United States Patent

Butler

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[54] ROTARY ENGINE

[72] Inventor: **James L. Butler,** 16th and Highway 1, Montara, Calif. 94037

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[52] **U.S. Cl.** **418/173,** 418/176, 251/325

[51] **Int. Cl.**.....**F01c 1/00,** F03c 3/00, F04c 1/00

[58] **Field of Search**.....418/62, 64, 67, 176, 173; 251/325

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Primary Examiner—Carlton R. Croyle
Assistant Examiner—Richard E. Gluck
Attorney—Townsend and Townsend

[57] **ABSTRACT**

A fluid-activated engine having a pair of rotors with one of the rotors being eccentrically mounted within the other rotor and rotatable about a tubular axle having a fluid inlet port. A buttress interconnects the rotors and is pivotally mounted on the inner periphery of the outer rotor to cause both rotors to rotate in the same plane and direction about their different axes. Inlet valve means in said axle controls the flow of a fluid under pressure through a passage in the inner rotor to an expansion chamber defined between the rotors to cause a fluid force to be exerted on the buttress to effect rotation of the rotors and a power take-off shaft coupled thereto. Valve means is provided in the outer rotor to exhaust the fluid from the expansion chamber. The inlet valve means and the outlet valve means can be constructed to permit forward or reverse rotation of the rotors.

9 Claims, 9 Drawing Figures

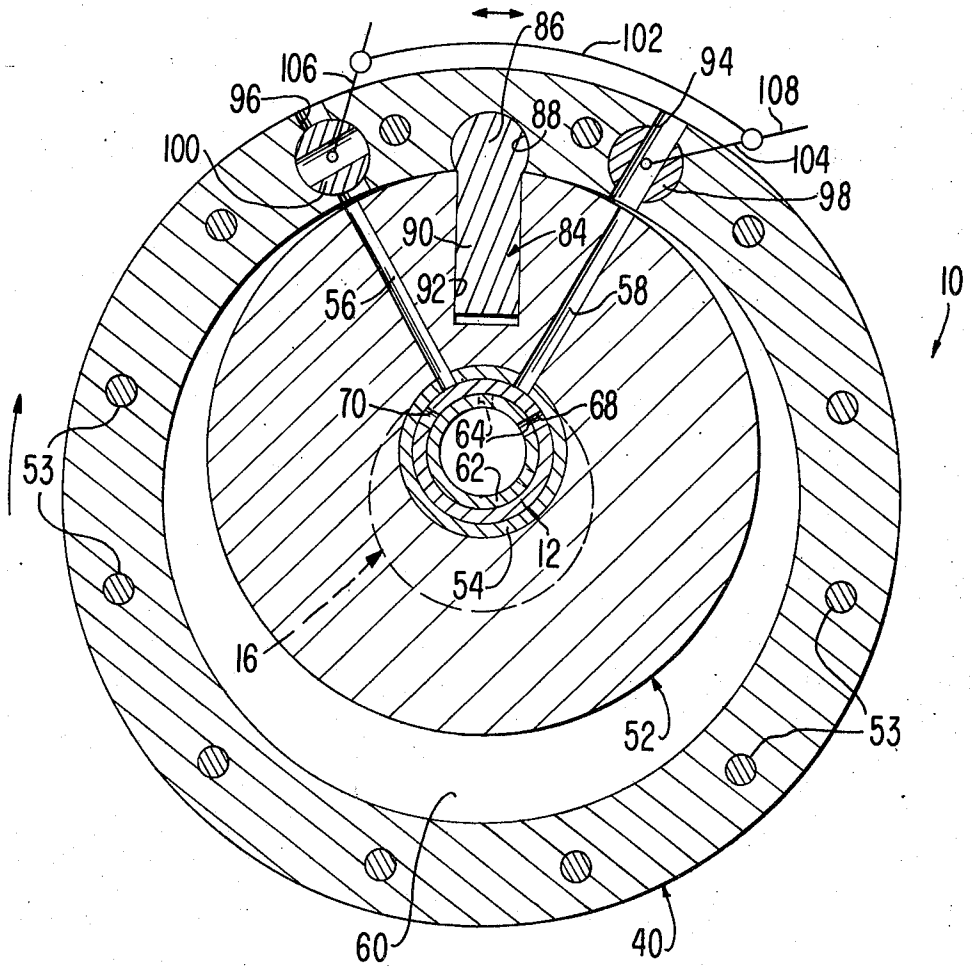


FIG. 1

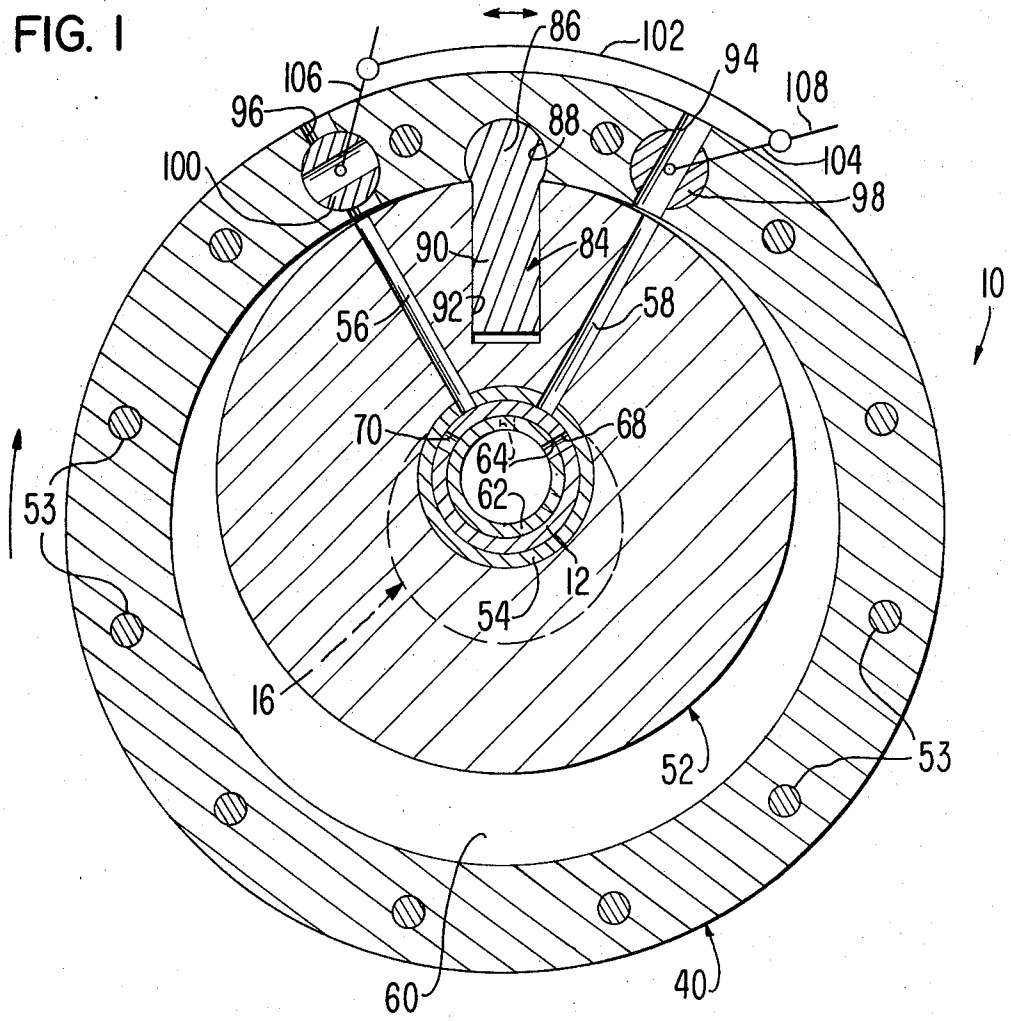


FIG. 3

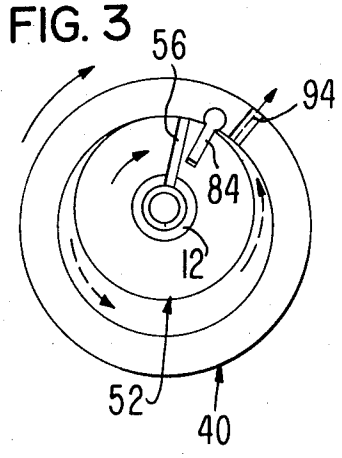


FIG. 4

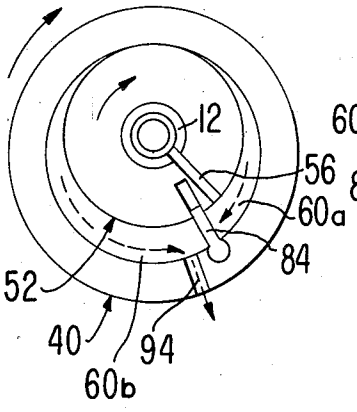
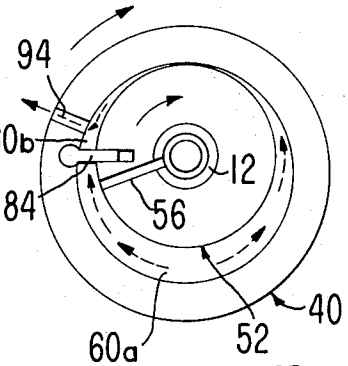


FIG. 5



INVENTOR.
JAMES L. BUTLER

BY

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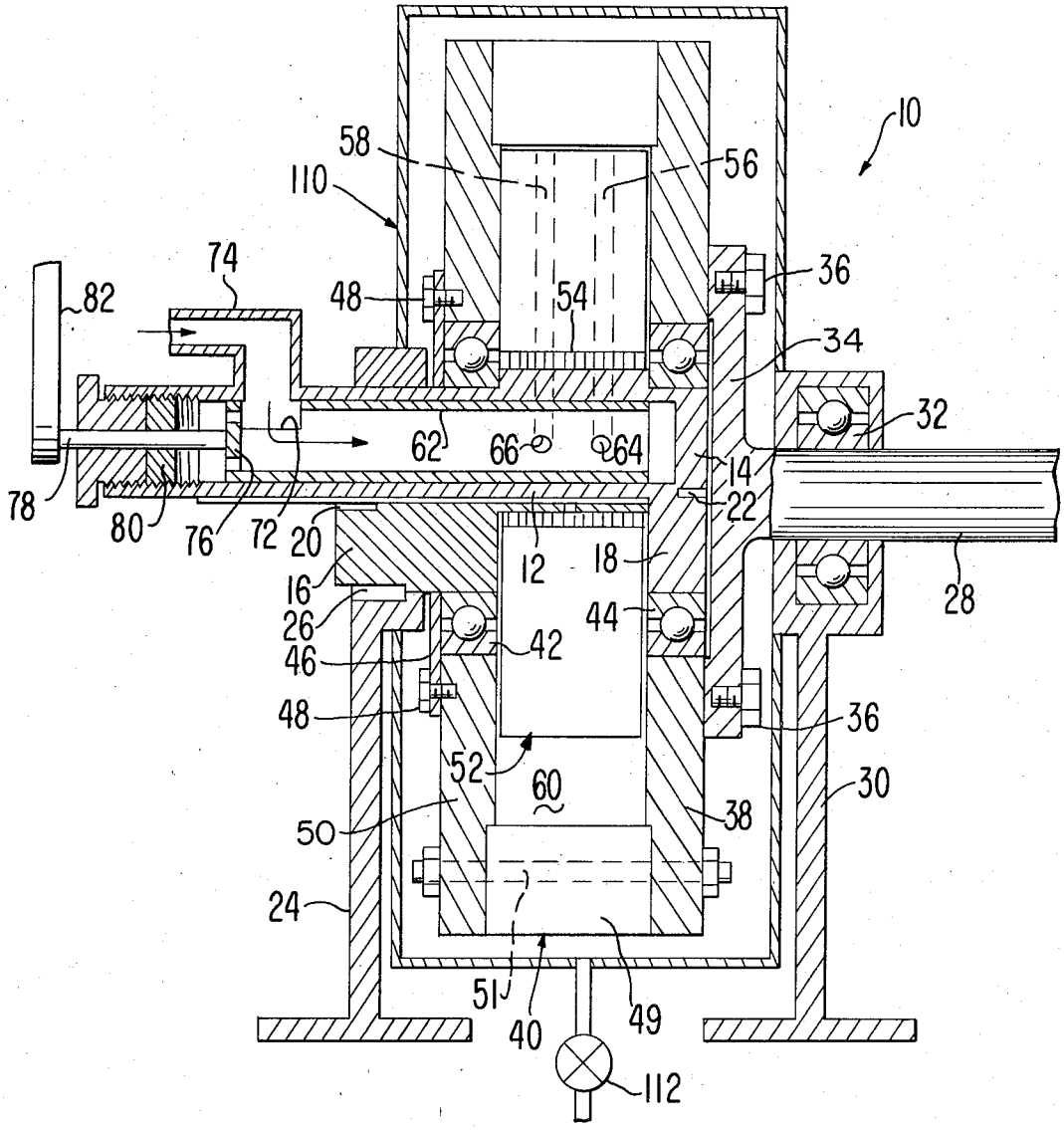


FIG. 2

INVENTOR.
JAMES L. BUTLER

BY Townsend and Townsend

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FIG. 6

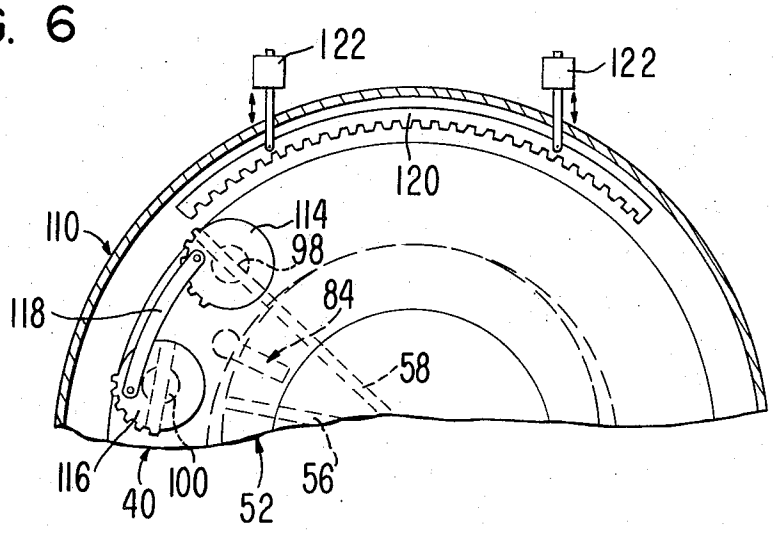


FIG. 8

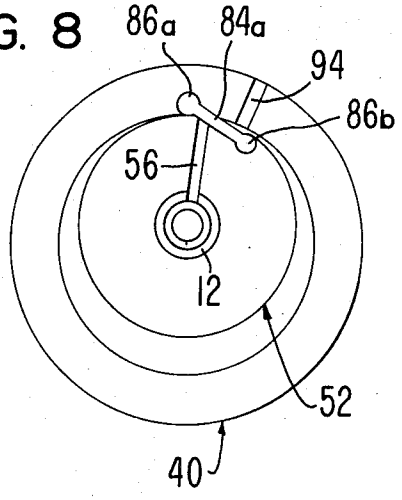
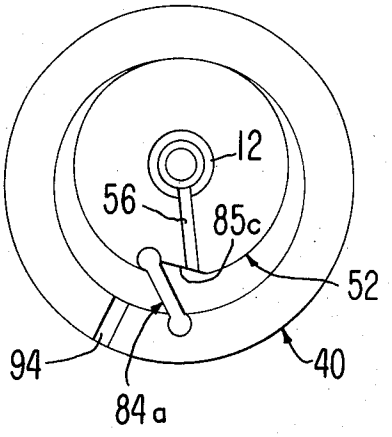


FIG. 9



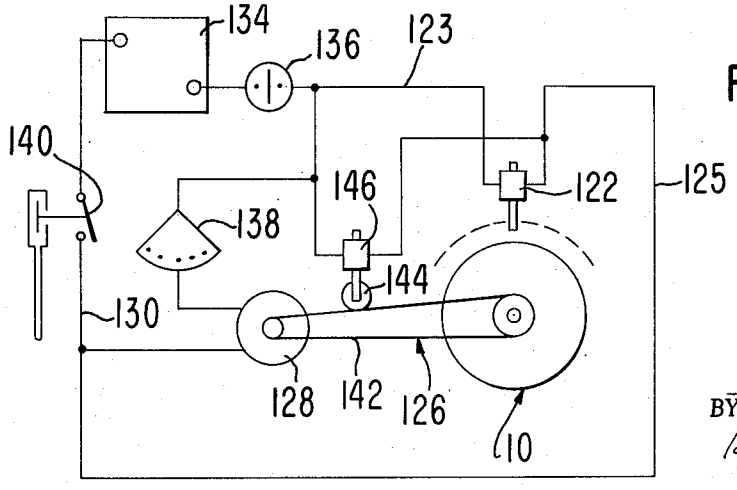


FIG. 7

INVENTOR.
JAMES L. BUTLER

BY Townsend and Townsend

ATTORNEYS

ROTARY ENGINE

This invention relates to improvements in fluid-actuated engines and, more particularly, to such an engine having a pair of rotors mounted eccentric to each other.

While the present invention can be operated with the use of any one of a number of different pressurized fluids, it is especially adapted to be operated with steam under pressure. The engine of this invention can, therefore, provide an improved steam engine which represents a departure from conventional rotary steam engines since the latter generally are of the rotary vane-stationary outer housing type.

Such conventional steam engines have a number of disadvantages because they oftentimes require replacement of the rotary vanes because of structural damage thereto due to the fluid pressures and friction exerted thereon. Also, such engines are complicated to produce and operate and are unsuitable for many power applications.

The engine of this invention not only is simple and rugged in construction and is applicable for a wide variety of uses, but also, it is made so as to provide an almost continuous power stroke when continuously supplied with steam or other fluid under pressure. The engine includes a pair of rotors, one within the other, which rotate about respective, parallel axes the distance between which determines the expansion chamber size and the rotors are interconnected by a buttress which pivots relative to one of the rotors, the buttress operating to divide a chamber between the rotors into an expansion chamber and an exhaust chamber as the rotors rotate about their axes.

The rotors rotate about a tubular axle which has inlet valve means for controlling the flow of a pressurized fluid through the axle and through the inner rotor to the expansion chamber. The pressurized fluid exerts a force on the buttress to cause rotation in the same plane and direction of the rotors about the axle to provide the power stroke for the engine. The outer rotor has suitable valve means for exhausting the spent fluid in the exhaust chamber during the rotation of the rotors.

Another feature of the engine of this invention is the provision of means for permitting the engine to be reversible. Both the inlet valve means and the exhaust valve means are constructed to allow for either forward or reverse operation of the engine. Means can also be provided to automatically condition the exhaust valve means for a particular forward or reverse operation when the inlet valve means is manually operated.

A further feature of the invention is the provision of means for initiating the rotation of the rotors so that sustained operation of the engine can be established once the rotors are set into rotation. Suitable electrical circuitry including a reversible starting motor is provided to start the rotation of the rotors and to be automatically cut out as fluid pressure builds up in the expansion chamber.

The primary object of this invention is to provide an improved fluid-actuated engine which has a pair of eccentrically mounted rotors, one within the other and interconnected by a shiftable oscillating buttress, wherein the rotors are housed within a shroud and, with the buttress, define an expansion chamber to which steam can be admitted from a tubular axle about which the rotors rotate to cause a fluid force to be exerted on the buttress to effect rotation of the rotors about the axle.

A further object of this invention is to provide an engine of the type described wherein the engine has a selectively actuated inlet valve means carried within the axle which allows a fluid under pressure to be directed to either of a pair of fluid passages through the inner rotor, whereby the fluid can be directed onto either side of the buttress to cause rotation of the rotors in a corresponding direction.

A further object of this invention is to provide a rotary steam engine which does not require vanes and which is reversible while, at the same time, the engine has a minimum number of parts to minimize maintenance thereof and has an almost continuous power cycle to render it highly efficient in operation with a concurrent continual exhaust cycle.

Other objects of this invention will become apparent as the following specification progresses, reference being had to the accompanying drawings for illustration of several embodiments of the invention.

IN THE DRAWINGS

FIG. 1 is a cross-sectional view of the rotors of the engine of this invention;

FIG. 2 is a vertical section through the engine, showing the rotors on the stationary axle;

FIGS. 3, 4 and 5 are views similar to FIG. 1 but on a smaller scale, showing the different positions of the rotors before and during a power stroke;

FIG. 6 is an enlarged fragmentary cross-sectional view of the structure for actuating the exhaust valve means of the engine;

FIG. 7 is a schematic view of the circuitry for starting the engine; and

FIGS. 8 and 9 are views similar to FIGS. 3–5 but showing another embodiment of the engine.

The rotary engine which is the subject matter of this invention is broadly denoted by the numeral **10** and includes a stationary, tubular axle **12** which is open at one end thereof and closed by a wall **14** at the opposite end. A pair of journal members **16** and **18** are secured to respective ends of axle **12** and are keyed thereto by keys **20** and **22**, respectively. Journal member **16** is carried at the upper end of a pedestal **24** and is keyed thereto by a key **26**. The opposite end of the shaft and journal member **18** are supported by a power take-off shaft **28** rotatably mounted in a bearing **32** at the upper end of a second pedestal **30**.

Shaft **28** has an end flange **34** which is secured by bolts **36** to the outer face of an end wall **38** of an outer rotor **40** rotatably mounted by ball bearings **42** and **44** for rotation on journal members **16** and **18**, respectively. Flange **34** holds bearing **44** in place on journal member **18**; whereas, bearing **42** on journal member **16** is held in place by an end plate **46** (FIG. **2**) secured by attachment screws **48** to the outer face of the opposite end wall **50** of outer rotor **40**.

Rotor **40** has a cylindrical sidewall **49** spanning the distance between end walls **38** and **50** and is secured thereto by bolts **51** which pass through holes **53** (FIG. **1**) in sidewall **49**. As shown in FIG. **1**, journal member **16** is shown in dashed lines as being eccentric with respect to axle **12**. Thus, rotor **40** rotates about an axis parallel with the axis of axle **12**.

A second, inner rotor 52 is disposed within rotor 40. Rotor 52 is tubular and has an inner bushing 54 which is rotatably mounted on axle 12 and is concentric therewith. Thus, rotors 40 and 52 rotate about respective parallel axes.

Inner rotor 52 has a pair of radially extending, longitudinally spaced fluid passages 56 and 58 therethrough for admitting a fluid under pressure, such as steam or the like, into the space or chamber 60 (FIG. 1) formed between rotors 40 and 52. Rotary engine 10 is adapted for forward or reverse operation. In forward operation, passage 56 is used to admit steam to chamber 60 and for reverse operation, passage 58 is used for this purpose.

The steam inlet means for engine 10 comprises a steam inlet tube 62 rotatably mounted within axle 12 and having a pair of spaced steam exit ports 64 and 66 which are longitudinally aligned with each other as shown in FIG. 2. Port 64 is movable into register with a first port 68 through axle 12 when tube 62 is rotated in a clockwise sense when viewing FIG. 1. When port 64 is in register with port 68, port 66 is out of register with a second port 70 through axle 12. Conversely, when tube 62 rotates in a counterclockwise sense when viewing FIG. 1 through a predetermined arc, port 66 moves into register with port 70 and port 64 is out of register with port 68. An equilibrium position for port 64 and thereby port 66 is shown in dashed lines in FIG. 1.

Passage 56 is movable into and out of alignment with port 68 in axle 12 as the rotors rotate relative to the axle. Similarly, passage 58 moves into and out of alignment with port 70 of axle 12 as the rotors rotate thereon. Thus, passage 56 is in the same plane as ports 64 and 68 and passage 58 is in the same plane as ports 66 and 70.

Axle 12 and tube 62 project laterally from journal member 16 as shown in FIG. 2 Tube 62 has an arcuate slot 72 therein which is in alignment with a steam inlet pipe 74 rigidly connected to axle 12 and extending outwardly therefrom. A closure 76 rigidly secured to tube 62 closes the adjacent end thereof and a shaft 78 secured to the closure extends outwardly therefrom through the end of axle 12. A gland assembly 80 rotatably mounts shaft 78 within axle 12 and a lever 82 coupled to the outer end of shaft 78 is used to manually rotate the same to thereby rotate tube 62 within axle 12. In this way, either port 64 can be moved into alignment with port 68 or port 66 can be moved into alignment with port 70. For forward operation of rotary engine 10, i.e., for rotation of rotors 40 and 52 in a clockwise sense when viewing FIG. 1, tube 62 will be in a position such that ports 64 and 68 will be in alignment with each other. For reverse operation of the rotary engine, tube 62 will be in a position such that ports 66 and 70 will be in alignment with each other.

Rotors 40 and 52 are interconnected by a barrier or buttress 84 which extends longitudinally of axle 12 and moves with the rotors around the axle. Buttress 84 has a cylindrical end portion 86 which is pivotally mounted within a recess 88 in the inner surface of rotor 40, the recess being substantially complemental to end portion 86. The buttress has a transversely rectangular main body portion 90 which is shiftably received within a groove 92 formed in the outer surface of rotor 52. Thus, as rotors 40 and 52 move together, main body portion 90 of buttress 84 slides in and out of groove 92 and the buttress itself oscillates in one direction relative to the outer rotor as the rotors rotate through a half revolution starting with the top dead center position shown in FIG. 1 and then oscillates in the opposite direction relative to the outer rotor as the rotors rotate through the other half revolution starting with the bottom dead center position diametrically opposed to the top dead center position.

When the buttress is in positions other than the top dead center position shown in FIG. 1, it presents a barrier which divides chamber 60 into two parts, namely, an expansion chamber on the upstream side of the buttress and an exhaust chamber on the downstream side thereof. The expansion and exhaust chambers are effectively isolated from each other since, at all times, rotors 40 and 52 are in substantially sealing engagement with each other at one location, namely, in the vicinity of the uppermost extremity of rotor 52 when viewing FIG. 1. Chamber 60 will, therefore, always have the same crescent shape shown in FIG. 1 although it will periodically be divided into the expansion and exhaust chambers whose volumes will continuously vary due to the movements of the buttress about axle 12.

Rotor 40 has a pair of exhaust passages 94 and 96 therethrough, passage 94 being used to exhaust steam from the exhaust chamber when rotary engine 10 is operating at a forward direction and exhaust passage 96 being used to exhaust steam about the exhaust chamber when the rotary engine is operating in a reverse direction. A rotary valve 98 is disposed within passage 94 and a rotary valve 100 is disposed within passage 96. These valves are coupled together by a linkage 102 and arms 104 and 106, respectively, the arms being pivotally connected to linkage 102 and the linkage and arms being shown diagrammatically in FIG. 1. A handle 108 coupled with linkage 102 is manually operated to the valves together. The valves are oriented in respective passages 94 and 96 in a manner such that, when valve 98 allows the exhaust of steam through passage 94, valve 100 blocks passage 96 and vice versa.

A hollow, cylindrical housing or shroud 110 surrounds outer rotor 40 and is rigidly secured in any suitable manner to the stationary portions of rotary engine 10. For purposes of illustration, the left-hand sidewall of the shroud is coupled to journal member 16 and to the upper end of pedestal 24 while the right-hand sidewall of the shroud is coupled to the bearing housing for bearing 32. Passages 94 and 96 exhaust steam into shroud 110 and a suitable valved drain pipe 112 is coupled with the bottom of the shroud to permit the exit of steam condensated therefrom.

In operation, rotary engine 10 is assembled in the manner shown in FIGS. 1 and 2 and assuming forward operation of the engine is desired, tube 62 is rotated by manually moving lever 82 until ports 64 and 68 are in alignment with each other. This position can be indicated by a scale adjacent to lever 82 or, in the alternative, suitable stops can be provided to stop the rotation of tube 62 when ports 64 and 68 are aligned.

Pipe 74 is coupled to a source of steam under pressure and steam is allowed to enter tube 62 and pass through ports 64 and 68 when passage 56 is aligned therewith. Initially, rotors 40 and 52 will be set into operation in any suitable manner, such as by a starting motor arrangement hereinafter described. As the ro-

tors commence to rotate, buttress **84** will rotate therewith and in a clockwise sense when viewing FIG. **1**. Passage **56** will periodically move into alignment with ports **64** and **68** and when it does, a charge of steam will pass into the expansion chamber on the upstream side of buttress **84** so as to exert a fluid force on the buttress causing the rotors to rotate in a clockwise sense. FIG. **3** illustrates the position of passage **56** before it moves into alignment with ports **64** and **68** and prior to the formation of the expansion chamber by buttress **84**. FIG. **4** illustrates the position of passage **56** immediately after it has moved out of registry with ports **64** and **68**. FIG. **4** also shows that buttress **84** divides chamber **60** into an expansion chamber **60*a*** on the upstream side of the buttress and an exhaust chamber **60*b*** on the downstream side of the buttress.

The exhaust chamber is in fluid communication with passage **94** since valve **98** is in the open position. Thus, fluid can be purged from exhaust chamber **60*b*** through passage **94** as the rotors continue to rotate. FIG. **5** illustrates a third position of the rotors as they rotate about axle **12**.

The exhausted steam passes into shroud **110** and, after condensation, can be directed outwardly therefrom through drain pipe **112**. Rotation of the rotors causes rotation of power take-off shaft **28** so that structure to be driven and coupled with shaft **28** can be driven thereby in response to the rotation of the rotors.

Rotary engine **10** can operate in a reverse direction by opening valve **100** and closing valve **98** and by rotating tube **62** in a clockwise sense when viewing FIG. **1** to cause port **66** to move into alignment with port **70** as port **64** moves out of alignment with port **68**. Rotors **40** and **52** are set into rotation in a counterclockwise sense when viewing FIG. **1** by the starting means as steam is supplied to tube **62**. Thus, steam will enter the expansion chamber on the upstream side of the buttress each time passage **58** moves into alignment with ports **66** and **70**. Also, exhaust fluid in the exhaust chamber downstream of the buttress will be exhausted through passage **96** into shroud **110** as the rotors continue to rotate. The steam adjacent to the upstream side of the buttress exerts a force thereon which causes the rotors to rotate about axle **12** and this rotation continues so long as steam is admitted to the expansion chamber through passage **58** for each revolution of the rotors.

Means can be provided to automatically reverse the operative positions of valves **98** and **100** when it is desired to cause reverse operation of engine **10** during start-up thereof. To this end, valves **98** and **100** are provided with shafts (not shown) to which respective gears **114** and **116** are connected. A link **118** interconnects the gears in the manner shown in FIG. **6** so that the two valves can move together. The teeth on each gear cover only one-fourth of the outer periphery of each gear.

A rack **120** is mounted within shroud **110** for movement toward and away from the rotors and meshes with the gears to cause the same to rotate the valves in the proper sense when the starting motor starts the rotation of the rotors. After the gears have been rotated through an angle of 90° by the rack, the latter has no further effect on the gears even though the rack remains in its operative position.

The means for moving the rack toward the rotors includes a pair of solenoids **122** having shafts **124** projecting through the shroud and coupled with the rack. Actuation of the solenoids causes the shafts to move inwardly of the shroud to move the rack into its operative position at which it is able to mesh with gears **114** and **116** if the corresponding valves need to be reversed. If the valves are already in proper position, the rack will have no effect on the gears. As shown in FIG. **6**, the valves are set for forward operation of engine **10**, i.e., for clockwise rotation of the rotors.

The rack is forced inwardly only for a relatively short time interval. At the expiration of this interval, the solenoids are deactuated and springs (not shown) associated with solenoids **122** return the rack to its retracted position shown in FIG. **6**.

The control circuit for starting engine **10** is shown in FIG. **7** and includes a belt and pulley assembly **126** coupling a reversible electric motor **128** to power take-off shaft **28**. Motor **128** is electrically connected by leads **130** and **132** to the terminals of a storage battery **134**. A key switch **136** and a manual switch **138** are coupled in series with lead **132**. Switch **138** is preferably carried by lever **82** (FIG. **2**) which rotates inlet valve tube **62**. A pressure-actuated switch **140** carried by the outer rotor at a suitable location and coupled in series with lead **130** is responsive to the fluid pressure in the expansion chamber. This switch is normally closed and is opened when the steam pressure is developed in the expansion chamber. Thus, the electrical circuit to motor **128** is opened after the motor has commenced the rotation of rotors **40** and **52** and after steam has been directed into the expansion chamber.

Belt **142** of belt and pulley **136** is normally loose on the pulley of the assembly and is tensioned by a roller **144** coupled with a solenoid **146** coupled by leads **137** and **139** to leads **130** and **132**. Solenoid **136** is actuated when switches **136** and **140** are both closed and it forces roller **144** against belt **142** to tension the same and thereby place motor **128** in driving relationship to engine **10**.

Solenoids **122**, only one of which is shown in FIG. **7**, are coupled in series by leads **123** and **125** with battery **134** through switches **136** and **140**. Thus, rack **120** is formed inwardly of the shroud and into a position where gears **114** and **116** can mesh with the rack when switches **136** and **140** are closed.

A modified version of the rotary engine is shown in FIGS. **8** and **9** and relates to a different type of buttress for interconnecting rotors **40** and **52**. To this end, the buttress **84*a*** has a cylindrical end portion **86*a*** which is pivotally mounted within recesses on the inner surface of rotor **40**. The buttress has a cylindrical end portion **86*b*** at its opposite end which is pivotally mounted within a recess in the outer surface of rotor **52**. The adjacent portion of the outer surface of rotor **52** is cut away to present a flat surface **84*c*** (FIG. **10**) against which the flat side face of the buttress can engage when the buttress is in the region at which the two rotors are contiguous with each other, as shown in FIG. **9**.

The modified version of the engine operates in essentially the same manner as the first-mentioned version except that the buttress does not move radially inwardly and outwardly of rotor **52** but pivots in the recess of the rotors while the main body of the buttress moves toward and away from flat surface **84*c*** of the inner rotor. The steam inlet means and exhaust means

described above with respect to the first version can be used with the modified version without exception.

What is claimed is:

1. A rotary engine comprising: a hollow, stationary axle having a pair of spaced ports therethrough; a pair of rotors, one rotor being within the other rotor; means mounting the inner rotor for rotation on said axle about the axis of the latter, said inner rotor having a pair of radial passages therethrough alignable with respective ports in the axle as the inner rotor rotates thereon; means mounting the outer rotor on the axle for rotation about an axis parallel with the axis of rotation of the inner rotor, said rotors having respective portions spaced apart to present a chamber therebetween, said outer rotor having a pair of exhaust passages extending outwardly therethrough; an actuatable valve for each exhaust passage, respectively; means coupled with each valve for actuating the same, whereby one exhaust passage can be open when the other exhaust passage is closed; a buttress interconnecting the rotors and movable through the chamber to divide the latter into an expansion chamber and an exhaust chamber; means on the axle for supplying fluid under pressure thereto; means in the axle for selectively opening and closing said ports thereof; and a shroud surrounding the outer rotor and coupled to the axle, said exhaust passage being in fluid communication with said shroud.

2. A rotary engine as set forth in claim 1, wherein is provided means coupled with the valves for moving the same together with the valves being oriented to cause each passage to be open when the other passage is closed.

3. A rotary engine as set forth in claim 1, wherein said opening and closing means includes a tube rotatably mounted within the axle and having an inlet port for each port of the axle, respectively, and means coupled with the tube for rotating the same relative to the axle.

4. A rotary engine as set forth in claim 1, wherein is included a power take-off shaft rigidly secured to the outer rotor and disposed axially thereof.

5. A rotary engine as set forth in claim 1, wherein said mounting means for the inner rotor comprises a bushing rotatably mounted on the axle, said mounting means for the outer rotor comprising a pair of spaced journal members eccentrically mounted on the axle, and bearing means on each journal member, respectively, for mounting a corresponding portion of the outer rotor thereon.

6. A rotary engine as set forth in claim 1, wherein is included a starting motor releasably coupled to the rotors for initiating the rotation thereof, means coupling the motor to a source of electrical power, and means releasably connecting the motor to the rotors.

7. A rotary engine as set forth in claim 6, wherein said motor coupling means is responsive to the fluid pressure in said chamber, said motor connecting means being responsive to the actuation of the motor, said valve being rotatable, and including means responsive to the actuation of the motor for rotating the valves to change the operative positions thereof.

8. A rotary engine comprising: a hollow axle adapted to be coupled with a source of fluid under pressure and having a fluid exit port; a pair of rotors mounted on the axle for rotation relative thereto, a first of the rotors being within the second rotor and rotatable about the axis of the axle; means mounting the second rotor on the axle for rotation about an axis parallel with the axis of the first rotor, whereby the rotors are eccentric to each other to present a chamber therebetween, the first rotor being provided with a fluid passage therethrough for placing the chamber in fluid communication with said exit port; a tube rotatably mounted in the axle and having a port movable into and out of registry with said exit port for controlling the flow of fluid under pressure through said exit port; a buttress carried by one of the rotors and shiftably coupled in the other rotor, said buttress being operable to divide the chamber into two parts as the rotors rotate together, said passage communicating with one of the chamber parts; exhaust means on the second rotor and communicating with the other chamber part for exhausting the latter as the rotors rotate; and a shroud surrounding said rotors and disposed to receive the fluid exhausted from said other chamber part.

9. A rotary engine comprising: a stationary hollow axle adapted to be coupled with a source of fluid under pressure and having a fluid exit port; a pair of rotors mounted on the axle for rotation relative thereto, a first of the rotors being within the second rotor and rotatable about the axis of the axle; a pair of spaced journal members eccentrically mounted on the axle and disposed for mounting the second rotor on the axle for rotation about an axis parallel with the axis of the first rotor, whereby the rotors are eccentric to each other to present a chamber therebetween, the first rotor being provided with a fluid passage therethrough for placing the chamber in fluid communication with said exit port; a power take-off shaft rigidly coupled to the second rotor; means in the axle for controlling the flow of fluid under pressure through said exit port; a buttress carried by one of the rotors and shiftably coupled in the other rotor, said buttress being operable to divide the chamber into two parts as the rotors rotate together, said passage communicating with one of the chamber parts; exhaust means on the second rotor and communicating with the other chamber part for exhausting the latter as the rotors rotate; and a shroud surrounding said rotors and disposed to receive the fluid exhausted from said other chamber part.

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