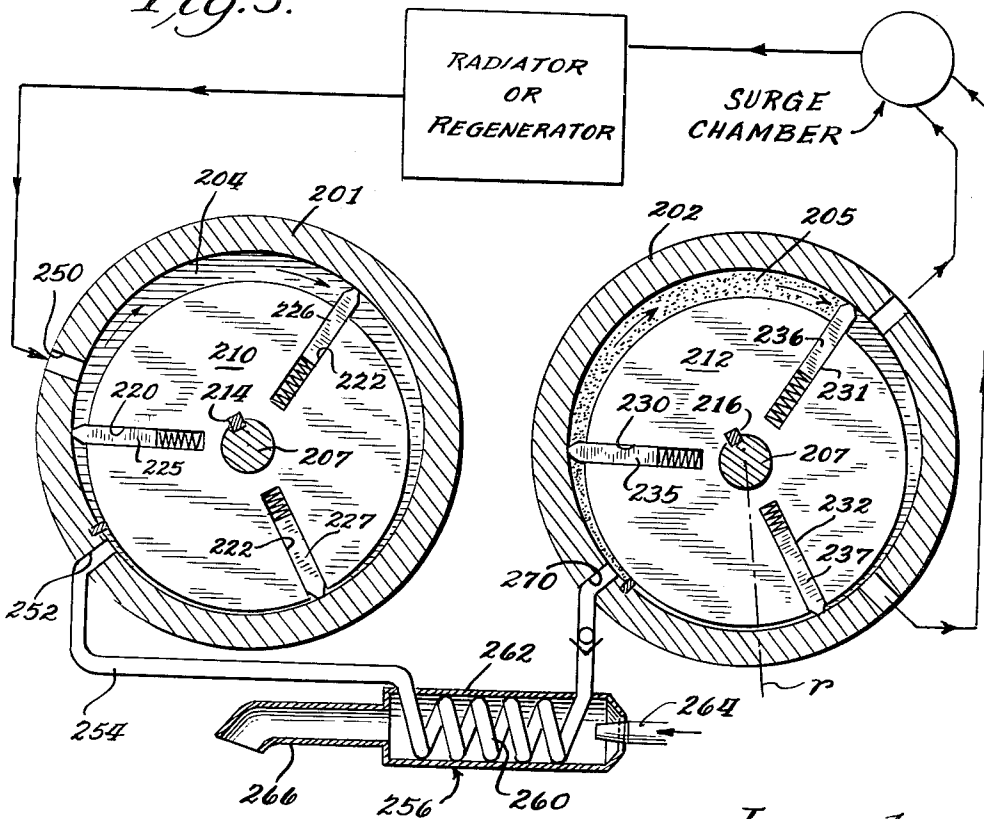


Fig. 6

Fig. 5.



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ROTARY ENGINE

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9 Claims. (Cl. 60—59)

The present invention relates to improvements in rotary type prime movers, and particularly, although not exclusively, to rotary type internal combustion engines.

It is an objective of the present invention to provide an improved rotary prime mover of the type employing twin rotors in associated chambers, being of a simplified and more economical construction while capable of delivering a high power weight performance ratio.

Another objective of the present invention is to provide an improved rotary device which is functional on practically any source of motive power including low grade hydrocarbon fuels and steam. A further objective of the present invention is to provide an improved rotary engine so constructed that bearing and seal problems are minimized.

The foregoing, as well as other and further objectives and advantages of the present invention will become apparent from a reading of the following detailed description of what is now believed to be the preferred embodiment thereof taken in conjunction with the appended drawings, wherein:

FIG. 1 is a plan view of a prime mover constructed in accordance with the present invention;

FIG. 2 is a view, partially in section, taken along line 2—2 of FIG. 1;

FIG. 3 is an enlarged fragmentary portion of the prime mover of FIG. 2 taken along lines 3—3 thereof;

FIG. 4 is a schematic representation of the exemplary prime mover of FIG. 1 illustrating the interrelationship of the dual rotors;

FIG. 5 is a schematic illustration similar to that of FIG. 4, and further showing an alternative embodiment of the present invention; and

FIG. 6 illustrates the construction of one of the vane members employed in the device of FIG. 1.

With particular attention now to the preferred embodiment of the prime mover illustrated in FIGS. 1 and 2, the exemplary prime mover is indicated generally by the identifying character 10. As stated, the prime mover is of a rotary type, employing dual rotors for the compression and expansion of gases. Accordingly, a housing or casing 12 is provided, and comprises a pair of suitable end plates 14, 16, which are conveniently of circular cross section, although it will be appreciated that any profile which is satisfactory from a manufacturing standpoint will suffice. A center plate or divider 18 is likewise provided, and spacer rings 20 are located respectively between the center plate 18 and the end plates 16 and 14. The spacers 20 are of a generally toroidal configuration in the embodiment shown and when assembled as indicated in FIG. 1, define with the center plate 18, and the respective end plates 14 and 16, two cylinders, designated for convenience as 23 and 25 in FIG. 1.

The chambers are not strictly circular, but more oblong in cross section. More particularly, the chambers, which are identical, are generated in cross section by two intersecting arcs described about two centers,  $C_1$  and  $C_2$  such that the arc subtended by the smaller radius is approximately  $120^\circ$  while that generated by the larger radius is  $240^\circ$ . A suitable number of bolts 27 are disposed about the periphery of the casing 12, and pass transversely through the end plates, the spacers and the center plates where a nut 29 is tightened down to hold the respective parts of the casing assembly together. It will be noted in

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FIG. 1 that the center plate, spacers, and end plates are formed with cavities indicated by the single designating character 33. All of the cavities 33 are so positioned as to be interconnecting when the housing 12 is assembled, thereby providing a space through which a cooling fluid may be circulated if so desired. Alternatively, the housing 12 may be designed with appropriately placed fins for air cooling purposes.

A drive shaft 40 is journaled in the housing, passing transversely through the chambers in a position such that its axis lies at the axis of generation of the smaller of the two arcs about the point  $C_1$ , thus making it eccentric of the main portion of the chamber. The chambers themselves are identically radially oriented about the shafts, which passes through each, so that the radial distance from the center of the shaft, to the periphery of the chamber, is identical, in each chamber. The shaft 40 is of any suitable diameter, and is mounted on bearings 42 residing in bearing housings 44 formed in the end plates 14 and 16, respectively. Suitable bearing caps 46 and 48 are disposed respectively over the bearings 42 where they are fastened by means of cap screws 51 to the end plates 14, 16. Each cap 46, 48, is, of course, provided with a suitable bore through which the shaft 40 passes. As indicated in the cap 48 (FIG. 1) an additional O-ring seal 53 may be provided if desired to provide additional sealing against the escape of gases from the cylinders 23, 25.

In accordance with the invention, a pair of rotors 60 and 62 are disposed respectively in the chambers 23, 25 on the shaft 40, where they are secured by a suitable key 65. The rotors are preferably of a circular construction and of a diameter such that they are rotatable in the chamber with a slight clearance on a radial liner, extending from the axial center of the chamber through the axis of the shaft 40.

With reference to FIG. 2, the rotor 60 is provided with three radially extending vane members 67, 69 and 71. In a like manner, the rotor 62 is provided with vanes 73, 75 and 77. Each of the vanes lie in radial planes spaced from one another by  $120^\circ$ . The vanes 67, 69 and 71 are reciprocable within guideways 80, 82 and 84, and suitable means such as exemplified by springs 86, 88 and 90 (illustrated schematically in FIGS. 4 and 5) may be conveniently disposed in the base of the guideways for the purposes of urging the vanes outwardly and against the inner peripheral wall of the chamber 23. The construction of the rotor 62 is the same, and the vanes 73, 75 and 77 are disposed respectively in guideways 91, 93 and 95 and biased outwardly by springs 98, 99 and 100.

In accordance with one aspect of the invention, the bias for the vanes is, in the production form, provided by a heavy coil spring 101 disposed in a lubrication cavity 102 defined respectively by openings in the center plate 18, and webbing of the rotors. Thus, at the base of each vane there is a transverse pin 103 projecting through an appropriately disposed radial slot 104 in the side wall of the rotor, and the aforesaid coil spring bears upon the rod of each vane in a direction to urge the same outwardly. The equidistant radial spacing of the vanes, i.e.,  $120^\circ$  apart, is such that when one of the vanes is in its retracted position because of the position of the rotor, the rod of that vane acts against the spring, urging it in the direction of the reaction force on such vane. Such urging affects the remaining two rods, causing them to be urged radially outwardly with substantial force. Accordingly, the other vanes are urged with sufficient force against the peripheral wall of the chamber to bring about excellent sealing between the work areas defined by the vanes. It will be noted that when the vanes on the rotors 60, 62 are aligned, a common rod may be used between the two as seen in FIG. 1.

The invention in another of its aspects provides a finned piston type vane construction having excellent strength properties and wear resistance. More particularly, each vane of the present invention comprises a cylindrical piston-like portion 106 and an upper slotted portion 107 for the reception of a pair of transverse fins 108 of suitable thickness. The fins are biased into sealing engagement with the side walls of the chamber, in the present instance by means of a compression spring 109 inserted in an appropriate receptacle defined respectively in the fins. The piston is sealed with respect to the bore by means of an O-ring disposed in a nicked down groove suitably located just below the inner terminal ends of the fins. The present construction provides good sealing with the outward bias of the fins on the wall, and because of the thick cylindrical construction, the vanes are capable of withstanding substantial pressures in the work areas. It is anticipated that suitable fluid pressure might be used to apply the necessary biasing force as an alternative, and without departure from the invention.

With each of the vanes biased against the peripheral wall of the chamber, the space between the rotor and the peripheral chamber wall becomes divided into three variable volume working sectors or spaces defined respectively by the surfaces of the rotor and the peripheral wall of the chamber between adjacent vanes. It will be appreciated from examining FIG. 4, for example, that as the shaft 40 rotates, and the rotors with it, the working space, for example, between the vanes 73 and 75 progressively decreases. Gas present in this working space, therefore, becomes highly compressed. Referring to FIG. 4, the gas in the working space between the vanes 75 and 77 illustrates a further state of compression of the gaseous material. A compression ratio may be determined by the shape of the chamber, which as previously indicated, is elongated. Any desired ratio will be possible by chamber design, which would fix the volume of the largest working sector in comparison to the smallest (just before discharge).

Each rotor is provided with a sealing arrangement which permits satisfactory lubrication and cooling of the rotor within the chamber while at the same time inhibiting the passage of compressed gases into the lubricating system which might cause contamination thereof. To this end, flexible compression seals 121 are provided in preformed peripheral arcuate slots 122 conveniently machined in the peripheral edge of the rotor. The slots are discontinuous at the vanes, when sealing is affected there by means of the fins as previously described. As seen in FIG. 1, the compression seals may be biased outwardly by means of a number of strategically placed springs 123. Other means of effecting a pressure seal are likewise contemplated.

As indicated, the rotor 62 functions, in the preferred embodiment, as a compression rotor although either rotor may be used. Compressed gases are then transferred, in accordance with the invention, to the chamber 23, where the rotor 60 functions as a power rotor, given driving impetus sufficient to drive the compressor rotor, and to drive same device connected to the shaft 40 by the expanding gases in the respective working spaces, defined by the vanes on the rotor. So as to limit undesirable expansion, and to direct the forces of the expanding gases, a stationary vane 110 is provided in the wall of the spacer ring 20 between the side wall 12 and the center plate 18. A stationary vane 110 is disposed on a radial line extending from the center of the eccentric shaft, and is therefore in continuous contact with the peripheral wall of the rotor 62. The stationary vane 110 is suitably positioned immediately downstream of a discharge transfer port 111, suitably formed in the wall of the spacer 20 for the transfer of the compressed gases to the power chamber. The stationary vane 110, which, as seen in FIG. 2, is biased outwardly against the peripheral wall of the rotor by means of a spring 112 which is adjustably positioned in

a bore 113 in the wall of the spacer and held by means of screw 114. Again fluid pressure readily available in the engine might be transmitted through appropriate means to bias the vane outwardly, as an alternative, or in cooperation with the spring 112. The stationary vane is sufficiently short to prevent its being sheared off during operation, and the leading edges thereof are cammed to guide the movable vanes over the stationary vane with minimum impact.

The foregoing arrangement provides a simplified means of periodic inspection and replacement of the stationary vane. The vane, of course, inhibits the passage of compressed gases into the expanded areas beyond the vane in direction of rotation of the rotor 62. The compressed gases are thus forced out through port 111, which is in communication with chamber 23, by means of a suitable transfer passage 120 (illustrated in FIG. 4 as tubing), but in a practical sense, as seen in FIG. 3, for example, may be formed directly through the spacers and the center wall 18 to provide direct communication.

Depending upon the particular adaptation of the prime mover, the character of the gas introduced into compression chamber 25 is readily variable to suit particular needs. For purposes of illustration, it will be presumed that the prime mover 10, in the preferred embodiment, is functional as a rotary internal combustion engine. Thus, an intake port 125 is provided in the wall of the spacer, as illustrated, between the relatively large working area defined between the vanes 73 and 75. The port 125 may be connected to any suitable source of fuel, and/or air.

For purposes of this description, a combustible mixture of gaseous fuel may be introduced to the intake 125 and be compressed in the chamber 25 by the rotation of the rotor as previously indicated, and the compressed mixture is then ejected under high pressure through the passage 120 to the expansion chamber through a port 130. At a convenient place downstream of the port 130, a suitable ignitor, such as a glow plug or a spark plug 131 may be positioned, which, when fired, will instantly raise the temperature of the highly compressed combustible mixture resulting in a controlled explosion. The explosion, of course, will cause a rapid expansion of gases, which will operate against the vane 67 protruding from the rotor 60 and against the peripheral wall of the chamber 23. In order to provide a reaction surface for the rapidly expanding gases, a stationary vane 132 is provided behind the port 130 as indicated in FIG. 4. The construction of the stationary vane 132 is similar to that of the vane 105, and a screw 134 disposed in a bore 136 holds a compression spring 138 against the vane 132, biasing the same against the wall of the rotor 60. While rotor movement is such that the gas exploded behind the vane 67 (FIG. 4) will not, in the usual case, back up in the port 130, under heavy load conditions some back up may occur. Accordingly, in order to prevent backfire through the passage 120, a suitable check valve or other device of any known construction (indicated at 140) may also be provided.

Expansion of the gases will cause the rotor 60 to rotate in a direction indicated by the arrow A, and as the gases become sufficiently expanded, they are exhausted through an exhaust port 143. As will be seen from FIG. 4, the exhaust port is positioned in a working area which has a larger, but progressively decreasing volume. Thus, exhaust gases are placed under a pressure and given sufficient momentum that almost complete scavenging of the exhaust gases is possible. Additional smaller exhaust ports may be placed in suitable positions to obtain more complete scavenging where the described port is inadequate for some special purpose.

Further in keeping with the invention, in the preferred form, the rotors 60 and 62 are so disposed upon the shaft 40, that the rotors are parallel, and the working chambers defined between the two are identical at all times. It has been found that this arrangement causes no particular balance problems, but gives highly efficient performance

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in that the action taking place in the respective working chambers, because of identical volumes (though different pressures), provides smooth and high output operation. The present construction also lends itself to separation of the chambers where a particular application would make the same desirable.

The present invention lends itself to a number of different motivating gases. For example, in the FIG. 4 arrangement, air alone may be inducted through the port 125 and compressed by the rotor 62, and fuel may be injected through any suitable injector arrangement, indicated in phatom only, in FIG. 4 at 150. Injection may be in the tube 120 (as shown), or directly into the chamber if preferred. Thus, a combustible mixture is introduced through port 130 into the chamber 23 in the work area between vanes 67 and the stationary vane 132 where it may be fired by the ignitor as indicated.

A further advantage of the construction of the present invention is that a closed circuit arrangement is shown schematically, and it will be appreciated that the details of construction are substantially identical to those described. Therefore, for the purposes of brevity, the construction will be described in schematic form as shown, and with respect to a pair of casings 201 and 202 defining therein chambers 204 and 205 respectively. A shaft or shafts 207 pass through the chambers, displaced by a predetermined amount from the axial center thereof, and rotors 210 and 212 are disposed on the shaft by means of suitable keys 214 and 216 for rotation therewith. The rotor 210 is provided with bores 220, 221 and 222 defining guideways for vanes 225, 226 and 227, respectively, each of which is suitably biased by spring means provided therefor. In a like manner, rotor 212 is provided with bores 230, 231 and 232 defining guideways for suitably constructed vanes 235, 236, and 237, likewise, biased by suitable spring means against the outer peripheral wall of the chamber 205 to define work spaces as previously described.

In this case a non-combustible gas is introduced through intake port 250 where it undergoes compression through the rotation of the rotor 210 as previously explained. The compressed gaseous material is ejected through a port 252 and passes through a passage 254 which, in the present instance, is connected to a suitable heat exchanger indicated generally by the identifying character 256. It will be appreciated that any suitable heat exchanger arrangement would be usable within the intent and scope of the present invention. For purposes of simplicity, the passage 254 is shown as coiled at 260 where it is enclosed in a pipe 262 which, at one end is provided with a burner 264 which forces hot gases across the tubes 260. A suitable exhaust manifold 266 is provided for exhausting of the hot gases.

Thus, the gases previously compressed within the chamber 204 are ejected into the passage 254 where they are superheated in the compressed state prior to being introduced through port 270 into the chamber 205. The expansion of the superheated gases within the work spaces defined within the chamber 205 causes rotation of the rotor 212 with a sufficiently great power to drive the compression rotor 210 as well as to perform useful work on the shaft 207 which may be connected to any desired apparatus. The expanded gas may then be cooled in a regeneration unit as shown (FIG. 5) and recirculated through suitable lines into the induction chamber through port 250 for reuse.

The same general arrangement will be usable for steam as well as other heated or super cooled gases. In such case, a regenerator unit, indicated in the closed circuit between the two chambers, will be used so as to bring the steam or other fluid to a condition of pressure and temperature which would permit its optimum use with the rotary prime mover as described.

As is now apparent, the present invention provides a rotary type prime mover in which a pair of rotors are pre-

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sented in cooperative relation to bring about a continuous compression process of a fluid continuously received from a suitable source, whereupon such gases are transferred to a power rotor which is acted upon by high pressure gases to produce a net output, over and above that required to drive the compressor rotor. Not unlike a multiple reciprocating piston engine in its action, the process of intake, compression, power release and exhaust are taking place continuously as the working sector between each set of vanes progressively changes in volume as the rotor rotates.

As explained, the devices constructed in accordance with the present invention are functional as internal combustion engines as well as being usable in a closed circuit arrangement having importance in the area of space travel where regeneration and reuse of a gaseous charge is important.

I claim as my invention:

1. A rotary prime mover, comprising, in combination, a housing defining a pair of elongated smooth walled chambers therein, one said chamber being a compression chamber and the other a power chamber, a shaft journaled in said housing and passing through said chambers, a cylindrical rotor disposed upon said shaft in each of said chambers, each said rotor having a plurality of equally spaced radially extensible vanes, said vanes on each rotor being radially aligned, and rods extending between said rotors interconnecting said so aligned vanes, spring means connected with said rods, said spring means continuously biasing said vanes outwardly against the inner wall of said chamber, adjacent vanes defining a variable volume work space therebetween, a compressible fluid being received in a relatively large volume work space of said compression chamber, and being compressed as said rotor rotates, a passage formed in the peripheral wall of said housing for transferring said compressed fluid from said compression chamber to said power chamber, heater means connected with said power chamber, adjacent said passage for heating said compressed fluid, whereby said heated, compressed fluid rapidly expands in said power chamber against said vanes on said power rotor for causing rotation of the same to drive said shaft.

2. A device of the type set forth in claim 1 wherein means is provided between said chambers for super heating said fluid compressed in said compression chamber.

3. A device as set forth in claim 1 wherein the fluid introduced into said compression chamber is air, and means is provided between said chambers for injecting gaseous fuel into said compressed fluid prior to its entry into said power chamber.

4. In a closed circuit rotary prime mover, the combination of a housing having a central wall defining an oblong compression chamber and an identical oblong power chamber, a drive shaft journaled in said housing and said central wall respectively and disposed transversely in said chambers, said chambers being identically radially oriented with respect to said shaft, a cylindrical rotor mounted in each chamber for rotation with said shaft, and centrally disposed thereon so that the radial distance between the edge of said rotor, and the peripheral wall of said chamber remains the same at all times, while said rotor is rotating within said chamber, each said rotor having three circumferentially equally spaced vane members disposed in radial slots therein, a coil spring disposed about said shaft, and engaged with said vanes for biasing the same outwardly against the peripheral wall of said chamber, said compression chamber having an intake port opening therein at a point spaced from said rotor for receiving a low temperature compressible gas, said gas being compressed by said vane rotor as the same is rotated in said chamber, a passage formed in the peripheral wall of said housing between said compression chamber and said power chamber, said passage opening into said chambers at a point in each where the rotor and chamber wall are closest to one another, a heater open-

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ing into said power chamber, adjacent said passage therein, for heating gas compressed in said compression chamber, and transferred through said passage to said power chamber, said heated compressed gas expanding in said power chamber against the vanes of said power rotor so as to cause the same to rotate, thereby applying power to said shaft, and an exhaust port in said power chamber for expelling expanded gases.

5. A rotary prime mover as described in claim 4 wherein conduit interconnects said intake port and said exhaust port, for recirculating said expanded gas through said system.

6. A rotary prime mover as set forth in claim 4 wherein each chamber is formed by a pair of smoothly intersecting arcs drawn about two spaced centers, one of said centers being on the axis of said shaft.

7. In a closed circuit rotary prime mover, the combination of a housing having a central wall defining an oblong compression chamber and an identical oblong power chamber, a drive shaft journaled in said housing and said central wall respectively and disposed transversely in said chambers, said chambers being identically radially oriented with respect to said shaft, a cylindrical rotor mounted in each chamber for rotation with said shaft, and centrally disposed thereon so that the radial distance between the edge of said rotor, and the peripheral wall of said chamber remains the same at all times, while said rotor is rotating within said chamber, each said rotor having three circumferentially equally spaced vane members disposed in radial slots therein, said vanes on each rotor being parallel and parallel vanes being rigidly interconnected, a coil spring disposed about said shaft between said rotors, and engaged with said vanes for continuously biasing the same outwardly against the peripheral wall of said chamber, said compression chamber having an intake port opening therein at a point spaced from said rotor for receiving a low temperature compressible gas, said gas being compressed by said vaned rotor as the same is rotated in said chamber, a passage formed in the peripheral wall of said housing between said compression chamber and said power chamber, said passage opening into said chambers at a point in each where the rotor and chamber wall are closest to one another, a heater opening into said power chamber, adjacent said passage therein, for heating gas compressed in said compression chamber, and transfer through said passage to said power chamber, said heated compressed gas expanding in said power chamber against the vanes of said power rotor so as to cause the same to rotate, thereby applying power to said shaft, and an exhaust port in said power chamber for expelling expanded gases therefrom.

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8. In a closed circuit rotary prime mover, the combination of a housing having a pair of end walls, a central wall, and spacers between said walls defining an oblong compression chamber and an identical oblong power chamber, a drive shaft journaled in said housing and said central wall respectively and disposed transversely in said chambers, said chambers being identically radially oriented with respect to said shaft, a cylindrical rotor mounted in each chamber for rotation with said shaft, and centrally disposed thereon so that the radial distance between the edge of said rotor, and the peripheral wall of said chamber remains the same at any point, while said rotor is rotating within said chamber, each said rotor having three circumferentially equally spaced vane members disposed in radial slots therein, a coil spring disposed about said shaft, and engaged with said vanes for biasing the same outwardly against the peripheral wall of said chamber, said compression chamber having an intake port opening therein at a point spaced from said rotor for receiving a low temperature compressible gas, said gas being compressed by said vaned rotor as the same is rotated in said chamber, a passage formed in the peripheral wall of said housing between said compression chamber and said power chamber, said passage opening into said chambers at a point in each where the rotor and chamber wall are closest, a heater opening into said power chamber, adjacent said passage therein, for heating gas compressed in said compression chamber, and transfer through said passage to said power chamber, said heated compressed gas expanding in said power chamber against the vanes of said power rotor so as to cause the same to rotate, thereby applying power to said shaft.

9. A rotary prime mover as set forth in claim 8 wherein said spacers are ring-shaped, the inner wall being oblong to define the shape of said chamber.

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