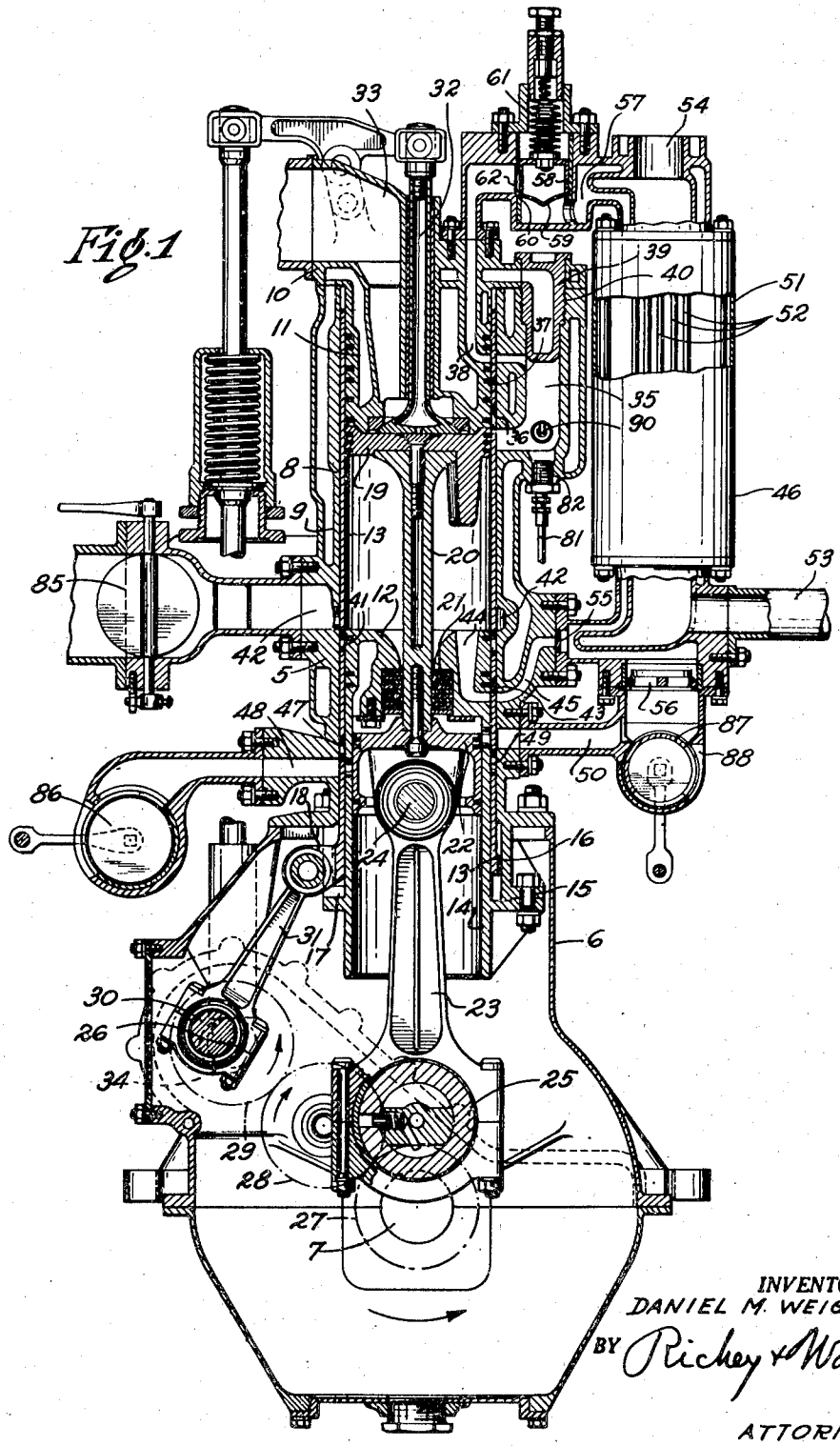
Sept. 14, 1948. D. M. WEIGEL 2,449,262

VALVE ARRANGEMENT FOR EXTERNAL-COMBUSTION ENGINES

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Fig. 1



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Filed Feb. 4, 1943 2 Sheets-Sheet 2

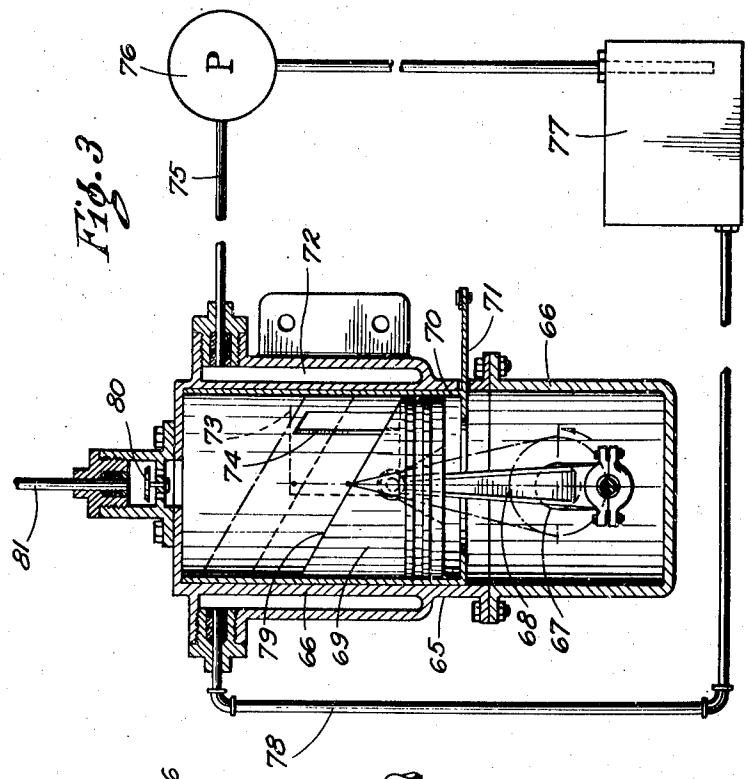


Fig. 3

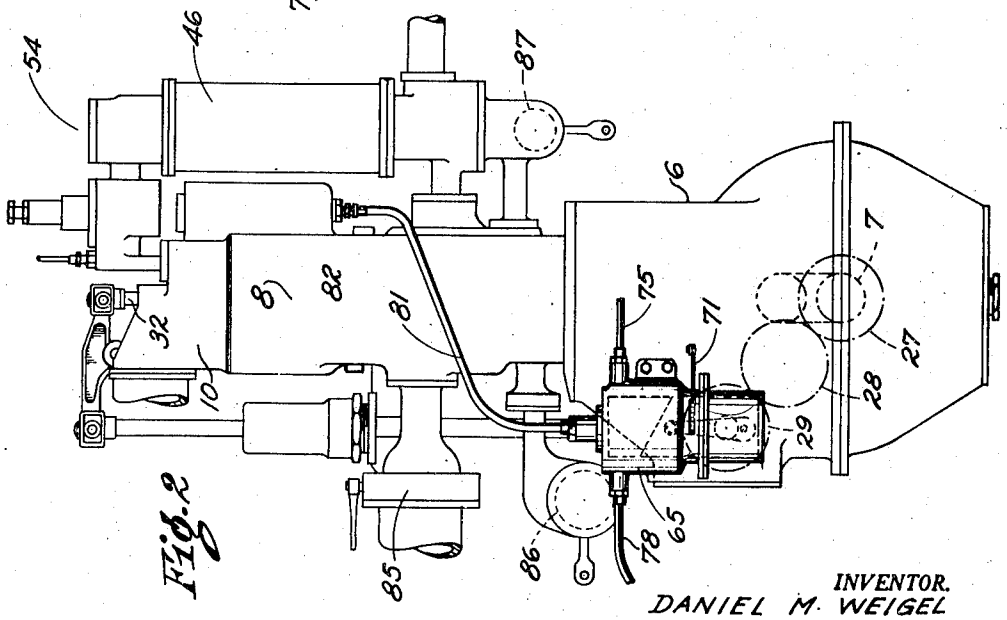


Fig. 2

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Patented Sept. 14, 1948 2,449,262

UNITED STATES PATENT OFFICE

2,449,262

VALVE ARRANGEMENT FOR EXTERNAL-COMBUSTION ENGINES

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Application February 4, 1943, Serial No. 474,671

8 Claims. (Cl. 60—44)

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This invention relates to external combustion engines and particularly to an improved injection type engine.

The principal objects of the present invention are to incorporate in an injection engine operating on a constant volume combustion cycle, such as that disclosed in my Patent No. 2,364,330, issued December 5, 1944, a greater flexibility and wider range of compression pressures without substantial increase in size or number of parts of the engine; to provide an improved and simplified valve arrangement in which a single sleeve valve controls communication of a combustion chamber with an intercooler and a power cylinder, and also controls inlet and outlet valves for each of two separate compression cylinders; and to provide means to vary the amount of air admitted from an intercooler to a combustion chamber in accordance with the opening of a throttle valve on the intake of a compression cylinder supplying compressed air to the intercooler, so that the fuel injector pump and the air throttle may be directly coupled and varying quantities of air and fuel in substantially constant proportions may be admitted to the combustion chamber depending upon the position of the throttle control.

Other objects and advantages will appear from the following detailed description of the preferred embodiment of the invention.

Referring to the drawings:

Fig. 1 is a vertical sectional view of one cylinder of an external combustion engine constructed according to the present invention;

Fig. 2 is an end view of the same; and

Fig. 3 is an enlarged sectional view of a fuel injector pump with a diagrammatic showing of the fuel piping.

The engine illustrated includes a cylinder block 5 having a crankcase 6 secured to one end and supporting a crankshaft 7. A cylinder 8 is formed in the cylinder block and surrounded by a water jacket 9. The upper end of the cylinder is closed by a head 10 having a depending water jacketed portion 11 extending into the cylinder, and the lower end is closed by a cover 12.

A valve sleeve 13 is slidably mounted within the cylinder 8 and extends at its upper end into the space between the cylinder 8 and the depending portion 11 of the head. The cylinder cover 12 is formed with a depending skirt portion 14 which is bolted at 15 to an annular flange 16 depending from the cylinder block. The flange 16 is slotted as shown at 17 and the lower end of the sleeve 13 is formed with a laterally projecting lug 18 which works in the slot 17. The sleeve 13 slidably bears on the inner surface of the cylinder 8 and on the outer surface of the cylinder cover 12 and its skirt 14.

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A piston 19 provided with suitable packing rings slidably bears within the sleeve 13 and is reciprocable between the portion 11 of the cylinder head and the cylinder cover 12. A piston rod 20 is secured to the piston 19 and projects through a central opening in the cylinder cover 12, the joint being sealed by a suitable stuffing box 21. The lower end of the piston rod 20 is secured to a cross head 22 which is formed as an auxiliary piston so as to bear throughout its circumference on the inner surface of the skirt 14 of the cylinder cover 12. A connecting rod 23 is journalled on a suitable wrist pin 24 carried by the cross head 22 and at its other end is journalled to a crank pin 25 of the crankshaft 7.

A suitable cam shaft 26 is arranged to be driven by the crankshaft 7 at a one-to-one ratio, as for example by a gear 27 on the crankshaft 7, an intermediate gear 28 and a gear 29 on the cam shaft 26. The cam shaft 26 is formed with a crank pin 30 to which is journalled a connecting rod 31 which has its other end pivotally connected to the lug 18 projecting from the lower end of the sleeve 13. The crank pin 30 is arranged so as to reach its upper dead center about 90° ahead of the crank pin 25.

A poppet valve 32 opens through the center of the cylinder head 10 and its depending extension 11. A suitable exhaust passage 33 is formed in the head and is arranged to be opened to the interior of the cylinder 8 when the poppet valve 32 is open. The valve 32 is operated by a suitable rocker arm and push rod actuated by a cam 34 on the cam shaft 26.

A combustion chamber 35 is formed in the cylinder block adjacent the upper end of the cylinder 8. A port 36 is cut through the sleeve 13 and is arranged to open the combustion chamber 35 to the interior of the cylinder 8 in one position of the sleeve 13. Similarly a port 37 is arranged to open communication between the combustion chamber 35 and a passage 38 in one position of the sleeve 13. Preferably the combustion chamber is closed at its upper end by a plug 39 removably threaded into the cylinder block, as indicated at 40.

At its lower end the sleeve 13 is provided with port openings 41 arranged to open communication between the interior of the cylinder on the under side of the piston 19 and an air intake

passage 42, which may be formed as illustrated to partially or completely surround the cylinder. Another port 43 formed in the sleeve 13 is arranged to open communication between an outlet passage 44 formed in the cylinder cover 12 and a passage 45 leading to an intercooler 46. Thus the under side of the piston 19 is arranged to inspire air through the intake passage 42 and compress the same through the passages 44 and 45 into the intercooler 46.

Below the cylinder cover 12 the sleeve 13 is provided with a port 47 arranged to open communication between another inlet passage 48 and the interior of the skirt 14 above the cross-head 22. A port 49 formed in the sleeve valve is arranged to open communication between the interior of the sleeve 14 and a passage 50 which also leads to the intercooler 46.

The various ports in the sleeve valve 13 are arranged so that as the piston starts on its downward stroke from the position illustrated in Fig. 1 the port 36 opens the combustion chamber 35 to the interior of the cylinder 8, the port 43 opens the interior of the cylinder 8 below the piston 19 to the passage 45 leading to the intercooler and the port 47 opens the space between the cross-head 22 and the cylinder cover 12 to the intake passage 48. These ports remain open substantially throughout the downward stroke of the piston 19, or in other words remain open during the lower half of the reciprocation of the sleeve 13. As the crank pin 25 passes its lower dead center the crank pin 30, which is leading the crank pin 25 by about 90°, moves the sleeve 13 into the upper half of its reciprocation. This movement of the sleeve 13 closes the ports 36, 43 and 47 and opens the ports 41 and 49 so as to establish communication between the intake passage 42 and the interior of the cylinder 8 on the under side of the piston 19 and also to establish communication between the passage 50 leading to the intercooler 46 and the space between the cross head 22 and the cylinder cover 12.

The port 37 in the sleeve valve 13 is arranged to open the passage 38 in the cylinder head to the combustion chamber 35 for a short period during the upper half of the stroke of the sleeve 13 after the port 36 has closed the combustion chamber from the interior of the cylinder head. This occurs during the upward stroke of the piston, beginning, for example, about 45° after bottom center and ending about 45° before top center. Thus communication between the combustion chamber and the passage 38 is again closed by the sleeve before the port 36 again opens the combustion chamber to the interior of the cylinder 8 on the downward stroke of the sleeve.

The intercooler 46 may consist, as illustrated, of a casing 51 which encloses a plurality of water tubes 52 communicating at one end with a water inlet 53 and at the other end with a water outlet 54. The air passages 45 and 50 lead through feather valves 55 and 56 respectively into the interior of the casing 51 so that the air passes around the tubes 52.

The opposite end of the intercooler 46 opens into an air passage 57 which communicates with the passage 38 in the cylinder head through the pressure regulating valve 58. This valve consists of a slidable plug 59 normally pressed against a seat 60 by an adjustable spring 61. When the plug 59 is positioned on the seat 60 its lower face is opened to the air pressure in the passage 57 and one of its side surfaces closes the port 62 leading to the air passage 38 in the cylinder head. Thus the valve 58 normally closes communication between the outlet passage 57 of the intercooler 46 and the passage 38 in the cylinder head and opens communication between these passages when the pressure in the passage 57 exceeds the tension of the spring 61.

A fuel injector pump 65 is arranged to be driven so as to inject fuel into the combustion chamber 35 once during each reciprocation of the piston. Conveniently the pump may be connected directly to the cam shaft 26 as illustrated in Fig. 2. Any suitable type of pump may be used. The illustrated embodiment consists of a casing 66 containing a crankshaft 67 driving a connecting rod 68 pivoted to a piston 69. The piston reciprocates within a rotatably adjustable sleeve 70 which can be turned to different angular positions by the arm 71. An annular passage 72 is formed to surround the portion of the casing 66 containing the sleeve 70, and is arranged to communicate with the interior of the sleeve through an opening 73 cut through the wall of the casing 66. The sleeve 70 is formed with a relatively narrow opening 74 arranged to register with the opening 73 in different angular positions of the sleeve 70. The annular chamber 72 is connected through a pipe 75 to a fuel pump 76 which draws fuel from a main tank 77, and is also provided with a return pipe 78 leading back to the fuel tank 77. Thus when the pump 76 is operated the annular chamber 72 is maintained full of fuel.

The piston 69 has an inclined upper face 79 which cooperates with the slot 74 in the sleeve 70 to vary the quantity of fuel pumped on each stroke depending on the annular position of the sleeve 70. The interior of the casing 66 above the piston 69 communicates through a check valve 80 with the pipe 81 which leads to an injector nozzle 82 opening into the interior of the combustion chamber 35.

Assuming the space above the piston 69 has first been filled with liquid fuel, the piston on its down stroke draws in additional fuel from the annular chamber 72 through the opening 73 and the slot 74. On its up stroke fuel is returned from the interior of the sleeve 70 to the annular chamber 72 until the inclined upper face 79 of the piston 69 passes the upper edge of the slot 74. Through the remainder of the upward stroke of the piston fuel is forced through the check valve 80 and the pipe 81 into the combustion chamber 35. With the sleeve 70 turned so as to position the slot 74 as illustrated in Fig. 3, the piston 69 moves but a short distance after passing the upper end of the slot 74 so that a relatively small amount of fuel is pumped on each stroke. By turning the sleeve 70 so as to position the slot 74 adjacent the opposite side of the opening 73 a greater portion of the stroke of the piston occurs after the upper edge of the piston has passed the upper edge of the slot 74 so that a larger quantity of fuel is pumped on each stroke.

The air intake passages 42 and 48 are provided with throttle valves 85 and 86 respectively. The air outlet passage 50 is also preferably provided with a valve 87 which in one position opens the passage 50 to the atmosphere through a port 88 and in another position closes the passage 50 from the atmosphere so that air forced thereinto must pass through the check valve 56 into the intercooler 46. The throttle valve 85 and the arm 71 which adjusts the position of the sleeve 70 in the fuel pump 65 may be manipu-

lated simultaneously or separately in any desired manner. The valves 86 and 87 are preferably separately controlled.

With the controls arranged in this manner the engine is preferably proportioned so that the ratio between the displacement volume of the cylinder 8 on the under side of the piston 19 and the volume of the combustion chamber 35 is equal to the desired maximum compression ratio of the engine. The displacement volume of the space within the skirt 14 and above the cross-head 22 may then be used as a supercharger to compensate for the reduction of atmospheric pressure caused by increases in altitude.

To start the engine arranged in this manner the throttle 85 and the control arm 71 of the fuel injector pump may be left in closed position, the valve 87 closed, the valve 86 opened and the engine turned over by any suitable starting motor until the desired maximum pressure is built up in the intercooler 46. The valve 87 may then be opened so that the cross-head 22 pumps idly without load and the throttle 85 and injector pump control 71 opened to admit air and fuel. Each upward stroke of the piston 19 inspires a quantity of air through the port 41 and the air intake 42, the quantity depending upon the degree of opening of the throttle valve 85. Each downward stroke of the piston forces the inspired air into the intercooler 46. By reason of the cooling of the air in the intercooler a substantial part of the heat of compression is removed so that the pressure in the intercooler increases substantially in accordance with the law of isothermal compression. The tension of the spring 61 is set at some value in excess of atmospheric pressure and less than the maximum pressure that would be obtained by isothermal compression of a volume of air equal to the displacement volume on the under side of the piston 19 into the volume of the combustion chamber 35. This can be a relatively high compresssion ratio since the compression is not limited by the rise in temperature of the air which occurs in the adiabatic compression in the ordinary engine. Preferably the compression ratio is on the order of 17 to 1, a ratio such that if the compression were adiabatic the temperature of the air would exceed the ignition temperature of the fuel.

Preferably the tension of the spring 61 is adjusted to be but slightly less than the maximum compression pressure. After the intercooler 46 has been filled with air at a pressure which just balances the tension of the spring 61, the additional quantity of air forced into the intercooler by any given stroke of the piston 19 raises the valve 58 against the tension of the spring 61 and holds the valve raised so that the outlet 57 of the intercooler is open through the port 62 to the passage 38 in the cylinder head until a quantity of air equal to that forced into the intercooler has passed out through the port 62. During the next upward stroke of the piston 19 the sleeve valve 13 closes the port 36, so that the combustion chamber 35 is separated from the cylinder 8, and thereafter opens the port 37 so that air can enter the combustion chamber 35 from the intercooler 46. As soon as a quantity of air equal in weight to that forced into the intercooler on the preceding stroke of the piston 19 has entered the combustion chamber 35 the valve 58 is again closed by the spring 61. Thereafter as the piston 19 continues its upward stroke the sleeve valve 13 closes the port 37 and fuel is injected into the combustion chamber through the injector

82. At about the time the piston 19 reaches its upper dead center the valve 36 is opened and the combustible mixture in the chamber 35 is fired by any suitable means, such as the spark plug 90. The exact relation between the firing of the mixture, the opening of the valve 36 and the position of the piston 19 may be varied slightly to obtain the best results. Preferably the firing is initiated before the piston 19 reaches its top center and the valve 36 is opened before ignition is complete, so as to avoid building up too great a pressure in the combustion chamber 35.

After the mixture in the chamber 35 has been ignited and the valve 36 has opened so as to establish communication between the combustion chamber and the interior of the cylinder 8, expansion of the gases forces the piston 19 downwardly on its next stroke. At a suitable point during the downward movement of the piston 19, as for example at between 40° and 60° prior to bottom dead center, the cam 34 opens the exhaust valve 32 so that the cylinder may blow down to or below atmospheric pressure before the piston 19 reaches its bottom dead center. After the pressure in the cylinder 8 and the combustion chamber 35 have been reduced substantially to atmospheric pressure, and at a point near the bottom dead center of the piston 19, the sleeve valve 13 closes the port 36 so that the combustion chamber 35 is again separated from the cylinder 8. During the upward stroke of the piston 19 the exhaust valve 32 remains open so that the exhaust gases in the cylinder 8 are swept out by the piston. During this exhaust stroke the valve 37 again opens to admit a new charge of air from the intercooler 46 to the combustion chamber 35.

By reason of the regulating valve 58 it will be apparent that the quantity of air admitted to the combustion chamber 35 at each stroke is equal to the quantity of air inspired on the under side of the piston 19 and forced into the intercooler 46 on the preceding stroke. This in turn depends upon the setting of the throttle valve 85. Thus the control 71 for the fuel injector pump may be adjusted simultaneously with the movement of the throttle valve 85. The pump will inject the correct quantity of fuel into the combustion chamber for the quantity of air admitted from the intercooler 46. The response of the engine to changes of the throttle valve 85 and the injector pump control 71 is thus substantially instantaneous, regardless of the volume of air compressed in the intercooler 46.

The engine may then be supercharged to compensate for reductions in atmospheric pressure caused by an increase in altitude by closing the valve 87 and opening the valve 86 in proportion to the reduction in atmospheric pressure.

The engine controls may also be arranged so that the compression space above the cross-head 22 serves as an overcharger operating throughout the normal range of operation of the engine at sea level. For this purpose the combustion chamber 35 is increased in size so that the ratio of its volume to the combined volumes of the cylinder 8 on the under side of the piston 19 and the displacement volume above the cross-head 22 is equal to the desired compression ratio. The valve 87 is then maintained closed and the throttle valves 85 and 86 and the control 71 for the fuel injector pump are manipulated. The fuel injector pump is arranged to supply a greater quantity of fuel at any particular setting to conform to the greater quantity of air compressed

into the intercooler 46 by the two compression pistons 19 and 22. Thus an engine of greater maximum capacity for a given size is produced. This change may be conveniently effected by simply removing the plug 39 which closes the upper end of the combustion chamber 35 and replacing it with a shorter plug designed to increase the volume of the combustion chamber the correct amount for the particular length of stroke and diameter of skirt 14 included in the engine.

Although a preferred embodiment of the invention has been described it will be understood that the invention is not limited thereto. The pressure regulating valve, for example, may be used either in the engine disclosed, or in an engine such as that shown in my Patent No. 2,220,926, in which a combustible mixture of fuel and air is compressed into the intercooler. Similarly, other variations and rearrangements of the parts may be resorted to without departing from the scope of the invention as defined in the following claims.

I claim:

1. In combination with an external combustion engine having a combustion chamber, a reservoir of compressed gas, means driven by the engine for compressing gas into said reservoir, a throttle valve controlling the pressure of the gas compressed by said means, a conduit for admitting gas from said reservoir into said combustion chamber, a valve operated by said engine interposed in said conduit, a pump for injecting controllable quantities of fuel into said combustion chamber, a regulating valve in said conduit interposed between said reservoir and said first named valve, and means exerting a constant pressure on said regulating valve urging the same toward closed position to interrupt communication between said reservoir and said engine, said regulating valve being urged toward open position by the pressure in said reservoir.

2. In combination with an external combustion engine having a combustion chamber, a reservoir of compressed gas, means driven by the engine for inspiring and compressing gas into said reservoir, a throttle valve controlling the pressure of the gas inspired by said means, a valve operated by said engine for admitting gas from said reservoir into said combustion chamber once during each cycle of the engine, a pump for injecting fuel into said combustion chamber once during each cycle of the engine, a regulating valve interposed between said reservoir and said engine, and means exerting a constant pressure on said regulating valve urging the same toward closed position to interrupt communication between said reservoir and said engine, said regulating valve being urged toward open position by the pressure in said reservoir.

3. An external combustion engine comprising a main cylinder, a double-acting piston reciprocable in said cylinder, an auxiliary cylinder aligned with said main cylinder, means closing the adjacent ends of said main and auxiliary cylinders, a cross-head reciprocable in said auxiliary cylinder, a piston rod connecting said piston with said cross-head and extending through said closure means, a combustion chamber having a removable plug adapted to be varied in length to vary the volume of said chamber, an intercooler, valve means arranged to open one end of said main cylinder alternately to a gas intake and to said intercooler, valve means to open said auxiliary cylinder alternately to said intercooler and to a gas intake, a check valve interposed between said intercooler and said auxiliary cylinder, a second check valve interposed between said intercooler and said end of said main cylinder, valve means to open said combustion chamber alternately to said intercooler and to the other end of said main cylinder, and valve means to open said auxiliary cylinder to atmosphere to render the same inoperative when desired.

4. An external combustion engine comprising a main cylinder having power and compression ends, a double-action piston reciprocable in said cylinder, an auxilairy cylinder aligned with said main cylinder, means closing the adjacent ends of said main and auxiliary cylinders, a cross-head piston reciprocable in said auxiliary cylinder, a piston rod connecting said double-acting piston and said cross-head piston and extending through said closure means, an intercooler, valve means arranged to open the compression end of said main cylinder alternately to an air intake and to said intercooler, valve means to open said auxiliary cylinder alternately to said intercooler and to an air intake, check valve means between said auxiliary cylinder and said intercooler, check valve means between the compression end of said main cylinder and said intercooler, a combustion chamber, valve means to open said combustion chamber alternately to said intercooler and to the power end of said main cylinder, pressure regulating valve means between said combustion chamber and said intercooler, a pump for injecting fuel into said combustion chamber once during each cycle of said engine while said combustion chamber is closed from said intercooler and from the power end of said main cylinder, and ignition means in said combustion chamber arranged to initiate firing of the mixture in said combustion chamber while said combustion chamber is closed from said intercooler and from the power end of said main cylinder.

5. An external combustion engine comprising a main cylinder having power and compression ends, a double-acting piston reciprocable in said cylinder, an auxiliary cylinder aligned with said main cylinder, means closing the adjacent ends of said main and auxiliary cylinders, a cross-head reciprocable in said auxiliary cylinder, a piston rod connecting said piston with said cross-head and extending through said closure means, a combustion chamber, an intercooler, and a sleeve valve slidably mounted within said main cylinder and surrounding said auxiliary cylinder, said sleeve valve having ports arranged to open the compression end of said main cylinder alternately to an air intake and to said intercooler, a feather valve interposed between said intercooler and the compression end of said main cylinder, ports to open said auxiliary cylinder alternately to said intercooler and to an air intake, a second feather valve interposed between said intercooler and said auxiliary cylinder, ports to open said combustion chamber alternately to said intercooler and to the power end of said main cylinder, a pressure regulating valve interposed between said intercooler and said combustion chamber, and a pump for injecting fuel into said combustion chamber after said combustion chamber has been closed from said intercooler and before said combustion chamber is opened to the power end of said main cylinder.

6. An external combustion engine comprising a main cylinder having power and compression ends, a double-acting piston reciprocable in said cylinder, an auxiliary cylinder aligned with said

main cylinder, means closing the adjacent ends of said main and auxiliary cylinders, a cross-head reciprocable in said auxiliary cylinder, a piston rod connecting said piston with said cross-head and extending through said closure means, a combustion chamber, an intercooler, a pressure regulating valve interposed between said intercooler and said combustion chamber, and a sleeve valve slidably mounted within said main cylinder and surrounding said auxiliary cylinder, said sleeve valve having ports arranged to open the compression end of said main cylinder alternately to an air intake and to said intercooler, ports to open said auxiliary cylinder alternately to said intercooler and to an air intake, ports to open said combustion chamber alternately to said intercooler and to the power end of said main cylinder, a pump for injecting fuel into said combustion chamber after said combustion chamber has been closed from said intercooler and before said combustion chamber is opened to the power end of said main cylinder, and ignition means arranged to initiate firing of the mixture in said combustion chamber prior to the opening of said combustion chamber to the power end of said main cylinder.

7. In an external combustion engine of the fuel injection type, a combustion chamber, a reservoir for compressed air, means driven by the engine for compressing air into said reservoir, a pump driven by said engine for injecting fuel into said combustion chamber, means for controlling the quantity of fuel injected into said combustion chamber, a conduit for admitting air from said reservoir into said combustion chamber, a valve operated by said engine in said conduit, a second valve interposed between the first named valve and said reservoir, means exerting a constant pressure on said second valve urging the same toward closed position to interrupt communication between said reservoir and said combustion chamber, said second valve being urged toward open position by the pressure in said reservoir and means for controlling the quantity of air compressed into said reservoir independently of the control of said pump, whereby air pressure sufficient to open said second valve may be built up in said reservoir before fuel is admitted to said combustion chamber to start the engine.

8. An external combustion engine comprising a main cylinder having power and compression ends, a double-acting piston reciprocable in said cylinder, an auxiliary cylinder aligned with said main cylinder, means closing the adjacent ends of said main and said auxiliary cylinders, a cross-head reciprocable in said auxiliary cylinder, a piston rod connecting said piston with said cross-head and extending through said closure means, an intercooler, valve means arranged to open the compression end of said main cylinder alternately to an air intake and to said intercooler, valve means to open said auxiliary cylinder alternately to said intercooler and to an air intake, a combustion chamber, means for injecting fuel into said combustion chamber, valve means to open said combustion chamber alternately to said intercooler and to the power end of said main cylinder, a regulating valve interposed between said intercooler and said combustion chamber, and means exerting a constant pressure on said regulating valve urging the same toward closed position, said regulating valve being urged toward open position by the pressure in said intercooler.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
753,086	Mains	Feb. 23, 1904
1,237,373	Nordberg	Aug. 21, 1917
1,301,036	Cage	Apr. 15, 1919
1,386,394	Cage	Aug. 2, 1921
1,393,831	Rossman	Oct. 18, 1921
1,518,983	Hyvernaud	Dec. 9, 1924
1,878,326	Ricardo	Sept. 20, 1932
1,955,620	Büchi	Apr. 17, 1934
2,131,216	Brooke	Sept. 27, 1938
2,220,926	Weigel	Nov. 12, 1940
2,227,896	Fitzgerald	Jan. 7, 1941

FOREIGN PATENTS

Number	Country	Date
611,212	France	June 28, 1926
219,469	Germany	Feb. 28, 1910
247,745	Germany	June 6, 1912