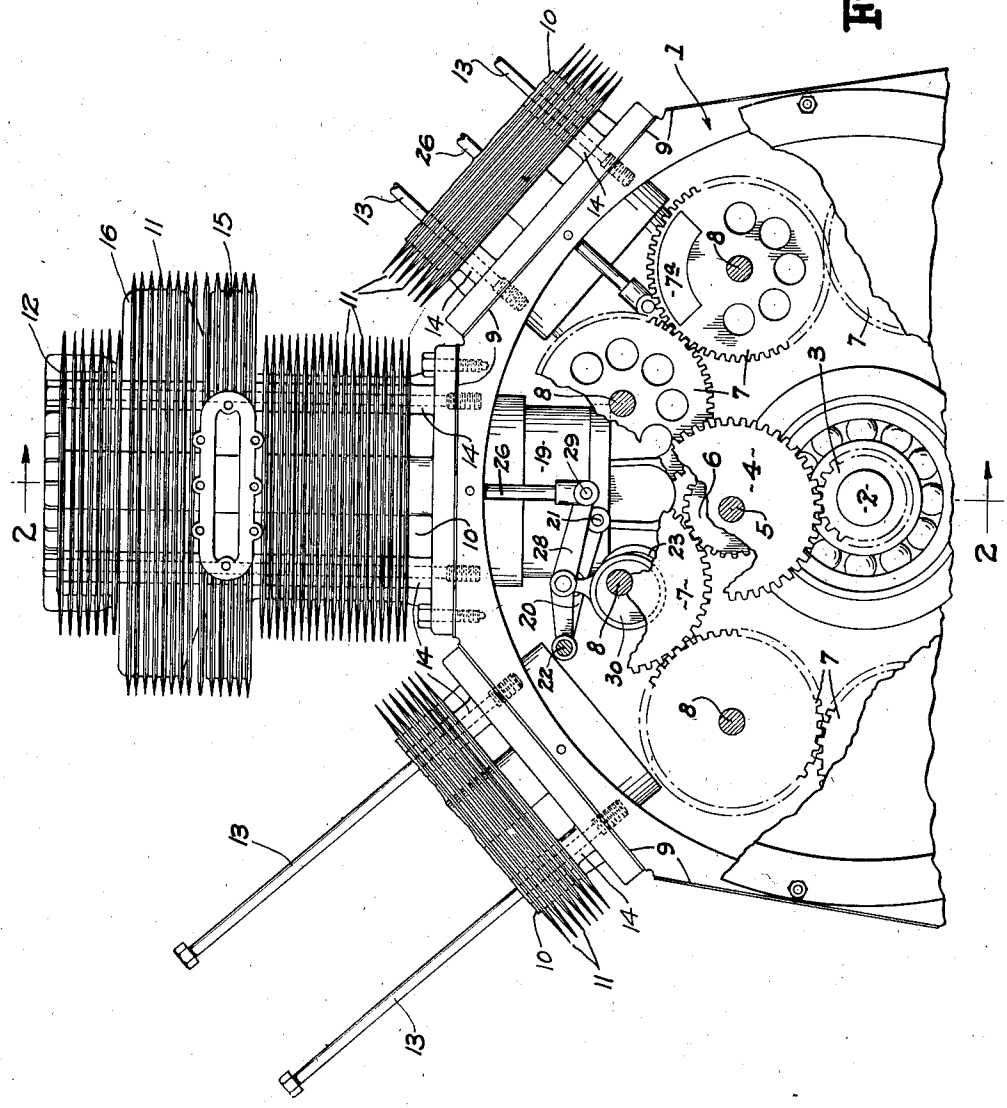
April 13, 1943. C. S. GOBY 2,316,160

INTERNAL COMBUSTION ENGINE

Filed Nov. 13, 1939 4 Sheets-Sheet 1

FIG. 1.



INVENTOR.
CLIFFORD S. GOBY

BY Hull, Brock & West
ATTORNEYS.

April 13, 1943. C. S. GOBY 2,316,160

INTERNAL COMBUSTION ENGINE

Filed Nov. 13, 1939 4 Sheets-Sheet 2

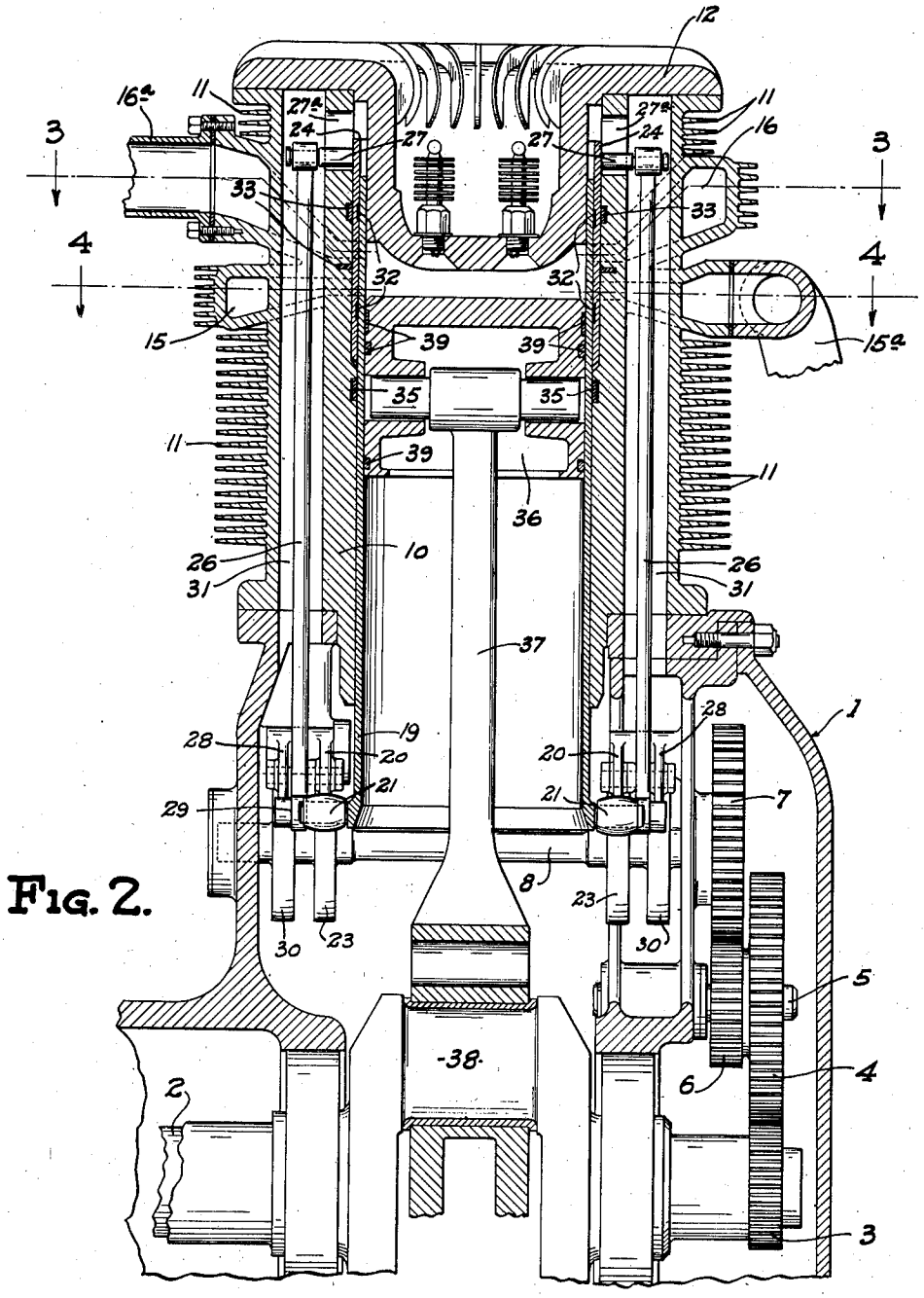


FIG. 2.

INVENTOR.
CLIFFORD S. GOBY

BY Hull, Brock & West.
ATTORNEYS.

April 13, 1943. C. S. GOBY 2,316,160

INTERNAL COMBUSTION ENGINE

Filed Nov. 13, 1939 4 Sheets-Sheet 3

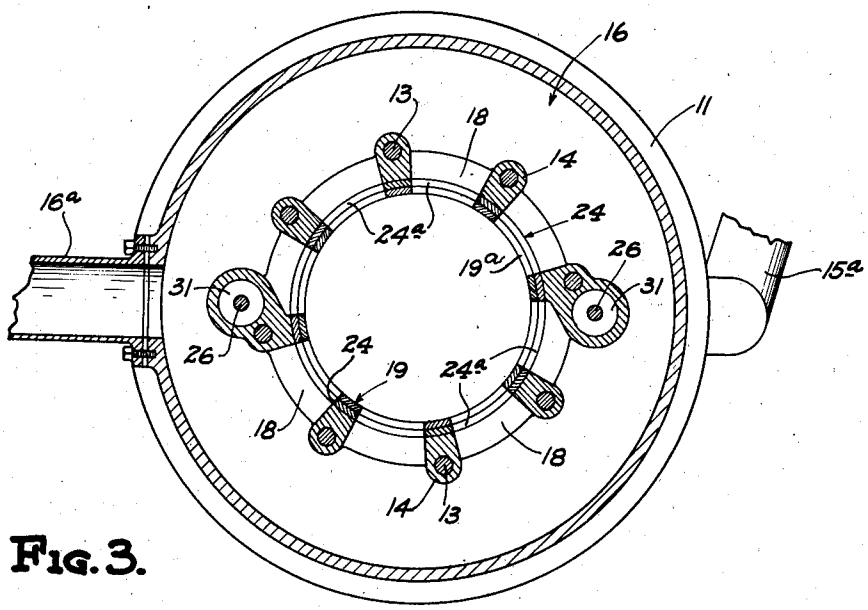


FIG. 3.

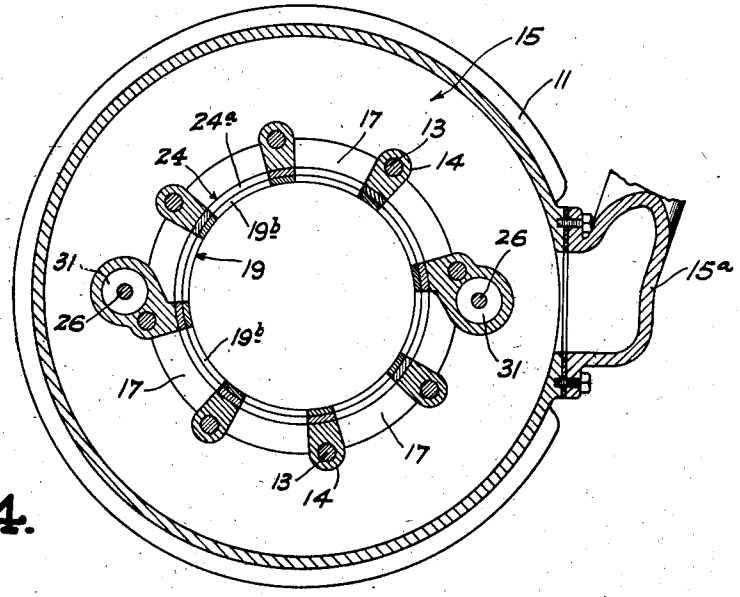


FIG. 4.

INVENTOR.
CLIFFORD S. GOBY

BY Hull, Brock & West
ATTORNEYS.

April 13, 1943. C. S. GOBY 2,316,160

INTERNAL COMBUSTION ENGINE

Filed Nov. 13, 1939 4 Sheets-Sheet 4

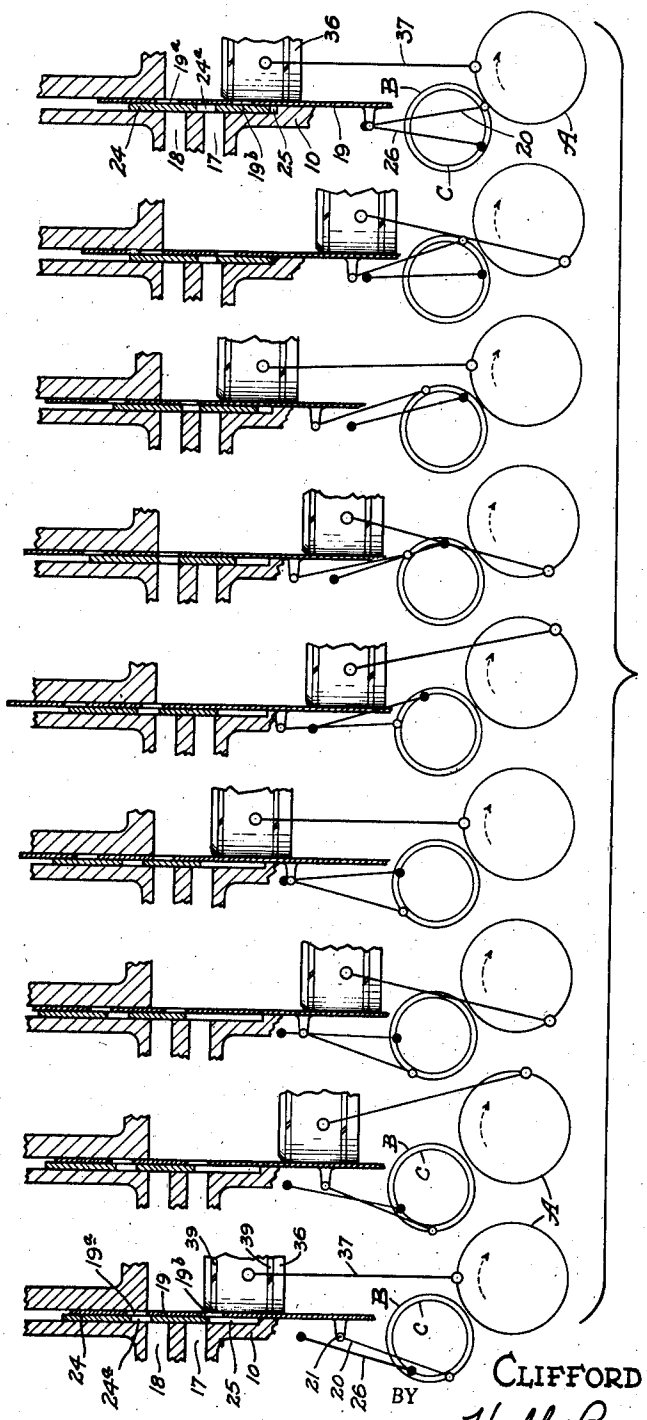


FIG. 5.

INVENTOR.
CLIFFORD S. GOBY
BY
Hull, Brock & West.
ATTORNEYS.

Patented Apr. 13, 1943

2,316,160

UNITED STATES PATENT OFFICE

2,316,160

INTERNAL COMBUSTION ENGINE

Clifford S. Goby, Cleveland, Ohio, assignor of one-half to Frank Kramer, Cleveland Heights, Ohio

Application November 13, 1939, Serial No. 303,942

8 Claims. (Cl. 123—75)

This invention relates to internal combustion engines and, while features of construction embodied therein are capable of more general use, they are especially useful in the production of aircraft engines and, in particular, of aircraft engines of the radial type.

Among the general objects of my invention are to obtain safer and more enduring power performance than is capable of realization by aircraft engines with which I am familiar. In the realization of this object, I employ a novel valve construction and a novel coordination of the same with respect to the cylinders and other engine parts with which they cooperate. I also provide a novel means for removing the stresses on cylinders of aircraft engines which is particularly valuable where aluminum or aluminum alloy is employed in the construction of the cylinders because of the ability of such metals to dissipate heat with great rapidity and thereby maintain a safe and proper cooling range for air-cooled engines.

Further and more limited objects and characteristics of my invention will be set forth hereinafter in connection with the detailed description of the parts shown in the drawings hereof, wherein

Fig. 1 shows a rear elevation, with parts broken away, of a portion of a radial engine such as is adaptable for use with aircraft;

Fig. 2 is an enlarged central longitudinal sectional view through one of the cylinders and the portion of the circular crankcase common to all of the cylinders, said section being taken on the line 2—2 of Fig. 1;

Figs. 3 and 4 are details in section taken on the lines 3—3 and 4—4 of Fig. 2, respectively; and

Fig. 5 is a diagrammatic view illustrating the positions of the valve elements with reference to the inlet and exhaust ports at different cycles of the piston movement.

Describing by reference characters the various parts shown in the drawings, 1 denotes the circular crankcase of a radial aircraft engine, the engine shown in part herein comprising nine cylinders, three of which are shown in Fig. 1. 2 denotes the crank shaft which is provided with a pinion 3 meshing with a master gear 4 supported on a shaft 5, the latter shaft being provided with a pinion 6 meshing with a gear 7 on one of the shafts 8. Each of the shafts 8 is provided with a gear 7, and these gears intermesh with one another in a well known manner.

While the crankcase has a cylindrical interior, it is provided on its exterior with flanged bases 9 to which the outer cylinder casings are secured by long through bolts which will be discussed hereinafter in connection with the cooperating features of the respective cylinders whereby they serve to anchor the cylinder casings securely and accurately to the crankcase, without danger of there being any material loss of heat dissipation by the cylinder casings.

Cylinder and valve construction

Each cylinder comprises an outer casing 10 provided with the usual heat-dissipating fins 11, with its base engaging the flanged seat 9 provided therefor on the crankcase. Each cylinder also has a head 12 which is firmly secured thereto by screw bolts 13 having their lower ends threaded into the crankcase and serving also to anchor the casings on their respective flanged seats. In order to obtain the most effective means for securing the cylinder casings to their seats, whereby all distortions of the casings and the parts therewithin may be avoided, the bolts are located as close as possible to the outside wall of each casing. The casings are provided each with hollow bosses 14 formed integral therewith and extending the full length thereof and through the bores of which the bolts 13 extend. The bores formed in the bosses intersect the exterior surface of the cylinder casing; in fact, substantially half of each bore is formed in its cylinder casing. By this arrangement, the heat-dissipating surface of each casing is slightly reduced, but it is at least compensated for by the extra metal contained within the bosses which, as stated, extend the complete length of the cylinder casings. It will be noted further that these bosses form in effect pillars, the bases whereof rest upon the flanged seats 9. In assembling, the bolts 13 are screwed in place in their respective flanged seats 9 and the cylinder casings and heads are then dropped over the bolts, after which the nuts on the outer ends of the bolts are set up, whereby the cylinder casings and their heads are anchored securely in place.

As will be pointed out hereinafter, this construction and mode of anchoring the cylinder casings removes the stresses therefrom and from the walls thereof as a whole and counteracts the effects of fatigue which is set up through prolonged operation of the engine, and particularly where aluminum or aluminum alloy is employed in the cylinder construction and where a large proportion of the cylinder casing has been re-

moved in providing the same with a circumferential series of ports, such as is shown herein. By my manner of anchoring the cylinder casings and heads to the crankshaft, I am enabled to make use of an upper and lower series of ports extending uninterruptedly around the entire circumference of the cylinder as well as the entire circumference of the sleeve and still preserve this portion of the latter and the parts therewithin against fracture and distortion.

The cylinder casing is provided with an inlet manifold 15 extending entirely therearound and with an exhaust manifold 16 also extending entirely therearound, the exhaust manifold being located above the inlett manifold. These manifolds are provided, respectively, with the inlet and exhaust pipes 15a and 16a. The inlet manifold communicates with a circumferential series of elongated ports 17 and the outlet manifold with similarly constructed and arranged ports 18. The supply of gaseous mixture to the ports 17 and the exhaust of gases of combustion through the ports 18 are controlled by my novel valve construction, which will now be described.

19 denotes a long sleeve which constitutes a valve as well as the inner wall of the cylinder and which, in its movements, is guided by the inner wall of the casing 10. This sleeve is connected at diametrically opposite portions of the bottom thereof with the reciprocating ends of rocking levers 20, as indicated at 21. The opposite ends of these rocking levers are pivoted upon a shaft 22, the intermediate portions being connected each to an eccentric strap mounted upon an eccentric 23 on the shaft 8. Similar means are provided for reciprocating the sleeve and the selector ring. The sleeve is provided, adjacent to its upper end, with a series of circumferentially arranged ports 19a which are adapted to be brought into registration with the ports 18, through the reciprocatory movements of the said sleeve: also with a series of circumferentially arranged lower ports 19b which are adapted to be brought into registration alternately with the ports 17 and 18 by such reciprocation.

Cooperating with each sleeve is a selector ring 24 which is mounted for reciprocation in a cylindrical guide 25 which is provided therefor in the interior wall of a cylinder casing. This ring is provided with a series of circumferentially arranged port 24a adapted to be brought into registration with the ports 19a and 19b of the sleeve valve 19 and alternately into registration with the inlet and exhaust ports 18 and 17 of the cylinder casing. The sleeve 19 and ring 24 are in close sliding engagement, one with the other, and the ring is operated from a shaft 8 by means of rods 26 which are connected to diametrically opposite portions of the top thereof by means of studs 27, the lower ends of these rods being each reciprocated by means of a rocker arm 28, to the reciprocating end of which the lower ends of each of the rods is connected, as shown at 29, the opposite end of each arm being also mounted upon a shaft 22 and the intermediate portion being pivotally connected to an eccentric strap mounted on the eccentric 30. Similar means are provided for reciprocating the selector rings for all of the cylinders.

It will be noted that the hollow bosses 14 are located between the inlet ports 17 and also between the outlet ports 18, thereby strengthening the cylinder casings at these places.

It will be noted that the rods 26 are mounted in large vertical ducts 31 formed in the cylinder casing. The bottoms of these ducts communicate freely with the crankcase and their upper ends with the tops of the sleeve 19 and selector ring 24, by means of the apertures 27a through which the studs 27 extend. These ducts thus afford a means for ensuring efficient lubrication of the upper portions of the selector ring and sleeve through the oil fog which is produced in the crankcase by the whirling parts therewithin.

One of the important features of my invention, whereby overheating of the valve mechanism is prevented, is the manner in which I drive the sleeves and selector rings, as well as the manner in which their ports cooperate with the inlet and exhaust ports in the cylinder casing. In all sleeve valve engines with which I am familiar, the sleeves are reciprocated once for every two reciprocations of the piston. This necessitates a speed of travel wherein vibrations that are practically negligible at lower speeds are increased to an extent which renders them dangerous. In the construction embodied herein, the sleeve and selector ring are reciprocated only once for every four reciprocations of the piston or for every four revolutions of the crankshaft. This is effected by the reduction gearing interposed between the crankshaft and the shafts 8, which serve to reciprocate the sleeve and rings through the means heretofore described. In the drawings, the gear 4 which is driven by the pinion 3 is twice the diameter of the latter; and the pinion 6 which meshes with the gear 7 is half the diameter of the latter, being also half the diameter of the other gears 7 by which the other shafts 8 are driven. Hence, with the crankshaft turning at a speed of 2000 R. P. M., the valve operating shafts 8 will be turning at only 500 R. P. M. This, together with the manner of operating the sleeves and selector rings from the valve shafts insures a very fine degree of balance and smooth running—factors which contribute largely to safety under prolonged operation. This overheating of the sleeve ports is also prevented by subjecting the ports 24a and 19b alternately to the action of the hot exhaust gases and the cool fuel mixture. While the ports 19a, as will appear from Fig. 5, are subjected only to the action of the hot exhaust gases, these ports are located in the upper portion of the sleeve 19 and are maintained out of the zone of combustion during practically the entire reciprocatory movement of the said sleeve. The maintaining of these parts cool is facilitated further by the fact that the sleeve and the selector ring are each reciprocated only once for every four reciprocations of the piston, thereby giving the ports a relatively long period of intermission between the times when they are subjected to the action of exhaust gases.

To further insure the smoothness of running, each valve shaft gear 7 is provided with a counterbalance 7a applied thereto at such point that each valve shaft, together with its eccentrics, rods, rocking arms, sleeve and selector ring, becomes a balanced unit in itself.

It will be noted that the selector ring is provided with sealing rings indicated at 32, located in shallow grooves provided within the interior surface of the said ring. In addition, contracting piston rings 33 are inserted in grooves formed within the cylinder casing above and below the exhaust ports. These sealing and contracting packing rings enable the selector ring to form an effective seal against the escape of gases due to high cylinder pressures. In addition, a contracting packing ring 35 is inserted in a groove in the

cylinder casing surrounding the exterior surface of the valve sleeve below the inlet ports. Each piston **36** is connected to the crankshaft by the usual connecting rod **37** and crank **38** and is provided with piston rings **39**.

Timing arrangement

Because of the four-to-one reduction in the reciprocatory movements of the sleeve and selector ring as compared with the reciprocatory movements of the piston, and because of the relative location of the ports in the sleeve and ring with respect to the inlet and exhaust ports in the cylinder casing, a special timing arrangement must be made, which timing arrangement will be explained in connection with the timing diagram illustrated in Fig. 5, wherein, in the individual diagrammatic views, the circles A represent the paths traveled by the cranks of the crankshaft while operating the cylinder sleeve valves through the connections described hereinbefore and the circles B and C represent the orbits traveled by the eccentrics **23** and **30**. In the nine individual views the crank, sleeve, and selector ring are shown in the relative positions which they occupy at the same instant of time in the successive cylinder casings of a nine-cylinder radial engine constructed in accordance with my invention.

It will be seen from these views that the sleeve and the selector ring move in unison throughout substantially each complete reciprocation of the same instead of moving in opposition to each other, as is the case where two sleeve valves have been employed heretofore. The only change in this unison of movement is due to a slight advance in the selector ring over the sleeve whereby the former passes over its top and bottom centers slightly in advance of the sleeve. By reference to the right hand view in Fig. 5, it will be seen that the port **19a** in the sleeve valve is in nearly full open position and will assume its full open position when the piston travels a slightly greater distance in the direction indicated by the arrow. However, the selector ring will have been raised intermediate the position shown in the right hand view and that shown in the left hand view, bringing the ports **24a** thereof in register with the ports **18** and **19a**, which permits the free escape of the exhaust gases. Except for this slight change in the direction, the sleeve and the selector ring travel always in the same direction and at substantially the same rate of speed, although the throw of the selector ring is less than that of the sleeve, as will be evident from Fig. 5. The fact that they travel so together facilitates their counterbalancing and reducing to a minimum the friction created between them due to their reciprocatory movements. Finally, the employment of the short selector ring renders it permissible to operate the sleeve at a much lower rate of speed than is usually employed with sleeve valves. It also enables the use of wide clear ports which encircle the entire circumference of the cylinder and thus induce a highly effective flow of gas without resorting to hazardous valve overlapping, with its susceptibility to dangerous backfires and disaster. The selector ring as constructed and operated provides an effective means for sealing the burning gases within the cylinder from the inlet port and from the supply of gaseous fuel thereto.

It will be noted that the contracting piston rings **33** and **35** are inserted in grooves formed within the cylinder casing and not in grooves formed within the exterior walls of the sleeve valve and of the selector ring. This is because of the fact that the cylinder casing is made of aluminum or aluminum alloy and hence should not be subjected to the sliding pressure of rings inserted into the exterior surface of the sleeve valve and of the selector ring.

Due to the construction and arrangement of the parts described herein, I am enabled to obtain the following important advantages over other sleeve valve constructions with which I am familiar: (1) to employ inlet and exhaust ports that encircle the entire circumference of the cylinder but without danger of distortion or fracture in this zone, due to fatigue; (2) to determine the opening and closing points of the valve by the fixed edges of the ports in the cylinder casing, instead of by the lapping of the valve sleeve against another relatively moving element; (3) due to the manner of operating the valve sleeve and selector ring, to practically eliminate movement of the ring against the exterior surface of the valve sleeve; (4) to drive the valve sleeve and the selector ring uniformly and from diametrically opposed points thereby to eliminate any undue driving stresses; (5) to eliminate sleeve and cylinder distortion; (6) to obtain a valve operation which is positive and certain at high engine speeds; (7) to eliminate the danger of overheating the sleeve ports; (8) to provide an effective seal against the escape of gases, due to high cylinder pressures through the location of the contracting packing rings; (9) to operate safely under high compression; and (10), in general, to obtain safer and more enduring power performance than has been hitherto capable of accomplishment in engines of the type to which my invention relates.

Having thus described my invention, what I claim is:

1. An internal combustion engine comprising a cylinder casing having a circumferential series of inlet ports extending therearound and a circumferential series of exhaust ports extending therearound and longitudinally spaced from the inlet ports, a cylinder sleeve reciprocably mounted within the said casing and having longitudinally spaced circumferential series of ports extending therearound and adapted to register with the two series of ports in the casing, a selector ring reciprocably mounted in the casing and surrounding the cylinder sleeve and provided with a circumferential series of ports extending therearound and adapted to register alternately with the two series of ports in the casing, an inlet manifold surrounding all of the inlet ports in said casing and adapted to supply gaseous fuel to all of said inlet ports, an exhaust manifold surrounding all of the exhaust ports in said casing and adapted to receive exhaust gases from all of said exhaust ports, a piston reciprocable in said cylinder sleeve, a crankshaft, and driving connections between said crankshaft and said piston, sleeve and ring for reciprocating the sleeve and the ring once for every four reciprocations of the piston and for bringing one series of ports in the sleeve into and out of register with the exhaust ports of the casing and for bringing the other series of ports in the sleeve alternately into and out of register with the inlet and exhaust ports of the casing and for bringing the series of ports in the ring alternately into and out of register with the exhaust ports of the casing and with the first series of ports in the sleeve and into and out of register with the inlet ports in the casing and with the second series of ports in the sleeve.

2. An internal combustion engine comprising a crankcase, a cylinder casing having vertically spaced inlet and exhaust ports, a cylinder sleeve reciprocably mounted in said casing and having one or more ports in its upper portion adapted to be brought into and out of registration with said inlet and exhaust ports, a selector ring reciprocably mounted within the casing exteriorly of said sleeve and having one or more ports adapted to be brought into and out of registration with said inlet and exhaust ports, a piston in said cylinder sleeve, a crankshaft in said crankcase, driving connections between said crankshaft and said piston, cylinder sleeve and selector ring for reciprocating the same in timed relation to one another, the driving connections for the selector ring comprising rods reciprocably mounted in ducts formed in said casing and connected to substantially equi-angularly spaced portions of the top of said ring by studs extending through apertures extending inwardly above the tops of said ring and sleeve, the bottoms of said ducts communicating with said crankcase and providing spaces between the inner walls thereof and the said rods for the free passage of lubricating fluid to the upper portions of said sleeve and ring.

3. An internal combustion engine comprising a cylinder casing having inlet and exhaust ports, a cylinder sleeve reciprocably mounted within said casing and having one or more ports adapted to register with said inlet and exhaust ports, a selector ring reciprocably mounted within the casing and surrounding said sleeve and having one or more ports adapted to register with the inlet and exhaust ports, a piston reciprocably mounted in said sleeve, means for reciprocating the piston, sleeve and selector ring in timed relation to one another, the means for reciprocating the sleeve and ring comprising a shaft and means for rotating the same, rocker arms connected to opposite sides of the bottom of said sleeve, rocker arms and rods connected thereto and to opposite sides of the top of said ring, and means driven by said shaft for reciprocating said rocker arms.

4. In the engine set forth in claim 3, the means for rotating the shaft comprising a driven gear thereon, means for driving said gear, and a counterbalance carried by said gear for the said sleeve, selector ring, rocker arms and the connections between said arms and the said sleeve and ring.

5. In the engine set forth in claim 3, the means for reciprocating the rocker arms comprising eccentrics driven by said shaft and operatively connected with said arms intermediate of the ends of the latter and the means for rotating the shaft comprising a driven gear thereon and a counterbalance carried by said gear for the said sleeve, selector ring, rocker arms, eccentrics, and the connections between the rocker arms and the sleeve and selector ring.

6. An internal combustion engine comprising a cylinder casing having longitudinally spaced inlet and exhaust ports, a cylinder sleeve reciprocably mounted within the said casing and having longitudinally spaced ports, one of which is adapted to be brought into and out of register with the inlet port of the casing and the other of which is adapted to be brought alternately into and out of register with the exhaust port of the casing, a selector ring reciprocably mounted in the casing and surrounding the cylinder sleeve and provided with a port, a crank shaft, driving connections between said crank shaft and said piston, sleeve and ring for reciprocating the sleeve and ring once for every four reciprocatings of the piston and for bringing one of the ports in the sleeve into and out of register with the exhaust port of the casing and the other port in the sleeve internately into and out of register with the inlet and exhaust ports of the casing and for bringing the port in the selector ring alternately into register with the inlet and exhaust ports of the casing and simultaneously therewith into register with the cooperating ports in the sleeve.

7. In the engine recited in claim 6, the driving connections including means for moving the sleeve and selector ring in the same direction throughout substantially each complete reciprocatory movement thereof.

8. An internal combustion engine comprising a crankcase, a cylinder casing having vertically spaced inlet and exhaust ports, a cylinder sleeve reciprocably mounted in said casing and having one or more ports in its upper portion adapted to be brought into and out of registration with said inlet and exhaust ports, a selector ring reciprocably mounted within the casing exteriorly of said sleeve and having one or more ports adapted to be brought into and out of registration with said inlet and exhaust ports, a piston in said cylinder sleeve, a crankshaft in said crankcase, driving connections between said crankshaft and said piston, cylinder sleeve and selector ring for reciprocating the same in timed relation on one another, the driving connections for the selector ring comprising a rod reciprocably mounted in a duct formed in said casing, said rod being connected to the top of said ring by a stud extending through an aperture extending inwardly above the top of said ring and sleeve, the bottom of said duct communicating with the said crankcase and providing a space between the inner wall thereof and said rod for the free passage of lubricating fluid to the upper portions of said sleeve and ring through said aperture.

CLIFFORD S. GOBY.