Nov. 6, 1951 F. D. BUTLER 2,573,689

INTERNAL-COMBUSTION ENGINE VARIABLE COMBUSTION CHAMBER

Filed Dec. 12, 1947 3 Sheets-Sheet 1

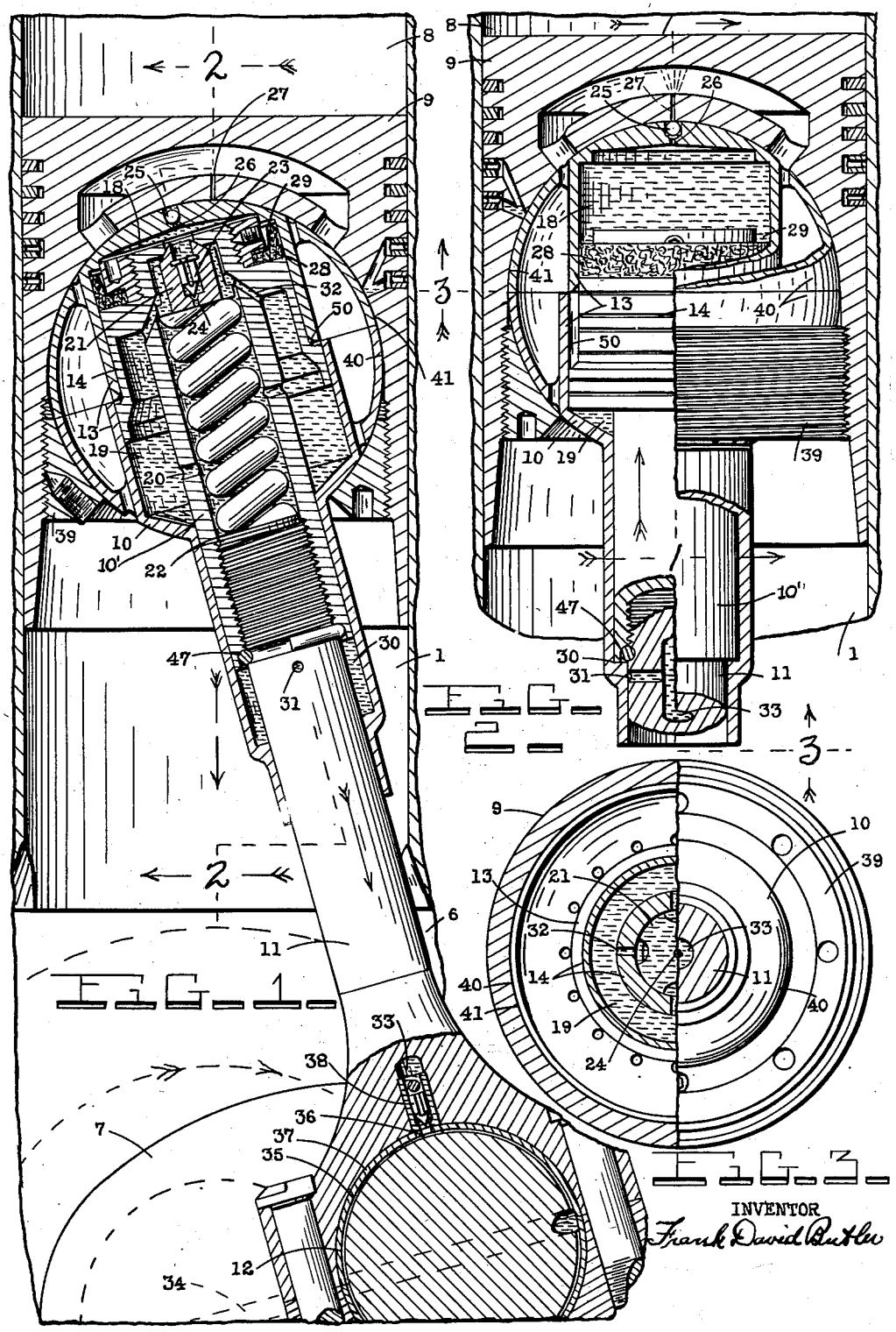


FIG. 1

FIG. 2

FIG. 3

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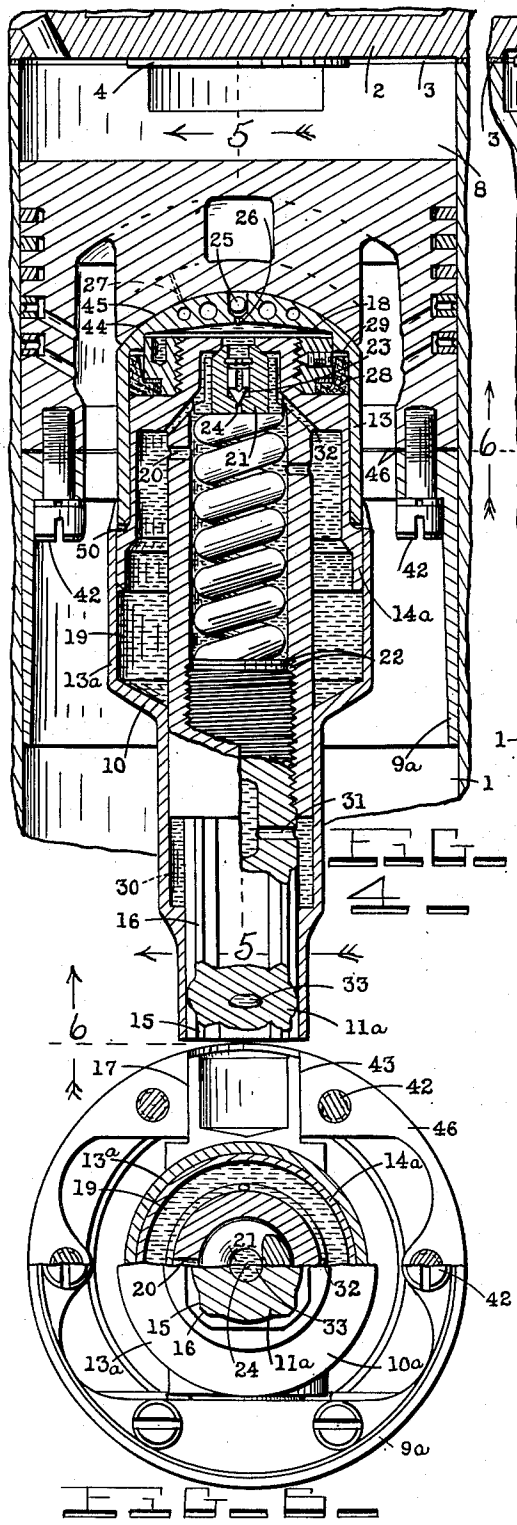


FIG. 4

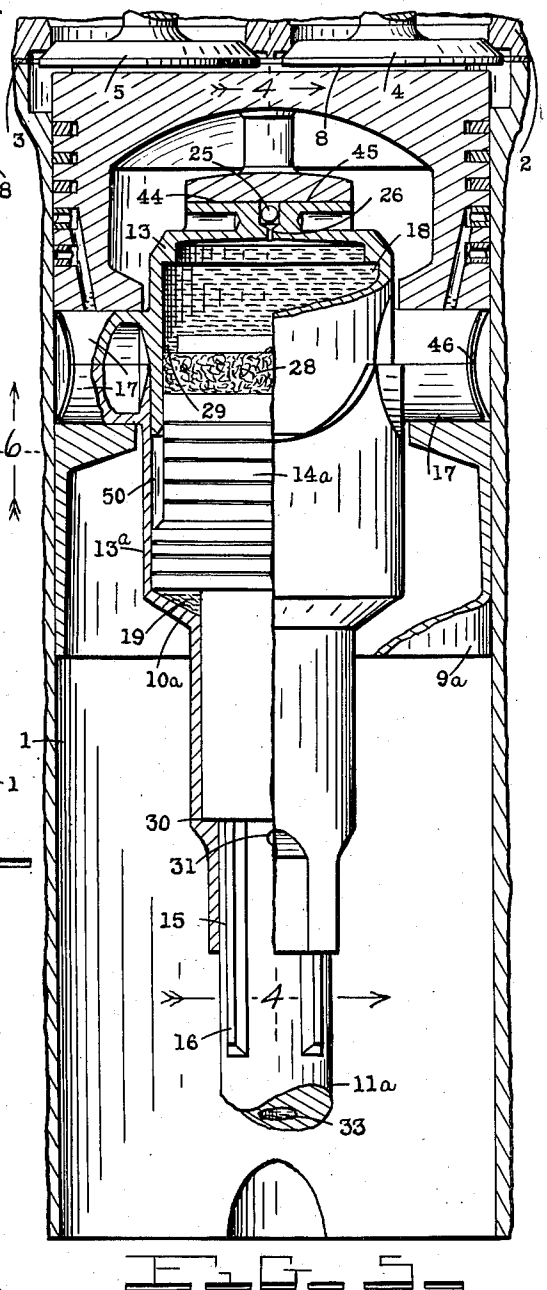


FIG. 5

FIG. 6

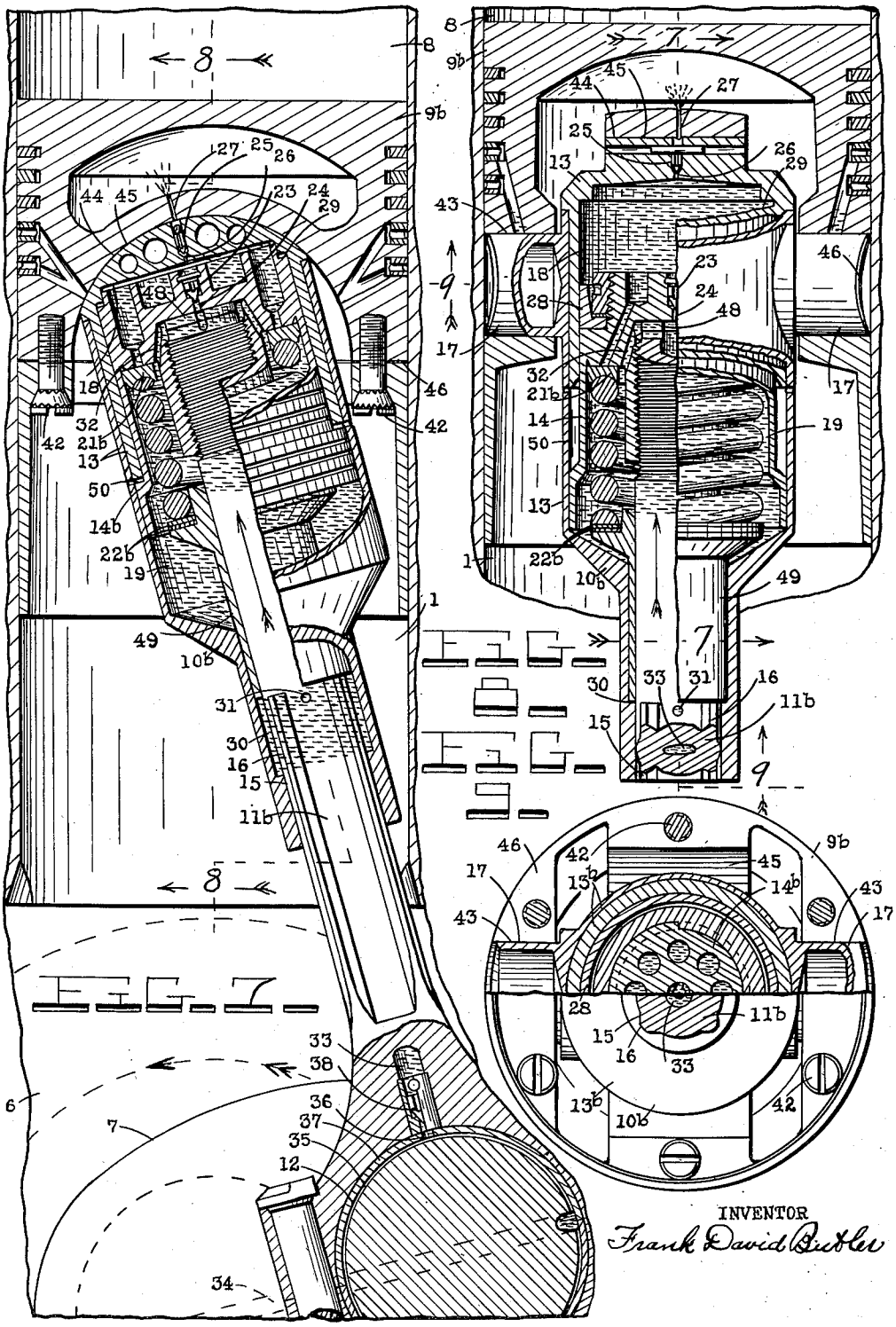
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INTERNAL-COMBUSTION ENGINE VARIABLE COMBUSTION CHAMBER

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INTERNAL-COMBUSTION ENGINE VARIABLE COMBUSTION CHAMBER

Frank David Butler, Washington, D. C.

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3 Claims. (Cl. 123—78)

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In general my present invention relates to improvements in internal combustion engine variable combustion chamber controlling devices and particularly to that type wherein such controlling device is mounted within the main piston of such engine and is operated automatically and hydraulically by lubricating oil under pressure from the lubricating oil system of such engine, and similar to device for which I filed for patent in the United States Patent Office on November 22, 1947, Serial No. 788,304.

The improvements reside in the following: stepping the auxiliary piston to a plurality of diameters and thus practically equalizing the projected areas on either side of such auxiliary piston; providing a relatively small orifice and check valve operating in conjunction with a journal and bearing for purposes of air venting the hydraulic system of the device; providing means for removal and replacement of the auxiliary piston and cylinder within the main piston other than by removable trunnion journals; providing the auxiliary cylinder with integral in place of removable splined keyway; and, providing a complete revision of the operating valves and the principle of operation of the device in order to produce a more dependable, durable, accessible and efficiently operating assembly.

A better understanding of the improvements will be had from a reading of the following specification and the accompanying drawings of which latter: Fig. 1 is a transverse section of my present invention as applied to one of the main pistons of a modern multi-cylindered internal combustion engine and illustrates the auxiliary cylinder thereof ball-journal supported in said main piston and at its full downward movement over the auxiliary piston thereof and as it would appear (excepting on an angle thereto and with the movable elements of the device in a different position of travel) on the dotted and broken line 1—1 of Fig. 2; Fig. 2 is a longitudinal section of the device as it would appear (excepting as mentioned regarding Fig. 1) on the dotted and broken line 2—2 of Fig. 1 and illustrates the auxiliary cylinder at full upward movement over auxiliary piston; Fig. 3 is a bottom plan view of Fig. 2 partly in section and as it would appear on the dotted and broken line 3—3 of Fig. 2; Fig. 4 is similar to Fig. 1 excepting illustrating the auxiliary cylinder split in two at the centerline of the trunnion journals thereof and so supported within the main piston and as it would appear on the dotted and broken line 4—4 of Fig. 5; Fig. 5 is similar to Fig. 2 excepting illustrating

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the assembly Fig. 4 and as it would appear on the dotted and broken line 5—5 of that figure; Fig. 6, is a bottom plan view, partly in section, of Fig. 4 and as it would appear on the dotted and broken line 6—6 of that figure; Fig. 7 is similar to Figs. 1 and 4 excepting illustrating a variation in the assembly of the device and as it would appear (with the exception of a slight variation in construction) on the dotted and broken line 7—7 of Fig. 8; Fig. 8 is similar to Figs. 2 and 5 with practically the same variation in the assembly as illustrated in Fig. 7 and as it would appear on the dotted and broken line 8—8 of latter named figure; Fig. 9 is a bottom plan view, partly in section, of Fig. 8 and as it would appear on the dotted and broken line 9—9 of that figure.

With further reference to the drawings, and particularly to Figs. 1–3, wherein similar numerals indicate similar parts in the several views:

The numeral 1 indicates the usual enbloc cylinder casting of a multi-cylindered (four stroke cycle) internal combustion engine, 2 the enbloc cylinder head casting, 3 the head gasket, 4 one of the inlet valves, 5 one of the exhaust valves, 6 the crank-case and 7 the crank-shaft. The combustion chamber 8 is formed between the under side of the cylinder head 2 and the upper end of the main piston 9 within the main cylinder 1 and is variable in cubical size by the automatically and hydraulically operated control device unit 10 flexibly mounted within said main piston. The connecting rod 11 is cylindrical and externally threaded at its upper end for connection with the sleeve 10' of the piston 14 and it has a journal 12 at its lower end.

This combustion chamber controlling device unit 10 consists of the following; an elongated auxiliary cylinder 13 made in two halves with each half having a different size internal bore and each bore adapted to be secured in tandem with the other and said cylinder being adapted to be trunnion and/or ball journal suported within said main piston 9; an elongated auxiliary piston 14 having a plurality of external diameters with a head at the smaller diameter end thereof and its elongated internally threaded tubular portion 10' at the larger diameter end thereof and both ends being adapted to be slidably mounted within the tandem adjacent halves of said auxiliary cylinder; it may be modified to have means in the form of a splined keyway 15 (as seen only in Figs. 4 to 9 inclusive) integral with one half of cylinder 13 and corresponding to and operating in conjunction with a splined key

16 (integral with the connecting rod) for maintaining alignment between the connecting rod journal 12 and the trunnion journals 17; a closed cylindrical chamber 18 located within cylinder 13 adjacent head end of piston 14 and adapted to contain lubricating oil under pressure therewithin; a closed annular shaped chamber 19 located within cylinder 13 adjacent tubular end of piston 14 and (in Figs. 1 to 6 inclusive) having an inner compartment thereof connected therewith through access ports 20 (in piston 14), and adapted to contain lubricating oil under pressure therewithin; a spring loaded combined fluid operating and relief valve 21 located in chamber 19 and seating towards chamber 18 over a relatively large hole (Figs. 1 to 6 inclusive) and/or a series of relatively small holes (Figs. 7 to 9 inclusive) located in piston 14 and otherwise connecting chambers 18 and 19; means in the form of a plurality of annular shaped washers 22 for the purpose of manually adjusting the tension setting of the spring 22' of said valve 21; means in the form of a non-return check valve 23 located between chambers 18 and 19 and seating towards the latter over a restriction orifice 24 that would otherwise connect these two chambers; means in the form of a relatively minute non-return check valve 25 located in the upper half of cylinder 13 adjacent to and seating towards chamber 18 over a minute restriction orifice 26 that would otherwise connect the top of said chamber 18 with outside of cylinder 13, and which opening intermittently operates in conjunction with a minute restriction orifice 27 (in main piston 9) for purpose of ejecting air and a small quantity of lubricating oil from chamber 18 to open space within main piston 9; an annular L-shaped (leather and/or other suitable oil resisting flexible packing material) packing ring 28 (secured adjacent head end of piston 14) adapted to make the auxiliary piston 14 fluid tight within the smaller bore of cylinder 13; an annular shaped upper dash-pot 29 formed between the flanged collar (at head end of piston 14) and flanged recess in upper inward end of (upper half of) cylinder 13 and adapted to have oil fluid trapped therein and thus to cushion the auxiliary cylinder 13 as it approaches the downward end of its travel over piston 14 as said trapped oil seeps therefrom said dash-pot; a similar annular shaped lower dash-pot 30 located inside of lower end of cylinder 13 (under piston 14) and having intermittent access with inside of rod 11 through port 31 in latter and being adapted to have oil trapped therein and thus to cushion auxiliary cylinder 13 (as latter approaches the extreme upper end of its travel over piston 14) as said trapped oil seeps therefrom said dash-pot 30; means in the form of a series of diagonally extending ports 32 located in piston 14 at extreme upper end of chamber 19 for purpose of venting air from latter to vicinity of lower end of orifice 24; and, access means for supplying lubricating oil fluid under pressure from the usual engine lubricating oil system to said device 10 via a non-return check valve.

With reference to Figs. 1 and 7, oil under pressure from the usual forced feed lubricating oil system of the engine is supplied to the elongated access hole 33 (extending through the rods 11 and 11b) from the usual diagonally extending hole 34 (in shaft 7) via the annular shaped groove 35 (in journal 12) thence via the radially extending hole 36 (in the insert bearings 37 of the rods 11 and 11b) and thence via the non-return check valve 38 (in the feet of the rods) into said access hole 33. This valve 38 is for the purpose of preventing the oil in the connecting rods and the auxiliary cylinders from returning to the main lubricating oil system while engine is not in operation and thus preventing 10 and 11 from becoming full of air at such times.

As illustrated in Figs. 1 to 3 inclusive, the auxiliary cylinder 13 may be made in two semi-circular (ball shaped) halves and in such case the main piston 9 is equipped with a removable (annular and semi-circular shaped) externally threaded retainer ring 39 for the purpose of securing said halves of said cylinder 13 oscillatably in place on its ball-journal 40 within the ball shaped bearing 41 within main piston 9. This arrangement has the disadvantage of not allowing the connecting rod 11 any lateral motion in piston 9 but has the advantage of eliminating the use of the splined alignment keyway 15 and key 16.

As illustrated in Figs 4 to 6 inclusive, the auxiliary cylinder 13a may be made in two halves with the split at the centerline of the trunnion journals 17 thereof and in such case the main piston 9a is made in two halves held securely together by a series of machine screws 42. In such an arrangement (in addition to the bearing bore 43 in piston 9a for trunnion journals 17) a semi-circular shaped journal 44 is provided (at upper end of cylinder 13a) having a semi-circular shaped bearing 45 (in upper half of main piston), and an adjustment shim 46 is also provided (between the halves of piston 9a) for wear take up on such journals and bearings.

Similarly as illustrated in Figs. 7 to 9 inclusive, the auxiliary cylinder 13b may be made in two halves with the joint therebetween located above the trunnion journals 17 and in the vicinity of journal 44 in order to simplify the unit 10b as a whole. Fig. 7 also shows the arrangement of the auxiliary piston 14b with the packing ring 28 omitted and with the combined control and relief valve 21b annular in shape in lieu of conical in shape as illustrated in Figs. 1 to 6 inclusive. As illustrated in these Figs. 7 to 9 inclusive, a removable tubular and T-shaped bushing 49 is used as a shoulder for spring of valve 21b so that outside diameter of rod 11b could be kept at a minimum considering strength required.

In Figs. 4–6, those parts which are not identical but are similar to corresponding parts of Figs. 1–3 are given the same reference numerals with the suffix "a" added. Likewise, in Figs. 7–9, the suffix "b" is used.

In Figs. 1 to 3 inclusive the auxiliary piston 14 is screwed tightly over the threaded portion of the upper end of rod 11 and is shouldered against the annular shaped spring steel locking ring 47, while in Figs. 4 to 6 inclusive it is shouldered against the upper ends of splined key 16, and in Figs. 7 to 9 inclusive it is shouldered against the spring steel lock washer 48.

In manufacturing, the auxiliary cylinder 13 and auxiliary piston 14 should both be preferably made of heat treated and hardened steel and the tandem outside diameters of 14 and corresponding inside diameters of 13 should be ground to minimum allowed slidable clearance tolerance so that the packing ring 28 should not have to be required.

As may not be understood (in the case illustrated), the relations that exist between the top projected area of auxiliary piston 14 and main

piston 9 is in the ratio of four to one. Thus during the average of 220 degrees of crank-shaft rotation of the fuel inlet period (of the engine four stroke cycle operation) the vacuum produced in combustion chamber 8 (due to displacement of main piston 9 within main cylinder 1) simultaneously produces a relatively higher (by ratio of four to one) vacuum in fluid chamber 18 and results in oil being induced from access hole 33 and/or chamber 19 into chamber 18 via orifice 24 and past check valve 23 during this inlet period. Thus it can be understood (in case illustrated) that each cubical inch of oil fluid supplied to and/or removed from the chamber 18 results respectively in a decrease and/or increase in the cubical size of combustion chamber 8 of four cubical inches. Thus also it can be seen that only a relatively small quantity of lubricating oil fluid is handled to and from chamber 18 to produce a major change in the cubical size of chamber 8.

As may not be understood, (in the case illustrated) the projected area of the tubular end of auxiliary piston 14 (minus the projected area of the connecting rod 11 entering thereinto chamber 19) is a trifle larger than the projected area of the head end of said piston. Thus during the full upward and/or downward movement of the auxiliary cylinder 13 over auxiliary piston 14 only a small quantity of oil would be required from the main lubricating oil system, and then only during the downward travel of auxiliary cylinder 13.

As may also not be understood (in the case illustrated) the full displacement of main piston 9 in main cylinder 1 is 42 cubical inches, the full size of the combustion chamber is 7 cubical inches and the resulting full compression ratio is seven. Now (as the relations between the projected areas of upper ends of main piston 9 and auxiliary piston 14 is one to four) the setting of the combined operating and relief valve 21 is a trifle over four times the peak combustion pressure in combustion chamber 8 resulting from a compression ratio of seven being used therein. Thus it can be seen that the auxiliary cylinder 13 would never strike the top of auxiliary piston 14 inasmuch as when this would happen the compression ratio in combustion chamber 8 would be below seven due to extra travel allowed cylinder 13 over piston 14. Also (in this example case illustrated) the combustion chamber 8 in Fig. 4 is at its maximum size (with the main piston 9*a* on top dead center) of 7 cubical inches, while in Fig. 5 (with piston 9*a* likewise on top dead center) the combustion chamber 8 is at its minimum size of ½ cubic inch. Thus the difference is 6½ cubical inches, and this figure divided by four (the ratio between top projected areas of 14 and 9) gives 1⅝ cubical inches, which latter is the quantity of oil that would have to be displaced from (and/or to) chamber 18 in order to produce this 6½ cubical inch change in size of combustion chamber 8. It is understood that the annular shaped chamber 50 resulting from stepping the mentioned diameters of the auxiliary unit is opened to outside of the auxiliary cylinder at all times.

With reference to Figs. 1 to 3 inclusive, as the minute orifice 27 (in this particular instance) must be located concentric with piston 9, cooperation therebetween and the outlet from orifice 24 past check valve 25 occurs four times during one complete engine operating cycle, and that due to likelihood of air being induced therethrough into chamber 18 at the bottom of the

inlet stroke, the valve 25 becomes necessary. While in the assemblies Figs. 4 to 9 inclusive, it can be seen that by placing this orifice 27 at location illustrated in Fig. 7 that the cooperation mentioned would only occur during the middle of the compression and exhaust strokes of said cycle and that the check valve 25 (in such case) is not an essential feature in construction. Assuming therefore that a minute quantity of air and/or oil is to be ejected from chamber 18 to space outside of 13 through 27 during the middle portion of said compression and exhaust strokes and that an extremely minute quantity of oil is ejected from 18 through orifice 26 to journal 44 and bearing 45 during the complete engine operating cycle (minus the inlet period) and that simultaneously during the inlet period oil is supplied to chamber 18 via orifice 24 past check valve 23. It can thus be seen that the orifices 26 and 27 should be minute in size as compared with orifice 24 in order to build up the quantity of oil in chamber 18 and simultaneously keep the quantity of oil required to operate unit 10 as low as possible.

With reference to Fig. 7 in particular and assuming that the auxiliary cylinder 13*b* is near the downward end of its travel over auxiliary piston 14*b* (as illustrated in such figure) and that the engine is started in the usual manner, then the operation of the device would be as follows: as soon as the shaft 7 starts rotating and oil pressure (of approximately 40 pounds gage) is established on the lubricating oil system, oil under pressure is supplied to unit 10*b* via access connections previously described; if not already full of oil (due to non-return check valve 38 retaining oil in unit 10*b*), the chamber 19 fills with oil first and then during each succeeding inlet period oil is induced into chamber 18 (via orifice 24 and past check valve 23) and simultaneously during the middle portion of each succeeding compression and exhaust stroke a relatively small quantity of air and/or oil is ejected from chamber 18 via orifices 26 and 27 and past check valve 25 to outside of cylinder 13*b*; as soon as combustion chamber 8 has been thus reduced sufficiently to produce a compression ratio in excess of seven within said chamber 8, then (due to peak combustion pressure resulting therefrom such compression ratio in said chamber 8) the fluid control and relief valve 21*b* would be lifted from its seat (due to resulting pressure produced in chamber 18) and oil fluid would be discharged therefrom chamber 18 past said valve 21*b* into chamber 19; this automatic discharge of oil mentioned would cause the auxiliary cylinder 13*b* to move slightly downward and would prevent the compression ratio in combustion chamber 8 from exceeding slightly in excess of seven; the object being to be able to increase the size of the combustion chamber 8 instantly and to decrease its size slowly so as to allow for rapid engine acceleration without danger of excessive compression ratios, and, thus by automatic movement of the auxiliary cylinder upward and downward over auxiliary piston 14*b* by hydraulic force results in a constant compression ratio of seven (in case illustrated and described) being established and maintained during practically the entire power range of the engine.

The invention herein described may be manufactured, used and sold by or for the Government of the United States of America for governmental purposes without the payment of any royalty thereon or therefor.

I claim:

1. In combination with a cylinder of an internal combustion engine, an engine piston forming with said cylinder a compression chamber, said piston carrying means providing an internal auxiliary working chamber comprising a plurality of aligned cylindrical bores of different diameter, with that having the smallest diameter adjacent the head end of the piston, a connecting rod terminating in a stepped auxiliary piston within and complemental to the bores of said auxiliary chamber for movement therein, said rod having a longitudinal passageway opening through the head of said auxiliary piston by way of a restricted orifice for communication with the space between said auxiliary piston head and said internal working chamber, and a second passage through said head and having a check valve permitting flow of fluid through said head in the other direction to the interior of said auxiliary piston, the effective area of the auxiliary piston at its largest diameter, to which said rod is connected, being larger than the effective area at its smallest diameter.

2. In combination with a cylinder of an internal combustion engine, an engine piston forming therewith a compression chamber, a separate auxiliary cylinder pivotally but non-slidably mounted in said piston, a connecting rod terminating in an auxiliary piston within said auxiliary cylinder, said rod having an internal passageway for conveying fluid to said auxiliary cylinder by way of said auxiliary piston, said auxiliary cylinder and said engine piston having complemental ball-shaped surfaces, said auxiliary cylinder having a relief valve opening outwardly through its ball-shaped surfaces, said engine piston having a cavity and a port opening from its ball-shaped surface into said cavity, said port located to register with said relief valve only in certain normal positions of said auxiliary cylinder with respect to said engine piston.

3. In combination with a cylinder of an internal combustion engine having force feed lubrication, an engine piston forming with said cylinder a compression chamber, said piston carrying means providing an auxiliary cylinder bore therewithin, a connecting rod terminating in an auxiliary piston within said bore, a sleeve around said rod and closing the lower end of said bore, said rod having an internal passageway extending from its crank shaft journal into a central space within said auxiliary piston, an opening from said space through the head of said auxiliary piston, a hollow valve controlling said opening and urged upwardly to seated position by a relatively heavy spring, an upwardly opening check valve disposed within said hollow valve, and a second spring relatively weaker than said first mentioned spring urging said upwardly opening check valve downwardly against its seat.

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