

Aug. 20, 1929.

G. A. PRINDLE

1,725,418

FOUR-CYCLE INTERNAL COMBUSTION ENGINE

Filed Oct. 15, 1924

3 Sheets-Sheet 1

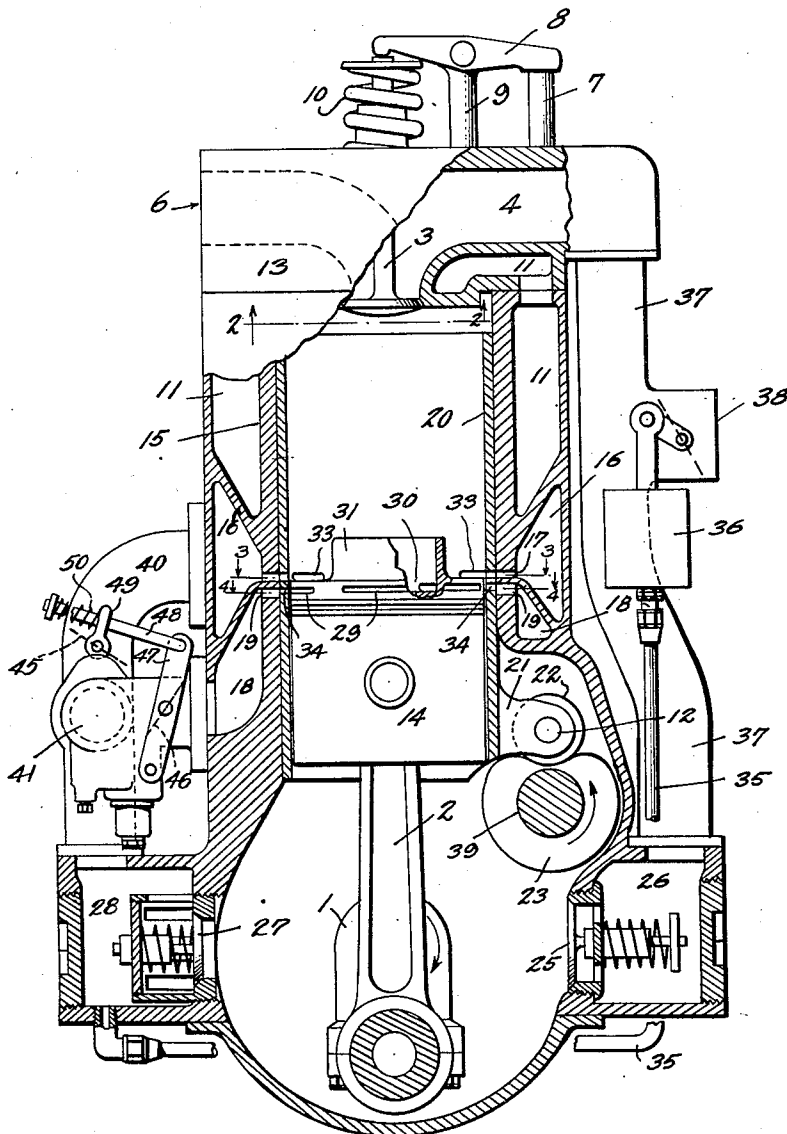


Fig. 1.

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3 Sheets-Sheet 2

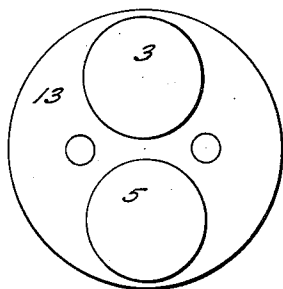


Fig. 2.

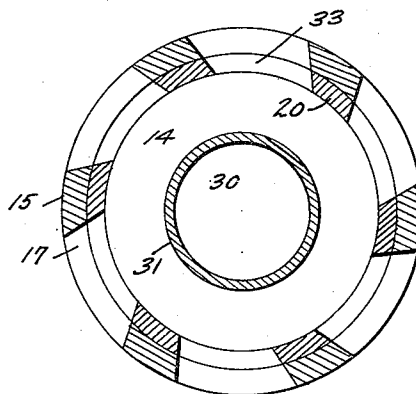


Fig. 3.

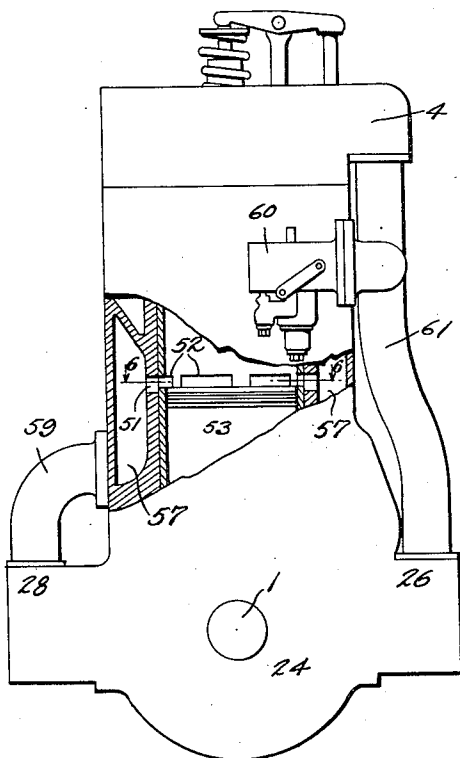


Fig. 5.

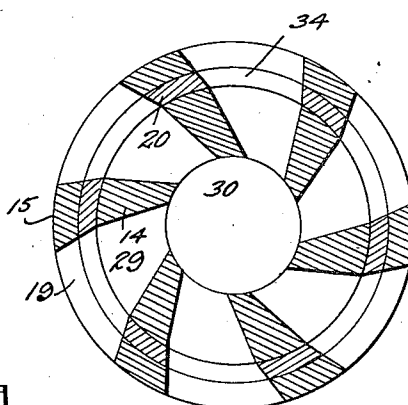


Fig. 4.

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3 Sheets-Sheet 3

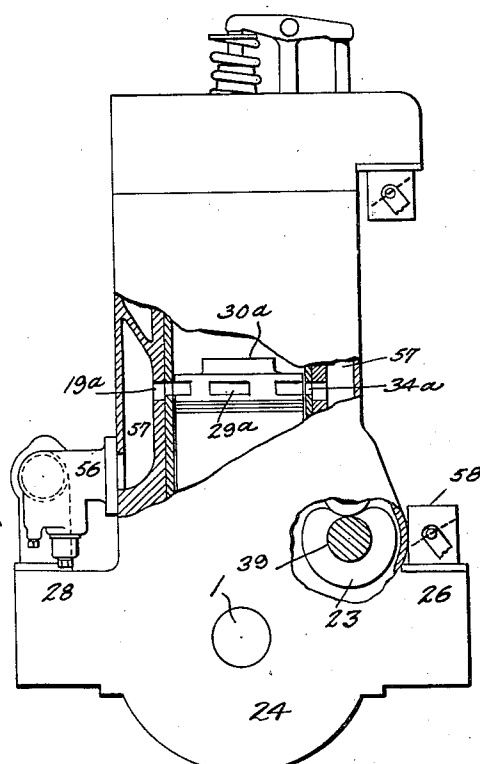


Fig. 7.

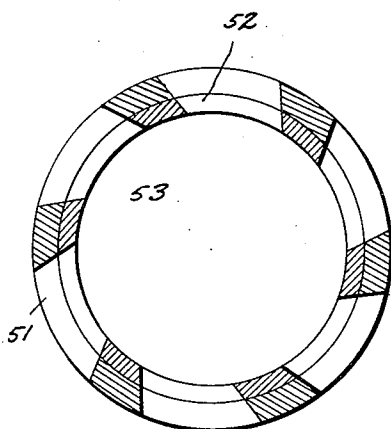


Fig. 6.

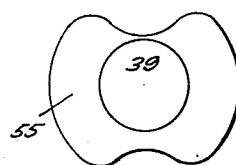


Fig. 8.

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UNITED STATES PATENT OFFICE.

GLEN A. PRINDLE, OF NEAR REASNOR, IOWA.

FOUR-CYCLE INTERNAL-COMBUSTION ENGINE.

Application filed October 15, 1924. Serial No. 743,770.

This engine is a development of the two-cycle internal combustion engine, patent to Prindle, No. 1,593,880, issued July 27, 1926.

The object of this invention is an internal combustion engine that is efficient and economical in the use of fuel and maintains full sea-level power at high altitudes without the use of a separate blower or supercharger.

Figure 1 is a vertical transverse sectional view parts being broken away and in sections.

Figure 2 is a view of the under side of the cylinder head on the line 2—2 Figure 1, showing the inlet valve head, the exhaust valve head and the spark-plug holes.

Figure 3 is a cross-sectional view on the line 3—3 Fig. 1 showing air ports thru the cylinder wall and air ports thru the sleeve valve, said air ports being placed at an angle with respect to the radii of the cylinder.

Figure 4 is a cross-sectional view on the line 4—4 Fig. 1 showing rich gas ports thru the cylinder, rich gas ports thru the sleeve valve and passages thru the piston, said ports and passages being placed at an angle with respect to the radii of the cylinder.

Figure 5 is a vertical transverse sectional view of another embodiment of my invention, parts being broken away and in section.

Figure 6 is a cross-sectional view on the line 6—6 Fig. 5 showing ports thru the cylinder and ports thru the sleeve valve, said ports being placed at an angle with respect to the radii of the cylinder.

Figure 7 is a vertical transverse sectional view of still another embodiment of my invention, parts being broken away and in sections.

Figure 8 is a vertical transverse view of the sleeve valve actuating cam that may be used in some of the embodiments of my invention.

Figure 9 is a fragmentary view showing the valve actuating mechanism and the crank-case divided into tight compartments.

Figure 10 shows the pressure control means.

Figure 11 shows the sleeve valve actuating spring and the tight partition in the crank-case.

Referring to the drawings the crank-shaft 1, connecting-rod 2, inlet valve 3, inlet passage 4, exhaust valve 5, exhaust passage 6, push rod 7, rocker-arm 8, rocker-arm support 9, valve spring 10, and water space 11 are of ordinary construction.

Cylinder head 13, piston 14 with its passages 29, cavity 30 and flange 31; cylinder 15 with its associated parts, air passage 16, air ports 17, rich gas passage 18 and rich gas ports 19; valve 20 with its ports 33 and ports 34; lug 21 attached to valve 20 and carrying roller 22 by means of a pin 12; cam-shaft 39 with inlet valve actuating cam 65 Figure 9, exhaust valve actuating cam 66 Figure 9 and sleeve valve actuating cam 23; and the crank-case 24 with its associated parts, inlet valve 25, inlet chamber 26, outlet valve 27 and outlet chamber 28 are of special design.

The operation of the engine is as follows:

Each time the piston 14 moves upward toward the cylinder head 13 air enters the crank case 24 thru air inlet 38, air pipe 37, inlet chamber 26 and non-return valve 25. On each down stroke of the piston toward the crank case air is forced thru the non-return valve 27 into the outlet chamber 28.

On the suction stroke of the piston air is drawn thru air inlet 38, air pipe 37, inlet passage 4 and around inlet valve 3, said inlet valve 3 being held open at this time by means of a cam 65 Figure 9 which engages the lower end of pushrod 7 raising same which in turn opens the inlet valve 3 thru the agency of rocker-arm 8. This cam 65 is attached to cam-shaft 39, said cam-shaft being driven at one-half crank-shaft speed by suitable means such as gearing or chain (not shown). As the piston nears the end of its downward stroke the cam 23 (which is attached to cam-shaft 39) attains such a position that the sleeve valve 20 is allowed to move downward actuated by the friction of the piston 14 moving downward within the said sleeve valve 20 and, if necessary, by the additional downward pressure of a spring, 67 Figure 9. By the time ports 34 in the sleeve valve 20 register with passages 29 in the piston the sleeve valve 20 is moving with the same speed and in unison with the piston 14. Just before passages 29 and ports 34 begin to register with air ports 17 the inlet valve 3 is allowed to close. When passages 29 and ports 34 register with air ports 17 air under pressure from outlet chamber 28 passes thru air pipe 40, air passage 16, air ports 17, ports 34 and passages 29 into cavity 30 and thence into the interior of the cylinder driving the products of the previous combustion from passages 29 and cavity 30. On account of the shape of the ports 17 and 34 and the passages 29 this air is given a

rapid whirling motion. Farther downward movement of the piston and sleeve valve causes ports 33 in the sleeve valve to register with air ports 17 in the cylinder wall allowing air under pressure to pass from 28 thru 40, 16, 17 and 33 over the top of the piston 14 into the interior of the cylinder. On account of the shape of 17 and 33 this air is also given a rapid whirling motion.

At this time passages 29 and ports 34 register with rich gas ports 19 and air from outlet chamber 28 passes thru air pipe 40 into carburetor 41 where it takes up fuel to form a rich mixture then it enters rich gas passage 18 and passes thru 19, 34 and 29 into cavity 30 and thence into the interior of the cylinder. On account of the shape of the ports 19 and 34 and the passages 29 this gas is given a rapid whirling motion. Figures 1, 3 and 4 show the engine with the various parts in this position, that is with the piston 14 and the sleeve valve 20 in their lowest position on the intake stroke. As the piston and sleeve valve move upward the passages 29 and ports 34 again register with air ports 17 but at this time the pressure inside the cylinder is nearly as great as the pressure in 16 so that but a small amount of air passes thru the ports and passages. The sleeve valve 20 soon reaches its limit of travel as determined by the cam 23 and the cylinder head 13, the piston moves on upward on the compression stroke and at the proper instant ignition takes place in the whirling rich gas in the central part of the combustion chamber. After the piston reaches top dead center it passes downward on the power stroke, as the piston nears the end of the power stroke the exhaust valve is opened, as in an ordinary four-cycle engine, this exhaust valve is opened by means of a cam 66 as was the case of the inlet valve 3. It should be noted that the cam 23 still holds sleeve valve 20 in its highest position with ports 17, 19, 33 and 34 closed so no air, rich gas or exhaust gas can pass thru them. After passing lower dead center on the power stroke the piston passes upward on the exhaust stroke driving before it the products of the previous combustion. After the piston reaches top dead center it starts downward on the suction stroke. The exhaust valve may be timed to close at top dead center or it may be timed to stay open for a while after the piston has started downward on the suction stroke and the inlet valve has opened as this will tend to more thoroughly clear the exhaust gases from the combustion chamber. This completes the cycle.

It will be noted that air is drawn into the cylinder during the greater part of the suction stroke and that air is admitted to the crank-case during the compression stroke and during the exhaust stroke to be forced into the outlet chamber during the power stroke and the suction stroke respectively. This air passes, part of it directly and part of it by way of the carburetor, into the interior of the cylinder near the end of the suction stroke, thus supplying nearly three times the volume that is drawn into the cylinder of an ordinary four-cycle engine, allowing this engine to maintain full sea-level power at great altitudes.

The peculiar arrangement of the passages thru the piston, the ports thru the sleeve valve wall and the ports thru the cylinder wall causes the rich gas and the air to be given a rapid whirling motion upon entering the cylinder. This rich gas and the air are still whirling rapidly at the time of ignition which causes the flame to be quickly carried to all parts of the combustible charge.

On account of the centrally located cavity 30 in the top of the piston and the flange surmounting the piston and surrounding the cavity, the whirling rich gas is kept near the center of the cylinder with a surrounding shell of air, free or nearly free from gas. Ignition takes place in the rich easily burning mixture and the flame burns out into an excess of air or supporting atmosphere allowing all the hydrogen and all the carbon in the fuel to combine with the oxygen in the air, the surrounding shell of air preventing the loss of a large amount of heat thru the piston and the cylinder wall during the power stroke.

With the rich gas stratified centrally of the combustion chamber at the time of ignition it is possible, over most of the power and speed range of the engine, to control the power output and speed by the use of the rich gas throttle 46 alone, while enough air is admitted to keep the compression as high as desired.

From the above it will be seen that this engine is efficient and economical in the use of fuel and maintains full sea-level power at great altitudes without the use of a separate blower or supercharger. An exhaust driven or other type of supercharger may be used with this engine if it is desired to have this engine maintain full sea-level power at such great altitudes that the air weighs less than one-third of what it weighs at sea-level.

Pressure control means 36 Figures 1 and 10 may be used to keep the pressure in the crank-case 24, outlet chamber 28 etc. within the desired limits and throttles 45 and 46 may be connected by 47, 48, 49 and 50 leaving but one throttle control 54.

By the use of cam 55 Fig. 8 in place of cam 23 Fig. 1, the sleeve valve 20 will move down slightly at the end of the power stroke causing ports 34 to register with ports 17 (after the exhaust valves have opened) allowing a small amount of air to pass into the cylinder to help clear the spent gas from the

cylinder and combustion chamber by forming a layer of air over the top of the piston between the piston and the spent gas.

Figure 7 shows another embodiment of my invention, in this case the passages 29^a thru the piston are the same as those in Fig. 4 except that they may be higher and hence larger. There is but one series of ports 19^a in the cylinder wall, and but one series of ports 34^a in the sleeve valve wall. These ports are the same as 19 and 34 Fig. 4 except that they may be higher and hence larger. Air alone is drawn into the cylinder during the greater part of the suction stroke and all the air from 28 passes thru carburetor 56 where it takes up fuel to make a mixture that is richer than normal, then passes thru 57, 19^a, 34^a, 29^a and 30^a into the cylinder during the last of the suction stroke and the first of the compression stroke, the rest of the cycle is the same as described on pages 2, 3 and 4. If desired the carburetor may be connected to 58, the inlet to the inlet chamber 26 and crank-case 24, in place of between 28 and 57 as shown in Fig. 7, in this case a pipe will have to be connected between 28 and 57 as shown at 59 Fig. 5.

Figure 5 is still another embodiment of my invention. In this case an ordinary piston 53 is used, ports 51 in the cylinder wall are the same as ports 19^a Fig. 7 and ports 52 are the same as 34^a Fig. 7. The carburetor 60 is connected to inlet pipe 61, which in turn is connected to inlet chamber 26 and inlet passage 4. This allows a fuel mixture of the correct proportions of fuel and air, to be drawn into the cylinder during the greater part of the suction stroke, and into the crank-case during the compression stroke, and during the exhaust stroke. This fuel mixture is forced into the outlet chamber 28 during the power stroke and during the suction stroke respectively and passes from 28 thru 59, 57, 51 and 52 into the interior of the cylinder during the last of the suction stroke and the first part of the compression stroke. The rest of the cycle is the same as an ordinary four-cycle engine. If it is desired to keep fuel mixture from the interior of the crank-case, carburetors may be placed as shown in Fig. 11.

In a multicylinder engine, outlet chamber 28 need be no more than a passage way for the contents of the crank-case; the smaller the number of cylinders the larger the outlet chamber must be. The crank-case must be divided into compartments by partitions 68 Figures 9 and 11 to co-act with the pistons to form compressors, or if desired a separate compressor may even be used in place of using the crank-case.

I claim:

1. In a four-cycle internal combustion engine, a cylinder having the combination of air inlet, ports intermediate the ends there-

of and rich gas inlet ports below said air inlet ports, means to open and to close said ports at predetermined points in the cycle of operation, air inlet ports and exhaust ports at the upper end and means to open and to close said ports at predetermined points in the cycle of operation.

2. In an internal combustion engine, a cylinder having the combination of, valve controlled air inlet ports and valve controlled rich gas inlet ports intermediate the ends thereof, valve controlled inlet port at the upper end and valve controlled exhaust port at the upper end.

3. In an internal combustion engine, a cylinder having the combination of, valve controlled air inlet ports intermediate the ends thereof, valve controlled rich gas inlet ports below said air inlet ports, valve controlled inlet port at the upper end and valve controlled exhaust port at the upper end.

4. In an internal combustion engine, a cylinder having the combination of, valve controlled air inlet port at the upper end, valve controlled exhaust port at the upper end and valve controlled air inlet ports intermediate the ends thereof and rich gas inlet ports below the air ports, said air inlet ports and rich gas inlet ports being placed at an angle with respect to the radii of the cylinder.

5. In a four-cycle internal combustion engine, a sleeve valve suitably slidably mounted within the cylinder, said sleeve valve having intermediate the ends thereof air inlet ports and rich gas inlet ports, a piston suitably slidably mounted within the sleeve valve, said piston having a cavity located centrally of the top thereof, a flange surrounding the cavity and surmounting the piston and passages near the top of the piston leading from the periphery thereof to the central cavity, said passages being adapted to register with the inlet ports in the sleeve valve when the inlet ports in the sleeve valve register with the inlet ports in the cylinder wall.

6. In a four-cycle internal combustion engine, a sleeve valve suitably slidably mounted within the cylinder, said sleeve valve having air inlet ports intermediate the ends thereof and having rich gas inlet ports below the air inlet ports, a piston suitably slidably mounted within a sleeve valve, said piston being furnished with passages near the top leading, at an angle with the radii of the piston, from the periphery of the piston to a cavity located centrally of the top thereof, said cavity being surrounded by a flange which surmounts the piston, the passages in the piston being adapted to register with certain of the inlet ports in the sleeve valve when the inlet ports in the sleeve valve register with the inlet ports in the cylinder wall.

7. An internal combustion engine having

in combination a cylinder having ports intermediate the ends thereof, ports at the upper end and means to open and to close said ports, a sleeve valve mounted within the cylinder, ports intermediate the ends thereof, said ports being adapted to register with the ports in the cylinder wall at predetermined intervals in the cycle of operation and means to operate said sleeve valve, a piston operating within the sleeve valve, said piston having a cavity located centrally of the top thereof, a flange surrounding the cavity and surmounting the piston and passages through the piston near the top leading from the periphery to the central cavity, said passages being adapted to register with the ports in the sleeve valve at certain intervals in the cycle of operation, a cam for actuating the sleeve valve and means to operate the cam, a crank-case provided with a non-return inlet valve and a non-return outlet valve, an outlet chamber connected to the outlet of the crank-case outlet non-return valve and connected to the inlet ports in the cylinder wall intermediate the ends thereof, and means to keep the pressure in the outlet chamber within the desired limits.

In testimony whereof I affix my signature.

GLEN A. PRINDLE.