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[21] Appl. No.

830,386

[22] Filed

June 4, 1969

[45] Patented

June 8, 1971

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[32] Priority

June 5, 1968
Germany

[31]

P 17 51 473.7

[50] Field of Search

123/75B,
75C, 119A

[56]

References Cited

UNITED STATES PATENTS

1,329,811

2/1920

Smith

123/75C

1,825,817

10/1931

Patterson

123/75C

1,833,802

11/1931

Violet

123/75C

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[54] AIR COMPRESSION FOUR-CYCLE PISTON
COMBUSTION ENGINE
2 Claims, 4 Drawing Figs.

[52] U.S. Cl.

123/75,
123/75(B), 123/75(C), 123/119(A)

[51] Int. Cl.

F02m 25/06,
F02b 47/08

ABSTRACT: An air compressing four-stroke cycle piston internal combustion engine in which exhaust gas is admixed to the combustion air taken into the cylinder means of the engine and in which during and preferably toward the end of the intake stroke of the respective cylinder means a time cross section is freed for the admittance of exhaust gas into the respective cylinder means.

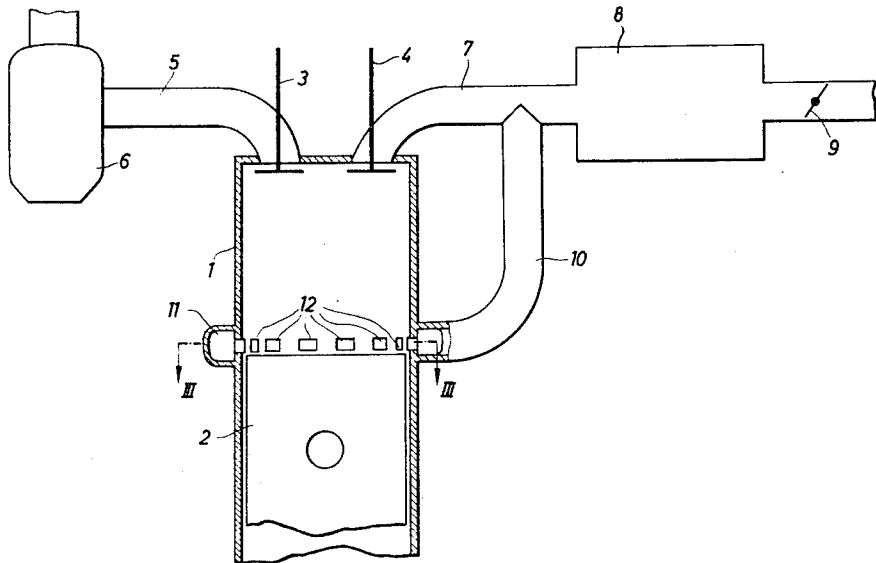
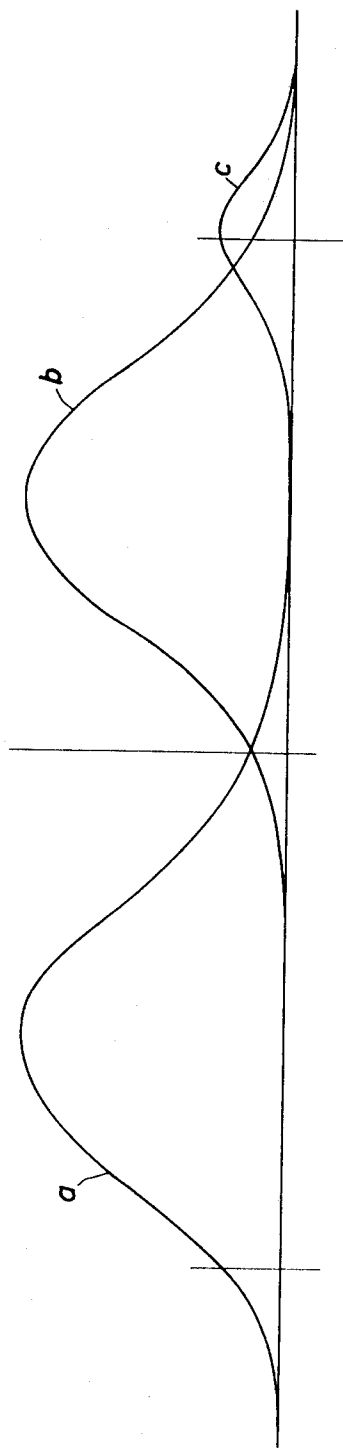
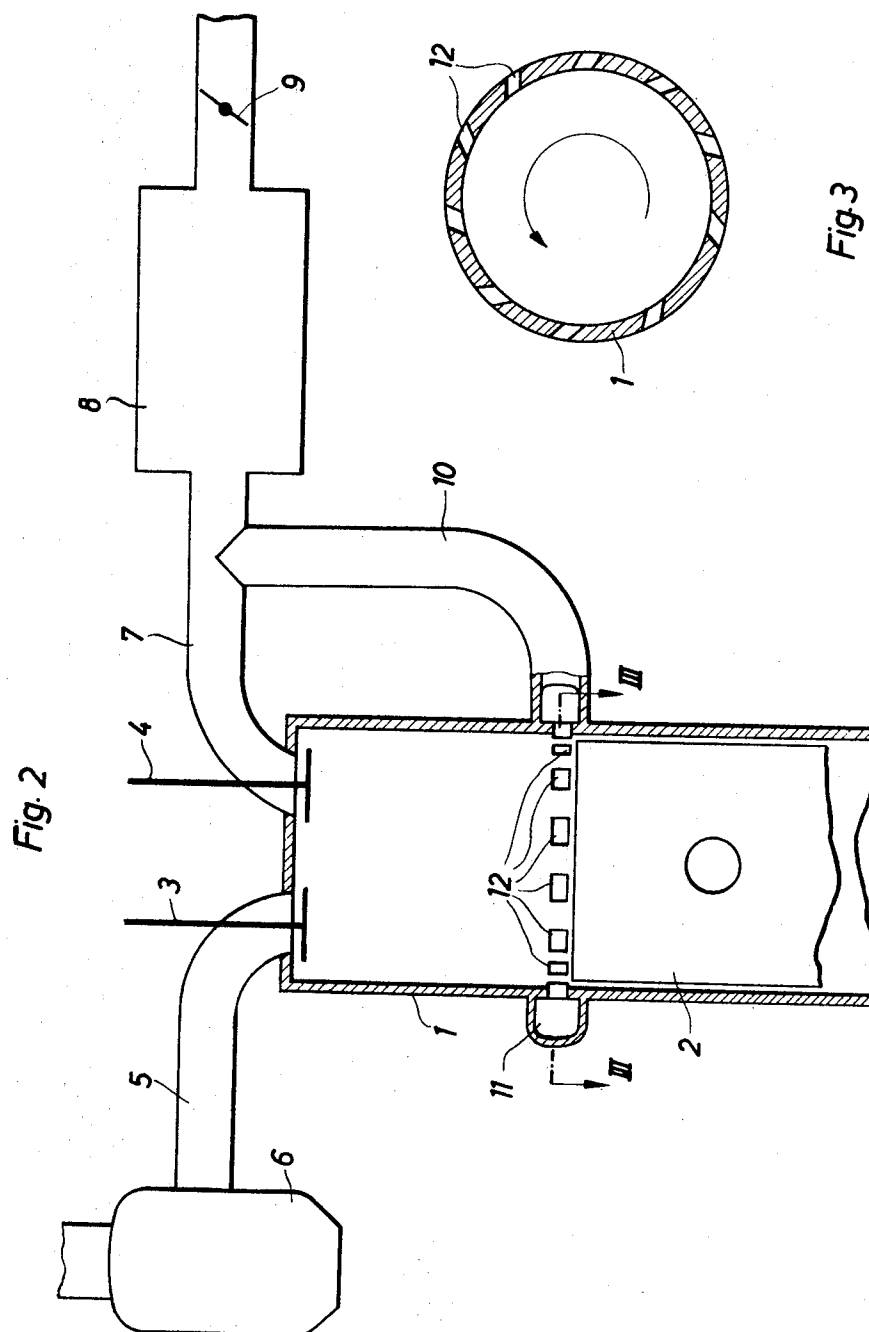


Fig. 1

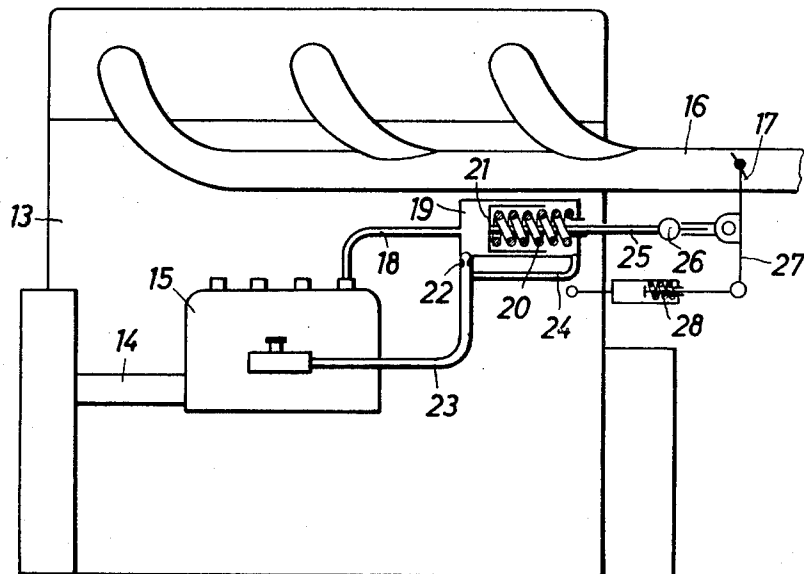


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Fig.4



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AIR COMPRESSION FOUR-CYCLE PISTON COMBUSTION ENGINE

The present invention relates to an air compression four-cycle-piston combustion engine with the admixture of exhaust gas and combustion air.

During the operation of air compressing four-cycle piston combustion engines with fuel of a low cetane number or with ordinary fuels at unusually low compression ratio, especially within the partial load area, ignition difficulties occur in view of the low temperature level prevailing in said area.

It is known to meet these difficulties by the admixture of engine exhaust gases to the drawn-in combustion air. The hereby obtained favorable effect is due to two components. On one hand the increase in temperature in the area brought about by the returned exhaust gases is of advantage. Furthermore the exhaust gas ingredients also initiate favorable reaction kinetic effects.

A problem not yet satisfactorily solved consists in the realization of the admixture in practice. Two fundamentally different ways of solving this problem have heretofore been selected. One way consists in throttling the exhaust gas flow, mostly by means of a flap, and it is taken for granted that during the time during which customarily with each four-stroke cycle piston internal combustion engine the opening periods of the inlet and outlet valve overlap, a part of the previously exhausted exhaust gas will flow back into the area in view of the pressure drop toward the area which pressure drop has been brought about by throttling in the exhaust conduit. This type of returning exhaust gases has, however, considerable drawbacks. On one hand it is necessary in view of the short time period which ordinarily is available for the return of the exhaust gases, that the exhaust gases flow in the partial load area and will have to be throttled strongly if any material effect is to be obtained. Strong throttling of the exhaust gases, however, automatically brings about high fuel consumption. Furthermore, it is a disadvantage that the returning exhaust gases will during the overlapping of the valves find only a relatively small space available and escape into the suction line whereby the latter will be soiled and heated up. While low pressure heads would possibly suffice when the valve overlap were increased, it would be necessary to put up with some drawbacks which will result from such increase in the valve overlap. These drawbacks are primarily the necessity for increasing the valve pockets which is a step having in most instances an unfavorable effect upon the design of the combustion chamber and thereby on the combustion. Furthermore there exists the danger that a stronger negative scavenging results which means that still more exhaust gases enter the suction conduit. The second way of solving the problems under consideration consists in that the exhaust gas is fed to the suction side of the engine, which, however, likewise has great drawbacks. In this connection it should be noted that the suction conduit, especially in the partial load area, where the admixture of exhaust gases is preferable, an air-exhaust gas mixture is obtained so that during a sudden switching from partial load to full load, still some combustion occurs due to lack of air, and the engine will show a certain sluggishness. A similar effect is also obtained in particular during a longer partial load operation and the considerable heating up of the suction line inherent thereto. Furthermore, the strong soiling of the suction line and the fact that the entire admixture system with its frequently very long conduits has to be insulated carefully against heat radiation represents a further undesirable feature.

It is, therefore, an object of the present invention to provide an air compression four-cycle piston internal combustion engine which will overcome the above-mentioned drawbacks.

This object and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 illustrates by way of a graph the control course of a four-cycle piston internal combustion engine in which the exhaust gas to be admixed to the internal combustion air is returned through the outlet valve of each cylinder.

FIG. 2 diagrammatically illustrates a section through a four-cycle piston internal combustion engine in which the return of the exhaust gases is effected by piston controlled passages in the cylinder.

FIG. 3 is a section taken along the line III-III of FIG. 2.

FIG. 4 diagrammatically illustrates an internal combustion engine with a throttle flap in the exhaust conduit and a device for adjusting the throttle in conformity with the respective load.

The problem outlined above has been solved in conformity with the present invention by the fact that during, preferably toward the end of, the suction stroke of the working cylinder or cylinders, a time period is permitted for the transfer of exhaust gases directly into the working cylinder or cylinders. The freeing of the time cross section for the return of the exhaust gases is, in conformity with the present invention, effected at a time at which already a considerable quantity of combustion air will be present in the respective working cylinder so that no longer any danger exists that returned exhaust gases will escape into the suction conduit. Moreover, the pressure drop necessary for returning the exhaust gases may be kept relatively small because for the intake of the exhaust gases a longer time period can be made available than is available with the customary valve overlap. Of great importance is also the fact that the exhaust gas is admixed to the combustion air at a time at which the combustion air has been heated already by hot engine parts, and this for the following reasons: The return of hot exhaust gases into the combustion air fundamentally results in a temperature increase in the cylinder. This means at the time of the admixture, a temperature of the mixture occurs which is higher than the temperature of the drawn-in combustion air. It is now the tendency to make this temperature increase particularly effective as to the creation of a high-temperature level toward the end of the intake stroke. This temperature level, however, is considerably higher when the exhaust gas is admixed to the combustion air not at the start of the intake or suction stroke but, in conformity with the invention, later, i.e. when the drawn-in combustion air has already been subjected to a heating up operation. Moreover, the later admixture is more advantageous insofar as the contact time of the exhaust gases with the fresh air is less so that the ignition accelerating and chemically active ingredients contained in the exhaust gases will have no opportunity to lose materially as to their effectiveness during too long a contact with fresh air. The direct feeding of the exhaust gases into the cylinder within the framework of the present invention may be effected according to the following two propositions.

According to one proposition, the time cross section (Zeitquerschnitt) to be made available in conformity with the present invention is freed by once more opening the outlet valve at an appropriate time. The other proposition consists in providing one or a plurality of exhaust gas feeding passages which are at an appropriate time opened up by corresponding working pistons. If the last-mentioned proposition is employed with a piston internal combustion engine in the working cylinder or cylinders in which the combustion air has a twist about the longitudinal axis of the cylinder toward the end of the suction stroke, it is advantageous to design the exhaust gas feeding so that they will aid in the generation of a twist. The generation of the pressure drop between the exhaust gas conduit and the working cylinder as it is necessary for the return of the exhaust gas may be effected either by throttling the exhaust gases or by throttling in the intake conduit. With exhaust gas turbocharged internal combustion engines, frequently the pressure head ahead of the exhaust gas turbine suffices for producing the pressure drop. In order not to affect the oxygen content of the cylinder charge during full load and furthermore in order not to interfere with the exploitation of the output, it is necessary to control the admixture of exhaust gases to the combustion air, in a manner known per se, in conformity with the load and/or the speed and, more specifically, in such a manner that at low load more exhaust gas and at full load very little or no exhaust gas at all is admixed while either the

feeding cross section for the exhaust gas or the throttling cross section producing the pressure drop may be controlled. The throttling cross section may be controlled, as is known per se, for instance by means of a flap.

A highly advantageous suggestion according to the invention with regard to the control consists, according to a further development of the invention, in effecting the control of the admixture of exhaust gases to the combustion air in direct conformity with the respective injected quantity of fuel. According to a further development of this concept, the fuel injection pump may be equipped with an additional pump element the delivery of which, which changes in conformity with the fuel delivery injected into each working cylinder, is used for actuating the element which controls the admixture of exhaust gases. It is advisable to dampen the movements of the control member, preferably hydraulically, to such an extent that between two successive strokes of the control no or no material return of the control member is effected.

Referring now to the drawing in detail, FIG. 1 illustrates the valve lifting curves of a four-stroke cycle piston internal combustion engine in the exhaust conduit of which the exhaust gases are choked by a throttle valve or throttle flap. The ordinary discharge valve lifting curve which starts shortly prior to the lower dead center point, i.e. shortly prior to the completion of the power stroke, has been designated with the letter *a* whereas the valve lifting curve of the inlet valve has been designated with the letter *b*. The outlet valve which as is customary closes shortly after the lower dead center point, i.e. after the suction stroke has started, opens, in conformity with the present invention, a second time shortly prior to the lower dead center point, i.e. shortly prior to the end of the suction stroke according to the curve *c* so that a portion of the choked exhaust gases in the discharge conduit will flow back into the working cylinder. The back flowing quantity is dependent on the magnitude of the choking pressure and the extent of the free time cross section.

With the internal combustion engine illustrated in FIG. 2, the working cylinder 1 has reciprocally mounted therein a piston 2 and is provided with an inlet valve 3 having adjacent thereto the suction conduit 5 and with an outlet valve 4 having adjacent thereto the discharge conduit 7. The intake conduit 5 has interposed therein an air filter 6. Interposed in said discharge conduit 7 is an accumulator 8 while a throttle valve or throttle flap 9 is arranged in the discharge conduit section 7a. Between the outlet valve 4 and the accumulator 8 a conduit 10 branches off from the discharge conduit 7 and leads to an annular chamber 11 surrounding the cylinder 2. Passages 12 of rectangular cross section lead from the interior of the annular chamber 11 into the cylinder 1. These passages 12 are so arranged with regard to the piston movement that they are freed by the piston 2 shortly prior to the completion of the suction stroke so that exhaust gas choked or accumulated in the discharge conduit 7 ahead of the throttle valve 9 will be moved into the cylinder chamber. Inasmuch as the present instance concerns a machine in which the combustion air has near the end of the intake stroke imparted thereupon a twist around the axis of the cylinder, the passages 12 have, as indicated in FIG. 3, been so positioned as to aid in the formation of the twist or whirl.

According to FIG. 4, the three-cylinder four-stroke cycle

piston internal combustion engine has been designated with the reference numeral 13. The engine is provided with a fuel injection pump 15 adapted to be driven by means of an auxiliary shaft 14. The discharge conduit of engine 13 is designated with the reference numeral 16. A throttle valve 17 is arranged in the discharge conduit 16 and is adjusted in conformity with the respective load. A portion of the exhaust gas accumulated or choked ahead of said throttle valve 17 is, but not shown in the drawing, returned into the cylinder by the discharge valve or valves which near the end of the intake stroke opens or open shortly once more. The load-dependent adjustment of the throttle valve 17 is effected in the following manner. The fuel injection pump 15 is equipped with a fourth pump element which delivers through a conduit 18 into the working chamber 19 of a piston 21 which is biased by a spring 20. Connected to the working chamber 19 of this piston is a conduit 23 controlled by a throttle 22 and connected to the suction side of the fuel injection pump 15. A relief conduit 24 of the spring chamber pertaining to piston 21 leads into the conduit 23 behind the throttle 22. Piston 21 is adapted through the intervention of a rod 25, a joint 26 and a lever 27 to adjust the throttle valve 17 in conformity with the changes in the delivery of the fourth pump element and thereby also in conformity with the changes of the fuel injection pump elements proper. Any material return of the throttle valve 17 between each two strokes of the actuating pump is prevented by a hydraulic damping device 28 which is connected to a lever 27.

It is, of course, to be understood, that the present invention is, by no means, limited to the particular showing in the drawing but also comprises any modifications within the scope of the appended claims. It is also to be noted that, if desired, a throttle 9a may be provided in conduit 5 to produce the desired pressure drop between exhaust gas conduit 7 and cylinder 1.

I claim:

1. An air compressing four-stroke cycle piston internal combustion engine which includes: cylinder means having inlet valve means and outlet valve means, inlet manifold means leading to said inlet valve means, outlet manifold means communicating with said outlet valve means for discharging exhaust gases discharged through said outlet valve means, said cylinder means being provided with inlet port means spaced from said outlet valve means in the axial direction of said cylinder means, adjustable throttle means interposed in said outlet manifold means for controlling the quantity of exhaust gases passing from said outlet manifold means to and through said inlet port means, conduit means leading from said outlet manifold means into said inlet port means, piston means reciprocable in said cylinder means and operable to control said inlet port means to permit exhaust gases from said conduit means to enter said cylinder means when said piston means during an exhaust stroke frees said inlet port means, and pump means for delivering fuel to said cylinder means and means responsive to the delivery of said pump means and operatively connected to said throttle means for controlling the latter in conformity with the delivery of said pump means.

2. An internal combustion engine according to claim 1, in which said means responsive to the delivery of said pump means includes an additional pumping element.