Jan. 2, 1945. E. E. CHRISTOPHER 2,366,595

INTERNAL-COMBUSTION ENGINE

Filed July 25, 1942 3 Sheets-Sheet 1

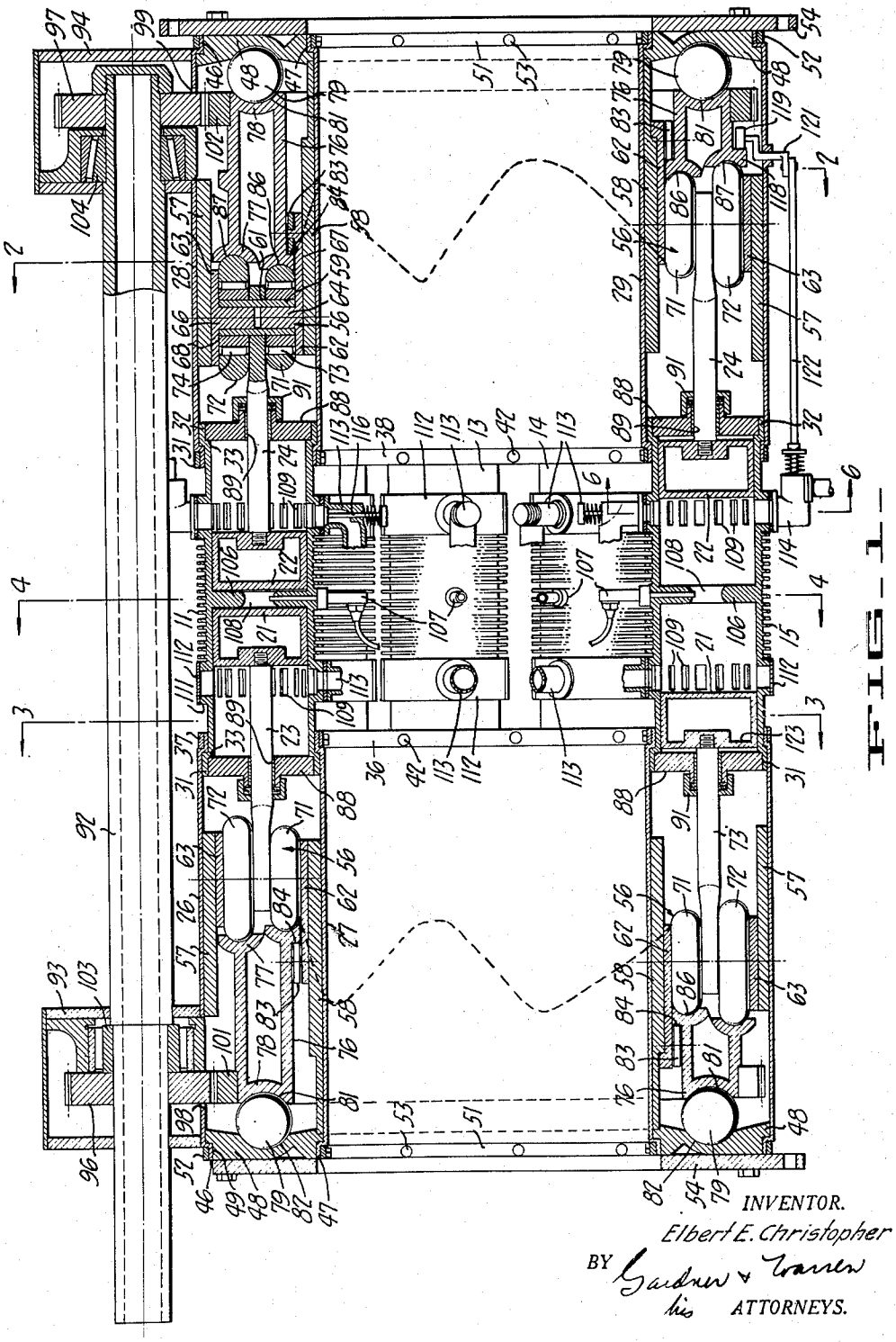


FIG. 1

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INTERNAL-COMBUSTION ENGINE

Filed July 25, 1942 3 Sheets-Sheet 2

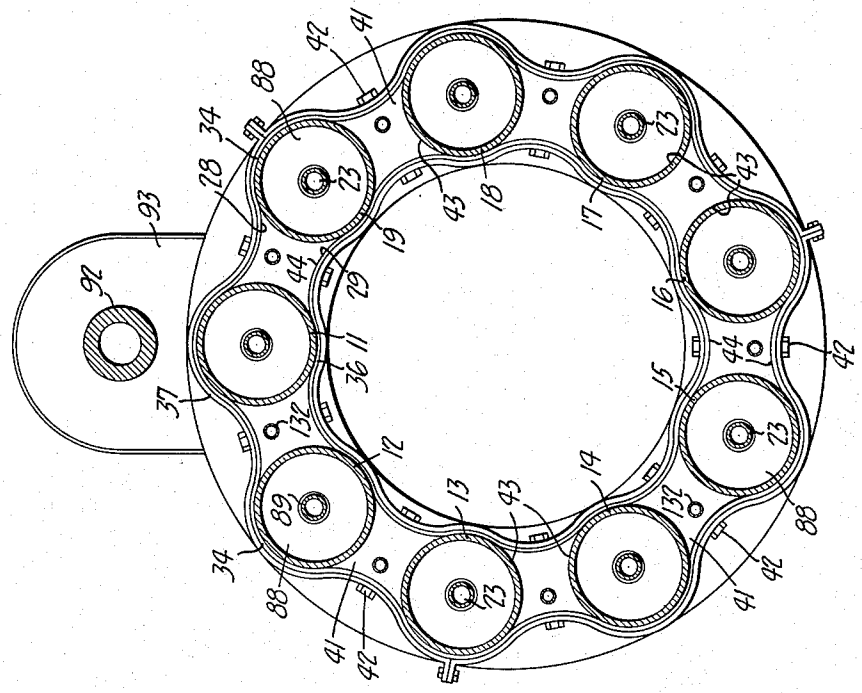


FIG. 3.

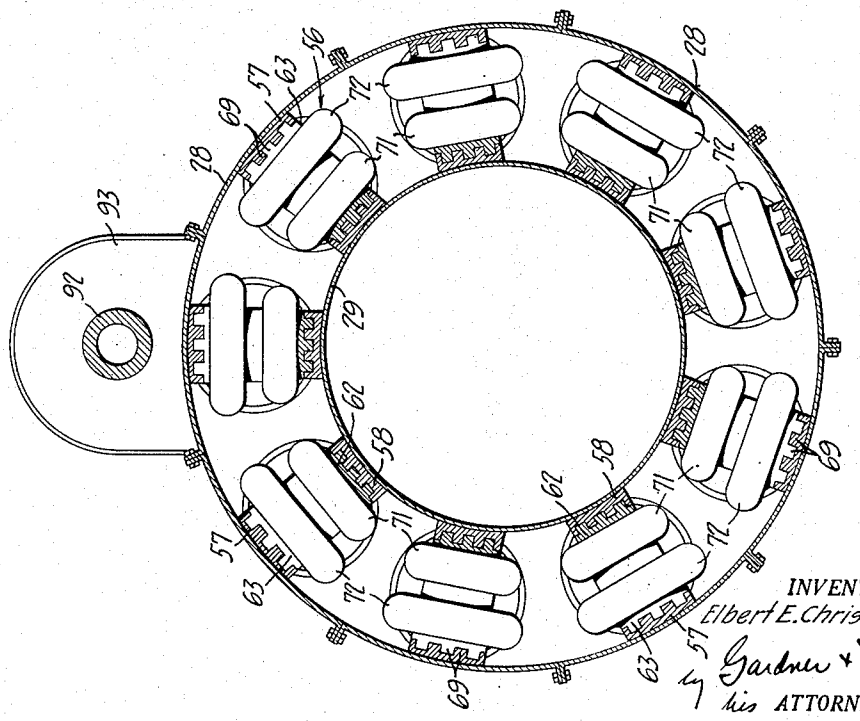


FIG. 2.

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Jan. 2, 1945. E. E. CHRISTOPHER 2,366,595

INTERNAL-COMBUSTION ENGINE

Filed July 25, 1942 3 Sheets-Sheet 3

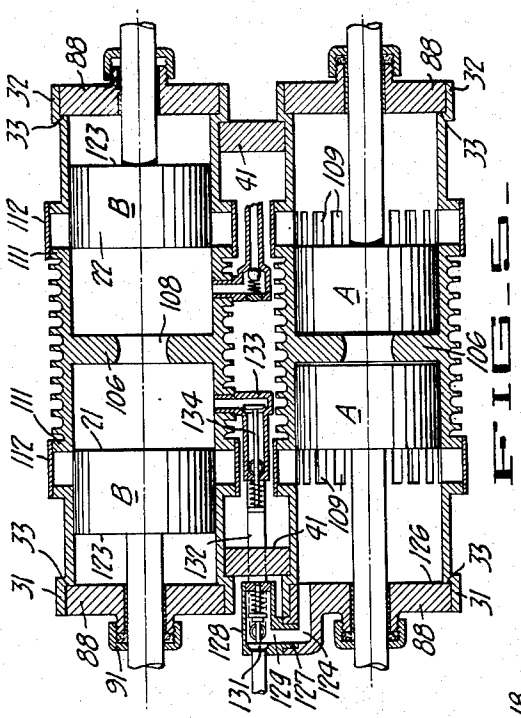


FIG. 5.

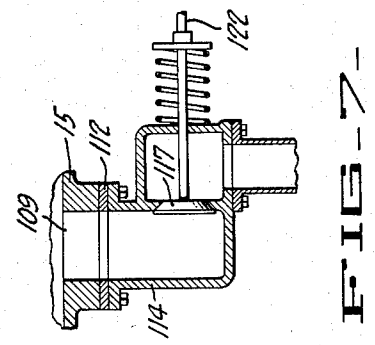


FIG. 7.

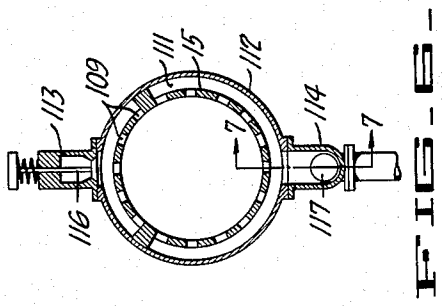


FIG. 6.

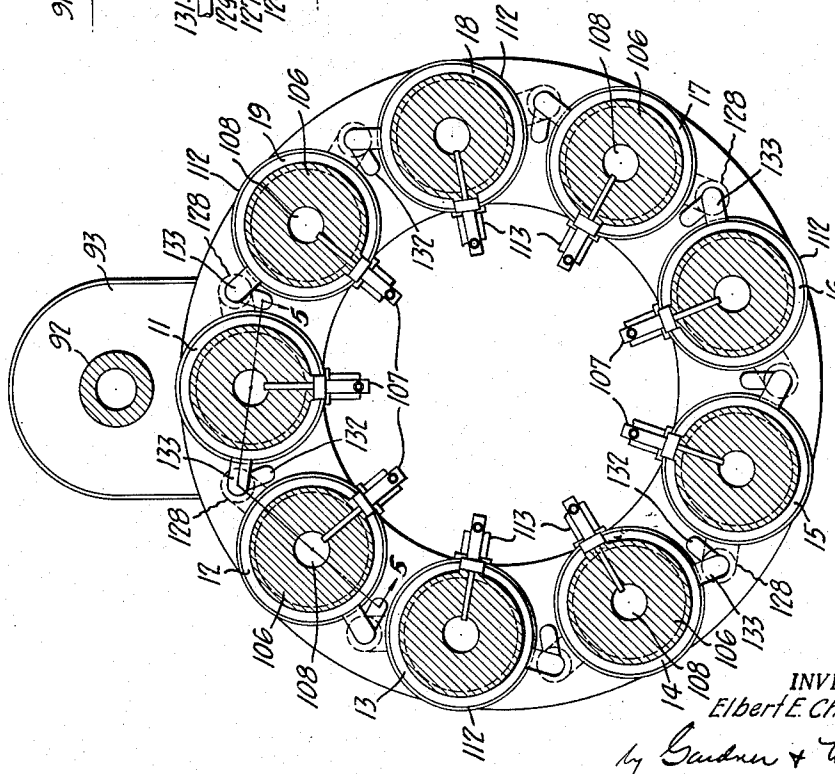


FIG. 4.

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UNITED STATES PATENT OFFICE

2,366,595

INTERNAL-COMBUSTION ENGINE

Elbert E. Christopher, Oakland, Calif.

Application July 25, 1942, Serial No. 452,342

12 Claims. (Cl. 123—51)

The invention relates to internal combustion engines and more particularly to the construction and arrangement of parts in a so-called "barrel" type engine.

The barrel type engine to which the present invention relates usually consists of a cylindrical bank of engine cylinders and reciprocating pistons therein in combination with a rotary cam ring mounted in endwise relation to the engine cylinders and having suitably inclined faces thereon operated upon by the reciprocating pistons so as to translate the reciprocating movement of the pistons into a rotary movement of the cam ring. While this type of engine has certain inherent advantages in reducing the number of operating parts, greater horse power to weight ratio, compactness in size, etc., there have been several defects in engines of this type heretofore proposed, notably the introduction of bends and torsional strains in the drive connection between the pistons and cam ring, and inadequate lubrication of the vital parts of the drive mechanism. As an object of the present invention and as an important feature thereof, these two important defects in previous engines have been entirely eliminated, and a construction provided wherein the operating mechanism between the pistons and the cam ring are subjected exclusively to a longitudinal thrust force and all of the vital drive parts are completely encased in an oil chamber.

Another object of the present invention is to provide an engine of the character above which may be quickly and readily taken apart or assembled and in which the repair and overhauling cost is greatly reduced from engines heretofore available.

A further object of the invention is to provide in a barrel type engine of the character described a novel and improved arrangement of the cylindrical bank of engine cylinders and the drive shaft and an improved drive connection between the drive shaft and the rotary cam ring.

Yet another object of the invention is to provide in an internal combustion engine of the character described a novel and improved mechanism for super-charging the cylinder combustion chambers.

Still another object of the invention is to provide a barrel type internal combustion engine wherein the normally reduced number and mass of parts characteristic of this type of engine are further reduced and the construction generally improved and strengthened to provide a more efficient, smoother running and more durable engine.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of the preferred form of the invention which is illustrated in the drawings accompanying and forming part of the specification. It is to be understood, however, that variations in the showing made by the said drawings and description may be adopted within the scope of the invention as set forth in the claims.

Referring to said drawings:

Figure 1 is a longitudinal sectional view of the engine of my invention.

Figures 2, 3 and 4 are transverse sectional views taken on the lines 2—2, 3—3, and 4—4, respectively of Figure 1.

Figure 5 is an enlarged longitudinal sectional view through a set of adjacent cylinders, the planes of the sections being indicated by the line 5—5 of Figure 4.

Figure 6 is a cross-sectional view of a cylinder taken on the line 6—6 of Figure 1.

Figure 7 is a fragmentary enlarged detail sectional view taken on the line 7—7 of Figure 6.

The engine depicted in the accompanying drawings consists of a cylindrical bank of engine cylinders 11, 12, 13, 14, 15, 16, 17, 18 and 19 provided by a plurality of tubes, marked with the aforesaid numbers 11–19, and supported in parallel coterminous relation in substantially equally circumferentially spaced relation around and at equal radii from a center axis of the bank. Mounted for reciprocation in each of the cylinders are opposed pistons 21 and 22 provided with longitudinal thrust rods 23 and 24 which project axially from the opposite ends of the cylinders into a space provided by pairs of spaced concentric inner and outer casings or shells 26, 27 and 28, 29 which partially embrace and extend longitudinally from the opposite ends of the cylinders. As a feature of the present construction and as best seen in Figures 1, 3 and 6, the opposite ends 31 and 32 of tubes 11—19 are enlarged to define a shoulder 33 around the tube adjacent the ends thereof which engages and interlocks with a pressed-out segmental cylindrical portion 34 formed in the adjacent ends of the shells 26—29 to fit around the inner and outer portions of the tube exteriors. The shells 26—29 and the tubes 11—19 are supported and fixed in the concentric arrangement above described and as illustrated in the drawings by means of pairs of supporting straps 36—37 and 38—39 which embrace

therebetween the end portions 34 of the shells 26—29 and in so doing also grip and hold in place the end portions 31 and 32 of the tubes. The shape of the straps 36 and 37 may be best seen in Figure 3 of the drawings, from which it will be noted that the interiorly mounted strap 36 is preferably continuous in its construction and formed in a sinuous fashion so as to seat and properly support the similarly formed end of shell 27 and also properly locate the tubes in their circumferentially spaced relation. The outer strap 37 is preferably made from two or more sections which are joined at their ends to provide a continuous gripping of the engaged end portion of shell 26. These sections are also of sinuous form complementary to the form of the inner band 36. Mounted circumferentially between the tubes 11—19 and closing the end space between the shells 26—27 and 28—29, are a plurality of filler blocks 41 which are secured in place between the tubes and between the shells by means of a plurality of bolts 42 which extend through the straps and shells and filler blocks. The filler blocks, as will be seen in Figure 3, are formed with concave end portions 43 which are formed to fit closely against the peripheries of adjacent tubes, and the sides 44 of the blocks are also concave to seat the contacting portions of the sinuous ends of the shells. The supporting construction at the opposite ends of the tubes is identical and hence a description of the construction at one end, as illustrated in Figure 3, will suffice for both ends. In connection with the foregoing, it will be understood that a tightening of the bolts 42 and the resultant drawing together of the strap members at the opposite sides of the shells and tubes, rigidly holds the assembly in a proper relation of the parts.

A similar type of construction is provided at the outer ends of shells 26—27 and 28—29 where the outer shells 26 and 28 are formed with an inwardly pressed reduced portion 46 and the inner shells 27 and 29 are formed with an outwardly pressed enlarged portion 47 to lock in an end closure and supporting ring 48, which is formed with a reduced outer end portion 49 which interfits with the shell portions 46 and 47. Embracing the shell portions 46 and 47 are inner and outer straps 51 and 52 which are clamped against the shells and end rings by means of a plurality of bolts 53. If desired, and as here shown, engine mounting rings 54 may be secured to the end closure members 48 to support the engine in the installation with which it is used. As will be understood the shape and form of the mounting members 54 will vary with different types of installations.

Connected to the outer ends of thrust rods 23 and 24 of the pistons are slide members generally denoted by numeral 56 and which are supported for longitudinal reciprocation upon bearing or guide blocks 57 and 58 carried by the inner and outer shells 26—29. The construction of the slide member and the guides for each of the piston thrust rods is the same and a description of one of the units will suffice for all. With reference to Figure 1, it will be noted that the slide member is composed of a plurality of sections assembled upon a center sleeve 59 mounted through a radical aperture 61 in the outer end of the thrust rod. Positioned at the inner and outer ends of the sleeves are slide blocks 62 and 63 which have stud portions 64 and 66 projecting into the interior of the sleeve and substantially flat base portions 67 and 68 slidably engaged upon the guide blocks 57 and 58. Preferably and as shown in Figure 2, the base portions 67 and 68 of the slide blocks and the engaged sides of the guide blocks 57 and 58 are formed with longitudinally extending tongue and groove portions 69 so as to confine the slide member to a longitudinal movement with respect to the guides. Mounted upon the sleeve 59 between the base portions 67 and 68 of the slide blocks and at opposite sides of the thrust rod are a pair of rollers 71 and 72 which are carried on the sleeve for free rotation by means of roller bearings 73 and 74.

As an important feature of the present invention and as best illustrated in Figure 1, there is mounted for free rotation between the outer ends of the slide members 56 and the end closure rings 48, what may be termed a full floating cam ring 76. This member is mounted substantially centrally between and concentric to the inner and outer shells 26—29 and is exclusively supported for rotation at its opposite ends 77 and 78 upon the rollers 71 and 72 of the slide member and a ball end thrust bearing 79 mounted between the cam ring end 78 and the adjacent end closure plate 48. Preferably, the cam ring end 78 is substantially planar, that is arranged in a plane substantially perpendicular to the longitudinal axis of the ring, and is formed with an annular end recess 81 providing a seat and bearing race for the bearing balls 79. The opposed end face of the closure rings 48 are preferably similarly formed with an annular recess 82 providing a bearing race and support for the opposite sides of the balls 79. The opposite end 77 of the cam ring is undulated to receive the end thrust of the slide members and to convert this end thrust into a rotary movement of the cam ring. Preferably in order to maintain a constant engagement of the rollers 71 and 72 with the adjacent undulated face 77 of the cam ring, I provide a roller 83 on one of the slide blocks, here the inner slide block 62 which engages a shoulder 84 on the cam ring and which follows the undulated form of the ring end 77. Since there is a difference in peripheral speed at the radially inner and outer portions of the cam face 77, I prefer to construct the inner and outer spaced rollers 71 and 72 of different diameter so as to approximately compensate for the different speeds of the cam portions engaged by the rollers. Accordingly and as shown in Figure 1, the radially inner roller 71 is of a somewhat smaller diameter than the outer roller 72. In conformity with this arrangement, the portion 86 of the cam face 77 engaged with the roller 71 is of somewhat greater longitudinal extent than the portion 87 of the cam face 77 engaged with the roller 72. Preferably, the cam portions 86 and 87 are recessed and the rollers 71 and 72 are rounded beveled to provide an interfitting relation as illustrated in Figure 1. As will be clear from the foregoing, the translation of the longitudinal thrust of the piston rods into a rotary displacement of the cam ring is effected without the introduction of any strain on the connected parts at right angles to the axis of thrust. In other words there is provided in the present engine a straight longitudinal alignment of the thrust rods, cam ring and end bearings for the cam ring, whereby all bending or lateral stress is eliminated. As another important feature of the above construction, it will be noted that the slide member, guides, cam ring and end thrust bearings therefor are all encased within a closed chamber which is preferably filled with

lubricating oil whereby all of these vital drive parts may run in oil and lubrication problems heretofore encountered with this type of engine completely eliminated. The oil chamber at the ends of the cylinders 11—19 is closed by means of end closure discs 88 fixed within the enlarged tube ends 31 and 32 and being formed with an axial opening 89 for receipt of the piston thrust rods 23 and 24. Preferably, a packing nut 91 is carried on the end closures 88 around the thrust rods and the openings 89.

As another important feature of the present invention, a drive shaft 92 is provided outside of the cylindrical bank of cylinders and in substantially parallel relation thereto and is operatively connected to the cam rings 76. As will be seen from Figure 1, there is mounted on the outer casings 26 and 28 adjacent the opposite ends thereof a pair of bearing housings 93 and 94 which receive and journal for rotation the opposite ends of shaft 92. Preferably the shaft 92 projects forwardly somewhat from the forward bearing housing 93 for connection of the mechanism to be driven by the engine. Mounted upon the shaft for rotation therewith within the bearing housings 93 and 94 are pinion gears 96 and 97 which project through openings 98 and 99 in the outer casings 26 and 28 to engage and enmesh with ring gears 101 and 102 mounted on the cam rings 76. Lubrication of these gears as well as the shaft bearings 103 and 104 within the housings 93 and 94 is effected by oil carried up through the openings 98 and 99 from the oil chamber by the pinion gears 96 and 97.

The engine pistons 21 and 22 are as aforementioned mounted in opposed position in the cylinders for out-of-phase reciprocation therein to and from a center dividing ring 106 mounted in the cylinders. The present engine is designed for Diesel or solid fuel injection and to this end a plurality of fuel injectors 107 are provided and in each instance mounted through the wall of the tubes at the radial inner side thereof and centrally of the tube length so as to project into and through the ring dividers 106. The fuel injectors are preferably mounted so as to inject the fuel diametrically across the opening 108 in the divider rings 106 and upon striking the opposite wall of the ring, the fuel is split off to the opposite longitudinal sides of the ring. The present engine is also designed for two-cycle operation and in keeping therewith a ring 109 of cylinder ports is provided adjacent the outer ends of the piston strokes for obtaining intake and discharge of air and gases of combustion. As will be best seen in Figures 1 and 6, there is formed on the tubes at the opposite longitudinal sides of the ports 109, a pair of outstanding annular shoulders 111 which are closed at their outer faces by a band 112, thus defining an annular chamber around the ports. Preferably, each of the annular chambers is divided by appropriate partitions into intake and exhaust chambers and suitable intake and exhaust fittings 113 and 114 applied thereto. In order to adapt the present engine to the use of a blower for placing the intake air under some initial pressure, I provide suitably operated valves 116 and 117 in the intake and discharge fittings 113 and 114 to regulate the introduction and discharge of air and products. As here shown, valve 116 is in the form of a spring pressed check valve, spring pressed to closed position and opened under the influence of the blower pressure. Preferably only a slight air pressure is required to open the valve, the function of the valve being primarily to seat against the initial exhaust pressure in the cylinder. On the other hand, exhaust valve 117 is operated in timed relation to the movement of the pistons by means of a special cam shoulder 118 on the cam ring 76 which engages and displaces a follower 119 which is in turn connected by crank 121 to the stem 122 of valve 117, see Figure 1. In this manner as the pistons 121 and 122 clear the ring of ports 109 at the end of the power stroke, exhaust valve 117 opens to discharge the spent products of combustion and the initially high exhaust pressure closes check valve 116 in the intake passage. As the exhaust pressure falls to below the blower pressure feeding the intake air, valve 116 opens and shortly thereafter exhaust valve 117 closes under the influence of cam 118 and follower 119, whereby the cylinder is charged with air for compression.

As another important feature of the present engine, the outer ends of the cylinders and the pistons are designed to provide air compression chambers from which air under pressure is passed into the combustion chamber of the next adjacent cylinder to provide a super-charging of the latter. As will be seen from Figure 1 of the drawings, the pistons 21 and 22 are of double ended construction, that is the normally skirt end of the piston is closed off to provide a head end 123 facing the outer ends of the cylinders. The thrust rods 23 and 24 are preferably secured directly to these ends as by threading one end of the thrust rod into a threaded socket provided in the head end 123 of the piston. The outer ends of the cylinders being closed by discs 88, an air compression chamber is thus provided between the closed ends 123 of the pistons and the end discs 88. With reference to Figure 5, it will be noted that the end discs 88 are each provided with an air passage 124 leading from the inside face 126 of the discs to the surrounding casing 26 or 28 where the casing is apertured to receive an end 127 of a valve casing 128, the end 127 being threaded into the body of the disc 88 to place passage 129 of the valve casing in registration with passage 124. Mounted within the casing 128 is spring pressed intake check valve 131 which functions to admit atmospheric air during the suction stroke of the piston away from the disc 88 and to automatically seat upon return movement of the piston to permit compression of the air. Air is discharged from the valve casing 128 by means of a conduit 132 leading therefrom to another valve casing 133 connected to the adjacent cylinder longitudinally thereof to discharge air into the power chamber of that cylinder. Mounted within valve casing 133 is a check valve 134, spring pressed to closed position and functioning to admit air from the air compression chamber to the combustion chamber so long as the pressure in the former is greater than that in the latter, and automatically seating to prevent a return movement of the gases of combustion from the combustion chamber to the air compression chamber. In accordance with the above, the undulations on the cam rings 76 are so arranged to provide an operating sequence in the adjacent cylinders such that the compression of air in the air compression chamber of one cylinder will lead the compression stroke in the combustion chamber of the adjacent cylinder by an amount sufficient to transfer the compressed air from the air compression cylinder into the

connected combustion chamber. The present arrangement using nine engine cylinders and a cam ring formation using three sinuous lobes whereby the pistons move through three cycles of operation during each complete rotation of the cam rings, will provide in combination with the structure above described, a proper operating sequence. However as will be understood, a different number of cylinders and a different arrangement of the cam rings may be adapted to effect this purpose. The sequence of operation provided by the present engine may be followed from Figure 5. At the outset it will be noted that pistons A in the lower cylinder of the view are just starting the air compression stroke, while pistons B in the upper cylinder of the view are just reaching the end of their power stroke. With the pistons in this position, the air compression chamber in the lower cylinder is being charged with air from the blower, which air enters through the ring of ports 109 in the lower cylinder. Pistons A move to close the ports 109 in their cylinder while pistons B move to open ports 109 in their cylinder. The initial transfer of air from the lower cylinder into the upper cylinder is prevented by valve 134 which functions to prevent the back firing of the products of combustion from the upper cylinder into the air compression chamber of the lower cylinder and also holds back the air in the lower cylinder until a pre-determined pressure has been reached. Further movement of pistons A start the compression stroke in the lower cylinder while pistons B return back across the ports in the upper cylinder so as to enclose the combustion chamber in the upper cylinder. However, it will be noted that the pistons A having a substantial lead over pistons B, equal to approximately the length of ports 109, the air pressure is built up faster in the air compression chambers than it is in the upper combustion chambers. As a result there is a transference of air from the air compression chambers in the lower cylinder to the combustion chamber of the upper cylinder to provide a supercharging of the latter. As pistons A reach the end of their stroke and start their return movement, the pressure in the air compression chambers immediately falls and check valve 134 closes to seal in the combustion chamber and at the same time the drop in pressure in the air chambers causes the intake check valve 131 to open to admit a fresh charge of air into the air compression chambers. The intake stroke in the air chambers in the lower cylinders lead the combustion or power stroke in the upper cylinder by the amount above noted and the pistons move to their first mentioned position, as illustrated in Figure 6.

I claim:

1. In a barrel type internal combustion engine having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust members extending longitudinally therefrom, an end support mounted in endwise spaced relation and in longitudinal alignment to said cylinders, a cam ring mounted between said support and the outer ends of said members, and end thrust bearings mounted between the opposite longitudinal ends of said ring and said support for journaling said cam ring and providing with said members the substantially exclusive support therefor.

2. In a barrel type internal combustion engine having a cylindrical bank of cylinders and pistons reciprocally mounted in said cylinders, annular rotary means mounted concentric to said cylinders and operated upon by said pistons to translate the reciprocating movement of said pistons to a rotary movement of said means, a drive shaft mounted outside of said bank of cylinders and along a longitudinal axis parallel to the axis of said bank, and gear means connecting said shaft and rotary means.

3. In a barrel type internal combustion engine having a cylindrical bank of cylinders and pistons reciprocally mounted in said cylinders, annular rotary means mounted concentric to said cylinders and operated upon by said pistons to translate the reciprocating movement of said pistons to a rotary movement of said means, a drive shaft mounted outside of said bank of cylinders and along a longitudinal axis parallel to the axis of said bank, a ring gear carried by said rotary means, and a pinion carried by said shaft and enmeshed with said ring gear.

4. In a barrel type internal combustion engine having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust rods extending longitudinally therefrom, an end support mounted in endwise spaced relation and in longitudinal alignment to said cylinders, a cam ring mounted between said support and the outer ends of said rods, end thrust bearings mounted between the opposite longitudinal ends of said ring and said support and said outer rod ends for journaling said cam ring and providing the substantially exclusive support therefor, a drive shaft mounted outside of said bank of cylinders and substantially parallel to the axis thereof, a ring gear carried by said cam ring, and a pinion carried by said shaft and enmeshed with said ring gear.

5. In a barrel type internal combustion engine having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust rods extending longitudinally therefrom, an end support mounted in endwise spaced relation and in longitudinal alignment to said cylinders, a circular bearing race provided in the radial face of said end support in cylindrical alignment with said thrust rods, a cam ring mounted concentrically between said race and said thrust rods and in cylindrical alignment therewith, roller bearing means carried by said thrust rods and engaged with the adjacent longitudinal end of said cam ring, and rotary bearing means mounted between the opposite end face of said cam ring and said bearing race whereby said cam ring is subjected to only longitudinal thrust.

6. In a barrel type internal combustion engine having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust members extending longitudinally therefrom, an end support independent of said members mounted in endwise spaced relation and in longitudinal alignment to said cylinders, an annular cam ring mounted between the outer ends of said thrust members and said end support and journaled for rotation upon the latter, a bearing race aligned with said thrust members and engaging between said ring and members, and a pair of rollers carried by the outer end of each of said thrust members and straddling the longitudinal axis thereof and mounted for rotation against said cam ring.

7. In a barrel type internal combustion engine

having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust members extending longitudinally therefrom, an end support independent of said members mounted in endwise spaced relation and in longitudinal alignment to said cylinders, an end thrust bearing carried by said support in alignment with said cylinders, a cam ring mounted in alignment between said bearing and the outer ends of said thrust members and having a substantially planar end face constantly supported by said thrust bearing, the opposite end face of said cam ring opposed to said thrust members being undulated, and rollers carried by said thrust members in engagement with said undulated cam face.

8. In a barrel type internal combustion engine, a plurality of tubes defining engine cylinders, and means supporting said tubes in substantially coterminous parallel relation and in equal circumferentially spaced relation at equal radii about a common central axis comprising, pairs of substantially concentric inner and outer straps adjacent the opposite ends of said tubes between which said tubes are mounted, and means for drawing said straps together for clamping said tubes therebetween.

9. In a barrel type internal combustion engine having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust rods extending longitudinally therefrom, an end support mounted in endwise spaced relation and in longitudinal alignment to said cylinders, concentric inner and outer annular members mounted in endwise relation to the ends of said cylinders, radially aligned longitudinally extending guides carried by said members in longitudinal alignment to said cylinders, a slide member reciprocally carried by said guides for longitudinal reciprocation and connected to the outer ends of said thrust rods, and a cam ring mounted between and journaled for rotation on said slide member and said end support.

10. In a barrel type internal combustion engine having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust rods extending longitudinally therefrom, an end support mounted in endwise spaced relation and in longitudinal alignment to said cylinders, concentric inner and outer annular members mounted in endwise relation to the ends of said cylinders, radially aligned longitudinally extending guide blocks carried by said members in longitudinal alignment to said cylinders, a slide member reciprocally carried by said guide blocks for longitudinal reciprocation and connected to the outer ends of said thrust rods, said slide member and said blocks being formed with interfitting tongue and groove portions confining said slide member to a longitudinal movement, and a cam ring mounted between and journaled for rotation on said slide member and said end support.

11. In a barrel type internal combustion engine having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust rods extending longitudinally therefrom, an end support mounted in endwise spaced relation and in longitudinal alignment to said cylinders, concentric inner and outer annular members mounted in endwise relation to the ends of said cylinders, radially aligned longitudinally extending guide blocks carried by said members in longitudinal alignment to said cylinders, a cam ring mounted concentrically between said slide member and said end support and having a substantially planar end face supported for rotation on said end support, the opposite end face of said cam ring being undulated, and a plurality of rollers carried by said slide member and bearing against said undulated cam ring face.

12. In a barrel type internal combustion engine having a cylindrical bank of engine cylinders and pistons reciprocally mounted within said cylinders and having thrust rods extending longitudinally therefrom, concentric inner and outer casings mounted in endwise longitudinally extending relation from the ends of said cylinders, radially aligned longitudinally extending guide blocks carried by said casings in alignment with said cylinders, a slide member reciprocally mounted on and between said guide blocks and guided thereby for longitudinal reciprocation and connected to the outer ends of said thrust rods, an end member closing the outer ends of said casings, a cam ring journaled for rotation upon said end member and operatively engaged by said slide member for translating the reciprocating movement of said pistons to a rotary movement of said cam ring, an end closure for said casings adjacent the cylinder ends thereof defining a closed chamber adapted for receipt of oil for lubricating the above enumerated parts contained in said chamber.

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