July 24, 1934. J. SCHUBERT 1,967,596

INTERNAL COMBUSTION ENGINE

Filed Nov. 5, 1931 5 Sheets-Sheet 1

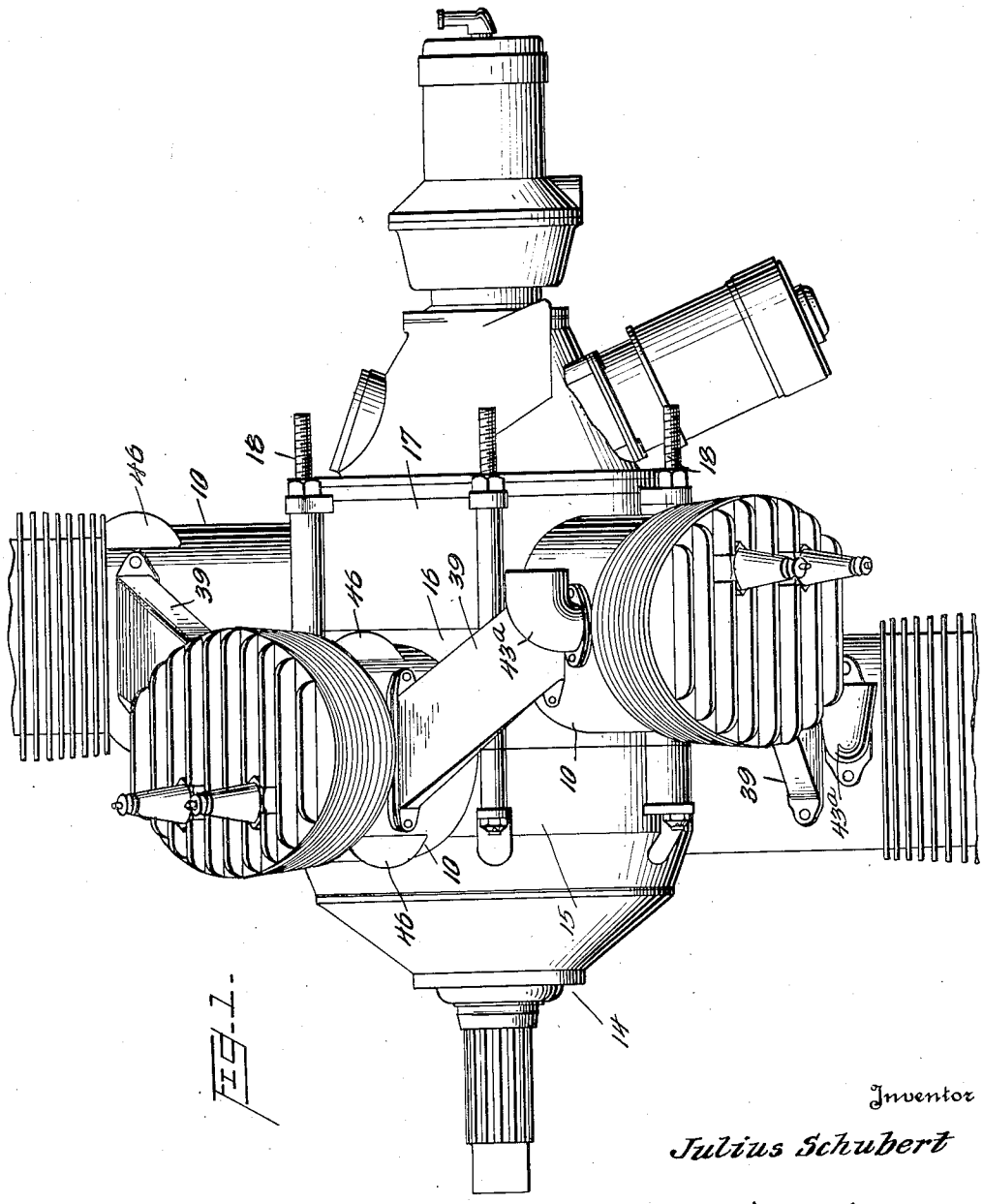


FIG. 1.

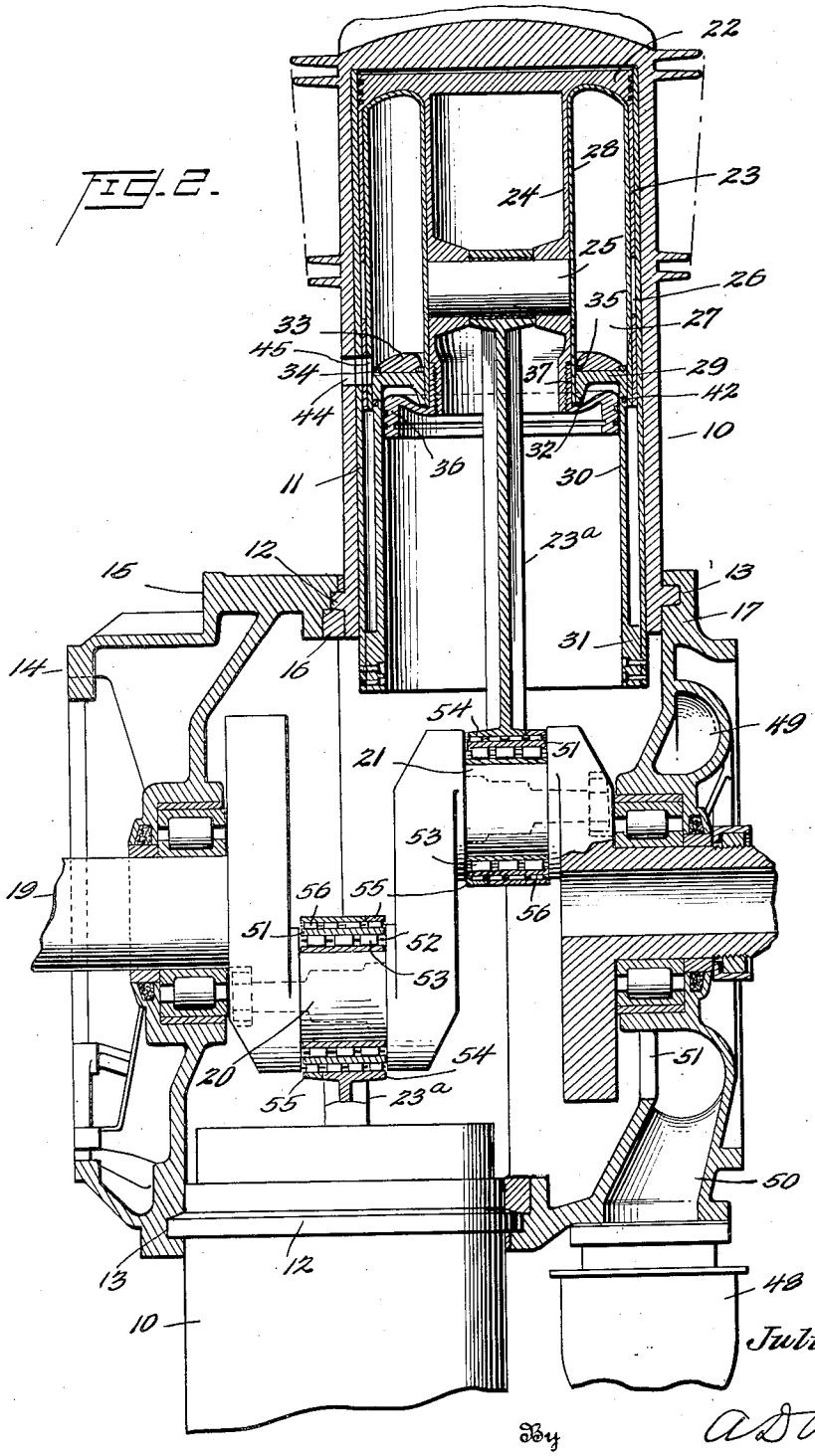
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July 24, 1934. J. SCHUBERT 1,967,596

INTERNAL COMBUSTION ENGINE

Filed Nov. 5, 1931 5 Sheets-Sheet 2

FIG. 2.



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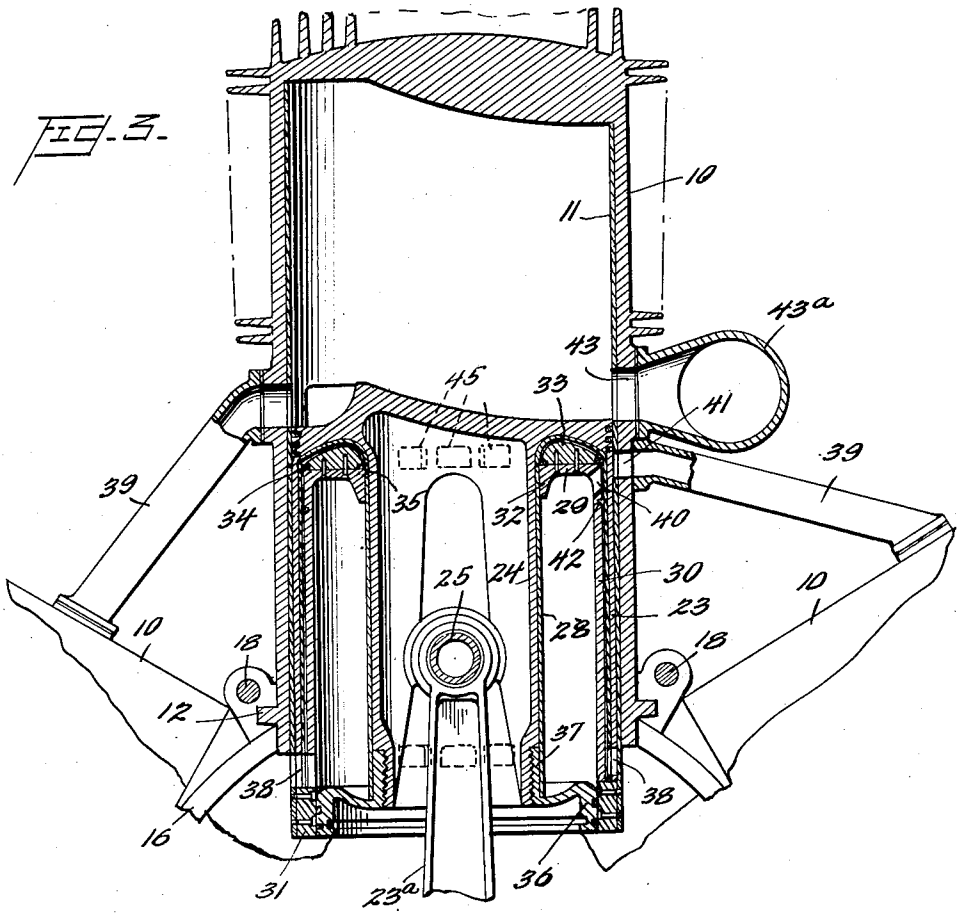
Attorney

July 24, 1934. J. SCHUBERT 1,967,596

INTERNAL COMBUSTION ENGINE

Filed Nov. 5, 1931 5 Sheets-Sheet 3

FIG. 3.



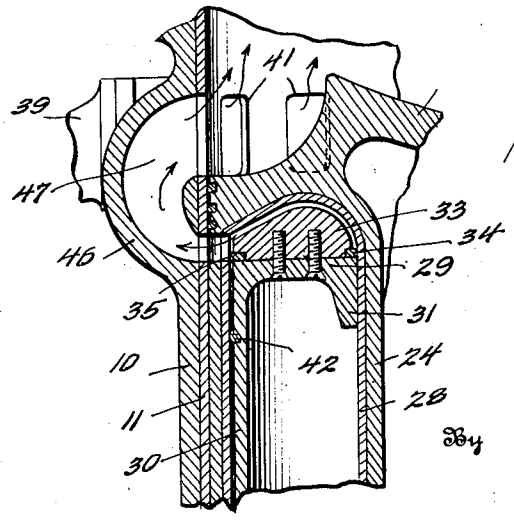


FIG. 4.

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July 24, 1934. J. SCHUBERT 1,967,596

INTERNAL COMBUSTION ENGINE

Filed Nov. 5, 1931 5 Sheets-Sheet 4

FIG. 5.

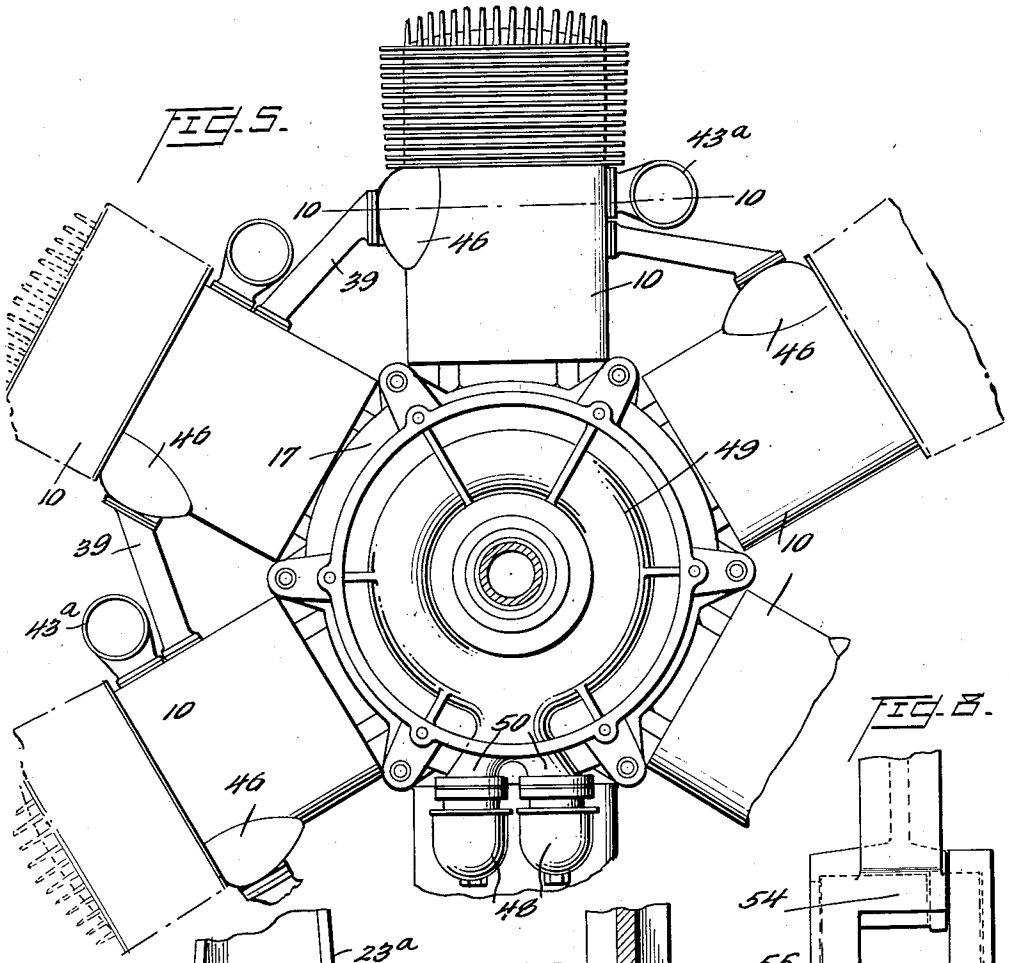


FIG. 6.

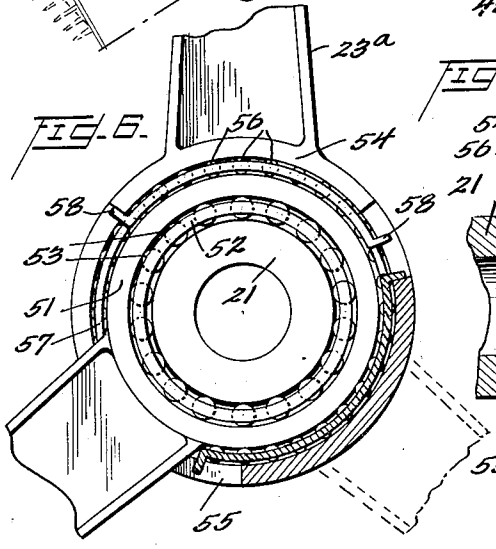


FIG. 7.

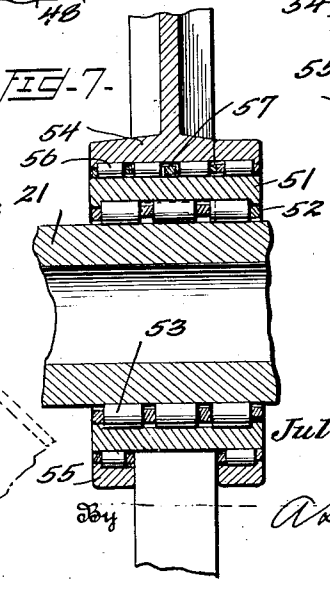
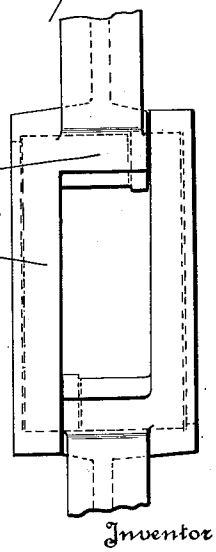


FIG. 8.



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July 24, 1934. J. SCHUBERT 1,967,596

INTERNAL COMBUSTION ENGINE

Filed Nov. 5, 1931 5 Sheets-Sheet 5

FIG. 9.

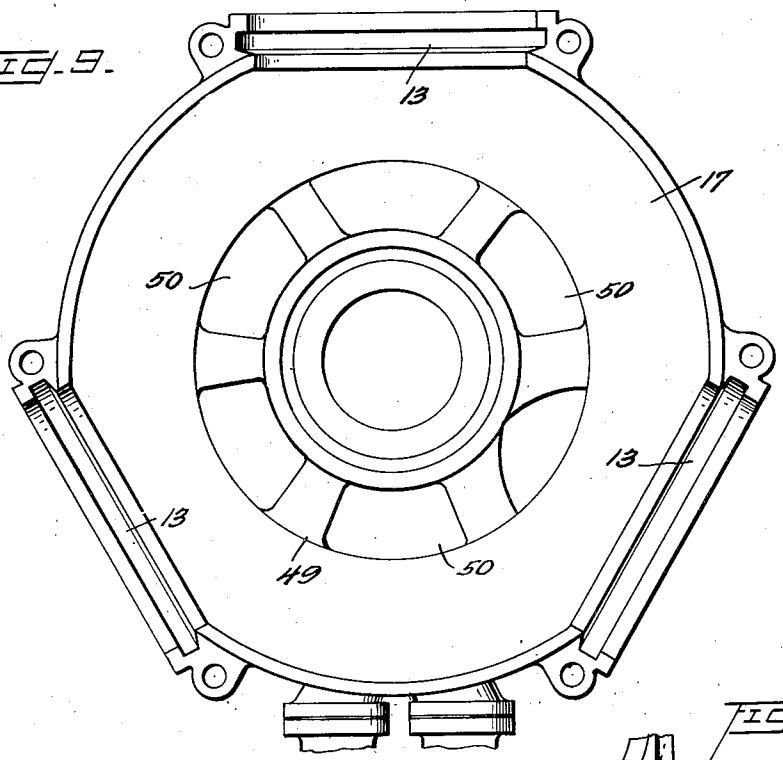


FIG. 10.

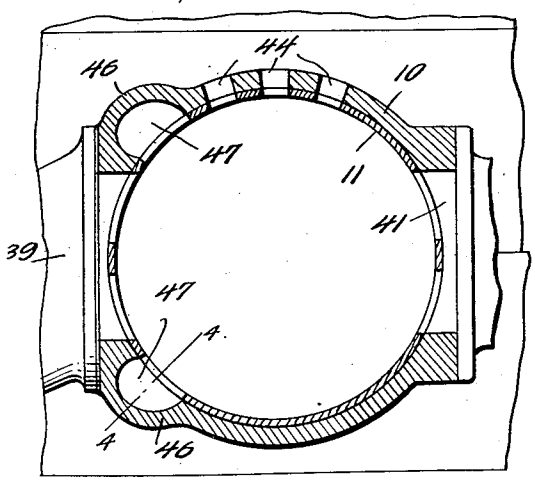


FIG. 11.

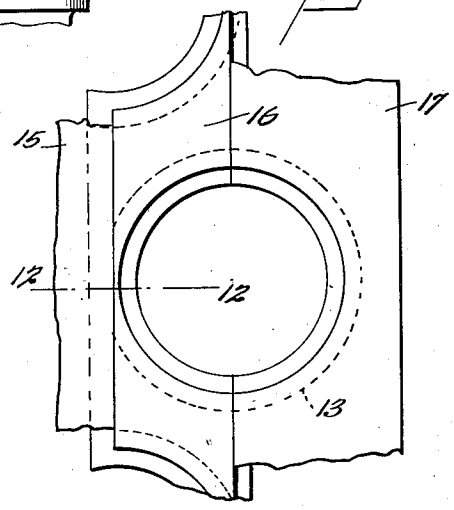
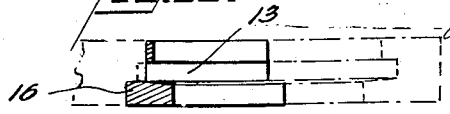


FIG. 12.



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UNITED STATES PATENT OFFICE

1,967,596

INTERNAL COMBUSTION ENGINE

Julius Schubert, Lyndhurst, N. J.

Application November 5, 1931, Serial No. 573,209

6 Claims. (Cl. 123—55)

This invention relates to internal combustion engines and, among other objects, aims to provide a very efficient, light-weight, two-cycle engine of the radial cylinder type adapted for use in the aeronautical, automotive, and marine fields, as well as in stationary power plants. This application involves important improvements in the engine disclosed in by pending application Ser. No. 438,209, filed Mar. 22, 1930.

Other aims and advantages of the invention will appear in the following description when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a top plan view of an engine embodying the invention;

Fig. 2 is a fragmentary sectional view through one of the cylinders;

Fig. 3 is an enlarged fragmentary sectional view through one of the cylinders and taken at right angles to the plane of the section in Fig. 2;

Fig. 4 is another enlarged fragmentary sectional view taken through an air inlet port in one of the cylinders;

Fig. 5 is a rear end elevation, parts being broken away;

Fig. 6 is an enlarged fragmentary view partly in section showing the preferred form of connecting rod bearings;

Fig. 7 is a vertical sectional view of the bearing assembly shown in Fig. 6;

Fig. 8 is a fragmentary side elevation of the assembled connecting rods, the bearings being omitted;

Fig. 9 is an elevation of one end of the preferred form of crank case;

Fig. 10 is a fragmentary sectional view taken on the line 10—10 of Fig. 5, the piston being omitted;

Fig. 11 is a fragmentary plan view of the preferred form of sectional crankcase; and

Fig. 12 is a sectional view taken on the line 12—12 of Fig. 11.

As far as I am aware, no efficient, high-speed, two-cycle engine suitable for aircraft and automotive use has been produced commercially. The best automotive and aviation engineers seem to have dismissed it from consideration as being too heavy and inefficient for such uses. The principal reason for this resides in the fact that no one apparently has succeeded in getting the proper lubrication, cooling, fuel distribution, high volumetric and thermal efficiency, speed and low weight per horsepower which are some of the most essential factors in the design of commercially practicable engines of this type. The ordinary two-cycle engines having crankcase compression are far too inefficient and heavy to be adopted generally.

Many efforts have been made to improve the old style two-cycle engines so as to increase their speed and efficiency. Among other things, stepped pistons have been employed to provide pumps for the fuel or fuel mixture.

In my aforesaid application, which discloses a radial engine, fuel mixture is delivered successively to staggered power cylinders by stepped piston pumps. The cylinders are there arranged in two staggered rows and those in each row are offset with respect to each other and longitudinally of the crank-shaft to make room for the connecting rod bearings on the two crankpins. While that type of engine is quite efficient at high speeds, it has no provision for delivering compressed air to the power cylinders. Moreover, there are several features which can be improved. The present invention provides a greatly improved two-cycle engine having two circular rows of staggered cylinders and composite pistons having provision for charging the power cylinders with both air and fuel mixture in proper timed relation so as to insure good scavenging action and very high volumetric efficiency. Furthermore, the principal aim is to simplify the design and construction so as to reduce the weight per horse power and greatly increase the efficiency of the engine at very high speeds. In short, the idea is to provide a commercially practicable six cylinder, two-cycle radial engine especially adapted for use in the automotive and aircraft fields.

Referring particularly to the drawings, the preferred embodiment of the engine is there shown as having six cylinders arranged in two staggered rows with the cylinders in one row overlapping the cylinders in the other row and all of the cylinders in each row being located with their axes in the same plane instead of being offset as disclosed in my aforesaid application.

In this example the cylinders 10 are shown as having cylindrical sleeves 11 which are preferably made of steel or some other wear resisting metal extending throughout the lengths of the cylinders and beyond their inner ends. At the lower or inner end of each cylinder casting there is shown an annular flange 12 adapted to be secured in a correspondingly shaped groove 13 in a sectional crankcase generally designated as 14. The crank case comprises a front section 15, an intermediate section 16 and a rear section 17, all of which are preferably secured

together by means of assembly bolts 18 (Fig. 1). These sections are preferably made of some relatively light and durable metal and are conveniently bolted together before being machined to receive the inner ends of the cylinders. The width of the intermediate section is equal to the distance between the axes of the two rows of cylinders. In other words, its opposite edges bisect the two rows of cylinders so that, when either the front or the rear section is removed, access can be had to the front or rear row of cylinders, respectively, without disturbing the other row. The reverse of this operation applies to the assembly of the cylinders in the crankcase.

Referring to Fig. 2 there is shown a crankshaft 19 having two crank pins 20 and 21 for both rows of cylinders. This crank-shaft is preferably made in sections or parts somewhat similar to that disclosed in my aforesaid application. Within each cylinder there is arranged a working piston 22 having a connecting rod 23 connected to one of the crank-pins. The piston is shown as being made of a hollow casting having an outer skirt 23 bearing against the sleeve 11 and an inner skirt 24 to receive the wrist pin 25. The outer skirt 23 preferably has openings 26 on diametrically opposite sides to permit insertion and removal of the wrist pin. As will be noted in Fig. 2, an annular chamber 27 is provided between the outer and inner skirts. This chamber and the working head of the piston are utilized to pump or compress air to charge the working cylinder on the inward stroke of the piston. In this example the chamber is lined with a sleeve 28 preferably, though not necessarily, formed of one piece of metal which serves to confine the wrist pin in its bearings, to cover the openings 26 in the outer skirt and to provide a wear resisting surface for the fixed or stationary lower end of the chamber.

In Fig. 3 there is shown an annular ledge 29 between the inner and outer skirts of the piston supported by a cylindrical sleeve 30 spaced from and bolted or otherwise removably secured to the inner end portion of the lining sleeve 11 of the cylinder. The inner end of the sleeve 30 preferably has an outer, annular flange 31 to space it from the inner sleeve 11 as shown. The annular ledge 29 is shown as having inwardly projecting flanges 32 to provide an adequate bearing surface for the outer wall of the lining sleeve on the inner skirt of the piston. On the ledge there is secured an annular block 33 having suitable grooves to receive outer and inner expanding and contracting rings 34 and 35, respectively, so as to prevent air from escaping between the ledge and the lining flange.

As will be noted in Figs. 2 and 3, the inner skirt 24 extends inwardly beyond the wrist pin and is provided with a removable, stepped enlargement constituting an annular fuel pump piston 36. In this instance the fuel pump piston has a screw threaded cylindrical flange 37 screwed on an externally threaded end portion of the skirt 24 and the upper face of the piston abuts the lower end of the lining sleeve 28 to lock and hold the sleeve in place. It will be further noted that the fuel piston is slightly corrugated in cross-section or has a sinuous, radial web to permit expansion and contraction. The provision of the removable piston or step on the inner end of the inner skirt makes possible the assembly of the composite piston in the cylinder. The step is not assembled until the working piston is inserted and the annular partition 29 is secured to the inner end of the cylinder sleeve 11. It will be seen that the fuel piston bears against the supporting sleeve 36 for the annular ledge 29. The space between the stepped piston and the lower side of the ledge constitutes a fuel pump chamber adapted to be charged with fuel from the crankcase. When the piston is in the inner end of its stroke it uncovers fuel intake ports 38 communicating with the crankcase. As the piston moves outwardly, it covers the ports and compresses the fuel charge in the fuel chamber so as to supply a charge to the next adjoining working cylinder in the other row of cylinders through a fuel conduit 39 when the working piston in said adjacent cylinder reaches the inner end of its stroke. The cylindrical sleeve 30 is shown as having a port 40 and one of the intake ports 38 at the lower end of the piston skirt registers with the port 40 and an opening 41 in the cylinder wall at the end of the conduit 39. To prevent fuel from escaping between the metal sleeve 28 on the inside of the outer skirt and the cylindrical sleeve 30 there is shown an expanding ring 42 below and adjacent to the port 40.

The piston in Fig. 3 is at the inner end of its stroke and the charge of fuel and air is being admitted while exhaust is taking place through the exhaust port 42 and the fitting 43. The inner face of the piston has compressed a charge of air, previously admitted to the air chamber through the ports 44, preferably, but not necessarily, at the front of the cylinder and the ports 45 through the outer skirt of the piston when said ports register at the outer end of the stroke. Referring to Fig. 4 the cylinder wall is shown as having cored enlargements 46 providing short air passages 47 from the lower end of the air chamber to a point above the piston. The air rushes into the cylinder under very high pressure and slightly ahead of the fuel charge which comes through the fuel conduit 39 and thus scavenges the products of combustion from the power cylinder before any of the fuel is admitted. The fuel pumping piston in the cylinder to the left of the working cylinder shown in Fig. 3 does not reach the outer end of its stroke to fully compress the fuel charge until the crank-shaft has rotated to the left about sixty degrees. This timing of the admission of air and fuel is of very great importance because of the desirability to scavenge the exhaust gases before the relatively rich fuel mixture has entered the working cylinder. Very little of the compressed air charge is lost through the exhaust port, but remains in the power cylinder to commingle with the rich fuel mixture and greatly increase the volumetric efficiency of the engine. As will be noted from the design, the volume of each charge in a power cylinder is measured by the volume of the fuel pumping chamber and of the air chamber. Moreover, the charges are compressed on both strokes of the pistons; that is to say, the air is compressed on the inward stroke, while the fuel charge is compressed on the outward stroke of the piston in the next adjacent cylinder.

Fuel mixture is admitted to the crankcase through one or more ordinary carburetors 48 on the rear section 17, a pair of carburetors being shown. The rear end wall of the crankcase section 17 is shown as being cored to provide a substantially annular manifold 49 to receive the mixture through a pair of branches 50 leading to the carburetors (see Figs. 5 and 6). The purpose of

the annular manifold, which has a series of openings 51 discharging into the crankcase is to insure proper distribution of the mixture to the various cylinders arranged around the periphery of the crankcase. The idea is to prevent an excess of rich fuel mixture from entering the fuel pumping chambers in the lower portion of the crankcase; otherwise an excess of condensed fuel would accumulate in the bottom portion of the crankcase and enter the lower cylinders, causing them to smoke and gum up with carbon before the upper cylinders. The annular manifold distributes the fuel mixture so that it is thrown by centrifugal force all around the inside of the crankcase adjacent to the inner ends of the cylinders and the mixture is thus kept practically uniform.

As has been previously stated, the cylinders in each row are arranged with their axes in the same plane. The connecting rods for each row of cylinders are also in the same plane. In this instance all of the connecting rods have roller bearings. Referring to Fig. 6 a master connecting rod at the lower left hand side is shown as having cylindrical bearing portion 51 extending the entire length of the crank-pin. Between the inner face of this bearing portion and the crank-pin is a metal cage 52 carrying a plurality of rollers 53. The outer surface of this bearing portion provides a bearing surface for the other two connecting rods. The upper connecting rod is shown as having a relatively wide bearing portion 54 extending part way around the cylindrical bearing 51 and is then stepped or cut away to provide a narrow ring 55 at the bottom as viewed in Fig. 7 which contacts with the left hand side of the connecting rod at the bottom. The narrow portion or ring 55 of the bearing merely serves to hold the bearing assembled. The wide part at the inner end of the connecting rod takes all of the thrust or load during the power and compression strokes. The wide part extends a little less than a third of the way around master bearing and is shown as having a plurality of rows of small rollers 56 retained in a cage 57 which is shaped to correspond with the shape of the bearing portion. The outermost row of rollers extends entirely around the bearing; while the two inner rows are coextensive with the wide part of the bearing. Now, the connecting rod necessarily has oscillating movement with respect to the bearing of the master connecting rod. Hence, it is necessary for the cage 57 to oscillate with the upper connecting rod in order to prevent its wide bearing portion from uncovering the rollers adjacent to the opposite ends of the wide part and permitting them to fall out. To this end, the ends of the wide part of the cage are bent radially outwardly or have flanges 58 against which the ends of the wide part 54 strike so as to prevent too much relative rotation of the cage and insure that all of the rollers will remain between the bearing surfaces. Incidentally, the roller cage will oscillate at less than half of the speed of the connecting rod. The third connecting rod has a bearing identical with the bearing just described. The wide part of it is shown in section in Fig. 6. The circumferential lengths of the wide portion are such as to permit the required relative oscillating movement of the bearings without clashing. That is the main reason for making them extend about a third the way around the bearing portion of the master connecting rod. It will be observed in Fig. 7 that the narrow ring portions of the two outer bearings are on opposite sides of the master connecting rod.

From the foregoing description, it will be seen that all of the parts of the described engine are relatively simple and can be standardized. The manufacture is greatly simplified and the parts can be assembled and dismantled with a minimum of effort. There are no valves or other delicate moving parts which require adjustment. The power can be varied to suit requirements without making expensive alterations in design. Moreover, engines of this type are designed to use different grades of fuel. The volumetric efficiency is very much greater than the efficiency of the same type of engine, utilizing only one stepped piston to compress the fuel charges only. By utilizing the same composite pistons for compressing additional air charges, the power is increased by at least one third. Furthermore, the design is the most compact arrangement possible and this enables the weight of the engine to be reduced to as little as one half pound per horse power—a very desirable feature in connection with aircraft engines.

Obviously, the present engine is not restricted to the particular embodiment thereof herein shown and described. It is not indispensable that all of the features shall be used conjointly, but they are capable of use in various combinations and sub-combinations.

What I claim is:—

1. A two-cycle internal combustion engine comprising, in combination, a crank case; six radial cylinders secured to the crank case in two circumferential rows with three cylinders in each row, the cylinders in one row being staggered with respect to the cylinders in the other row; a single crank shaft having two opposed cranks; a composite piston in each cylinder having a stepped annular portion constituting a fuel pump connected to deliver fuel charges from the crank case into the next adjacent cylinder in the other row; a pair of cylindrical skirts on the working piston; an annular stationary ledge between the skirts defining an air compression chamber; and short conduits in the cylinder wall connecting the air compression chamber with the working cylinder so as to charge the working cylinder when the piston reaches the inner end of its stroke, the initial charge of air being admitted slightly ahead of the charge of fuel mixture whereby it is utilized to scavenge the exhaust gases.

2. In a two-cycle internal combustion engine having separate rows of radial cylinders with the cylinders in each row staggered with respect to the cylinders in the other row; a sectional crank case having provision to be clamped longitudinally on the inner ends of the cylinders and hold them assembled; a lining sleeve in each cylinder projecting into the crank case; a composite piston in each cylinder having spaced cylindrical skirts projecting inwardly from the piston head; an annular fuel pumping piston removably secured to the inner end of the smaller skirt; a cylindrical supporting sleeve secured at its inner end to the lining sleeve and carrying a stationary annular ledge constituting the upper end of an annular fuel pumping chamber and the lower end of an annular air pumping chamber; fuel conduits connecting the outer ends of the fuel pumping chambers to the respective working cylinders in the next row; and air delivering conduits connecting the lower ends of the air chambers to their own power cylinders.

3. In a two-cycle internal combustion engine,

a sectional crank case; two circumferential rows of radial cylinders assembled in the crank case with the cylinders in one row staggered with respect to the cylinders in the other row; annular flanges formed on the inner ends of the cylinders; said sections of the crank case having annular grooves interlocking with said annular flanges to hold the cylinders assembled; assembly bolts extending longitudinally of the sections and clamping them against the cylinders; composite pistons arranged in the cylinders each having a pair of spaced cylindrical skirts; a removable pump piston associated with the innermost skirt; a cylindrical supporting wall within each cylinder adjacent to the inner wall of the outer skirt and constituting a cylinder wall for the fuel pumping piston; a fixed annular ledge carried by each cylindrical supporting wall and providing the outer end of the fuel pumping chamber and the inner end of an air compression chamber defined by the spaced skirts; and conduits connecting the fuel pumping chambers and the air compression chambers to the respective power cylinders, so arranged that each fuel pump supplies a charge of fuel mixture to a cylinder head of it in the other row while the air is admitted to the cylinder in the same row so that the air charges are delivered to the working cylinders slightly in advance of the fuel charges and scavenges the exhaust gases from the cylinders.

4. In a two-cycle internal combustion engine, a crank case composed of a pair of end sections and a relatively narrow intermediate section, each of said sections having interlocking joints; six radial cylinders secured to the crank case and arranged in two circumferential rows staggered with respect to each other; external annular flanges on the inner ends of the cylinders interlocking with and clamped between adjacent sections of the crank case; composite, skirted pistons and fixed annular abutments associated therewith arranged in the cylinders and providing separated fuel and air compressors within the outer skirt of each piston; a series of conduits connecting the fuel pumping chambers with the power cylinders, each conduit extending from one cylinder to the fuel pumping chamber in the cylinder of the other row behind it with respect to the direction of rotation of the engine; and air conduits connecting the air compressor chambers to their own power cylinders whereby the air enters the power cylinders slightly in advance of the fuel charges to scavenge the exhaust gases.

5. In a two-cycle internal combustion engine, a sectional crank case; a plurality of radial cylinders connected to the crank case and arranged in two rows staggered with respect to each other, there being three cylinders in each row; interlocking connections between the inner ends of the cylinders and the crank case; tie bolts extending longitudinally of the crank case between the cylinders and clamping the sections in assembled relation on the cylinders; a composite double-skirted piston in each cylinder having an annular fuel pumping piston connected thereto; a stationary, annular ledge within the piston between the skirts defining separated air compressor and fuel pump chambers; a conduit connecting each fuel pump chamber with the adjacent power cylinder in the other row; and means connecting each air compression chamber with its own power cylinder.

6. In a two-cycle internal combustion engine, a composite piston having a pair of spaced cylindrical skirts; a fuel pumping piston removably connected to the inner skirt and extending between the skirts; a cylindrical supporting member projecting outwardly from the inner ends of the cylinders between the inner wall of the outer skirt and the pumping pistons to provide a cylinder therefor; a stationary ledge supported by the cylindrical member intermediate the ends of the piston and filling the annular space between said skirts; said annular ledge constituting a division wall between and defining the upper end of the fuel pump chamber and an air compression chamber wholly within the piston; and conduits connecting said fuel chambers and air chambers to deliver both air and fuel mixture charges to the cylinders.

JULIUS SCHUBERT.