

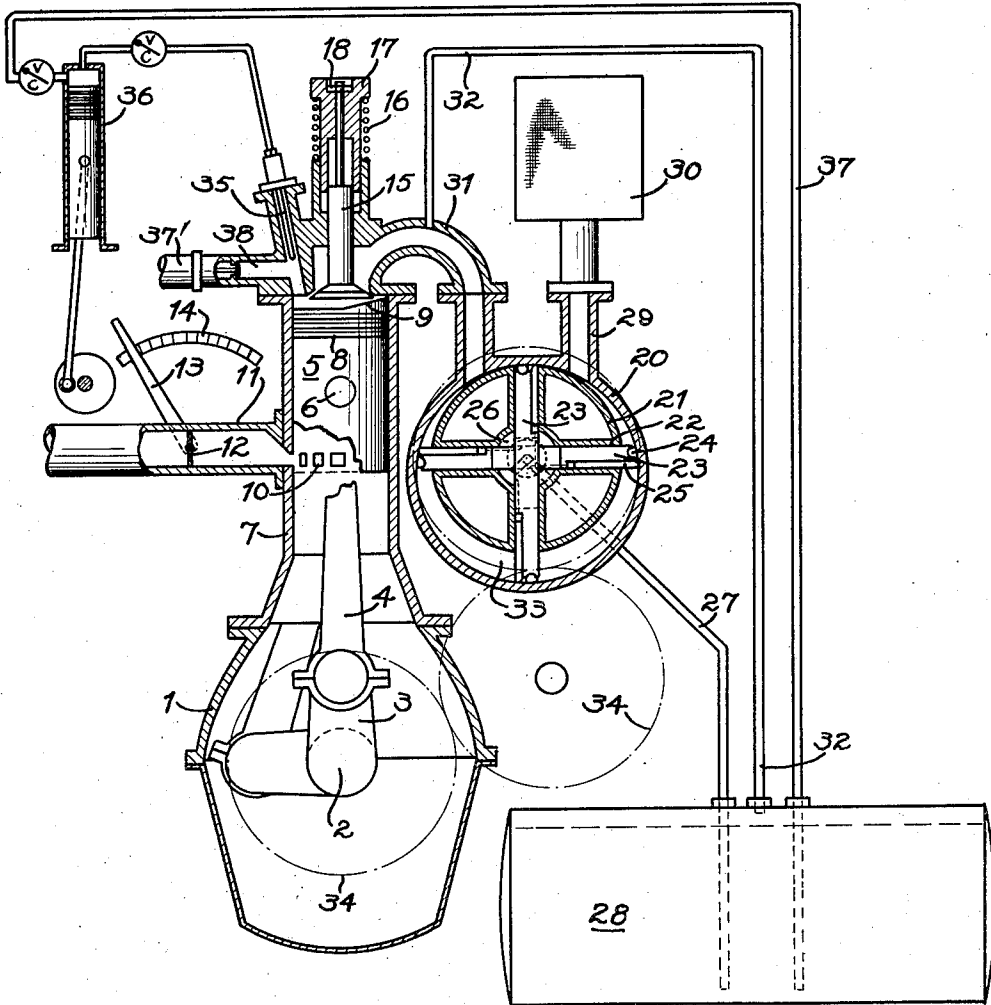
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TWO-CYCLE ENGINE

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TWO-CYCLE ENGINE

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Original application June 13, 1934, Serial No. 730,420. Divided and this application December 13, 1935, Serial No. 54,248

8 Claims. (Cl. 123—65)

My invention relates to two-cycle engines, and more particularly to two-cycle engines of the self-firing or Diesel type.

This application is a division of my prior application, Serial No. 730,420, filed June 13, 1934, for a "Convertible internal combustion engine and compressor."

Among the objects of my invention are: To provide a two-cycle engine in which complete scavenging may occur; to provide a two-cycle engine wherein scavenging may be controlled; to provide a two-cycle Diesel engine operable at variable speeds and which is particularly adaptable for idling; to provide a surge-charging system for a two-cycle engine; to provide a unique valve action in a two-cycle engine in conjunction with a positive fuel supply; to provide a means and method for supplying a Diesel engine cylinder with a weak fuel mixture insufficiently rich to fire on heat of compression; to provide a means and method for creating an explosion in said mixture; and to provide a simple and efficient two-cycle engine adapted to utilize low grade fuel.

My invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is, therefore, to be understood that my method is applicable to other apparatus, and that I do not limit myself, in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

In my prior application above-referred to, I have disclosed an engine operating on the two-cycle principle, combined with an air-starting system. The present application deals solely with the power cycle of that engine and the structure utilized to accomplish that cycle.

In the drawing, the figure is a schematic and diagrammatic representation of a single engine cylinder and appurtenances thereto, showing a preferred arrangement for accomplishing the operation and structure of my invention.

Before describing the operation of my preferred engine, I desire to refer to the figure for a more detailed description of the structure involved, a crank case 1 supporting a conventional crank shaft 2 on bearings not shown, as is well known in the art.

Journalled on crank arm 3 is connecting rod 4 operating piston 5 through the medium of wrist pin 6, the piston reciprocating within a

cylinder 7, the piston, of course, being provided with the usual rings 8.

I also prefer to provide the top of the piston with an inclined surface 9 over a portion of its area, this surface being positioned to direct exhaust gases through exhaust ports 10 adjacent the lower end of the cylinder and located to be uncovered through the final 35° of the power stroke crank travel. The gases from these exhaust ports are collected by an exhaust pipe 11 having therein, preferably adjacent the engine, an exhaust control valve 12 operated by an exhaust control arm 13 moving over a quadrant 14.

The cylinder head assembly is provided with a floating valve 15 supported by a valve spring 16 operating against a valve sleeve 17 which in turn operates the valve through an operating washer 18. The spring and sleeve are so arranged that the valve, when the engine is not operated, remains cracked by a definite amount, this amount of course varying, but in a particular engine I may prefer to allow the valve to open $\frac{1}{8}$ of an inch before spring influence occurs.

For charging the engine with air or gaseous fuel, I prefer to utilize a positive pressure compressor comprising a compressor shell 20 wherein there is rotated a vane web 21 having four slots 22 therein. This vane web is, as is usual in such compressors, positioned to one side of the center of the shell 20, and crossed vanes 23 are mounted therein and freely movable in slots 22. The ends of the vanes are provided with a friction shoe 24 and a floating vane 25, both shoe and floating vane cooperating to maintain a perfect seal at the ends of the vanes during rotation of the compressor, thus providing positive pressure.

This compressor has been described in detail in my copending application, Serial No. 730,420, filed June 13, 1934. In that prior application I have described resilient means for pressing the floating vane 25 against the inner wall of the shell. While that method is perfectly satisfactory, I prefer in this particular instance to utilize oil pressure to hold the vanes against the wall, and I have therefore provided the central cavity 26 of the web 21 with oil under pressure from line 27 leading from fuel oil tank 28. This oil passes to the backs of the vanes and presses the vanes against the wall.

Atmospheric air is taken into the inlet 29 of the pump through a screen 30, and the compressed air and gas mixture is delivered to the cylinder above valve 15 through storage conduit

31. Inasmuch as gases under pressure exist in this chamber, I prefer to take off a pressure pipe 32 therefrom and lead this to fuel oil tank 28 above the oil line, and seal the fuel oil tank, thus providing pressure to force fuel oil into the central chamber 26 of web 21; thence by the crossed vane bearings into the main compressor chamber 33 and also to the rear of the fly vanes 25 to force them against the shell wall. I prefer to drive this compressor at crank shaft speed, as indicated by broken gear lines 34.

On the side of the cylinder head opposite the storage conduit 31 I prefer to position a fuel injection nozzle 35, supplied, as is customary in the art, from a fuel injection pump 36 receiving fuel oil through pipe 37 from fuel tank 28. While I have shown the fuel pump 36 apart from the engine, it is of course to be understood that this pump is either directly connected to or synchronized with the rotation of the crank shaft of the engine in order that a charge of fuel oil be injected into the cylinder through nozzle 35 at each firing interval.

Opening into the cylinder head just below the end of fuel injection nozzle 35 is the starting-air entrance valve 37¹, and I prefer to position this valve sufficiently far back from the nozzle 35 so that a small auxiliary chamber 38 is formed, the usefulness of which will be explained later.

In the operation of a specific engine built in accordance with the basic structure above outlined, certain relative values may be mentioned in order that the relationship of sizes and pressures may be more fully understood. For example, I have found it desirable that the free air capacity of the compressor be the same as the piston displacement of the cylinder, and I have further found it desirable that the cubical content of the storage conduit 31 be also approximately the same as the piston displacement. Thus, there will always be a charge for the cylinder in storage chamber 31 while the next charge is making up within the compressor.

I also prefer to operate the compressor, in this specific example, to have an output pressure of fifteen pounds per square inch. With these figures and dimensions in mind, I will proceed to follow the complete cycle of operation of the device.

In the first place, and as it is customary to start engines such as the one described above with compressed air, and as in a two-cycle engine running at full speed it is desirable to have exhaust ports of as large area as possible and uncovered before the piston reaches bottom center; it can readily be seen that these two actions are in some degree incompatible. It is therefore desirable to partially close the exhaust during starting in order to obtain full benefit of the starting-air as it will then act on the final 35° of crank rotation. I therefore prefer, for starting purposes, to partially close valve 12 in the exhaust line, a convenient method of control being arm 13.

Air under pressure from some suitable source is admitted to the engine through valve 37¹, reaching the top of the piston 8 through chamber 33. The piston will then start down, under the air influence, but at the same time the valve 15 will close, due to the fact that the air pressure within the cylinder is greater than that within the storage conduit 31. As the piston 8 starts down, however, the compressor will be rotated, raising the pressure within the storage conduit 31, and storing therein air under pressure; this

air, however, being in fact a weak fuel mixture because as pressure builds up in storage conduit 31, fuel oil will be forced through pipe 27, past the vanes of the compressor into the compressor chamber 33, and is there mixed with the intaken air. I prefer to so adjust the leakage, either by construction of the vanes themselves or by a valve, not shown, in fuel line 27, that the amount of fuel vapor in the charge stored in storage conduit 31 is less than that which will enable the charge to be ignited by the heat of compression after it arrives in the cylinder.

As the piston reaches the downward end of its stroke and starts back up again, starting-air is of course discontinued by the proper commutating device utilized in the starter, and pressure within the cylinder is built up, due to the upward travel of the piston, thus keeping the valve 15 closed. At top dead center injection of fuel oil will take place through nozzle 35, and the cylinder will fire without utilizing any of the charge stored in storage conduit 31. As the piston starts down, under the influence of this charge, the gases burn and pass out of the exhaust port when uncovered; and as the pressure drops, due to the exhaust of the gas in the cylinder, valve 15 will open under the influence of the pressure of the charge existing in storage conduit 31 and the charge therein sweeps into the cylinder, charging and scavenging. As the piston reverses direction and continues its upward travel, valve 15 will close as soon as the pressure inside the cylinder becomes greater than that within the storage conduit; the charge in the cylinder will be compressed and a new charge will be placed in storage conduit 31 by the compressor.

When the charge now in the cylinder is fully compressed injection takes place, but it is only necessary now to inject just enough more fuel so that sufficient may be added to that already present in the compressed charge to bring it up to the point where it will ignite under the heat of compression, whereupon firing occurs and the cycle is repeated.

I have found, however, that certain definite pressure relationships take place during this cycle. For example, under normal operation both the cylinder and cylinder head, and at least a portion of the storage conduit 31, are hot, due to conduction from the engine; and I may desire to so design the engine that heat is readily conducted to the entire storage conduit 31. Under these conditions the stored charge is heated, and I have found that while the compressor output pressure may be fifteen pounds, the pressure of the charge within the storage conduit 31 may rise at or near the time of discharge into the cylinder to as high as thirty pounds, the vanes of the compressor nearest the outlet then acting as valves to prevent this excess pressure from affecting the individual portions of the charge under compression between the vanes. Then, as the valve opens, the charge surges into the cylinder where it is still further heated, and the expansion of the gases caused by the sudden accumulation of heat therein, and the exhaustion of conduit 31 by the rush into the cylinder, causes the valve to close instantaneously, irrespective of the piston motion; in fact, the operation of the valve is entirely independent of the valve spring, the spring merely being present for control, and the action of the valve is exceptionally snappy—it opens quickly and closes quickly. I may prefer, in or-

der to prevent hammering, to utilize also a closure spring to ease the closing snap.

Thus, the charging of my cylinder is in reality a surge, and the surge is trapped within the cylinder because of the quick action of the floating valve; and it is possible, except for the desirability of the prevention of hammering of the valve with consequent tendency toward crystallization, to operate the valve without any springs whatsoever, it being controlled entirely by differential pressure. The springs are merely present to affect the degree of control and the rate of action.

I have also found that even during the operation of the device, that the exhaust control throttle valve 12 is highly important in that it will control scavenging; in other words, partial closure of valve 12 will prevent all unburned gases from being exhausted. As the incoming charge enters the cylinder, it does not appear to mix readily with the exhaust gases but rather appears to ride on top of a layer of exhaust gas. I have found, therefore, that exhaust control is a convenient adjunct of throttling the engine; and I have also found that by closing up the exhaust while running at slow speed, the engine can be made to idle more perfectly and lug without misfire at low speeds. It is of course entirely possible and quite practical to tie up and interlink the exhaust valve 12 with either the injected fuel supply or the compressor supply or both in order to obtain an extremely effective speed control.

Several other features are made available by the construction and method of operation: The valve itself does not need a perfect seat; the valve can be made nearly as large as the cylinder diameter, and therefore requires only a short opening; a long piston stroke with its accompanying advantages may be used; no timing of the valve is necessary as it is entirely operated by differential pressure; use is made of the heat of the engine to increase the pressure of the charge, thus cooling the engine and increasing its thermal efficiency at the same time; due to the fact that in multicylinder engines pistons in adjacent cylinders may be placed at different crank angles, one storage conduit 31 and one compressor may be utilized to supply adjacent cylinders; the supply of fuel gas is synchronized with the needs and use of the engine in direct proportion to the speed as the compressor rotates synchronously with the crank shaft.

In the discussion of the mechanical parts above, I have mentioned that I prefer to leave an auxiliary chamber 38 extending laterally from the end of the injector nozzle 35. This I find is valuable in keeping the injector nozzle clean, as during the operation of the engine the mixture within this chamber will be insufficiently charged to ignite, but the gases in the chamber will be affected by the various pressure changes in the cylinder. Thus, there is a continual breathing of gas to and from this chamber past the outlet of the injector nozzle, thus tending to keep the nozzle clean, to completely remove all fuel, and to obviate the possibility of fouling by carbon or other foreign materials.

In addition, the breathing action of the auxiliary chamber removes fuel oil dribbling from the injector after injection and propels it into the combustion chamber, thus helping to redeem any imperfection in the initial combustion.

I claim:

1. The method of operating an internal com-

bustion engine which comprises externally compressing a charge of weak fuel-air mixture, storing said charge and simultaneously heating said charge, releasing said heated charge into a heated engine cylinder to still further increase its pressure, compressing said charge, and adding sufficient liquid fuel to said charge to cause ignition by heat of compression.

2. The method of operating an internal combustion engine which comprises externally compressing a charge of weak fuel-air mixture having a volume at intake temperature having a desired ratio to piston displacement, storing said charge and simultaneously heating said charge, releasing said heated charge into a heated engine cylinder to still further increase its pressure, utilizing said increased pressure to trap said charge in said cylinder, compressing said charge and adding sufficient liquid fuel to said charge to cause ignition by heat of compression.

3. The method of operating an internal combustion engine which comprises externally compressing a charge of weak fuel-air mixture having a volume at intake temperature having a desired ratio to piston displacement, storing said charge and simultaneously heating said charge by heat generated by engine operation to increase its pressure, releasing said heated charge into a heated engine cylinder to still further increase its pressure utilizing said increased pressure to trap said charge in said cylinder, compressing said charge and adding sufficient liquid fuel to said charge to cause ignition by heat of compression.

4. The method of operating an internal combustion engine which comprises externally compressing a charge of weak fuel-air mixture storing said charge and simultaneously heating said charge by heat generated by engine operation to increase its pressure without ignition, releasing said heated charge into an engine cylinder in the form of a surge, compressing said charge in said engine cylinder and adding additional fuel thereto to cause ignition.

5. The method of operating an internal combustion engine which comprises externally compressing a charge of weak fuel-air mixture, storing said charge and simultaneously heating said charge by heat generated by engine operation to increase its pressure, releasing said heated charge into an engine cylinder while exhaust ports are open, and controlling the effective aperture of said exhaust ports during operation.

6. The method of operating an internal combustion engine which comprises externally compressing a charge of weak fuel-air mixture, having a volume at intake temperature substantially equal to piston displacement, storing said charge and simultaneously heating said charge by heat generated by engine operation to increase its pressure releasing said heated charge into a heated engine cylinder to still further increase its pressure, utilizing said increased pressure to trap said charge in said cylinder compressing said charge, adding sufficient liquid fuel to said charge to cause ignition by heat of compression, externally compressing and preheating another charge during the utilization period of the first charge and controlling the effective aperture of said exhaust ports during operation.

7. An internal combustion engine comprising a cylinder and a piston, and an unrestrained inlet valve for said cylinder operable to open and close solely in accordance with the pressure balance on opposite sides thereof, means for storing a charge of gas under pressure on the inlet side of said

valve during the period when engine compression closes said valve, means for releasing exhaust gas pressure in the cylinder after combustion has taken place thereby causing the charge to surge
5 into said cylinder, said charge being trapped by automatic closure of said valve, and means for adding sufficient fuel to said gas to cause firing by heat of compression.

8. In combination with an engine cylinder and

piston wherein a gaseous charge is fired by heat of compression, means for supplying air under a positive pressure to said cylinder, means for charging said air with fuel to form a mixture just below that necessary to fire under compression, and means for supplying sufficient additional fuel on the compression stroke to bring said mixture to the proportions causing combustion.

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