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FREE PISTON ENGINE-COMPRESSOR APPARATUS

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3 Sheets-Sheet 1

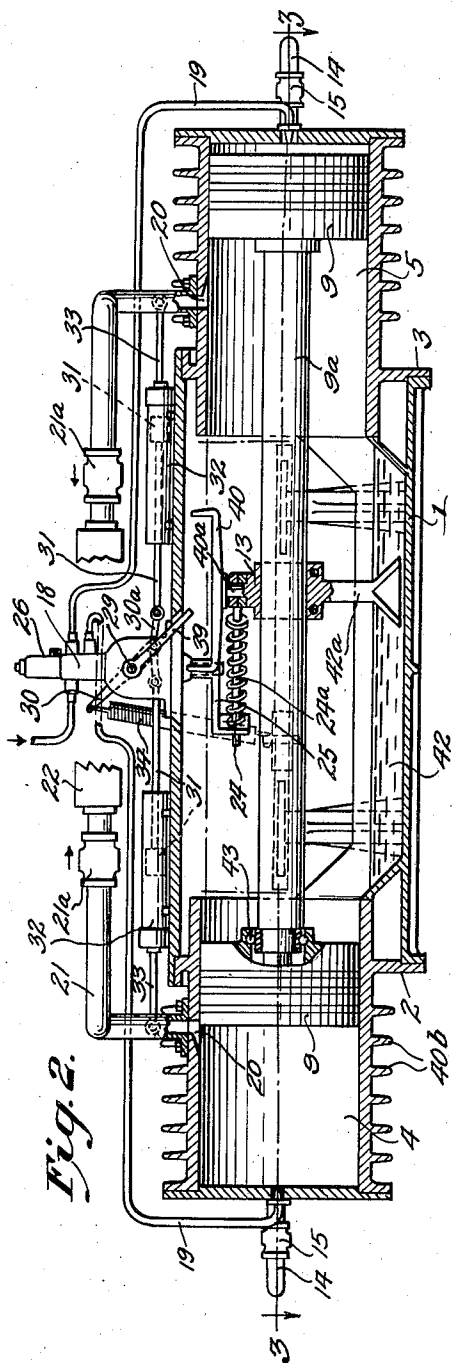


Fig. 2.

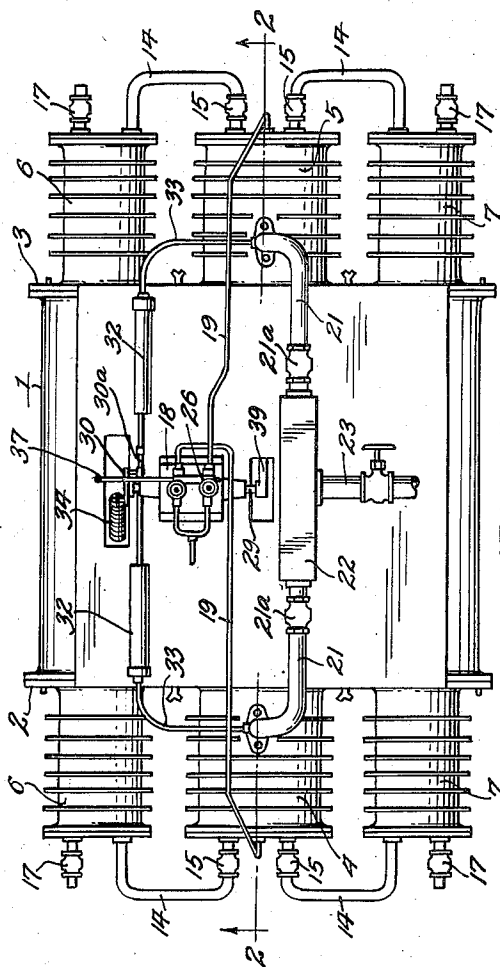


Fig. 1.

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3 Sheets-Sheet 2

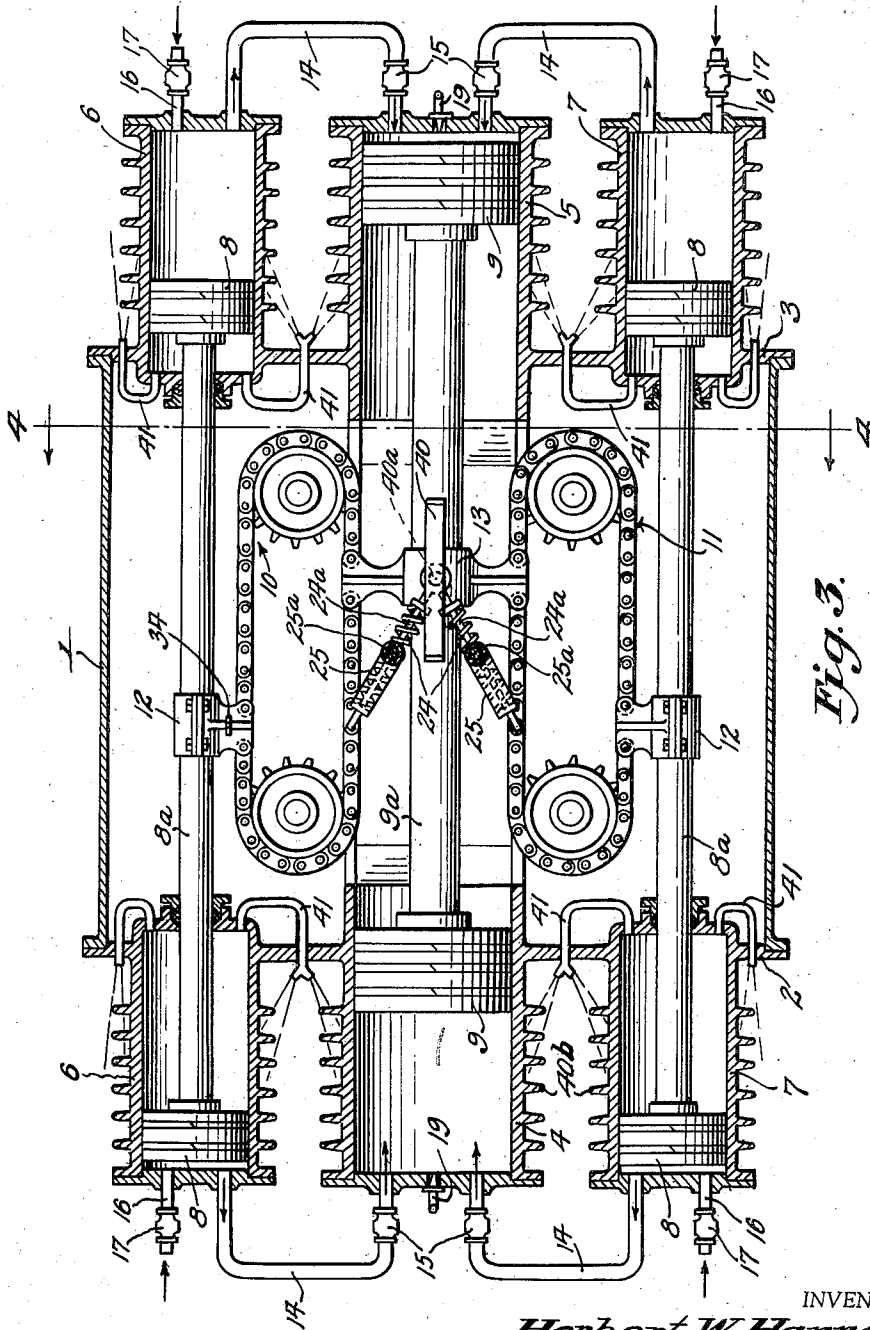


Fig. 3.

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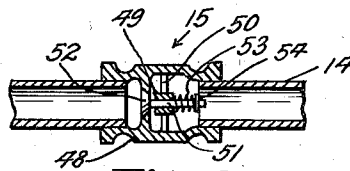
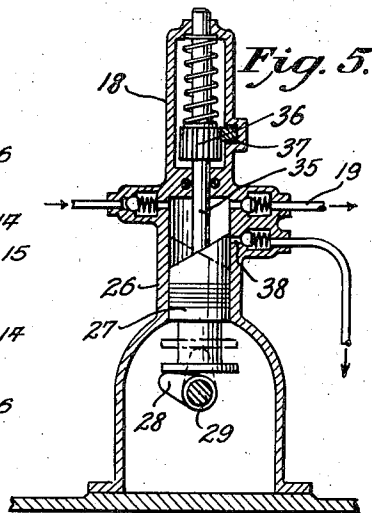
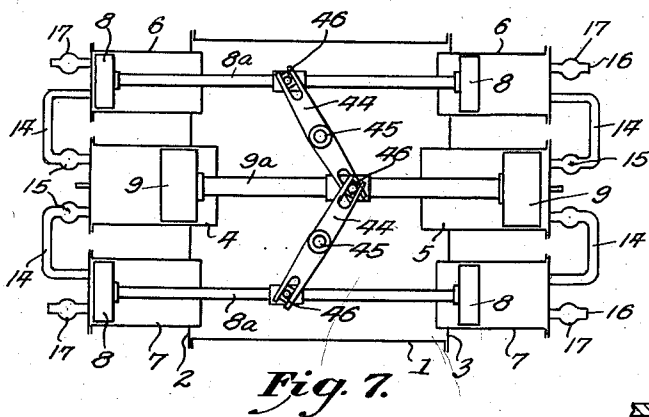
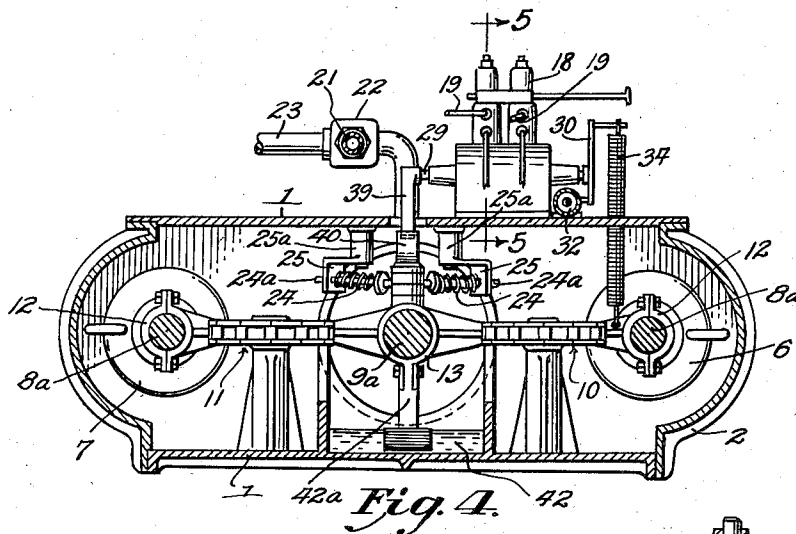
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3 Sheets-Sheet 3



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FREE PISTON ENGINE-COMPRESSOR APPARATUS

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2 Claims. (Cl. 123—46)

This invention relates to internal combustion engines and has particular reference to engines of the crankless type wherein the power or combustion cylinders of the engine are arranged in spaced longitudinally aligned order and in parallel relation with correspondingly aligned and spaced air-compressing cylinders, the said cylinders receiving sliding pistons joined by rigid connecting rods for unitary movement, the construction being such that power derived from the engine pistons is employed to impart operative movement to the pistons of the air-compressing cylinders. Such engines are commonly referred to as free piston engine-compressor power units.

The general object of the invention is to provide an engine-compressor power unit of this kind which is an improvement generally on prior apparatus of the specific type indicated.

Other objects of the invention are to provide: an improved motion-translating mechanism for imparting sliding movement to the connecting rods and pistons of the air-compressing cylinders by power derived from the pistons and connecting rod of the engine cylinders; to construct and arrange the motion-translating mechanism so that the operating forces imparted thereby to the air-compressing pistons will be in opposition to that of the power or engine pistons; to provide improved check valve equipped passage means for conducting air compressed in said air-compressing cylinders from said last-named cylinders to the engine cylinders and confining the same in the engine cylinders while the pistons therein are advanced on their air-compressing strokes, so that upon the completion of said last-named strokes the air in the engine cylinders will be in a second or final stage of high compression and temperature and adapted for combining with and firing liquid fuel injected under pump pressures into the engine cylinders; to provide in such an engine a fuel pump having a slidable, fuel-displacing piston which is moved when traveling in one direction against spring-biasing forces by an eccentric mounted on the actuating shaft of the pump; to provide piston and cylinder means actuated by pressures obtained from the exploded fuel gases to impart operating movement to the associated fuel pump shaft; to provide improved means for effecting initial operation of the fuel pump before fuel combustion in the engine cylinders takes place; to provide a piston for such a fuel pump wherein the fuel-displacing end of the pump piston is terminated in an angularly beveled face, and wherein associated means are provided for rotating the pump piston about its longitudinal axis to cause the face thereof, upon working strokes of fixed length, to variably cover and uncover an associated fuel-discharge port of the pump, whereby to vary the volume or amount of fuel displaced by the pump and delivered during any one period of its operation to the engine cylinders; to provide such an engine-compressor unit with endless chain means for transmitting the reciprocatory motion of the engine piston rod into corresponding but oppositely directed motion on the part of the compressor piston rod; to provide a novel spring-type power booster for the slid-

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able piston rod of the engine cylinders, the booster functioning after the manner of a flywheel in releasing stored-up energy therein at the ends of the stroke of the rod to assist in the application of power to the rod in effecting final or second stage compression of the air in the engine cylinders; to provide improved means for air cooling the finned wall structure of the engine and compressor cylinders; and in other improvements hereinafter defined in greater detail.

In the drawings:

Fig. 1 is a top plan view of the engine-compressor unit of the present invention;

Fig. 2 is a vertical longitudinal sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a horizontal longitudinal sectional view taken along the line 3—3 of Fig. 2;

Fig. 4 is a transverse vertical sectional view taken on line 4—4 of Fig. 3;

Fig. 5 is a detail vertical sectional view taken on the line 5—5 of Fig. 4 and disclosing the construction of a fuel pump used in connection with the apparatus;

Fig. 6 is a sectional view of one of the cylinder check valves; and

Fig. 7 is a diagrammatic plan view of a slightly modified form of the present invention.

Referring to the drawings, the numeral 1 designates the casing of my improved engine-compressor, the casing having mounted thereon oppositely disposed identical heads 2 and 3. Carried by these heads and arranged oppositely to one another in longitudinally aligned order are fuel-burning power cylinders 4 and 5. The heads also carry air-compressing cylinders 6 and 7 which, as here shown, are located on each side of the power cylinders 4 and 5 in spaced parallel order therewith. Connecting directly the reciprocatory pistons 8 of each pair of oppositely disposed air-compressing or pressure cylinders 6 and 7 are rigid piston rods 8a and, similarly, the sliding pistons 9 of the power cylinders 4 or 5 are rigidly connected by a piston rod 9a.

Motion-transmitting means are provided between the rods 8a and 9a. Such means may comprise the sprocket and chain mechanisms 10 and 11, shown in Fig. 3, the chains thereof lying generally parallel to the piston rods. Carried by the piston rods 8a and 9a and connected to the chains are clamps 12 and 13. The arrangement of these parts is such that when the piston rod 9a moves in one direction, the rods 8a will be caused to reciprocate in the opposite direction.

Connecting the outer ends of the pressure cylinders 6 and 7 with those of the power cylinders 4 and 5 are compressed air-transmitting conduits 14 in which are contained check valves 15. Also, each air-compressing cylinder is provided with an air inlet 16 having a check valve 17, the latter permitting air to be drawn from the atmosphere into the cylinders 6 and 7 when the pistons 8 thereof move in an inward direction.

Upon the return or outward strokes of the pistons 8 in the pressure cylinders 6 and 7, the air displaced therefrom is forced through the conduits 14 and into the power cylinders 4 and 5. This air is held in the power cylinders by the check valves 15.

Leading from a fuel pump 18 to the cylinders 4 and 5 are liquid fuel conducting lines 19. By the use of these lines, fuel under pressure, exceeding that of the air in the cylinders 4 and 5, is injected in a timed manner and fired by heat derived from the highly compressed air into which the injected fuel is brought into intimate admixture. The resultant expansion of the exploded fuel will cause the piston in the fired cylinder or cylinders to travel inwardly and uncover a port 20 in each power cylinder (see Fig. 2), permitting the fired gases and compressed air from

the compressor cylinders to exhaust through the pipes 21, containing check valves 21a, and into a manifold 22. From the manifold, the gases may be led through a conduit 23 to a point of work performance, such as a motor, turbine or other gaseous fluid-driven work tool, not shown. The power pistons 9 which are alternately fired, will be checked at the end of their power strokes by the air pressure developed in a complementary cylinder just prior to fuel combustion therein.

To aid each power piston in its final air-compressing stage of operation, use may be made of a pair of diverging springs 24. These springs are mounted on push rods 24a which are pivoted at their inner ends for support on the clamp 13 attached to the piston rod 9a. The outer ends of the spring rods protrude through end walls of casing-mounted brackets 25. As shown in Fig. 4, these brackets are pivoted as at 25a to the under side of the casing 1. It will be seen, upon reference to Fig. 3, that as the piston rod 9a moves to the left, the springs 24 will be compressed until the pivotal axis of the spring rods on the rod clamp 13 passes the pivotal axes of the brackets 25 on the casing 1. At this time the brackets and rods will have assumed positions causing the springs to exert their compressive or stored-up energy in the direction of the moving piston. This spring action will act on the order of a fly wheel to aid the pistons 9 in completing their strokes against the resistance of increasing pressure in the cylinders 4 and 5.

Due to the fact that this engine-compressor unit does not employ a crankshaft, the strokes of the power piston or pistons 9 may be varied with the amount of fuel admitted to the power cylinders. Therefore, the exhaust port 20 is here shown as of a tapered design (see Fig. 2), so that as the stroke length of the pistons 9 is increased, the greater will be the area of the ports 20 uncovered by the power pistons. This variation in power stroke length is, of course, relatively slight and will not effect the working of the associated fuel pump 18 or its normal full stroke operation.

Therefore, a fuel pump construction is provided which may be so regulated as to vary the amount of fuel delivered to the power cylinders even though the stroke of the pump piston does not vary in length. To this end, the fuel pump is formed to include a casing 26 (see Fig. 5) having a cylindrical bore in which a piston 27 is slidably mounted and in this instance operated by a cam 28 fixed to a shaft 29. This shaft carries at one end thereof a crank lever 30 (see Fig. 2) which has link connections 30a with the ends of a piston 31 slidable in each of a pair of aligned cylinders 32 mounted on the casing 1. Connected to the cylinders are pilot pipes 33 leading to the exhaust pipes 21 from which gaseous pressures are derived to operate the pistons 31 in producing pump operation.

It will be evident that as the power cylinders 4 and 5 are fired, the exhaust gases will, through the sliding alternate operation of the pistons 31, rock the pump shaft 29 and thereby effect the actuation of the pump piston 27. There are two pump pistons disclosed, one for each power cylinder. Attached to the upper end of the crank lever 30 is a tension spring 34, the latter having its lower end connected to one of the chain clamps 12. The movement of the piston rod carrying the clamp 12 will cause the spring 34 joined therewith to pass the center line of the pump shaft 29 which had been initially rocked by one of the pistons 31. The tension of the spring 34 will, in this manner, serve as an off-center restraint to hold the lever 30 in either of its extreme end positions until subsequently shifted by action of the pistons 31.

The pump piston 27 is shown as having attached thereto a stem 35 which carries a gear 36 meshing with a gear rack 37. The gear rack may be manipulated to turn the angularly beveled upper end of the piston 27 so that it will completely cover when in its raised position a drain port 38 and thereby deliver a full charge of fuel to the fuel inlet line 19 of a power cylinder. By turning the

piston 27 about its longitudinal axis so that it will more or less uncover the port 38, a certain amount of the fuel will pass through the drain port and, therefore, a smaller amount of the fuel will be delivered to the line 19. The turning of the pistons 27 will in no way effect the full stroke thereof but will affect the speed of the motor-compressor unit and length of stroke of its power pistons.

In initially starting the compressor, when no exhaust pressure is present to operate the pistons 31 of the pump mechanism, an end of the pump shaft 29 has attached thereto a lever 39, shown in Fig. 2, which is engaged by the spaced upright tines of a fork 40 mounted on the upper end of the pivot stud 40a carried by the clamp 13 of the piston rod 9a. The fork will thus function to rock the lever 39 and the pump shaft 29 independently of the piston 31. After the engine has started, the pistons 31 will take over the working of the fuel pump. If desired, the cylinders of the compressor may be provided with fins 40b for cooling. In addition, the cylinders 6 and 7 may have their inner ends provided with breather nozzles 41 having outlets directed so as to flow cool air displaced from the inner ends of the cylinders 6 and 7 on the return stroke of the pistons 8 over the fins of the cylinders to cool the same.

The base of the compressor is preferably formed to include an oil sump 42 which has communication with the open inner ends of the power cylinders. Attached to the chain clamp 13 is a paddle 42a which extends into the sump and serves to splash oil into the cylinders during the compressor operation. If desired, antifriction bearings 43, shown in Fig. 2, may be provided between the piston and rods to permit rotation of the pistons to equalize wear between the pistons and the walls of their associated cylinders.

In Fig. 7 a modified form of connection between the power and pressure pistons has been disclosed wherein instead of chains, as in the preferred form, a pair of rocking arms 44, which are pivotally mounted at 45 intermediate their ends, are used, said arms having the ends thereof pivoted at 46 to the power and pressure piston rods in providing opposite sliding motion between the rods 8a and 9a.

As shown in Fig. 6, the check valve 15 comprises an outer valve casing 48 formed with a transverse web 49 providing a valve seat. The casing is also provided with an internal spider 50 which slidably supports the stem 51 of a movable valve 52. The valve member 52 is biased toward a normally closed position by means of a light compression spring 53 interposed between the spider 50 and a collar 54 carried on the stem 51. In this manner, air under pressure within the line 14 will unseat the valve head 52 to permit passage of compressed air from the lines 14 into the engine cylinders 4 and 5. The check valves 17 and 21a are identical in construction to the valves 15.

In operation, the present engine-compressor apparatus may be started through the use of any suitable means, not shown, adapted to impart reciprocation to either of the connecting rods 8a or 9a and thence to the entire moving system. For example, if desired, starting energy may be furnished by alternately introducing compressed air through the inlets 16 associated with the compressor cylinders 6 and 7. Assuming that the engine pistons 9 are placed in reciprocating motion, air within the engine cylinders 4 and 5 will be compressed to produce sufficient heat to ignite fuel injected into the cylinders at the extreme end of the advancing stroke of the pistons 9. During the initial starting reciprocation of the engine, the upright tines of the fork 40 function to rock the crank shaft 29 and the cam 28 alternately to cause the injection of fuel into the engine cylinders 4 and 5 as their pistons reach the extreme end of their compression strokes. Upon ignition of the fuel within the cylinders 4 and 5, the piston 9 which occupies the end of its compression stroke is forcibly displaced by the forces of the expanding gases

and moved in its return stroke to a point where the same uncovers at least a portion of the exhaust port 20. At this time, pressures are relieved within the associated engine cylinder to a point where scavenging air compressed within the adjacent compressor cylinders 6 and 7 passes through the check valves 15 and outwardly through the exhaust port 20 carrying with it burnt fuel gases.

Substantially at the time the exhaust port of one of the cylinders 4 or 5 is uncovered by its piston 9, fuel is injected into the opposite or opposing engine cylinder due to the operation of the timing motors 31, 32 which function to shift the cam 28 of the fuel pump and cause fuel to be injected into said opposite cylinder.

It will be understood that the combined effective areas of the compressor pistons 8 is less than the total effective area of the engine pistons 9, otherwise the engine would of course not operate due to load resistance. Also it will be understood that the pressure within the engine cylinders 4 and 5 is always substantially equal to load pressures, or the pressure within the manifold 22. Thus, depending upon the load placed on the engine by the work performed thereby, extremely high pressures are developed within the engine cylinders prior to the injection of fuel therein, and such pressures combined with the pressures attained through the explosion of fuel within the engine cylinders are supplemented by the air compressed within the compressor cylinders 6 and 7.

As previously stated, the length of the stroke of the engine pistons 9 and associated connecting rod 9a, and hence the speed of operation of the engine is controlled through varying the amount of fuel introduced to the engine cylinders through the fuel pump 18. However, it will be noted that the variance of stroke of the pistons 9 is limited to the effective length of the exhaust ports 20, and where a relatively small amount of fuel is introduced into the cylinders 4 and 5, the pistons 9 will only slightly uncover the exhaust ports 20, whereas the injection of a relatively larger amount of fuel within the engine cylinders 4 and 5 will result in an increased stroke on the part of the pistons 9 and a consequently greater opening of the exhaust ports 20.

In view of the foregoing, it will be seen that the present invention provides a relatively structurally simple engine-compressor apparatus which is characterized by a minimum number of relatively moving parts, as compared with ordinary piston and crank-operated internal combustion engines. The reduction in number of parts results in a consequent reduction of wear and increase in life of the engine.

While I have disclosed what I deem to be a practical and efficient embodiment of the present invention, it should be well understood that various modifications as to details of construction and design may be resorted to without departing from the spirit of the invention as comprehended within the scope of the appended claims.

I claim:

1. In a combustion engine; casing means defining a pair of opposed, relatively spaced, axially aligned fuel combustion cylinders, each having an exhaust gas outlet port communicating therewith intermediate its ends; a piston reciprocable in each of said combustion cylinders and movable therein between a dead center position covering the outlet port of the cylinder and positions on either side of said outlet port; a single linear shaft connected at its ends with said pistons and joining the latter for unified reciprocating movement; means for injecting fuel under pressure into said combustion cylinder at intervals timed to the reciprocating movement of said pistons; air-compressing piston-cylinder means positioned adjacent said combustion cylinders and having a compressed air outlet arranged in valve-controlled communication with each of said combustion cylinders, said piston cylinder means being operable to force air under pressure into each of said combustion cylinders; motion transmitting means connected between said shaft and said air-compressing piston-cylinder means for operating the latter through power derived from the burning of fuel within said combustion cylinders; and resiliently compressible means connected with said shaft and arranged to urge said shaft and the pistons connected therewith to move in either direction away from a dead center position.

2. A combustion engine as defined in claim 1, wherein said last-named means comprises a push rod pivoted to an intermediate portion of said shaft and movable therewith; bracket means carried by said casing means and slidably receiving said push rod; and a coiled compression spring having one end connected with said push rod and an opposite end abutting said bracket and arranged to be compressed upon movement of said pistons in either direction toward a dead center position.

References Cited in the file of this patent

UNITED STATES PATENTS

350,763	Oliver	Oct. 12, 1886
968,861	Lindstrom	Aug. 30, 1910
1,128,917	Tomasini	Feb. 16, 1915
1,416,210	Jung et al.	May 16, 1922
1,620,565	McKeown	Mar. 8, 1927
2,075,133	Pescara	Mar. 30, 1937
2,112,368	Janicke	Mar. 29, 1938
2,115,921	Steiner	May 3, 1938
2,303,794	Pescara	Dec. 1, 1942
2,473,204	Huber	June 14, 1949

FOREIGN PATENTS

143,319	Great Britain	May 20, 1920
369,149	Great Britain	Feb. 15, 1923