

[54] NONPOLLUTING ENGINE

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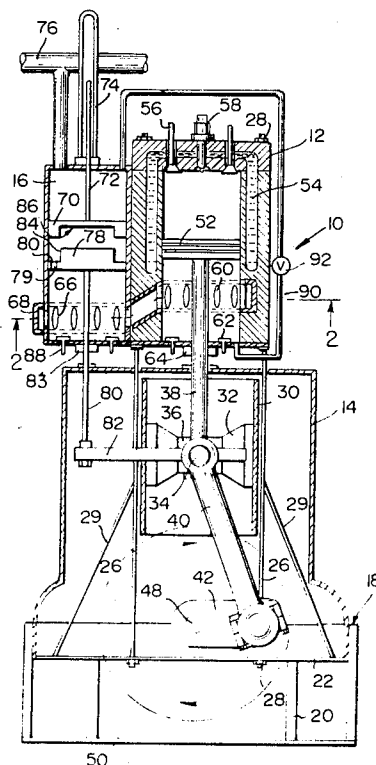
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[57] ABSTRACT

An improved nonpolluting low-emission two cycle diesel crosshead engine designed for the control of air pollution. The engine has a combustion cylinder adapted to slidably accommodate a reciprocating

piston. An upper end of the cylinder is provided with a conventional exhaust valve and a fuel injection nozzle. A plurality of apertures defined in a lower end of the cylinder interconnect the cylinder with an independent air chamber. The air chamber has a fluid pump providing an expansible interior volume to accommodate clean air displaced from the cylinder on the power stroke of the piston. A floating pump piston in the air chamber is urged toward a lower end of the chamber to intermittently force a clean, relatively cool charge of air into the cylinder for scavenging the smoke, particulates, fumes and other exhaust emissions and for supplying a clean air charge for compression. A piston lifter is adapted to return the pump piston to its initial position during the compression stroke of the piston; simultaneously, suction valves open to admit cooled and/or filtered air at atmospheric pressure into the air chamber and cylinder. A valve bypass conduit connects the cylinder and the independent air chamber to provide means for regulating the air pressure acting on the floating pump piston and to thus adjust the movement for particular operating conditions of the engine. In a modified embodiment, the independent air chamber is placed concentrically around the cylinder and is provided with a circular pump piston and piston lifter ring.

10 Claims, 10 Drawing Figures



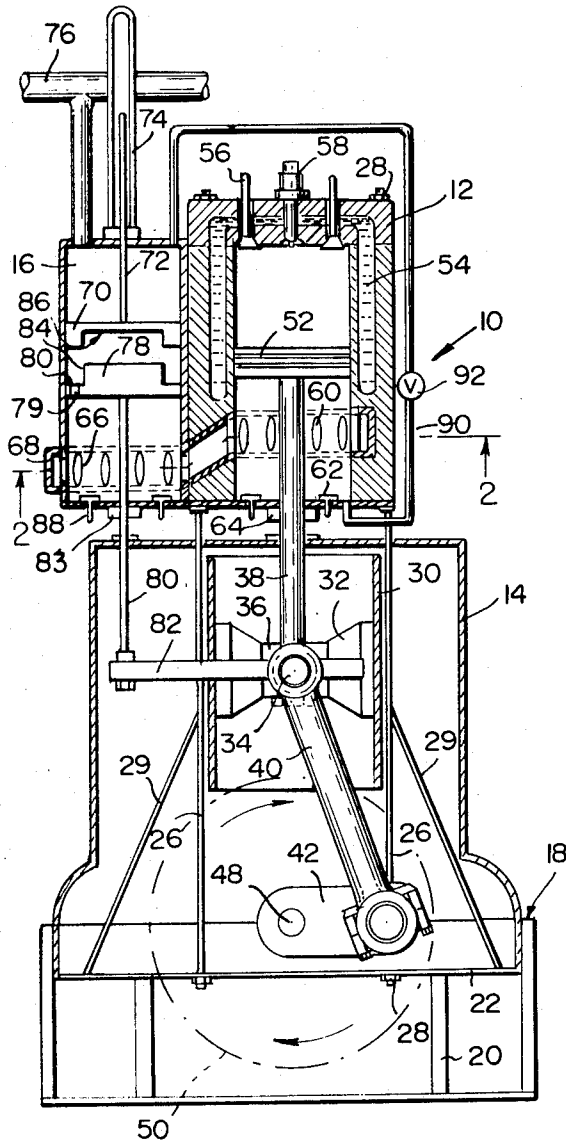


FIG. 1

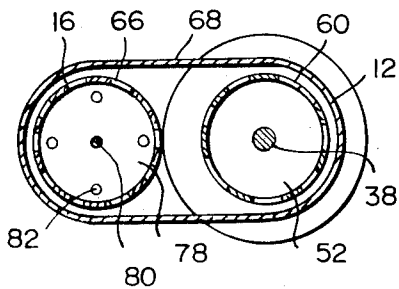


FIG. 2

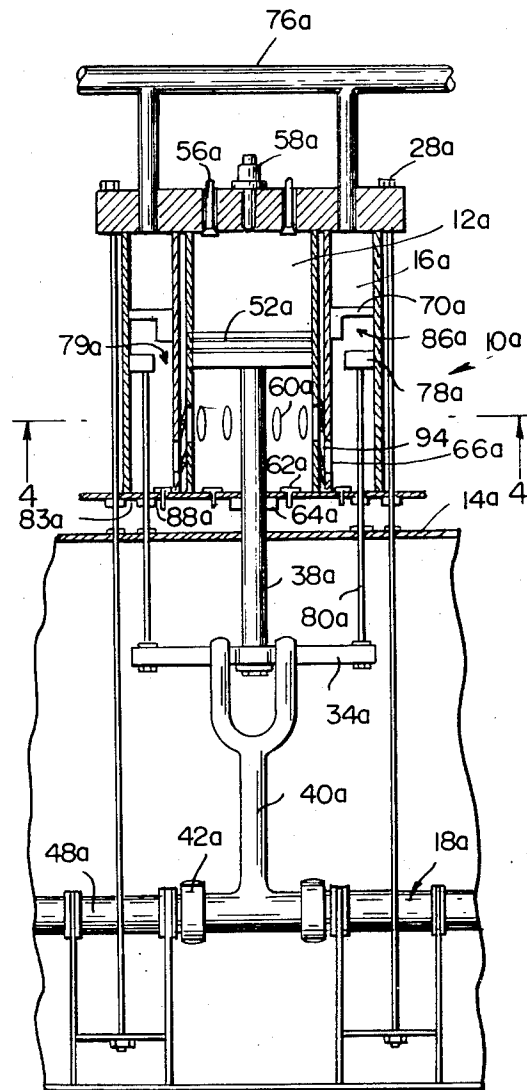


FIG. 3

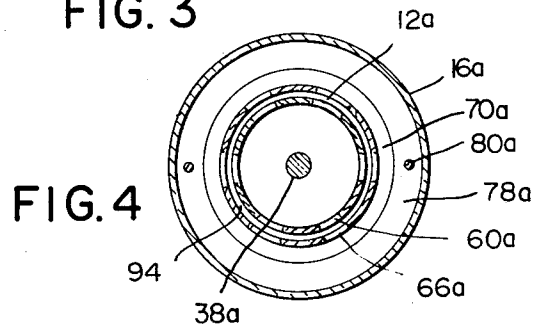
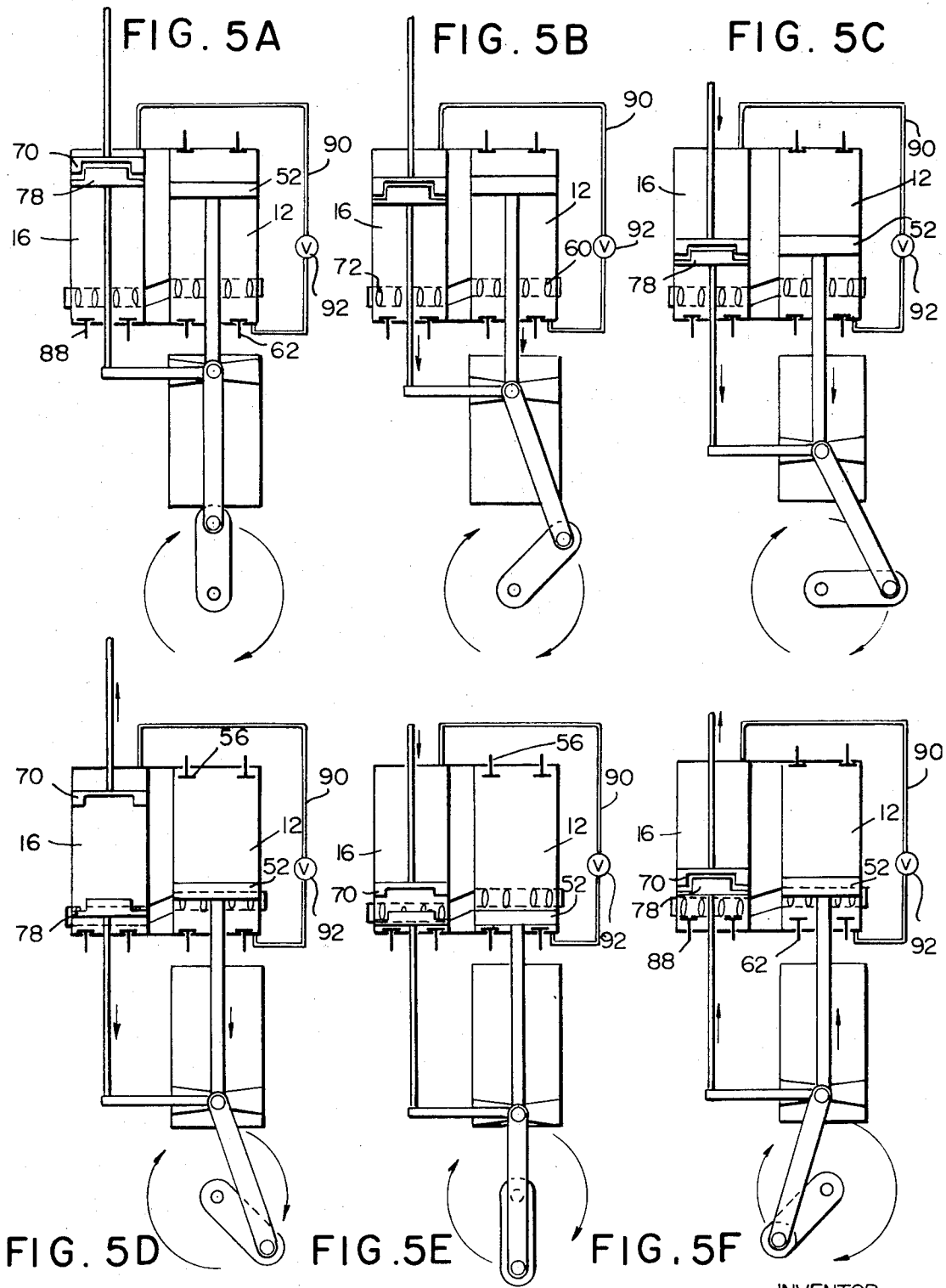


FIG. 4

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NONPOLLUTING ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to internal combustion engines and especially to an improved diesel engine.

In particular, the instant invention relates to a non-polluting, low-emission, two cycle diesel crosshead engine. The present invention is further concerned with an engine air system for supplying clean, cooled air for the reduction of engine exhaust emissions.

2. Description of the Prior Art

Diesel engines presently in use employ various engine air systems for introducing an air charge into the cylinder, e.g. crankcase compression, reciprocating air pumps, rotary displacement blowers and centrifugal or turbine blowers. Each of the above mentioned air systems has distinct shortcomings and furthermore is not specifically designed for air pollution control.

In the conventional two cycle diesel engine, an air charge is introduced into the cylinder for scavenging combustion gases which are removed through an exhaust port. Some of this air will mix with the combustion gases and will inescapably remain in the cylinder for compression. The amount of pure air retained in the cylinder for compression will vary directly with the quantity of fresh air injected during the scavenging operation. In some of the previously patented diesel engines, especially trunk types, the crankcase is used as a compressor for injecting air into the cylinder. The volume of air drawn into the crankcase will be determined by the volume of air displaced from the cylinder by the piston. This quantity of air will be slightly less than the volume of the cylinder because of the "clearance volume", i.e. space between the piston head and cylinder head. Consequently, the maximum volume of air available for scavenging and for retention in the cylinder for compression will be limited in amount. This supply of air is, in many instances, not fully sufficient for optimum power and efficient fuel consumption. As a result, the fuel is not completely combusted and more products of incomplete combustion will be contained in the exhaust gases. Additionally, the combustion gases will not be effectively removed in the scavenging operation. It should also be noted that when the lower cylinder or crank end of the cylinder is used as an air compressor, similar results are obtained. Another disadvantage of this engine air system is that the air compressed in the crankcase will absorb heat from within the crankcase and thereby lower the volumetric efficiency of the engine. Still another problem results from the fact that lubricating oil around the moving parts in the crankcase and other impurities in the crankcase become entrained in the air charge injected into the cylinder; this impure air merely adds to the pollutants already present in the cylinder.

The reciprocating air pumps and rotary displacement blowers of the prior art are conventionally driven from the engine crankshaft. These direct driven pumps and blowers have the distinct disadvantage that when the engine slows down, as with a heavy load, the volume of air injected into the cylinder will be reduced. Since the engine requirements for scavenging and charging increase with engine load, this reduction of air injected will effectively impair the scavenging and charging operation with resultant inefficient combustion and an

increase in pollutants. Furthermore, when initially starting the engine, the direct driven blower must be continuously turned over with starting air until it has completely filled the air heads at sufficient pressure for scavenging during which period of time there will be considerable exhaust emissions.

The centrifugal blowers are either motor driven or driven by exhaust gas turbines. However, neither type of centrifugal blower is very efficient for compressing air to pressures above a few ounces, and furthermore, these centrifugal blowers are quite noisy. The improved diesel engine of this invention is designed to alleviate the foregoing disadvantages and to provide a relatively low emission pollution-free clean engine.

SUMMARY OF THE INVENTION

This invention encompasses a two cycle diesel crosshead engine, an essential feature of which is an improved air supply system utilizing an independent air chamber interconnected with an engine cylinder for the intermittent injection of clean, pure, relatively cool air into the cylinder for scavenging combustion gases and for charging the cylinder. The clean air effectively removes the pollutants and/or smoke contained in the cylinder exhaust gases, and supplies a relatively pure charge of cool air for compression. The cool air substantially reduces the amount of work necessary for compression, and also provides for more efficient combustion because the cooler and consequently denser air injected has more oxygen to effectively unite with the hydrocarbon fuel, thus reducing the products of incomplete combustion and resultant exhaust emissions.

An important feature of the air chamber resides in a floating pump piston which acts as a fluid spring or pump and provides an expansible interior volume for receiving air displaced from the cylinder. A pressure differential maintained in part by manifold air supplied independently to the air chamber on one side of the pump piston intermittently urges the pump piston in a direction which forces clean air into the cylinder for removal of combustion gases. A valve bypass conduit leading from the cylinder to the air chamber supplements the manifold air supply. The air pressure in the air chamber can thus be increased to synchronize the pump piston movement for adjustment with the engine operation conditions, e.g. by increasing the manifold air pressure during light load, the pump piston can be moved faster to force an adequate air charge into the cylinder for scavenging and compression by the more rapidly moving piston. An engine driven pump piston lifter is provided with air cushioning means for restoring the floating pump piston to its initial position during cylinder compression; simultaneously, suction valves are opened to admit fresh air at atmospheric pressure, both to the air chamber and cylinder. The fresh air so admitted may be filtered and/or pre-cooled by auxiliary means.

Another advantage of this air supply system is that not only will pollution be reduced, but the resultant "clean" engine will run smoothly and efficiently and will thus produce uniform power with a minimum of cylinders.

Having thus summarized the invention, it will be seen that an object thereof is to provide a nonpolluting, low-emission engine of the general character described

herein which is not subject to the disadvantages of the prior art.

Specifically, it is an object of this invention to provide an improved diesel engine, including an air system supplying pure air for scavenging combustion gases from the cylinder.

Another object of this invention is to provide an improved diesel engine having an independent air chamber including a floating pump piston for receiving air displaced from the cylinder and for intermittently injecting a charge of cooled air into the cylinder for more efficient compression and more complete combustion.

It is a further object of this invention to provide an improved diesel engine with a valved bypass conduit for regulating movement of the floating pump piston and for adjusting same for the particular operating conditions of the engine.

The above and other objects, features and advantages of the invention will be apparent from the following description of the preferred embodiments when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings, in which are shown the preferred embodiments of the invention:

FIG. 1 is a longitudinal sectional view through the two cycle diesel crosshead engine of this invention and shows the location and interrelationship between an independent air chamber and a cylinder;

FIG. 2 is a sectional view taken substantially along a plane 2—2 of FIG. 1 and shows an air passageway interconnecting the air chamber and the cylinder;

FIG. 3 is a longitudinal sectional view through a modified embodiment of this invention wherein an independent air chamber is arranged concentrically around a cylinder and further includes therein a circular pump piston and pump piston lifter ring;

FIG. 4 is a sectional view taken substantially along plane 4—4 in FIG. 3 and shows an air passageway interconnecting the air chamber and the cylinder; and

FIGS. 5A—5F show schematically various phases in the operation of the two cycle diesel engine of this invention and diagrammatically illustrates the concurrent action of the independent air chamber in supplying scavenging and charging air.

DETAILED DESCRIPTION OF THE INVENTION

Referring now in detail to the drawings, the reference numeral 10 denotes generally a two-cycle diesel engine of this invention. The diesel engine 10 is comprised of a cylinder 12, a crankcase 14, and an engine air supply system including an independent air chamber 16.

The crankcase 14 is supported on a base which includes a platform 18 made up of transverse steel girders 20 and steel plates 22; appropriate vibration isolation means may be incorporated therein. Although the engine 10 as shown in FIG. 1 is arranged in a generally vertical orientation, it may be oriented horizontally and in other suitable arrangements. A plurality of vertical struts or longitudinal bolts 26 extend from the base 18 through crankcase 14 to support the cylinder 12 and air chamber 16. The vertical struts 26 are secured to the

base 18 and cylinder 12 by means of nuts 28 or other similar fasteners. The longitudinal struts 26 may further be reinforced by diagonal bracing 29.

A pair of channel members 30 are suitably affixed to and supported by the vertical struts 26 and form a track for slidably accommodating a guide or crosshead 32. A connecting rod pin 34 having a suitable pin bearing 36 pivotally connects an upper connecting rod 38 and a lower connecting rod 40 to the crosshead 32. One end of the upper connecting rod 38 is provided with a piston 52 which is slidably accommodated within cylinder 12. The reciprocating straight line motion of the piston 52 moves crosshead 32 within the track; the motion is translated into a rotary motion by the lower connecting rod 40 and a crank 42 which in turn rotates a crankshaft 48 and a flywheel 50.

A cooling jacket 54 is provided circumferentially around the cylinder 12 for maintaining a circulating flow of a heat absorbing fluid such as water, to dissipate generated heat. Additionally, oil is circulated interiorly through ducts in the piston 52 for removing heat therein. It should also be noted that the upper end or head of cylinder 12 is provided with exhaust valves 56 which can be operated by push rods in a well-known manner; a fuel injection nozzle 58 is also provided for supplying atomized fuel under pressure. The lower end of the cylinder 12 is provided with a plurality of air vents or ports 60 for permitting removal of the air in the cylinder 12 as the piston 52 moves downwardly on the power stroke. A plurality of suction valves 62 are designed to open to admit fresh air into the cylinder 12 as the piston 52 moves upwardly on the compression stroke. The operation of the valves 62 will be further discussed hereinafter. In order to insure air tightness in the cylinder 12 appropriate packing or sealing ring 64 is placed at the point of entry of the upper connecting rod 38 into the cylinder 12.

The details of the nonpolluting engine air supply system will now be discussed in further detail. The air chamber 16 is positioned adjacent to and can be formed integrally with the cylinder 12. The lower end of air chamber 16 is provided with a plurality of air ports or vents 66 similar to vents 60. A peripherally extending side wall 68 surrounding the cylinder 12 and air chamber 16 serves as a conduit or passageway for the transfer of air therebetween.

The air chamber 16 is further provided with a pump piston 70 having an upwardly extending guide 72 adapted to be slidably accommodated within tubular guide way 74, thus assuring proper alignment of the pump piston 70 during reciprocating movement within the air chamber 16. An air manifold 76 is used to supply air under relatively constant pressure to the air chamber 16. A pump piston lifter 78 is slidably accommodated within the air chamber 16 and designed for coaction with the pump piston 70. Accordingly, the pump piston lifter 78 is provided with a push rod 80, which is in turn securely attached to a cross arm 82 and is designed to move with the crosshead 32. It will thus be apparent for example, that as the crosshead 32 moves upwardly on the compression stroke, the push rod 80 and pump piston lifter 78 will likewise move upwardly within the air chamber 16 and move the pump piston 70 in the same direction.

Air tightness is maintained in the air chamber 16 by use of appropriate packing or sealing ring 83 provided around the push rod 80 at its point of entry into the air chamber 16. The pump piston lifter 78 is provided with a peripheral flange portion 80 having a plurality of apertures 79 passing therethrough so as to permit air flow around the pump piston lifter 78 when air is being forced into the air chamber 16, as on the power stroke of the piston 52. As the pressure of this air increases to or becomes greater than the manifold air pressure on the opposite side of the pump piston 70, it will cause the pump piston 70 to "float" or move upwardly to thereby provide an expandable interior volume in air chamber 16 for accommodating air displaced from cylinder 12 without creating any undue opposing workload on piston 52 during the power stroke. In an attempt to reduce undue wear on moving the parts within air chamber 16, direct contact between piston 70 and lifter 78 is avoided by means of an air cushion. This is achieved by having the pump piston lifter 78 provided with a raised portion 84 adapted to be received in a recess 86 formed in the piston 70. The aforementioned apertures 79 allow some of the air between the pump piston 70 and the pump piston lifter 78 to escape as these members approach each other; however, a layer of air will be trapped therebetween to form an air cushion.

A plurality of suction valves 88 are provided in the lower portion of the air chamber 16. These suction valves operate to admit fresh air as the pump piston lifter 78 moves upwardly in the air chamber 16. The air which enters through the suction valves 88 as well as suction valves 62 may be supplied from a separate auxiliary source (not shown) and can be pre-cooled and/or filtered air. Furthermore, the air contained within the air chamber 16 may be cooled directly while therein. It should also be apparent that the quantity of air within the air chamber 16 is directly dependent on the size of said chamber and accordingly the quantity may be varied in accordance with optimum operating conditions for the diesel engine.

In addition to the air supplied by manifold 76, a bypass conduit 90 having a valve 92 interconnects the cylinder 12 and the upper portion of the air chamber 16 for supplementing the manifold air supplied.

The operation of the two cycle diesel engine of this invention and the nonpolluting air system will be described in further detail with reference to the schematic drawings as shown in FIGS. 5 (A-F). The illustration "A" shows the piston 52 is at a top dead center position during the compression stroke wherein an air charge within the cylinder has been compressed. At this moment the pump piston 70 and pump piston lifter 78 are at their uppermost position with manifold air pressure of approximately 6 p.s.i.g. (in a typical example) being maintained in the upper portion or compartment of air chamber 16. The lower portion or compartment of the air chamber 16 is maintained at atmospheric pressure and contains clean air which enters through suction valve 88 as the pump piston lifter 78 moves upwardly in the air chamber 16. The suction valve 62 similarly allows clean air to enter the cylinder 12. In illustration "B" rapid expansion of the combustion gases drives the piston 52 downwardly in the cylinder 12, thereby displacing the air therein through air vents 60

and into the air chamber 16 via air vents 72. The air pressure within the lower portion of chamber 16 has been typically raised to 2 p.s.i.g. Illustration "C" shows the piston 52 in a progressively lower position wherein more of the air within cylinder 12 has been displaced into the air chamber 16 and the air pressure within the lower portion of chamber 16 has been gradually increased to typically 4-5 p.s.i.g. wherein some of the air is beginning to pass through the pump piston lifter 78. Illustration "D" shows the piston 52 at a point before bottom dead center wherein the air pressure within lower portion of air chamber 16 is equal to the manifold air pressure and the pump piston 70 is "floating" and responsive to upward movement to increase the interior volume of the lower portion of the air chamber 16 to thus accommodate more air therein and to reduce the resistance to downward movement of piston 52. It should be noted that exhaust valves 56 are now open.

In illustration "E", the piston 52 has descended to the bottom dead center position clearing the air vents 60 and permitting entry of the air from the air chamber 16. This scavenging air will be forced into the cylinder 12 by pump piston 70. The quantity of scavenging air will in part be determined by the volume of the air chamber 16 and accordingly the chamber 16 may be designed so that optimum quantities of air may be injected into the cylinder 12. It should be noted that the flow of air through the cylinder 12 is in one direction, i.e. unidirectional, thereby driving a maximum amount of burnt gases out through exhaust valves 56. It should be additionally noted that since this scavenging air is relatively fresh, pure, clean, filtered and pre-cooled, a more thorough cleaning operation is feasible and that the scavenging air itself will not add to the pollutants entrained within the exhaust gases. Since some of this air remains in the cylinder 12 to provide an air charge, the air will preferably be relatively cool, i.e. dense, containing an optimum amount of oxygen for combining with the hydrocarbons in the fuel. As a direct result, this engine will not only be nonpolluting, but will run smoother with more uniform power and this increased efficiency will minimize the number of cylinders needed for any requisite power requirements.

Illustration "F" shows the piston 52 moving upwardly to compress this new air charge. The suction valves 62 in the cylinder 12 and suction valves 88 in air chamber 16 are open at this point to admit fresh air at atmospheric pressure. The pump piston lifter 78 moves the pump piston 70 upwardly. However, as previously mentioned, an air cushion is maintained therebetween to reduce undue wear and to cushion contact between these two members. It should be pointed out that the relative air pressures referred to hereinabove are mentioned by way of example only and that other pressures to suit particular operating conditions can be maintained. In that respect, another feature of this invention includes means for regulating the pressure within the air chamber 16, particularly during varying engine operating conditions. This is achieved by means of a bypass conduit 90 which interconnects the upper portion of the air chamber 16 with the lower portion of the cylinder 12 whereby the valve 92 may be regulated to admit air from the cylinder 14 in varying quantities to as to supplement the manifold air pressure in the air chamber 16.

In an alternate embodiment, wherein like numerals are used to designate like parts with the suffix letter "a" being used in this embodiment; the FIGS. 3 and 4 show a two cycle diesel engine 10a provided with an air chamber 16a positioned circumferentially around a cylinder 12a. The engine 10a is mounted on a platform 18a and has a crankcase 14a housing a crankshaft 48a, a crank 42a and a forked end connecting rod 40a mounted to the crank 42a. A piston 52a provided for slidable accommodation within cylinder 12a is attached to an upper connecting rod 38a which has its end secured to the forked end of connecting rod 40a by means of a journalled connecting rod pin 34a. The air chamber 16a is provided with a circular pump piston 70a. However, no guide means is required because the ring configuration of pump piston 70a will assure proper alignment for reciprocating movement within the air chamber 16a. An annular recess 86a in the face of circular pump piston 70a is in confronting relationship with a conforming pump piston lifter ring 78a. The annular recess 86a is adapted to receive the pump piston lifter ring 78a and to create an air cushion therebetween similar to the air cushion formed in the aforementioned embodiment. The piston lifter ring 78a is moved within the air chamber 16a by means of push rods 80a which are securely affixed to the connecting rod pin 34a. It should be noted that a space 82a exists between the wall of the air chamber 16a and the ring 78a so that air may pass around the ring 78a to act on the piston 70a. The cylinder 12a has a plurality of air vents 60a which are connected by a passageway 94 to corresponding air vents 66a provided in air chamber 16a.

The operation of this modified embodiment will be similar in detail to the previously described embodiment. The FIG. 3 shows the engine 10a during the power stroke of piston 52a wherein exhaust valves 56a are closed and the air in cylinder 12a is being displaced through air vent 60a into air chamber 16a. The air pressure is being maintained in the upper portion of air chamber 16a by means of air introduced through manifold 76a, which is resiliently urging the circular pump piston 70a in a downward direction. As the pressure below the circular pump piston 70a builds up, this circular pump piston 70a will float or move upward to form an expansible interior volume in the lower portion of air chamber 16a and will act as a reservoir for receiving air displaced from cylinder 12a. The air so received in chamber 16a will be forced under pressure back into cylinder 12a when piston 52a has reached a point near the bottom of cylinder 12a thereby exposing air vents 60a for entry of the scavenging air. As the piston 52a and pump piston lifter ring 78a move upwardly, suction valves 88a and 62a permit fresh, pure air at atmospheric pressure to respectively enter air chamber 16a and cylinder 14a. A bypass conduit may be introduced to regulate the air pressure in air chamber 16a in the same manner as was previously described with respect to the other embodiment.

The preferred embodiment of this invention described a particular application with respect to two cycle diesel crosshead engines, it should be further apparent that this engine air supply system may be adaptable in other internal combustion engines.

Since various possible embodiments might be made of the present invention, and as numerous changes

might be made in the embodiment set forth, it is to be understood that all matter herein described or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described the invention, there is claimed as new and desired to be secured by Letters Patent:

1. A nonpolluting internal combustion engine capable of delivering smooth, uniform power with a minimum of exhaust pollutants comprising a combustion cylinder, a piston slidably accommodated for reciprocal movement within said cylinder, connecting means mechanically linking said piston to a crankshaft, a crankcase for housing said connecting means and crankshaft, air supply means having an independent air chamber, air passage means between said air chamber and cylinder, fluid pump means including pump piston means slidably accommodated within the air chamber for volumetric expansion to receive air displaced from the cylinder during movement of the piston in a first direction, said pump piston means being correspondingly adapted for movement from an initial position to a charging position for injection of a quantity of clean air into the cylinder to scavenge combustion gases and to supply an air charge and a pump piston lifter for returning the pump piston to the initial position upon movement of the piston in a second direction whereby the air charge is compressed in the cylinder.

2. A nonpolluting engine as claimed in claim 1 wherein the lower end of the cylinder is provided with a plurality of ports in communication with the air passage means, said ports being closed, after evacuation of the clean air in the lower portion of the cylinder, by passage of the piston in the first direction and alternately opened to admit the clean air charge from the air chamber prior to movement of the piston in the second direction.

3. A nonpolluting engine as claimed in claim 2 wherein the pump piston lifter is mechanically interconnected for simultaneous movement with the piston.

4. A nonpolluting engine as claimed in claim 1 wherein the pump piston substantially divides the air chamber into two compartments, one of the said compartments being in communication with the cylinder, the other of said compartments being maintained at a predetermined air pressure for controlling movement of the pump piston.

5. A nonpolluting engine as claimed in claim 4 further including a bypass conduit from the cylinder for supplementing the air supplied to the air chamber, and valve means in the bypass conduit for permitting regulation of the air flow to the air chamber in accordance with the operating conditions of the engine.

6. A nonpolluting engine as claimed in claim 2 wherein the air chamber is arranged concentrically around the cylinder and the fluid pump means includes a pump piston slidably accommodated within the air chamber for movement from an initial position to a charging position whereby air is forced through the air passage and into the cylinder and further the pump piston lifter ring is in confronting relationship with the pump piston for returning the pump piston to its initial position.

7. A nonpolluting engine as claimed in claim 2 including guide means for aligning the pump piston within the air chamber, the pump piston being further

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provided with receiving means for accommodating the pump piston lifter in close fitting relationship, whereby a layer of air is retained therebetween, thus forming an air cushion.

8. A nonpolluting engine as claimed in claim 7 wherein the pump piston lifter defines apertures therethrough for permitting the passage of air displaced from the cylinder.

9. A nonpolluting engine as claimed in claim 4 further including a suction valve in the cylinder for au-

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tomatically providing a supply of fresh air at atmospheric pressure during compression of the air charge.

10. A nonpolluting engine as claimed in claim 9 further including a suction valve in the air chamber for automatically providing a supply of fresh air at atmospheric pressure to the air chamber during movement of the pump piston to the initial position.

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