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MULTI-PISTON PRIME MOVER

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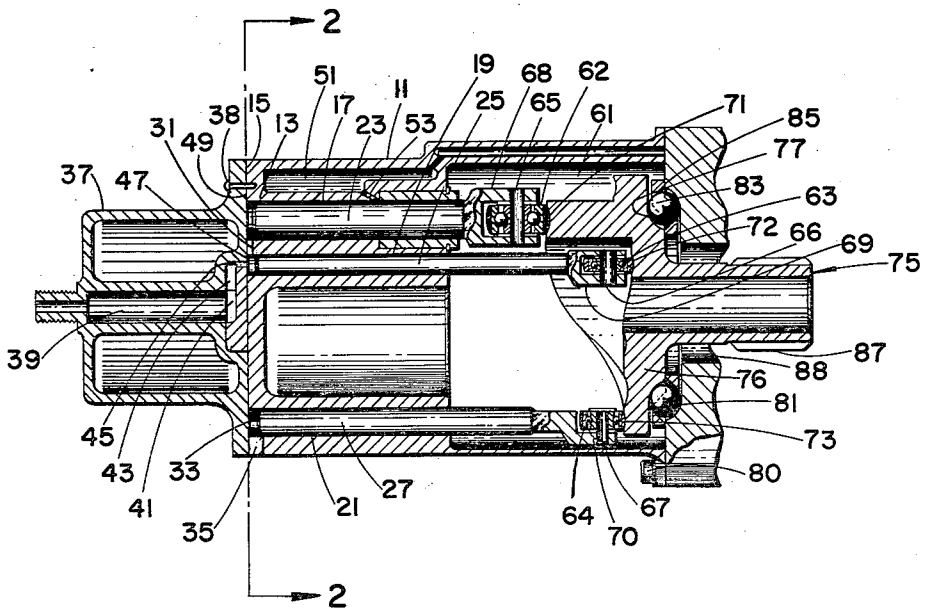


FIG. 1

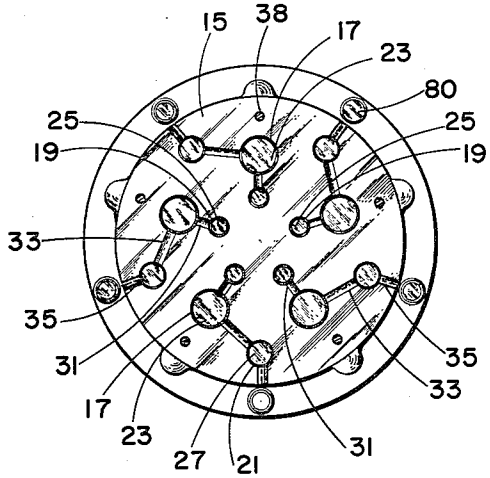


FIG. 2

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MULTI-PISTON PRIME MOVER

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This invention relates to positive displacement prime movers and is particularly concerned with such a prime mover in which hot gases drive pistons and means converts the axial motion of the pistons into rotating motion.

An object of the present invention is to provide an improved prime mover having a ring of reciprocating pistons driven by hot gases which turn a cam surface of an output member so that axial motion is changed directly to rotating motion.

A further object is the provision of such a prime mover having improved valving for the reciprocating pistons.

Another object is the provision of an improved hot gas prime mover constructed so that dynamic seals are eliminated in the hot gas area and a small localized area is subject to high temperature from the hot gases.

An additional object is to provide an improved prime mover having reciprocating pistons driving a cam-surfaced rotating output member and having flat-face sealing in the inlet valve control for the pistons.

The realization of the above objects along with features and advantages of the invention will be apparent from the following description and the accompanying drawing in which

FIG. 1 is a cross-sectional side view of a prime mover embodying the present invention and shows one of a plurality of reciprocating pistons arranged to drive and rotate an output member and one each of a plurality of inlet and outlet valve rods for the pistons, and

FIG. 2 is a transverse cross section along the lines 2—2 of FIG. 1 and shows circular arrangement of the five pistons and the corresponding valving and grooves for inlet, outlet and exhaust flows.

Referring to FIGS. 1 and 2, the main central housing 11 has an end wall 13 at left which has a flat transverse surface 15. Extending to the right from wall 13 is structure which provides five power piston bores 17, five inlet valve bores 19 and five outlet valve bores 21. Corresponding pluralities of pistons 23, inlet valve rods 25 and outlet valve rods 27 are slidably mounted in the respective bores 17, 19 and 21. Inlet grooves 31, outlet grooves 33 and exhaust grooves 35 in the flat surface 15 of end wall 13 extend respectively from the outer ends of the outlet valve bores 21 and from outlet valve bores radially to the exterior of housing 11. A gas inlet housing element 37 which is connected to housing 11 by screws 38 has an axial passage 39 which connects with central chamber 41 having five radial branch passages 43 (one appearing) and five axial feed passages 45 (one appearing) having a smaller diameter than inlet bores 19. Feed passages 45 open axially into the center of the inlet valve bores 19. A flat annular sealing surface 47 is provided around each feed passage 45 for the flat end of each of inlet valve rods 25 due to the flat surface 49 of housing element or wall 37 abutting the flat surface 15 of end wall 13. Hot pressurized gases are provided in axial passage 39 by means not shown. It is to be noted in FIG. 1 that inlet groove 31 leads to a clearance space adjacent wall 37 in front of piston 23 and such space is provided for each piston at the end of the return stroke for the beginning of the power stroke of each piston and further that outlet valve rods 27 will be subject to residual gas pressure on their beveled heads when cammed in blocking position due to the beveled part facing the outlet grooves 33. Lubrication for the pistons 23 is provided by means of pressurized lubricant chamber 51 and lubricant passages 53.

Main housing 11 is also formed with a cup-like chamber 61 opposite its end wall 13. The pistons 23, inlet valve rods 25 and outlet valve rods 27 project from the inner ends of their respective bores into chamber 61. Each piston and each rod has a wheel or roller 62, 63 and 64 connected to the drive ends thereof which are opposite the hot gas ends. Rollers 62, 63 and 64 are ball-bearing-mounted respectively by means of axles 65, 66 and 67 and brackets 68, 69 and 70. Each roller is axially aligned with its connected piston or rod and is contoured to fit into slightly-grooved circular cam surfaces 71, 72 and 73 formed in rotatable output member 75 whereby proper operation is assured between the rotating and reciprocating parts. Output member 75 has a transverse wall 76 (opposite the cam surfaces 71, 72 and 73) which has a peripheral thrust bearing shoulder 77. An output housing member 79 which is connected to central housing 11 by screws 80 abuts the end of central housing 11 and has an inwardly-extending bearing recess 81 facing the bearing shoulder 77. Ball bearings 83 having a separating cage 85 are positioned in the bearing shoulder 77 and recess 81 to provide for thrust forces and rotation. It is to be noted that the bearing structure is axially-aligned with the pistons 23 and cam surface 71. A splined output shaft 87 extends axially from output member 75 through an axial opening 88 in the output housing member 79 so that a device can be rotated by the present invention.

Referring to the slightly-grooved cam surfaces 71, 72 and 73, it is to be noted that the outer surface 73 has a profile cooperating with the outlet valve rods 27 to essentially block the outlet grooves 33 and exhaust grooves 35 until the end of the power stroke of corresponding piston and to permit clearance of the outlet grooves 33 and exhaust grooves 35 during the return stroke. The intermediate piston cam surface 71 has a sinusoidal profile such and is so positioned that, at the beginning of a power stroke, a tangential turning force is exerted by the pistons 23 on the output member 75. The inner cam surface 72 has a profile so that the inlet valve rods 25 seal against surfaces 47 around feed passages 45 until the beginning of the power stroke of the corresponding pistons 23 when cam surfaces 72 permit the inlet valve rods 25 to move to the right permitting gas flow through inlet grooves 31 to the faces of the pistons 23. The inlet valve rods 25 will move to the left and reseal as the pistons 23 approach the end of the power strokes due to the profile of the cam surfaces 72.

The operation of the prime mover begins when pressurized hot gases are provided in axial chamber 39. These gases flow into central chamber 41 to radial passages 43 and axial feed passages 45 as permitted by inlet valve rods 25. Certain of inlet valve rods 25 are positioned to the right to open position due to the profile of the inner inlet cam surface 72 and the urging of the pressure of the gases on the face of the inlet valve rods 25 while other inlet valve rods 25 are positioned in closed position due to cam surface 72. Complementary closed and open positioning of the outlet valve rods 27 will exist due to the profile of the outer cam surface 73 which causes leftward movement and restrains rightward movement of the outlet valve rods 27, the beveled heads of which are subject to gas pressure. The positioning of the inlet and outlet rods 25 and 27 will, of course, correspond to the positioning of the associated pistons 23. Since it is apparent that the pistons 23 will successively have power strokes and return exhaust strokes with overlapping, a detailed description of the operation of only one piston will be made. Thus, re-

ferring to FIG. 1, hot gases will flow from axial feed passage 45 through the left part of inlet valve bore 19 and inlet groove 31 to the clearance space in front of piston 23 at the top of FIG. 1. The gas pressure exerts a force on the face of the piston 23 which, in turn, exerts through roller 62 a force on piston cam surface 71. At the beginning of the power stroke, the high point of cam 71 has just passed piston roller 62. The relationship of the gas admission is so timed that the force on the cam surface 71 produces a tangential force component, creating a torque and causing output member 75 to rotate clockwise as viewed from the right. As output member 75 rotates, the inner cam surface 72 causes the inlet valve rod 25 to move to the left to shut off the incoming flow of high pressure hot gas to inlet groove 31 flow of high pressure hot gas to inlet groove 31. The gas in inlet groove 31 and piston bore 17 continues as it expands to push piston 23 until the piston cam surface 71 is approaching its low point at the end of the power stroke. At this time, the outer cam surface 73 does not restrain the outlet valve rod 27 and the outlet valve rod 27 unblocks outlet groove 33 and exhaust groove 35. Such positioning corresponds with the showing of outlet valve rod 27 at the bottom of FIG. 1. Thus, expanded low pressure gas passes from the piston bore 17 through oulet groove 33, outlet valve rod bore 21 and exhaust groove 35 to the exterior of housing 11 during the return stroke of piston 23. Outlet valve rod 27 remains in position for exit flow until inlet valve rod 25 again begins to move to permit inlet flow at which time the cycle repeats.

From the foregoing, it can be realized that an improved multi-piston prime mover has been provided for converting reciprocating motion directly into rotating motion. The pistons 23 are operably connected to the output member 75 by a simplified construction. The inlet and outlet valving for hot gases is achieved by the valve rods 25 and 27 and stationary housing having passages so that seals for a rotating part are not required. The multiplicity of pistons 23 gives reliable starting and smooth operation. The flow paths for the hot gases from axially-centered chamber 41 to piston bores 17 and then to exhaust are such as localize the effects of high temperature to parts adjacent the flow paths.

It is to be understood that changes can be made in the disclosed embodiment of the invention by persons skilled in the art wtihout departing from the invention as set forth in the appended claims.

What is claimed is:

1. A multi-piston prime mover comprised of housing means having a ring of piston bores, a rod-like piston slidably mounted in each of said piston bores, said housing means having an end wall closing off one end of said piston bores to provide gas chambers between said wall and said pistons, said pistons extending from the other ends of said piston bores, a rotatable output member having a circular cam surface facing said pistons, said pistons having low-friction means abutting said cam surface arranged so that said output member can be turned in relation to said pistons, said cam surface having profile so that when said pistons are successively moved toward said output member during power strokes a turning force will be exerted on said output member and so that said pistons will be successively returned in said piston bores to a position adjacent said end wall during return strokes, a hot gas supply chamber, gas inlet means connected to said gas supply chamber and said piston bores operable to admit gas to said bores so that said pistons are successively moved toward said output member to provide power strokes, said housing means having exhaust outlets, and gas outlet means connected to said piston bores and said exhaust oulets operable to release gas from said piston bores when said pistons are successively returned during return strokes, said gas inlet means including an inlet valve rod for each piston, said housing means having a ring of inlet valve bores adjacent and parallel to said ring of piston bores, said gas inlet means including the parts of said inlet valve bores adjacent said end wall and an axial feed passage opening centrally to each of said inlet valve bores, said inlet valve rods being slidably mounted in said inlet valve bores and extending from said inlet valve bores, said output member having a circular inlet valve cam surface facing said inlet valve rods, said inlet valve rods having roller means abutting said inlet valve cam surface, said inlet valve cam surface having a profile constructed so that said inlet valve rods at said axial feed passages block flow during piston return strokes and permit flow during piston power strokes.

2. A multi-piston prime mover comprised of housing having a cylindrical body, said cylindrical body having a ring of equi-spaced piston bores, a ring of equi-spaced gas inlet bores on an inner circle concentric with said ring of piston bores, said inner circle having a smaller diameter than the circle of said ring of piston bores, said piston and inlet bores having outer ends and inner ends, said body having a flat transverse surface at the outer ends of said bores, inlet grooves in said surface respectively connecting each of said inlet bores to each adjacent one of said piston bores, inlet end wall means having a flat surface abutting the flat transverse surface of said body, said inlet end wall means having inlet passages for a motive gas opening axially into said inlet bores, said inlet passages having a smaller diameter than the diameter of said inlet bores so that an annular sealing surface is provided, a rod-like piston slidably mounted in each of said piston bores, an inlet valve rod slidably mounted in each of said inlet bores, said inlet valve rods each having an outer end adapted to seat respectively on said annular sealing surfaces, said pistons and inlet valve rods having inner ends extending from the inner ends of said piston and inlet bores, an output member having circular cam means abutting said inner ends of said pistons and said inlet valve rods, inlet passages respectively connecting the outer ends of said inlet and piston bores, said circular cam means being constructed so as to position successively during return strokes said pistons adjacent said end wall means to begin a power stroke and to position successively during power strokes said inlet valve rods to admit gas to said inlet passages to move said pistons, said circular cam means being further constructed so that said pistons successively rotate said output member during power strokes and so that said inlet valve rods successively seat against said annular sealing surfaces during piston return strokes, and means for releasing gas from said piston bores as said pistons are successively repositioned to begin power strokes.

3. A multi-piston prime mover comprised of housing having a cylindrical body, said cylindrical body having a ring of equi-spaced piston bores, a ring of equi-spaced gas inlet bores on an inner circle concentric with said ring of piston bores, said inner circle having a smaller diameter than the circle of said ring of piston bores, said piston and inlet bores having outer ends and inner ends, said body having a flat transverse surface at the outer ends of said bores, inlet grooves in said surface respectively connecting each of said inlet bores to each adjacent one of said piston bores, inlet end wall means having a flat surface abutting the flat transverse surface of said body, said inlet end wall means having inlet passages for a motive gas opening axially into said inlet bores, said inlet passages having a smaller diameter than the diameter of said inlet bores so that an annular sealing surface is provided, a rod-like piston slidably mounted in each of said piston bores, an inlet valve rod slidably mounted in each of said inlet bores, said inlet valve rods each having an outer end adapted to seat respectively on said annular sealing surfaces, said pistons and inlet valve rods having inner ends extending from the inner ends

of said piston and inlet bores, an output member having circular cam means abutting said inner ends of said pistons and said inlet valve rods, inlet passages respectively connecting the outer ends of said inlet and piston bores, said circular cam means being constructed so as to position successively during return strokes said pistons adjacent said end wall means to begin a power stroke and to position successively during power strokes said inlet valve rods to admit gas to said inlet passages to move said pistons, said circular cam means being further constructed so that said pistons successively rotate said output member during power strokes and so that said inlet valve rods successively sent against said annular sealing surfaces during piston return strokes, means for releasing gas from said piston bores when said pistons are successively repositioned to begin power strokes, bearing means supporting said output member opposite said pistons and providing for rotation of said output member, said output member having an axial output shaft inwardly of said bearing means.

4. A multi-piston prime mover comprised of housing having a cylindrical body, said cylindrical body having a plurality of piston bores equi-spaced on intermediate circle, a plurality of inlet bores equi-spaced on an inner circle concentric with said intermediate circle, a plurality of outlet bores equi-spaced on an outer circle concentric with said intermediate circle, all of said bores having outer ends and inner ends, said body having a flat transverse surface at the outer ends of said bores, inlet grooves in said surface respectively connecting each of said inlet bores to each adjacent one of said piston bores, outlet grooves in said surface respectively connecting each of said piston bores to one of said outlet bores, exhaust grooves in said surface extending from said outlet bores to the peripheral surface of said body, end wall means having a flat surface abutting the flat surface of said body, said end wall means having inlet passages for a motive gas opening axially into said inlet bores, a rod-like piston slidably mounted in each of said piston bores, an inlet valve rod slidably mounted in each of said inlet bores, an outlet valve rod slidably mounted in each of said outlet bores, each of said pistons and said inlet and outlet rods having an outer end adjacent said grooves and an inner end extending from said bores, each of said inner ends having a roller device mounted thereon, an output member having a radially-outer cam surface abutting the roller devices of said outlet valve rods, said output member having an intermediate cam surface abutting the roller devices of said pistons, said output member having a radially-inner cam surface abutting the roller devices of said inlet valve rods, said intermediate cam surface having a profile so that at the beginning of and during the power stroke of each piston a tangential force successively causes said output to rotate and further so that each piston is successively returned to adjacent said end wall means during the return stroke, said radially-inner cam surface having a profile so that said inlet valve rods respectively clear said axial inlet passages and said inlet grooves to permit gas flow at the end of the return strokes of the pistons and so that said inlet valve rods respectively block said axial inlet passages and said inlet grooves near the end of the power strokes and during the return strokes, said radially-outer cam surface having a profile so that said outlet valve rods respectively block said outlet and exhaust grooves during the power strokes of said pistons and so that said outlet valve rods respectively clear said outlet and exhaust grooves during the return strokes of said pistons.

5. A multi-piston prime mover comprised of housing having a cylindrical body, said cylindrical body having a plurality of piston bores equi-spaced on intermediate circle, a plurality of inlet bores equi-spaced on an inner circle concentric with said intermediate circle, a plurality of outlet bores equi-spaced on an outer circle concentric with said intermediate circle, all of said bores having outer ends and inner ends, said body having a flat transverse surface at the outer ends of said bores, inlet grooves in said surface respectively connecting each of said inlet bores to each adjacent one of said piston bores, outlet grooves in said surface respectively connecting each of said piston bores to one of said outlet bores, exhaust grooves in said surface extending from said outlet bores to the peripheral surface of said body, end wall means having a flat surface abutting the flat surface of said body, said end wall means having inlet passages for a motive gas opening axially into said inlet bores, a rod-like piston slidably mounted in each of said piston bores, an inlet valve rod slidably mounted in each of said inlet bores, an outlet valve rod slidably mounted in each of said outlet bores, each of said pistons and said inlet and outlet rods having an outer end adjacent said grooves and an inner end extending from said bores, each of said inner ends having a roller device mounted thereon, an output member having a radially-outer cam surface abutting the roller devices of said outlet valve rods, said output member having an intermediate cam surface abutting the roller devices of said pistons, said output member having a radially-inner cam surface having a profile so that at the beginning of and during the power stroke of each piston a tangential force successively causes said output to rotate and further so that each piston is successively returned to adjacent said end wall means during the return stroke, said radially-inner cam surface having a profile so that said inlet valve rods respectively clear said axial inlet passages and said inlet grooves to permit gas flow at the end of the return stroke of the pistons and so that said inlet valve rods respectively block said axial inlet passages and said inlet grooves near the end of the power strokes and during the return strokes, said radially-outer cam surface having a profile so that said outlet valve rods respectively block said outlet and exhaust grooves during the power strokes of said pistons and so that said outlet valve rods respectively clear said outlet and exhaust grooves during the return strokes of said pistons, said output member having a peripheral bearing shoulder opposite said intermediate cam surface, a housing member having a bearing recess facing said bearing shoulder of said output member and having an axial opening, ball elements and a separating cage therefor positioned in said bearing shoulder and said recess to provide support for said output member, said output member having an output shaft extending through said axial opening of said housing member whereby the torque derived from said pistons can be utilized.

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