A. M. ROSSMAN.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED NOV. 25, 1918.

1,393,831.

Patented Oct. 18, 1921.

4 SHEETS—SHEET 1.

Fig. 1

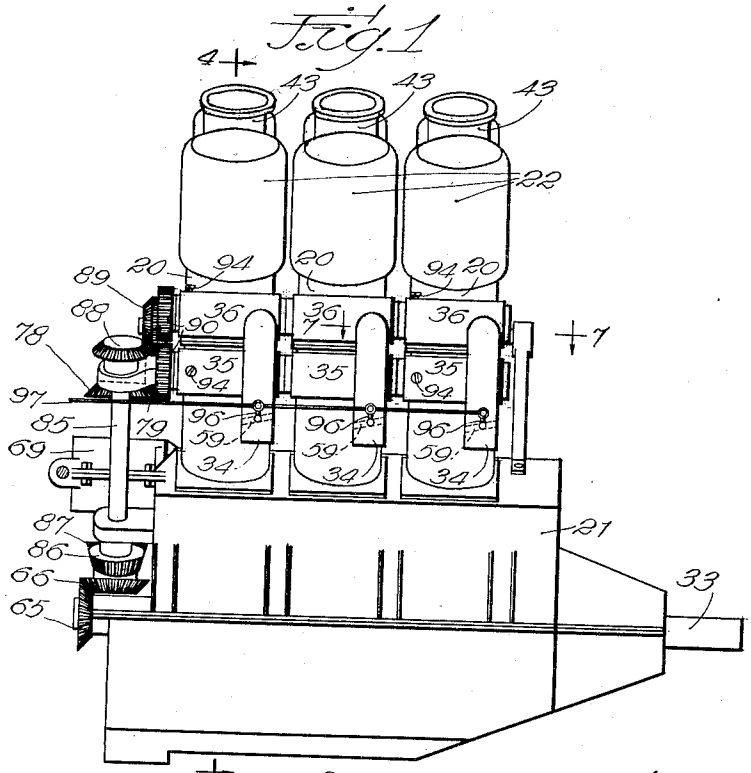
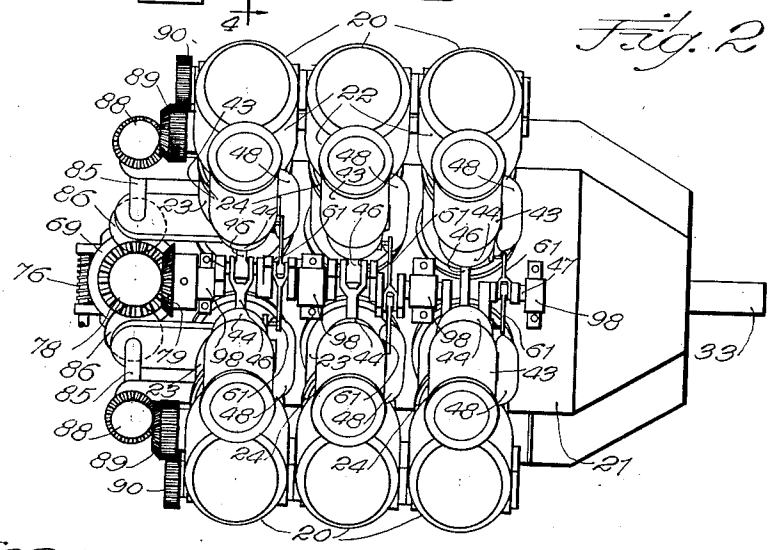


Fig. 2



Witnesses:

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4 SHEETS—SHEET 2.

Fig. 3

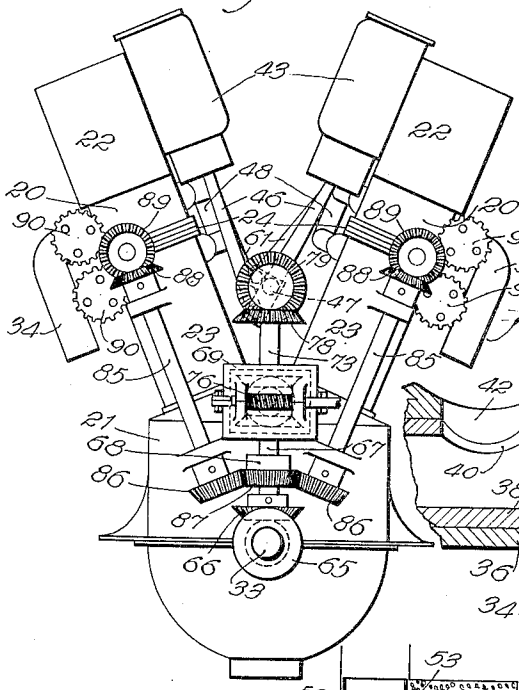


Fig. 5

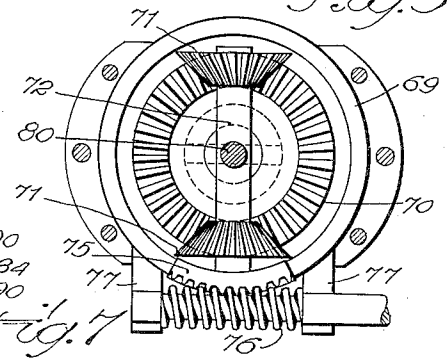


Fig. 7

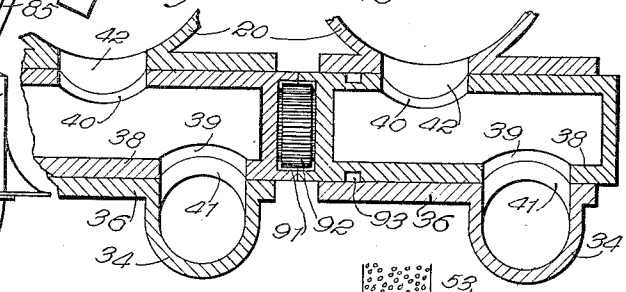


Fig. 8

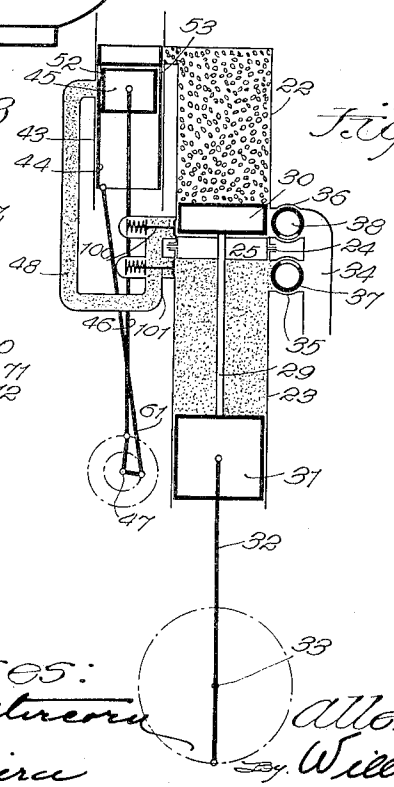


Fig. 9

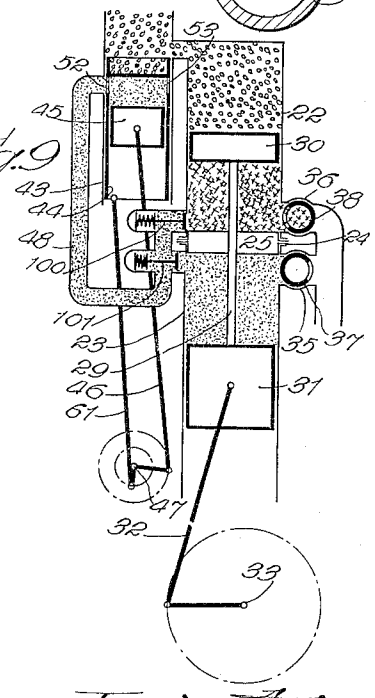
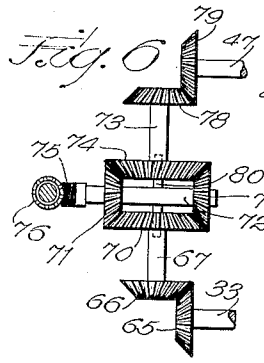


Fig. 6



Witnesses:

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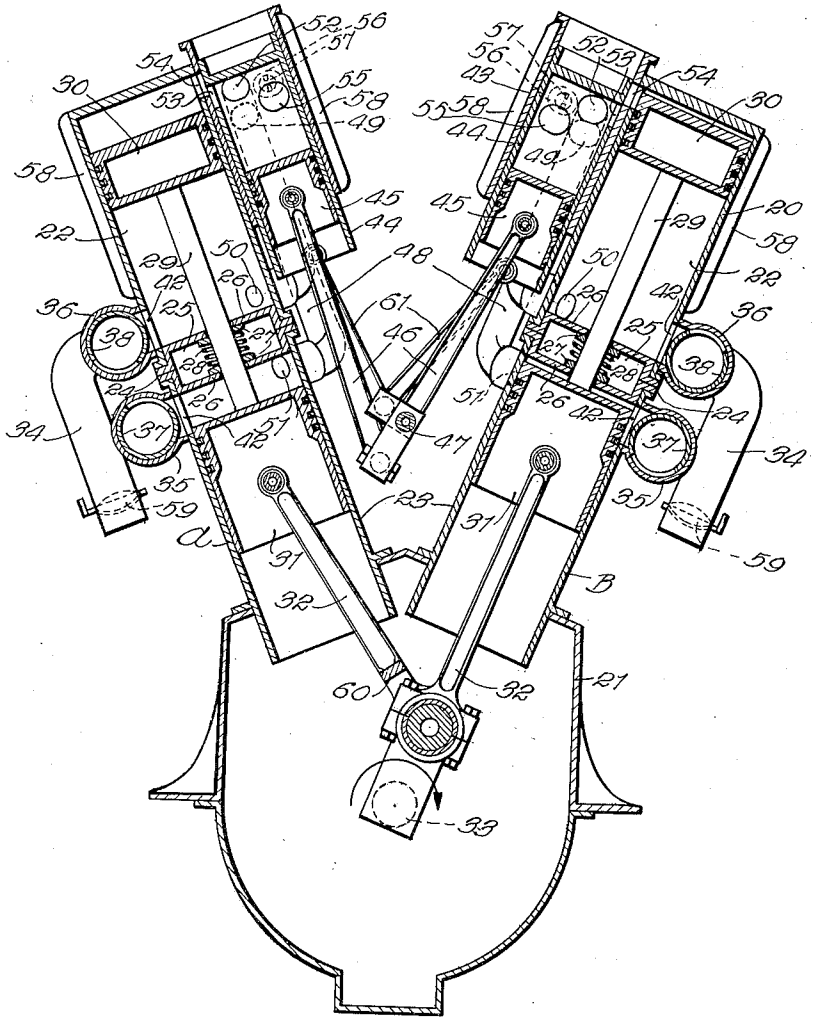
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4 SHEETS—SHEET 3.

Fig. 4



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4 SHEETS—SHEET 4.

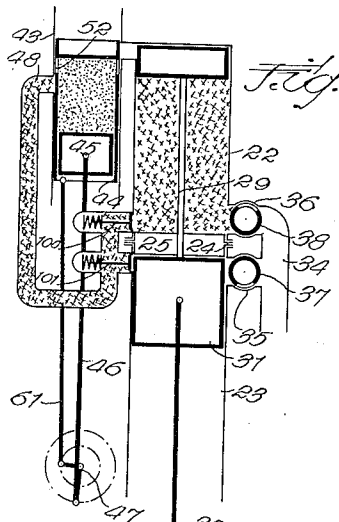


Fig. 10

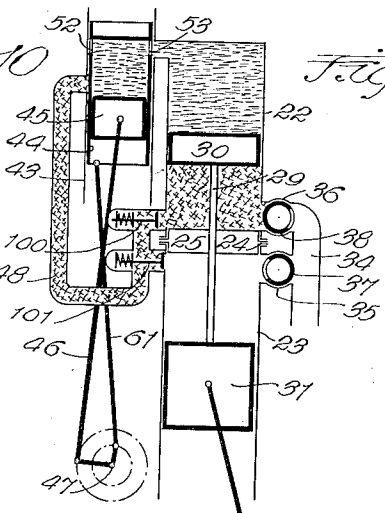


Fig. 11

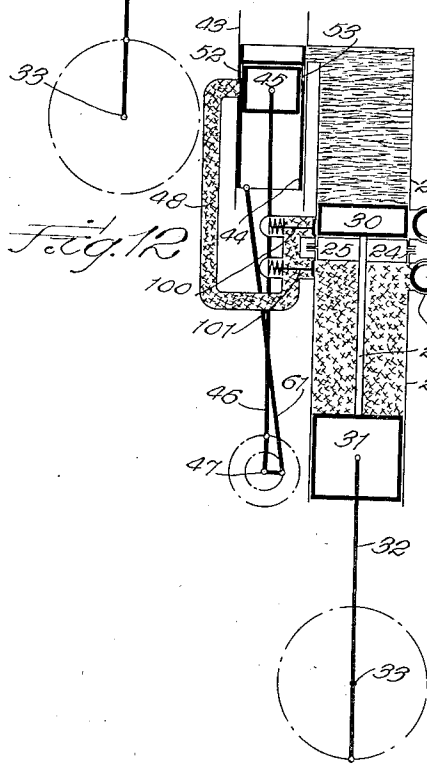


Fig. 12

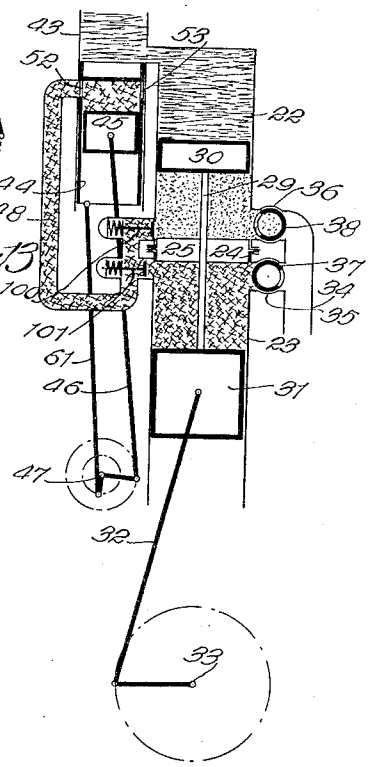


Fig. 13

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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

1,393,831. Specification of Letters Patent. Patented Oct. 18, 1921.

Application filed November 25, 1918. Serial No. 263,984.

To all whom it may concern:

Be it known that I, ALLEN M. ROSSMAN, a citizen of the United States, residing at Wilmette, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Internal-Combustion Engines, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to internal combustion engines and is especially concerned with engines of this type which are used for aeronautical purposes.

The principal objects of my invention are:—

First: To provide an engine for the above purpose which will have the same power output at all altitudes from sea level up to approximately 20,000 feet.

Second: To provide an engine having the above characteristics which is constructed of separate units, each of these units comprising a power cylinder, a combustion chamber or cylinder, means for supplying combustible charges to the combustion chamber, means for exploding the charges in said combustion chamber, means for conducting the exploded gases to the power chamber, and a scavenging piston for completely scavenging said combustion chamber. These units may be arranged side by side and provided with suitable pitmen for connecting the pistons in the power cylinders with a common crank shaft, and two or more rows of cylinders may be arranged at an angle to each other and connected to a common crank shaft to form a V-type engine.

Third: To provide an engine of the above type in which a single valve controls the admission of explosive charges to the combustion chamber, the discharge of the exploded gases from the combustion chamber into the power cylinder, and the exhaust from the power cylinder.

Fourth: To provide an internal combustion engine comprising a continuously active ignition means, such, for instance, as a continuous jump-spark.

Fifth: To provide an internal combustion engine in which the timing is effected by timing the contact of the explosive charges or mixtures with the igniting means.

Sixth: To provide an internal combustion engine in which the piston is relieved of side thrusts whereby the friction and lubrication are reduced to a minimum.

Seventh: To provide an internal combustion engine having a sleeve valve one end of which forms one end of the cylinder in which the sleeve valve operates.

Eighth: To provide an internal combustion engine in which the explosive charges are, during the compression thereof, in contact with a minimum amount of heated surface for a minimum length of time, thereby permitting higher compression and consequently higher initial pressures of the exploded gases.

Ninth; To provide an internal combustion engine with means for substantially completely scavenging the exploded gases, thereby permitting rapid inflammation and thorough combustion which in turn insures a maximum pressure from an ignited charge.

Tenth: To provide an internal combustion engine in which pre-ignition cannot take place in the power cylinder, thereby permitting the power cylinder to be worked at high temperatures with a resulting increase in efficiency.

Other objects, adaptabilities and capabilities will appear as this description progresses, reference being had to the accompanying drawings, in which:

Figure 1 is a side elevation of one embodiment of my improved engine.

Fig. 2 is a plan view thereof.

Fig. 3 is an end elevation.

Fig. 4 is an enlarged transverse section taken on a line corresponding to line 4—4 of Fig. 1.

Fig. 5 is a sectional detail view disclosing one means which I employ for advancing and retarding the sleeve valve relative to the main crank shaft, in order to time the explosions.

Fig. 6 is a more or less diagrammatical view of the driving connections between the main crank shaft and the valve crank shaft, including the means partially illustrated in Fig. 5.

Fig. 7 is an enlarged horizontal sectional detail taken upon line 7—7 of Fig. 1, showing details of the construction of my improved valve mechanism for controlling the admission of explosive mixture to the compression cylinders.

Figs. 8 to 13 are diagrammatic sketches showing the relative positions of various parts of my engine at different periods during a cycle of operation.

The same reference characters are used to indicate similar parts throughout the several figures of the drawings.

Referring to the drawings, the embodiment of my invention which I have illustrated comprises a plurality of units indicated as a whole by the reference characters 20, these units being arranged in two rows arranged at an angle to each other so as to form an engine of the V-type. The units are supported by a crank case 21, which, as will be described later on, houses a common crank shaft for the pitman rods of all of the units.

Referring to Fig. 4, each unit comprises a power cylinder 22 and a compressor cylinder 23, co-axially arranged and with their adjacent ends secured together as shown at 24. Interposed between the adjacent ends of the cylinders 22 and 23, and forming a common head for both of these cylinders, is an oil-containing chamber 25 formed by the flanged cup-shaped members 26, the flanges of which are secured between the adjacent ends of the cylinders 22 and 23. This chamber is filled with oil, which is prevented from escaping by means of packing rings 27 and the spring 28 which holds the packing rings tightly against the ends of the cup-shaped members. A piston rod 29 passes through the ends of the oil chamber 25 and the packing rings, and is provided at its upper end with a power piston 30 and at its lower end with a cross-head piston 31. A pitman rod 32 connects the piston with the main crank shaft 33 in the crank case 21. The reference character 34 indicates what for the purpose of convenience will be called an induction pipe, which is connected with a carbureter (not shown) or any other suitable means for providing a proper mixture of fuel and air. This induction pipe communicates with the two valve housings 35 and 36 respectively, in which are rotatably mounted the valves 37 and 38 respectively. These valves are hollow and, as shown in Fig. 7, are provided with two ports 39 and 40 arranged adjacent opposite ends of these valves and substantially 180 degrees apart, so that when the ports 39 register with the ports 41 of the communication pipe 34, the ports 40 will register with the ports 42 of the cylinders 22 and 23. The valves 37 and 38 are connected in driving relation, as will be described later on, so that when the ports of the valve 37 are arranged to supply explosive mixtures to the cylinder 23, the valve 38 will be in position to cut off communication between the induction pipe 34 and the cylinder 22. As a matter of fact, the ports in the valves 37 and 38 are spaced substantially 180 degrees from each other.

Mounted adjacent the upper end of each cylinder 22 is a combustion chamber or cylinder 43 in which slides the sleeve valve 44. A scavenging piston 45 reciprocates in the sleeve valve 44 and is connected by means of a pitman 46 with the valve crank shaft 47. A manifold 48 establishes communication between the adjacent ends of the cylinders 22 and 23 and the combustion cylinder 43, opening into the latter cylinder through the port 49 and communicating with the cylinders 22 and 23 through the ports 50 and 51 respectively.

The sleeve valve 44 is provided with a port 52 which is adapted to register with the port 49 at the proper time, and a second port 53, which is adapted to register with the port 54 to establish communication between the combustion chamber or cylinder and the power cylinder 22. The sleeve valve 44 is provided with a third port 55 which is adapted to register with a cavity 56 formed in the wall of the combustion chamber 43 and having fixed therein the spark plug or other igniting means 57. In order to eliminate the distributing apparatus incident to the ordinary ignition apparatus for multiple cylinder engines, I prefer to connect the spark plugs of my improved engine to a source of electrical energy which will produce a continuous spark between the electrodes of the spark plugs and to effect an advancement and retardation by controlling the operation of the sleeve valve 44 so that it will advance or retard the instant at which the explosive charges in the combustion cylinder come into igniting contact with the spark plug. The specific means for accomplishing this result will be described in detail later on.

I prefer to provide the power cylinder 22 and the combustion chamber 43 with a water jacket 58, as indicated in Fig. 4. The induction pipe 34 is provided with a throttle valve 59.

The pitman rods 32 of opposed cylinders are connected to the same crank of the crank shaft as shown in Fig. 4, one of the pitmen being bifurcated as indicated at 60. For the purpose of convenience, in further explaining the construction and operation of my engine, each pair of opposed cylinders will be referred to as sections, the complete engine being built up of sections arranged side by side. In the embodiment of my improved engine herein illustrated I have shown the cylinders of the units of each section arranged at an angle of substantially

45 degrees to each other. This means that if the crank shaft rotates in a clockwise direction, as indicated by the arrow in Fig. 4, the different events in cylinder A will occur 45 degrees ahead of the same events in the cylinder B. The crank of the crank shaft for the section adjacent that shown in Fig. 4 will be arranged so that the events in the cycle of operation in unit A of the section adjacent the unit shown in Fig. 4 will occur 75 degrees after the same events occur in unit B of the section shown in Fig. 4, and the same events will occur in unit B of the adjacent section 120 degrees after the occurrence of the same events in unit B of the section shown in Fig. 4. In other words, the pitmen of the different sections are connected to the crank shaft 120 degrees apart, and the different events of the cycle of operation of the units of each section occur 45 degrees apart.

The pitmen 46 of the scavenging pistons 45 are connected to the valve crank shaft 47 in the same manner in which the pitmen 32 are connected to the crank shaft 33, and the pitmen 61 which connect the sleeves 44 with the valve crank shaft 47 are likewise connected to this crank shaft in the same manner in which the pitmen 32 are connected with the crank shaft 33. The pitmen 61 are connected with their crank shaft so as to operate 180 degrees ahead of the pitmen 32, and the pitmen 46 are connected with the valve crank shaft so as to operate 90 degrees ahead of the pitmen 61. It is to be understood of course that the angular displacements of the various pitmen and cranks relative to each other are merely approximate, and some variation therefrom could be made without departing from the spirit of my invention.

I will now describe the means by which the valve crank shaft 47 is driven from the main crank shaft:—

As shown in Figs. 1, 2, 3 and 6, the main crank shaft is provided at one end with a bevel gear 65 which meshes with a bevel gear 66 connected to the lower end of the shaft 67 which is journaled in the bearing 68 on the crank case. The upper end of the shaft 67 projects into the differential housing 69 and is provided with a bevel gear 70 which meshes with the two differential pinions 71 mounted upon opposite ends of the shaft 72. A shaft 73 journaled in the differential housing is provided at its lower end with a bevel gear 74 which meshes with the sides of the differential pinions 71 opposite the gear 70. A segmental gear 75 is connected with one end of the shaft 72 and meshes with a worm 76. The worm 76 is journaled in bearings 77, forming a part of the differential housing, and can be rotated by any suitable means. A bevel gear 78 is secured to the upper end of the shaft 73 and meshes with a bevel gear 79 secured to the end of the valve crank shaft 47. The various gears which are comprised in the driving connection between the shafts 33 and 47 are of such relative proportion as to give a one-to-one drive between the shafts 33 and 47; in other words, the shaft 47 rotates in unison with the shaft 33. The shaft 72 is pivoted upon a pin 80, the upper end of which is secured in the lower end of shaft 73, and the lower end of which is secured in the upper end of the shaft 67.

From the above description it will be clear that by rotating the shaft 72 about the axis of the pin 80 or the axes of the shafts 67 and 75 in one direction or the other, the shaft 73 and consequently the shaft 47 will be displaced angularly with respect to the shafts 33 and 67 a distance equal to the angular adjustment of the shaft 72. Consequently by moving the shaft 72 in one direction about the axis of the pin 80, the various sleeve valves 44 will be actuated so as to cause an advanced uncovering of the spark plug 57 and consequently an advanced ignition; and by moving the shaft 72 in the other direction the opposite result,—namely, a retarded ignition will be produced. By thus varying the instant at which the explosive charges and the spark plug are brought into contact, I am able to discard the usual distributing and timing apparatus and avoid the troubles incident thereto.

The means for driving the valves 37 and 38 are as follows:—

A shaft 85 is mounted in suitable bearings upon each of the end units 20. These shafts are provided at their lower ends with the bevel gears 86 which mesh with the bevel gear 87 on the shaft 67. Bevel gears 88 at the upper ends of the shafts 85 mesh with the bevel gear portions of combined bevel and spur gears 89. The spur gear portions of the gears 89 mesh with spur gears 90 secured to the ends of the valves 37 and 38 adjacent this end of the engine to rotate these gears in the same direction. It should be noted, however, that since the ports 39 and 40 in the valves are 180 degrees from each other, it is immaterial which way the valves 37 and 38 rotate. The various gears between the shaft 67 and the valves should bear such relation to each other that these valves will rotate in unison with the shaft 67 and therefore with the main crank shaft.

Referring to Fig. 7, wherein I have illustrated the means for communicating the motion of the gears 90 to the valves for the remaining units of the engine, it will be seen that the adjacent ends of the valves are provided with circular recesses 91 having gear teeth formed on the walls thereof which mesh loosely with the teeth of the spur gear 92 which is loosely held in the cavity formed by the recesses in the adjacent ends of the

valves. The gear 92 forms the driving connection between the adjacent valves, but at the same time permits of slight displacement of one valve relative to the other, such as may occur in quantity production of engines embodying my invention. The valves at the ends of the engine are provided with peripheral annular grooves 93 (see Fig. 7), which are adapted to receive the ends of set screws 94 (see Fig. 1) so as to prevent longitudinal shifting of the valves relative to their seats.

The throttles 59 are each provided with a lever 96, and all of these levers are connected by a common operating link 97, by means of which they may be simultaneously actuated to open and close the induction pipes 34.

Referring to Fig. 2, it will be seen that the crank shaft 47 is provided with bearings 98 which support it from the crank case.

Having thus described the details of the mechanical construction of my improved engine, except as will be hereinafter noted, I will now describe the cycle upon which it operates:

Referring to Fig. 8, wherein the power piston 30 is shown at the end of its power stroke, the small circles in this cylinder indicating an ignited charge, it will be noted that the piston 31 has just completed a suction stroke and filled the compressor cylinder 23 with a combustible charge. The scavenging piston 45 is at practically the end of its scavenging stroke, and the sleeve valve is in such a position as to isolate the combustion chamber from both the power cylinder and the manifold 48.

In Fig. 9 the power piston is scavenging the power cylinder, the combustible mixture in the compressor cylinder is being forced into the combustion chamber or cylinder, and a fresh charge of combustible mixture is being drawn into the end of the power cylinder adjacent the compressor cylinder.

Fig. 10 shows the power piston at substantially the end of its scavenging stroke. The combustible mixture has been completely expelled from the compressor cylinder, the combustion chamber has been filled with combustible mixture and isolated from the manifold, and communication is about to be established between the combustion chamber and the upper end of the power cylinder. Ignition will take place at this instant, and as shown in Fig. 11, the ignited gases will expand, forcing the power cylinder downwardly on its power stroke. At the same time the scavenging piston in the combustion chamber moves upwardly to displace the ignited gases from the combustion chamber. As the power piston moves downwardly it displaces the combustible mixture from the lower end of the power cylinder and forces it into the manifold, and a fresh charge of combustible mixture is drawn into the compressor cylinder.

Fig. 12 shows the power piston at the end of its power stroke and the scavenging piston at the end of its scavenging stroke. The compressor cylinder is completely filled with combustible mixture.

Fig. 13 shows the power cylinder moving upwardly on its scavenging stroke and at the same time drawing in a fresh charge in the lower end of the power cylinder. The scavenging piston in the combustion chamber is moving downwardly, and the combustible mixture is flowing into the combustion chamber. The piston in the compressor chamber is moving upwardly and forcing the combustible mixture therein into the manifold.

It will be noted that Figs. 8 to 13 inclusive each disclose check valves 100 and 101 for controlling the flow of combustible mixture from the lower end of the power cylinder and from the compressor cylinder to the manifold, these check valves opening outwardly from their respective cylinders. These check valves control the ports 50 and 51 respectively of Fig. 4.

From the above description it will be seen that during each revolution of the main crank shaft the power cylinder and the compressor cylinder each force a cylinderful of combustible mixture into the combustion chamber, where it is exploded, so that there is a power impulse for each revolution of the crank shaft. I preferably make the capacity of the combustion chamber substantially 20 per cent. of the capacity of the power cylinder or the compressor cylinder.

In operating my improved engine at sea level the throttles are adjusted so that the pressure in the compressor cylinder and the power cylinder at the end of their suction strokes is approximately half of the atmospheric pressure. As the aeroplane which is driven by my engine ascends to higher levels, the throttles 59 are gradually opened until by the time the aeroplane reaches an altitude of 20,000 feet the throttles are completely open and the explosive mixture is entering the power and compressor cylinders at approximately full atmospheric pressure at that altitude. At an altitude of 20,000 feet the pressure of the atmosphere is substantially one-half that at sea level. Consequently, by thus regulating the throttles 59 in accordance with the varying atmospheric pressure, the compression in the combustion chamber will remain substantially constant and the power output will likewise remain constant.

By utilizing the lower side of the power piston to compress part of the explosive mixture, the additional piston displacement which must be provided to give sufficient

mixture for overload operation at 20,000 feet is only one-half of what would be required if the compression were all done by one single-acting piston. As the second cylinder and its cross-head piston have to withstand only the pressures and temperatures incident to compression, they can be built of an aluminum alloy with light weight walls and without waterjacketing, thereby reducing the weight of the engine. Because of the use of the cross-head piston in the compressor cylinder, the piston in the power cylinder exerts no side thrust against the cylinder wall and consequently the friction is reduced to a minimum and the lubrication problem correspondingly reduced. By providing means for regulating the stroke of the sleeve valve so as to regulate the time at which the explosive mixtures in the combustion cylinder contact with the ignition means, the usual timing and distributing apparatus can be dispensed with, and thereby eliminate the trouble due to broken cables, burned contacts, and other parts of the ordinary ignition apparatus which are subject to rapid deterioration.

While I have thought it unnecessary to illustrate such mechanism, it will be clear that an engine such as described above, having three or more power cylinders, can be made self-starting by the addition of a tank for the storage of a quantity of compressed explosive mixture and cocks for controlling the flow of compressed gas during the period of starting into the manifolds between the compressor cylinders and the combustion chamber.

Since the explosive mixture is taken into the combustion chamber at a comparatively low temperature, and the heated surfaces with which it comes in contact before ignition are about one-third of those exposed to the fresh gases in the ordinary type of engine, and since this gas is in contact with these heated surfaces during one stroke only and not during two strokes, as in the ordinary engine, the heating effected from these walls is about one-sixth of that in the standard engine. Also, because of perfect scavenging, the free gases are not heated by mixing with the residue of the products of combustion of the preceding mixture. The temperature of the mixture as it enters the combustion cylinder is consequently much lower than the temperature of the combustible mixture in an ordinary four-cycle engine at the beginning of the compression stroke, and a much higher compression pressure can be used in my engine than in the ordinary type of engine. This will result in a higher explosive pressure and hence a greater output per power stroke from a cylinder of a given size than is possible in the ordinary four-cycle engine.

Since the mixture is ignited before it enters the working cylinder, pre-ignition troubles are absent from this cylinder, and its walls may therefore be worked at high temperatures with a resulting increase in efficiency. Furthermore, the absence of burned gases which might mix with the fresh charge decreases the probability of "missing" and permits rapid inflammation and thorough combustion, which in turn insure a maximum pressure from an ignited charge.

While I have illustrated and described the preferred embodiment of my invention, it is to be understood that my invention is not limited to these details, but is capable of other adaptations and modifications within the scope of the appended claims. In particular, it should be noted that whereas I have illustrated and described the ignition means as comprising an ordinary spark plug to which ignition current is continuously supplied, this igniting means could be replaced by any means which would be continuously effective to cause ignition of the combustible mixture at the instant of contact. Furthermore, it is necessary that the ignition means be continuously effective only in the sense that it must be effective at any time to cause ignition of the combustible mixture. Its period of effectiveness need extend only from the most advanced position of the sleeve valve to the most retarded position of this valve. In other words, the ignition means must be continuously effective only during that period of the cycle of operation during which it may be desired to cause ignition of the combustible charges in the combustion chamber. It should also be clearly understood that although I have referred through the description of the construction and operation of my engine to the combustible mixture drawn into the power and compressor cylinders and forced into the combustion chamber or cylinder, my invention is not limited to an engine operating in this manner, and that it is intended to cover a construction in which air only is drawn into the power and compressor cylinders and forced into the combustion cylinder, means being provided for forcing the fuel into the combustion chamber under pressure at the proper time in a manner well known to those skilled in this art. Consequently, wherever the expression "combustible mixture" is used in this specification and the appended claims, it is intended that this expression is to cover air as well as a mixture of fuel and air.

Having thus described my invention, what I claim is:

1. An internal combustion engine comprising a power cylinder, a compressor cylinder co-axial with said power cylinder, a double-acting piston in said power cylinder, an elongated piston in said compressor cylinder, a common piston rod for both of said

pistons, a combustion chamber, a manifold for conducting explosive charges from said cylinders to said chamber, a sleeve valve in said combustion chamber for controlling communication between said manifold and said combustion chamber and between said combustion chamber and one end of said power cylinder, and for controlling the exhaust from said power cylinder, and a scavenging piston in said sleeve valve.

2. An internal combustion engine comprising a power cylinder, a compressor cylinder co-axial with said power cylinder, a double-acting piston in said power cylinder, a piston in said compressor cylinder, a common piston rod for both of said pistons, a combustion chamber, a manifold for conducting explosive charges from said cylinders to said chamber, a sleeve valve in said combustion chamber for controlling communication between said manifold and said combustion chamber and between said combustion chamber and one end of said power cylinder, and for controlling the exhaust from said power cylinder, and a scavenging piston in said sleeve valve.

3. An internal combustion engine comprising a power cylinder, a compressor cylinder, a piston in said power cylinder, a piston in said compressor cylinder, a combustion chamber, a manifold for conducting explosive charges from said cylinders to said chamber, a sleeve valve in said combustion chamber for controlling communication between said manifold and said combustion chamber and between said combustion chamber and one end of said power cylinder, and for controlling the exhaust from said power cylinder, and a scavenging piston in said sleeve valve.

4. An internal combustion engine comprising a power cylinder, a compressor cylinder, a piston in said power cylinder, a piston in said compressor cylinder, a combustion chamber, a manifold for conducting explosive charges from said cylinders to said chamber, a sleeve valve in said combustion chamber for controlling communication between said manifold and said combustion chamber and between said combustion chamber and one end of said power cylinder, and a scavenging piston in said sleeve valve.

5. An internal combustion engine comprising a power cylinder, a piston in said cylinder, a combustion chamber, means for supplying explosive charges to said combustion chamber under pressure, a sleeve valve in said combustion chamber controlling communication between said charge-supplying means and said combustion chamber and between said combustion chamber and said power cylinder, and for controlling the exhaust from said power cylinder, a scavenging piston in said combustion chamber, a crank shaft, and means for connecting said pistons with said crank shaft substantially 180 degrees apart.

6. An internal combustion engine comprising a power cylinder, a combustion chamber, means for supplying explosive charges to said combustion chamber under pressure, a sleeve valve in said combustion chamber controlling communication between said charge-supplying means and said combustion chamber and between said combustion chamber and said power cylinder, and for controlling the exhaust from said power cylinder, and a scavenging piston in said combustion chamber.

7. An internal combustion engine comprising a power cylinder, a combustion chamber, means for supplying explosive charges to said combustion chamber under pressure, a sleeve valve in said combustion chamber controlling communication between said charge-supplying means and said combustion chamber and between said combustion chamber and said power cylinder, and for controlling the exhaust from said power cylinder.

8. An internal combustion engine comprising a power cylinder, a piston in said cylinder, a combustion chamber, means for supplying explosive charges to said combustion chamber under pressure, a single valve in said combustion chamber controlling communication between said charge-supplying means and said combustion chamber and between said combustion chamber and said power cylinder, and for controlling the exhaust from said power cylinder, a scavenging piston in said combustion chamber, a crank shaft, and means for driving said pistons from said crank shaft substantially 180 degrees apart.

9. An internal combustion engine comprising a power cylinder, a piston in said cylinder, a combustion chamber, means for supplying explosive charges to said combustion chamber under pressure, a single valve in said combustion chamber controlling communication between said charge-supplying means and said combustion chamber and between said combustion chamber and said power cylinder, a scavenging piston in said combustion chamber, a crank shaft, and means for driving said pistons from said crank shaft substantially 180 degrees apart.

10. An internal combustion engine comprising a power cylinder, a piston in said cylinder, a combustion chamber, means for supplying explosive charges to said combustion chamber under pressure, and a single valve in said combustion chamber controlling communication between said charge-supplying means and said combustion chamber and between said combustion chamber and said power cylinder, and for controlling the exhaust from said power cylinder,

and means for mechanically scavenging said combustion chamber.

11. An internal combustion engine comprising a power cylinder, a double-acting piston in said power cylinder, a compressor cylinder co-axial with said power cylinder, an elongated piston in said compressor cylinder, a common piston rod for both of said pistons, a crank shaft, a pitman connecting said elongated piston with said crank shaft, a combustion chamber, and means providing communication between the adjacent ends of said cylinders and said combustion chamber and between the other end of said power cyinder and said combustion chamber.

12. An internal combustion engine comprising a power cylinder, a double-acting piston in said power cylinder, a compressor cylinder co-axial with said power cylinder, an elongated piston in said compressor cylinder, a common piston rod for both of said pistons, a crank shaft, a pitman connecting said elongated piston with said crank shaft, and a combustion chamber for supplying expansible gases to said power cylinder.

13. An internal combustion engine comprising a power cylinder, a double-acting piston in said power cylinder, a compressor cylinder co-axial with said power cylinder, a piston in said compressor cylinder, a common piston rod for both of said pistons, a crank shaft, and a pitman connecting said compressor-cylinder piston with said crank shaft.

14. An internal combustion engine comprising a power cylinder, a double-acting piston in said power cylinder, a compressor cylinder co-axial with said power cylinder, a piston in said compressor cylinder, a common piston rod for both of said pistons, a crank shaft, a pitman connecting said compressor-cylinder piston with said crank shaft, a combustion chamber, and means providing communication between the adjacent ends of said cylinders and said combustion chamber and between the other end of said power cylinder and said combustion chamber.

15. An internal combustion engine comprising a power cylinder, a double-acting piston in said power cylinder, a compressor cylinder, an elongated piston in said compressor cylinder, a common piston rod for said pistons, a crank shaft, a pitman connecting said elongated piston with said crank shaft, a combustion chamber, and means for conducting gases from said compressor cylinder and from one end of said power cylinder to said combustion chamber.

16. An internal combustion engine comprising a power cylinder, a double-acting piston in said power cylinder, a compressor cylinder, an elongated piston in said compressor cylinder, a crank shaft, and a pitman connecting said elongated piston with said crank shaft, a combustion chamber, and means for conducting gases from said compressor cylinder and from one end of said power cylinder to said combustion chamber.

17. An internal combustion engine comprising a power cylinder, a double acting piston in said power cylinder, a compressor cylinder, a piston in said compressor cylinder, a crank shaft, and a pitman connecting said compressor-cylinder piston with said crank shaft, a combustion chamber, and means for conducting gases from said compressor cylinder and from one end of said power cylinder to said combustion chamber.

18. An internal combustion engine comprising a power cylinder, a double-acting piston in said power cylinder, a compressor cylinder, a piston in said compressor cylinder, a common piston rod for said pistons, a crank shaft, and a pitman connecting said compressor-cylinder piston with said crank shaft, a combustion chamber, and means for conduction gases from said compressor cylinder and from one end of said power cylinder to said combustion chamber.

19. An internal combustion engine comprising a power cylinder, a combustion chamber, means for supplying a combustible mixture to said combustion chamber, a continuously-active means for igniting charges of combustible mixture supplied to said combustion chamber, a sleeve valve for controlling contact of said combustible mixture with said igniting means, a crank shaft, and driving connections between said crank shaft and said sleeve valve, comprising means for advancing and retarding said sleeve valve relative to said crank shaft.

20. An internal combustion engine comprising a power cylinder, a combustion chamber, means for supplying a combustible mixture to said combustion chamber, a continuously-active means for igniting charges of combustible mixture supplied to said combustion chamber, a valve for controlling contact of said combustible mixture with said igniting means, a crank shaft, and driving connections between said crank shaft and said valve, comprising means for advancing and retarding said valve relative to said crank shaft.

21. An internal combustion engine comprising a power cylinder, a combustion chamber, means for supplying a combustible mixture to said combustion chamber, a means for igniting charges of combustible mixture supplied to said combustion chamber, a valve for controlling contact of said combustible mixture with said igniting means, a crank shaft, and driving connections between said crank shaft and said valve, comprising means for advancing and retarding said valve relative to said crank shaft.

22. An internal combustion engine com-

prising a cylinder, means for supplying combustible mixture to said cylinder, a continuously-active igniting means, a valve controlling contact by said mixture with said igniting means, a crank shaft, and a driving connection between said crank shaft and valve, comprising means for advancing and retarding said valve relative to said crank shaft.

23. An internal combustion engine comprising a cylinder, means for supplying combustible mixture to said cylinder, a continuously-active igniting means, means controlling contact by said mixture with said igniting means, a crank shaft, and a driving connection between said crank shaft and said contact-controlling means, comprising means for advancing and retarding the contact between the combustible mixture and said igniting means.

24. An internal combustion engine comprising a cylinder, means for supplying combustible mixture to said cylinder, a continuously-active igniting means, means for causing contact between said combustible mixture and said igniting means, and means for timing said last-named means.

25. An internal combustion engine comprising a cylinder, means for supplying combustible mixture to said cylinder, an igniting means, means for causing contact between said combustible mixture and said igniting means, and means for timing said last-named means.

26. An internal combustion engine comprising a cylinder, means for supplying combustible mixture to said cylinder, an igniting means, and means distinct from said ignition means for timing the explosion of said combustible mixture.

27. An internal combustion engine comprising a power cylinder, a double-acting piston in said power cylinder, a combustion chamber, means for supplying combustible mixture to the crank end of said cylinder, means for conducting the compressed mixture from the said end of said power cylinder to said combustion chamber, means for exploding the combustible mixture in said combustion chamber, and means for conducting the exploded gases from said combustion chamber to said power cylinder.

In witness whereof, I hereunto subscribe my name this 15th day of November, 1918.

ALLEN M. ROSSMAN.

Witnesses:

EDNA V. GUSTAFSON,

FAE PETRIE.