June 2, 1931. J. M. ROYAL 1,808,380

AIRPLANE ENGINE

Filed Feb. 6, 1929 3 Sheets-Sheet 1

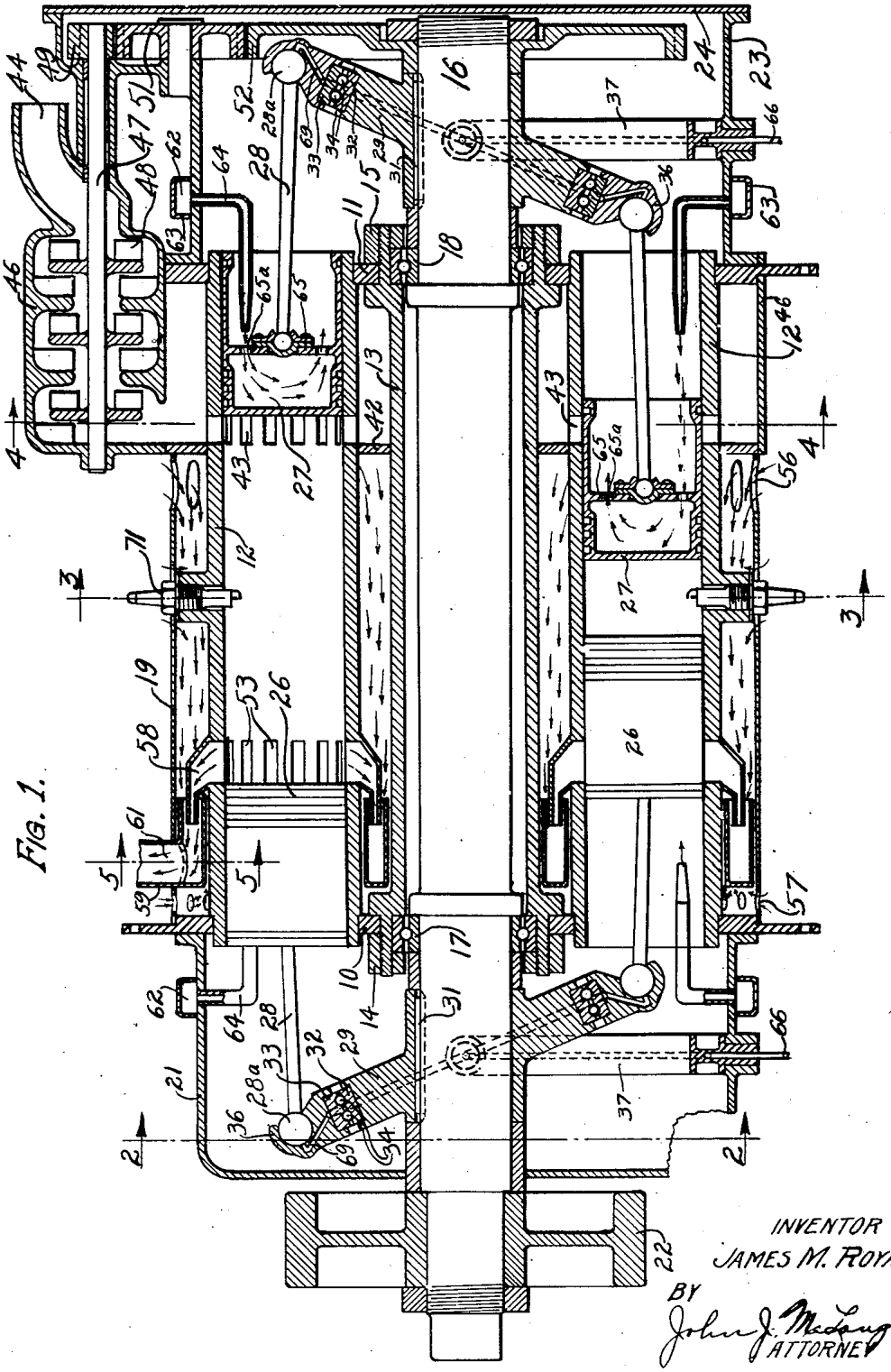

FIG. 1.

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AIRPLANE ENGINE

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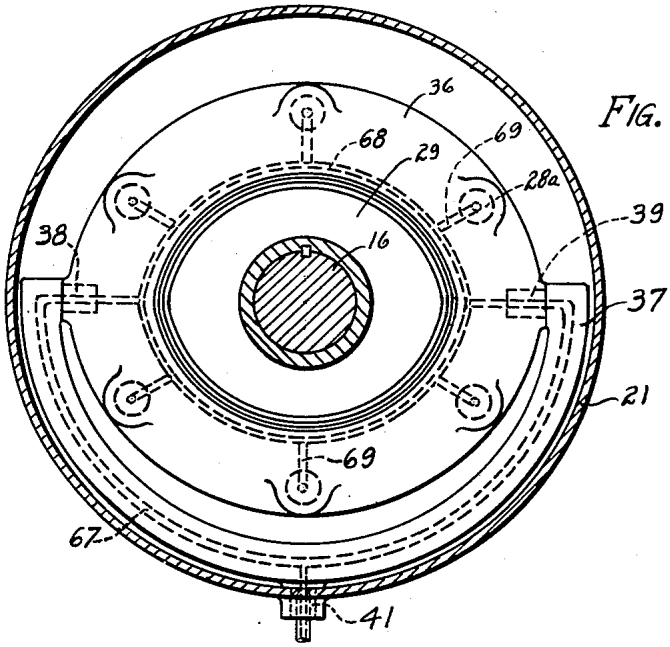

FIG. 2.

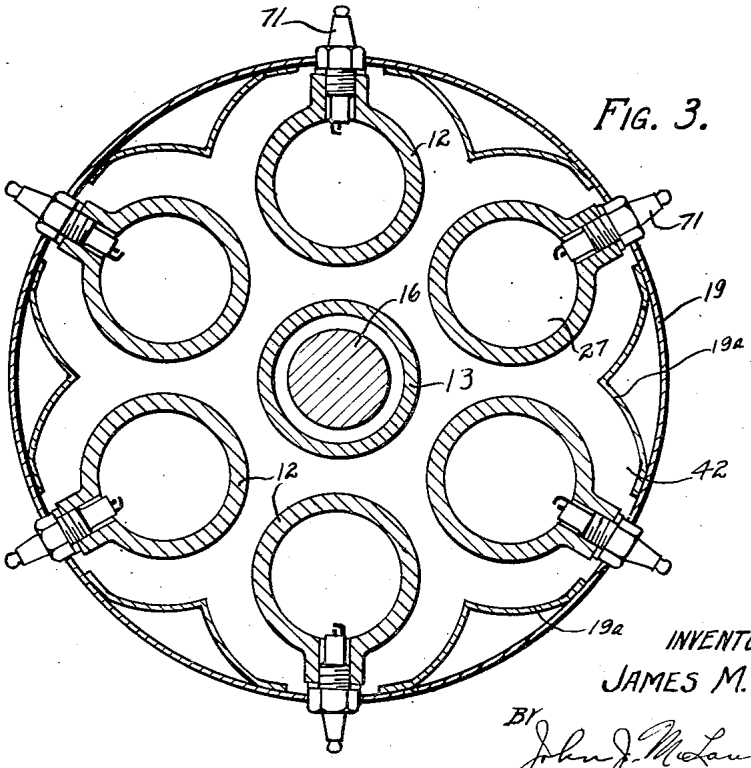

FIG. 3.

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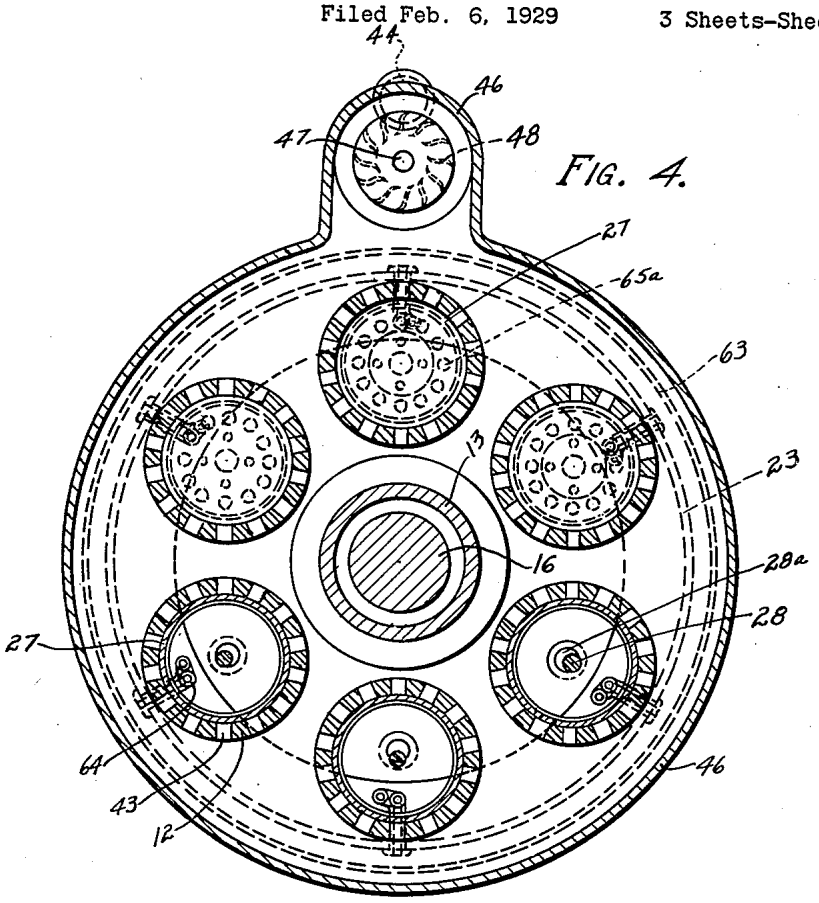

FIG. 4.

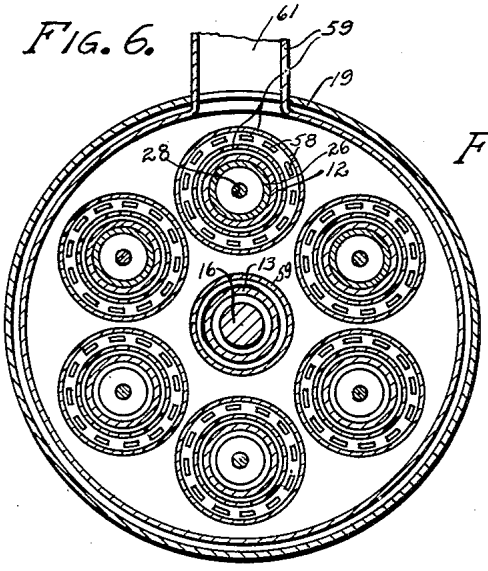

FIG. 6.

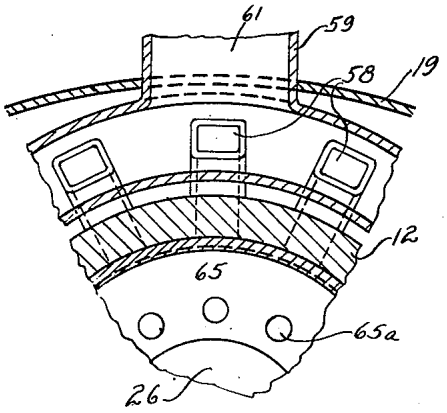

FIG. 5.

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1,808,380

UNITED STATES PATENT OFFICE

JAMES M. ROYAL, OF VILLA PARK, ILLINOIS

AIRPLANE ENGINE

Application filed February 6, 1929. Serial No. 338,014.

My invention relates to internal combustion motors.

It relates more particularly to an improved type of motor which combines a number of novel improvements so as to result in the production of a motor particularly adapted for aviation use.

Aviation motors which have been produced in the past have been mostly of conventional design; that is the cylinders were arranged either in a single line, in two converging lines to form a V-shaped motor, or around the axis of a circle as in the rotary and radial type of motors.

Among the disadvantages resulting from the actual use of motors of these types, is that these motors have a relatively great wind resistance making them undesirable for incorporation with certain types of air craft, and their weight is so distributed as often to require many undesirable compromises in design which the designing engineers would readily avoid if it were possible.

Another disadvantage is that these types of motors are manufactured of the lightest material possible consistent with strength, and the mass also decreased wherever possible while still maintaining the requisite theoretical strength. This lightening process has now been carried almost to a conclusion and still the industry finds a very great need for still lighter power-plants.

This manner of lightening motors results in a motor wherein the moving parts are very apt to break under any slight unusual strain. To overcome this disadvantage, it is necessary to employ the most careful workmanship and all of this adds very greatly to the cost of aviation motors, and this is so much the case that it is considered among aviation experts that one of the greatest factors in arresting the progress of commercial aviation is the present excessive cost of motors.

One of the principal objects of my invention is the provision of an internal combustion type of motor wherein a relatively large work output results per unit of weight.

Another object is the provision of such a motor which may be economically manufactured without the necessity of disproportionately sacrificing the mass of the moving parts.

Another object of the invention is the production of an improved type of motor offering relatively slight wind resistance.

Another object of the invention is the provision of a motor wherein the parts are interchangeable and may be quickly and easily assembled.

Another object is the provision of an internal combustion motor wherein the parts thereof may be produced largely of pressed steel.

Another object is to provide an improved two cycle motor particularly adapted for aviation work.

Another object is to provide an improved cooling and scavenging system for a two cycle motor.

These objects and the manner in which they are accomplished, together with additional objects and features, will be apparent from a consideration of the following detailed description taken with the accompanying drawings, wherein

Fig. 1 is a longitudinal sectional view showing one embodiment of my invention;

Fig. 2 is a sectional view through the outside casing and taken along the line 2—2 of Fig. 1, part of the mechanism being shown in elevation;

Fig. 3 is a vertical central section along the line 3—3 of Fig. 1;

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 1, looking in the direction of the arrows, and

Fig. 5 is an enlarged fragmentary sectional view taken along the line 5—5 of Fig. 1.

Fig. 6 is a reduced vertical sectional view through Fig. 1.

Referring now to the drawings, the present embodiment comprises front and rear assembly plates 10 and 11 respectively, into which cylinders 12—12 are adapted to extend in the manner shown. These cylinders are arranged concentrically about the center of the assembly plates and the centers of the plates are provided with large apertures through which the threaded ends of a sleeve 13 extend, this sleeve being secured in position by nuts 14 and 15. Within the sleeve

a shaft 16 is disposed having its ends projecting beyond the sleeve and provided with radial bearings 17 and 18, the two races of said bearings engaging the inside surface of the sleeve and the outside shaft surface respectively.

A cylindrical central casing 19 engages around and is co-extensive with the assembly plates 10 and 11. A front end casing 21 is suitably secured to the front assembly plate 10, and houses mechanism which will later be described. On the outside of this casing a fly wheel 22 is secured to the end of the shaft 16 which projects therethrough. At the rear of the motor, a substantially cylindrical casing 23 is provided having an end casing plate 24 fully enclosing the end of the shaft and all the mechanism at the rear of the motor.

Instead of the conventional type of motor wherein a cylinder head and single reciprocating cylinder are provided in each cylinder, I provide co-acting pistons moving away from each other and avoid the use of a cylinder head, with a mechanism for conveying the motion of the pistons to the single shaft.

In each of the cylinders are provided opposed pistons 26 and 27 equipped in a suitable manner with the usual rings and the like. Each one of the pistons has connected thereto by means of a ball type joint, a connecting rod 28 having at its outside end, a ball 28*a* forming a connection with an instrumentality which will now be described.

The means for transmitting the motion of the connecting rods 28 to the shaft 16 is the same at each end of the motor and accordingly they will be described as if they constituted a single mechanism, as the two ends of the motor in this respect are essentially alike.

Immediately adjacent the bearing 17, a wabbler plate 29 is secured to the shaft 16 by any suitable means as for instance, by a key 31. This wabbler plate 29 is in the form of a disc with a central but obliquely disposed aperture therein, causing it to fit at an angle on the shaft 16. In other words the true axis of the disc is at an angle to the axis of the shaft.

The outer edge of the wabbler plate 29 is grooved to receive an inner race 32 of a ball bearing of a combination radial and thrust type, the outer race being designated by the reference character 33 and a double race of balls 34 being provided between the two races. A driving ring 36 surrounds the wabbler plate and engages the outer race 33. This wabbler driving ring is preferably formed of two parts suitably held together, with sockets therebetween for receiving the balls 28*a* so as to form a universal joint connection with the rods 28.

In order to prevent the driving ring 36 from turning, a yoke 37 is provided having swivel connections 38 and 39 with the driving ring and a swivel connection 41 with the casing or housing 21. This yoke permits a free wabbler motion of the driving link 36 but prevents any turning thereof due to its normal tendency to turn with the shaft. This arrangement is the same for both ends of the motor except of course the wabbler plates incline in opposite directions so that they will appear at all times as indicated in the drawings.

The space within the confines of the assembly plates existing between the casing 19 of the cylinder is made use of to supply a combustible mixture to the cylinders and also as a scavenging and cooling chamber. In order to simplify the explanation of the present arrangement, the manner of supplying fuel to the cylinders will first be described.

Within the casing 19 and disposed a proper distance from the assembly plate 11, I provide an auxiliary separating plate 42, so that the entire space between this plate and the assembly plate 11 may be employed in lieu of an intake manifold. Immediately adjacent this auxiliary separating plate, a plurality of ports 43—43 are provided in the cylinder so that when the pistons reach their extreme end position these ports will be uncovered so that the combustible mixture within the intake chamber may be forced thereinto in accordance with the relative pressures within this chamber and the cylinder.

The manner of supplying the combustible mixture to this chamber may be varied very greatly while still maintaining the general features of the invention. I provide any suitable type of carburetor (not shown) the vaporized mixture from which is discharged into the intake opening 44 of a suitable compressor 46. This compressor is of any suitable type, the one in the drawings being shown as comprising a casing having journaled therein a shaft 47 on which are secured compressor blades 48. Shaft 47 is driven by a pinion 49 meshing with an idler 51, the idler being driven by a gear 52 which rotates with the shaft 16. This gear train is simply illustrative, however, as greatly modified means may be employed to secure the same results.

At the opposite ends of the cylinders from the intake ports 43, a plurality of discharge ports 53 are provided, these ports being so disposed with respect to the pistons that when the piston 26, for example, approaches the end of its outward stroke, these ports are uncovered thus permitting the scavenging of the burnt gases due partly to their own expansion, and, after the intake ports 43 are uncovered to the pressure of the incoming charge as it is driven through the instrumentality of the compressor 46.

This represents the entire scavenging means but in connection therewith, I have provided a cooling system which makes use of the mo-

tion of the exhaust gases to bring a supply of cool air into contact with the cylinders to cool the same. This feature, together with other cooling features, forming a part of the invention, will now be described.

The outer casing 19 has a series of ports 56 around one end thereof with a similar series of ports 57 of slightly smaller diameter around the other end. The cylinders have secured thereto so as to cover the exhaust ports 53, a plurality of air siphons 58 discharging into a small casing 59 on the inside of the main casing 19 and exhausting through an exhaust passageway 61. The siphons 58 are not connected into the casing but simply project thereinto so that as the exhaust gases pass through the siphons 58 into the siphon casing 59, the air around the discharge orifice of the siphon is caused to move with said gases, thus giving rise to a general movement of the air throughout the interior of the casing 19 substantially as indicated by the arrows. This air of course enters through the ports 56 and 57 and moves around into contact with the surfaces of all of the parts within the casing 19 so as to extract the heat therefrom. An auxiliary deflector 19*a* forming a part of the main casing keeps the air confined in contact with the cylinders.

It will be seen that since the movement of the gases into the cylinders and out of the same in the form of burnt gases is always in the same direction, the cylinders will tend to be hotter toward one end than toward the other. In other words greater heat tends to exist in the region of the exhaust end of the cylinders than in the intake end. The arrangement of the siphons 58 tends to obtain a greater flow of air past this point than past the other portions of the mechanism and accordingly more heat is removed therefrom. In addition, the arrangement of the siphon casing 59 with the ports 57 contiguous thereto has the effect of bringing a supply of fresh cool air at all times into contact with the hotter portions of the cylinders.

It will be seen that the movement of the air by the siphons 58 is only between the assembly plate 10 and the auxiliary plate 42. In other words, the portion of the cylinders between the assembly plate 11 and this auxiliary plate is not included in the cooling system. It is to be noted, however, that this portion of the casing acts as the intake manifold and at all times has the incoming charge circulating therethrough and this has a cooling effect. Very great cooling at this place is not necessary on account of the continuous flow of gases toward the exhaust end of the cylinders. Whatever cooling is effected by the incoming charge coming in contact with the warm outer surfaces of the cylinders not only is of advantage in effecting a partial cooling, but it brings the gases to the proper temperature for obtaining the most complete burning of the gases in the cylinders, and the most efficient operation of the motor.

As an auxiliary cooling means I have provided an arrangement whereby the piston heads are air cooled. The specific arrangement which I show comprises air passageways 62 and 63 on the outside of the motor casing, and having conduits 64—64 connected thereto and extending through the casing and then projecting at right angles toward the inside of the pistons. Air under pressure is provided in the air passageways 62 and 63 and a constant blast of air is directed against the inside of the pistons in the manner shown through parts 65*a* in the web 65 forming a part of the piston. Any suitable openings in the casing are provided for the escape of the air so introduced, or if desired it may be permitted to escape simply through the ordinary joints between the various portions of the casing.

In supplying the air to the passageways 62 and 63 the flow thereof may be regulated to obtain just the amount of air required. This air tends to supplement the cooling obtained by the siphon principle, or in certain respects it may be used entirely with other air or water cooling means provided for cooling the cylinder walls. Directing a continuous blast of air against the piston in this manner tends to keep the head thereof cooled thus avoiding the possibility of pre-ignition as is often inclined to take place if the head of the piston is overheated, particularly if it happens to have a slight deposit of carbon.

Any proper oiling system of course can be employed with a motor of this design, the oiling system of course having the usual oil reservoirs and oil pump (not shown). The usual type of oil lines are provided leading to the various moving parts all of which may be of standard form.

The particular arrangement of the wabbler plates, however, requires the arrangement of an oiling system which will be effective to supply sufficient oil thereto, and all of the mechanism associated therewith to produce proper operation without unnecessary wear. This arrangement will be substantially the same for both plates and accordingly explanation will be made as if only a single plate were used.

Oil under pressure is supplied from a suitable pump to an oil line 66 which is connected to an oil passageway in the pivot 41 of the yoke 37, this passageway connecting with an oil passageway 67, extending the full length of the yoke and connected through intermediate passageways to an annular passageway 63 in the driving ring 36 whence radial passageways 69 lead to the balls 28*a* on the connecting rods 28. From the passageway 68 a suitable supply of oil may be fed to the ball race, and any suitable system may be utilized for supplying oil to the other moving parts.

The piston 28, for example, may be made hollow so that a full force feed may be had to the universal joint connection (wrist pin) on the piston.

The motor as shown is adapted to operate on a two cycle principle using a standard motor fuel such as gasoline. In this event the charge is ignited by the usual spark plugs 71 controlled by any suitable timing mechanism (not shown).

A motor of this design, however, may be operated on the Diesel principle and very good results obtained. Diesel motors as far as I know have never been used for aviation work but I anticipate that by slight modifications in the structure herewith presented I can attain very great efficiency with crude oil fuel. I expect with this idea in mind to increase very greatly the cruising radius of the present commercial type of airplanes.

The operation of the motor should be clear from the preceding description. The pistons are brought together by the reverse action of the two wabbler plates to compress the gas between them in the region immediately adjacent the spark plug. Slightly before final compression (the exact time of course depends on the timing desired) the spark plug is energized to ignite the charge. As soon as the wabbler plates are in proper position the resultant expansion of the gases drives the pistons apart until the exhaust ports 53 begin to be uncovered. The exhaust now escapes through these ports and as soon as the intake ports 43 are uncovered the combustible mixture under pressure is forced into the cylinder and drives the burnt gases out by the force of their entrance. At the time that the scavenging is completed the pistons are again driven inwardly to cover the ports and again compress the new charge. The speed of the compressor 46 and consequently the pressure of the incoming mixture depends upon the speed of the motor. In this way when the motor is running slowly the flow of gases is slow and the reverse is true when the motor is running at high speed. Accordingly the timing of the piston however is such that substantially complete scavenging takes place at each stroke of the motor independent of the speed thereof.

Although I have described the specific details of my invention in order to make same clear to those skilled in the art, it is obvious that I do not restrict myself to the particular details described and the invention is limited only by the scope of the appended claims.

What I claim as new and desire to protect by Letters Patent of the United States is:—

1. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders formed of steel tubing, a pair of mutually coacting pistons in each cylinder, means for converting the motion of the pistons into reciprocating movement, pressed steel supporting means for the cylinders and a pressed steel outer casing adapted to cooperate with the cylinder supporting means to form an intake band and a cooling band.

2. An internal combustion motor having a plurality of radially disposed longitudinally aligned cylinders, a pair of mutually co-acting pistons in each cylinder, a centrally disposed shaft with a pair of wabbler plates one at each end of the cylinders, connections from the pistons to the wabbler plates for driving the shaft supporting means for the cylinders and an outside casing cooperating with the supporting means to form an intake passageway and a cooling belt completely enclosing the cylinders.

3. An internal combustion motor having a plurality of radially disposed longitudinally aligned cylinders, a pair of mutually coacting pistons in each cylinder, a centrally disposed shaft with a pair of wabbler plates one at each end of the cylinders, connections from the pistons to the wabbler plates for driving the shaft supporting means for the cylinders and an outside casing cooperating with the supporting means to form an intake passageway and a cooling belt completely enclosing the cylinders, the supporting means for the cylinders and the outside casing being formed of pressed steel.

4. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders, an assembly plate supporting the cylinders at each end, a centrally disposed shaft, a pair of mutually coacting pistons in each cylinder means for transferring the movement of the pistons to the shaft, an auxiliary separating plate between the assembly plates with its plane parallel to the planes of said assembly plates, and a housing band disposed about the auxiliary plate and one assembly plate, the space so confined serving as an intake passageway for supplying combustible mixture under pressure to the cylinders.

5. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders, an assembly plate supporting the cylinders at each end, a centrally disposed shaft, a pair of mutually coacting pistons in each cylinder means for transferring the movement of the pistons to the shaft, an auxiliary separating plate between the assembly plates with its plane parallel to the planes of said assembly plates, and a housing band disposed about the auxiliary plate and one assembly plate, the space so confined serving as an intake passageway for supplying combustible mixture under pressure to the cylinders, intake parts being provided in the cylinders communicating with said intake passageway.

6. In an internal combustion motor a plu-

rality of radially disposed longitudinally aligned cylinders, an assembly plate supporting the cylinders at each end, a centrally disposed shaft, a pair of mutually coacting pistons, in each cylinder means for transferring the movement of the pistons to the shaft, an auxiliary separating plate between the assembly plates with its plane parallel to the planes of said assembly plates, and a housing band disposed about the auxiliary plate and one assembly plate, the space so confined serving as an intake passageway for supplying combustible mixture under pressure to the cylinders, a central casing enclosing the greater portion of the cylinders, and means for moving a band of air through said casing in contact with the cylinders to cool the same.

7. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders, an assembly plate supporting the cylinders at each end, a centrally disposed shaft, a pair of mutually coacting pistons, in each cylinder means for transferring the movement of the pistons to the shaft, an auxiliary separating plate between the assembly plates with its plane parallel to the planes of said assembly plates, and a housing band disposed about the auxiliary plate and one assembly plate, the space so confined serving as an intake passageway for supplying combustible mixture under pressure to the cylinders, a central casing enclosing the greater portion of the cylinders, and means for moving a band of air through said casing in contact with the cylinders to cool the same, and deflectors on the inside of the casing, one between each pair of cylinders, for confining the moving air to increase its contact with the outer cylinder walls.

8. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders having intake ports near one end thereof and exhaust ports near the other end, a pair of mutually coacting pistons in each cylinder an impeller shaft, means for transmitting the motion of the pistons to the shaft, means resulting in the formation of a closed chamber surrounding the intake parts adapted to hold combustible mixture under pressure, means forming a cooling chamber surrounding the greater portion of the cylinders, and means for utilizing the action of the cylinder exhaust to maintain a movement of cooling air through said cooling chamber.

9. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders having intake ports near one end thereof and exhaust ports near the other end, a pair of mutually coacting pistons in each cylinder an impeller shaft, means for transmitting the motion of the pistons to the shaft, means resulting in the formation of a closed chamber surrounding the intake parts adapted to hold combustible mixture under pressure, means forming a cooling chamber surrounding the greater portion of the cylinders, and means for utilizing the acting of the cylinder exhaust to maintain a movement of cooling air through said cooling chamber, longitudinally of the cylinders, the general direction of movement of said air being from the intake end of the cylinders and toward the discharge end.

10. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders having intake ports at one end and exhaust ports at the other end thereof, means for supplying combustible mixture under pressure to said intake ports, air siphons connected to receive the scavenged gases from the exhaust ports, an auxiliary casing having the air siphons projecting thereinto so as to cause a movement of air with the exhaust through said auxiliary casing, and an outside casing having air passageways positioned to cause the air moved by said siphons to be drawn through said passageways and moved longitudinally of the cylinders.

11. The combination described in claim 10 wherein said ports are disposed entirely around said cylinders, with space between each pair of ports.

12. The combination described in claim 10 wherein said exhaust ports are disposed entirely about the cylinders with the air siphons so secured thereto as to permit the moving cooling air to contact with the cylinders between the exhaust ports to prevent overheating of the cylinders in the region of said ports.

13. In an internal combustion motor a plurality of radially disposed cylinders longitudinally aligned with a centrally disposed shaft, a pair of pistons in each cylinder, means connecting the pistons to the shaft to drive the same, an intake passageway entirely surrounding and enclosing one end of the cylinders and an exhaust passageway surrounding the other end, the cylinders having slots disposed entirely around the same in two sections one near each end thereof, to serve as intake and exhaust parts, a cooling passageway having ports at the end near the intake passageway, and air siphons connected to the exhaust ports and extending into the exhaust passageway so that a bodily movement of air takes place longitudinally of the cylinders from the ports in the cooling passageway out through the exhaust passageway, the intake end of the cylinders being partially cooled by the incoming charge.

14. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders, a pair of mutually coacting pistons in each cylinder, an annular passageway for cooling air adjacent the ends

of the cylinders, and a jet with one end connected to one of the annular air passageways and the other end thereof disposed to discharge cooling air against the back of a piston head.

15. In an internal combustion motor a plurality of radially disposed longitudinally aligned cylinders, an intake passageway for combustible mixture enveloping one end of the cylinders, an exhaust passageway near the other end thereof, means for causing a longitudinal movement of the body of air from the intake passageway along the cylinders to the exhaust passageway, a pair of mutually coacting pistons in each cylinder, an annular passageway for cooling air adjacent the ends of the cylinders, and a jet with one end connected to one of the annular air passageways and the other end thereof disposed to discharge cooling air against the back of a piston head.

In witness whereof, I hereunto subscribe my name this 5th day of January, 1929.

JAMES M. ROYAL.