

[54] **VARIABLE COMPRESSION RATIO
PISTON INCLUDING OIL FILTER
MEANS**

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[58] Field of Search **123/78 B, 48 B, 78 R, 48 R;**
92/82, 216; 91/422; 277/75; 137/454.2

[56] **References Cited**

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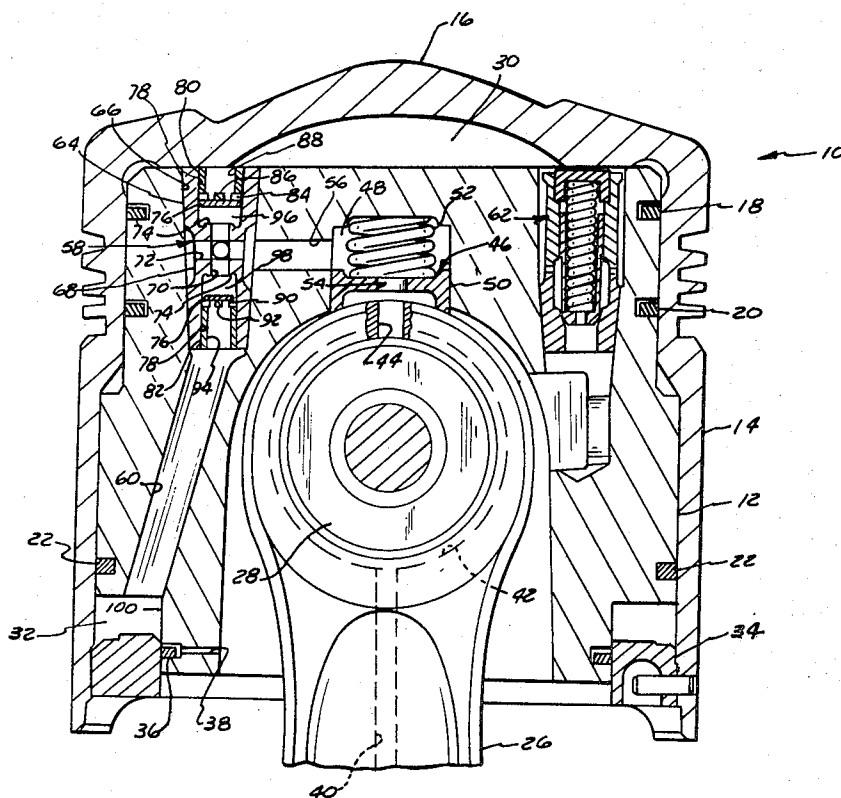
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[57] **ABSTRACT**

A two-part variable compression ratio piston provided with an upper and lower chamber, supply valve means connected with the lubrication system of the engine for supplying oil to the chambers in a manner which permits the parts by inertia forces and the forces generated by combustion chamber pressures to move relative to each other at a controlled rate to increase the compression ratio of the engine until a predetermined constant maximum combustion chamber pressure has been achieved, a discharge valve assembly for discharging some of the oil from the upper chamber to the engine crankcase when the pressure in the upper chamber exceeds a predetermined maximum value and a restricted discharge orifice formed in the inner member and connected to the lower chamber for discharging a controlled quantity of oil therefrom. The supply valve and discharge valve assembly are each formed with a conically shaped exterior surface that mates with a similarly shaped hole within the inner piston member for retaining the valves therein. A narrow annulus is formed between the inner member and the discharge valve for filtering oil before it enters the discharge valve so that impurities which might retain the valve in an opened position are filtered out of the oil. A second narrow annulus is provided between the discharge orifice and the lower chamber so that impurities that might plug up the orifice are filtered out of the oil.

13 Claims, 3 Drawing Figures



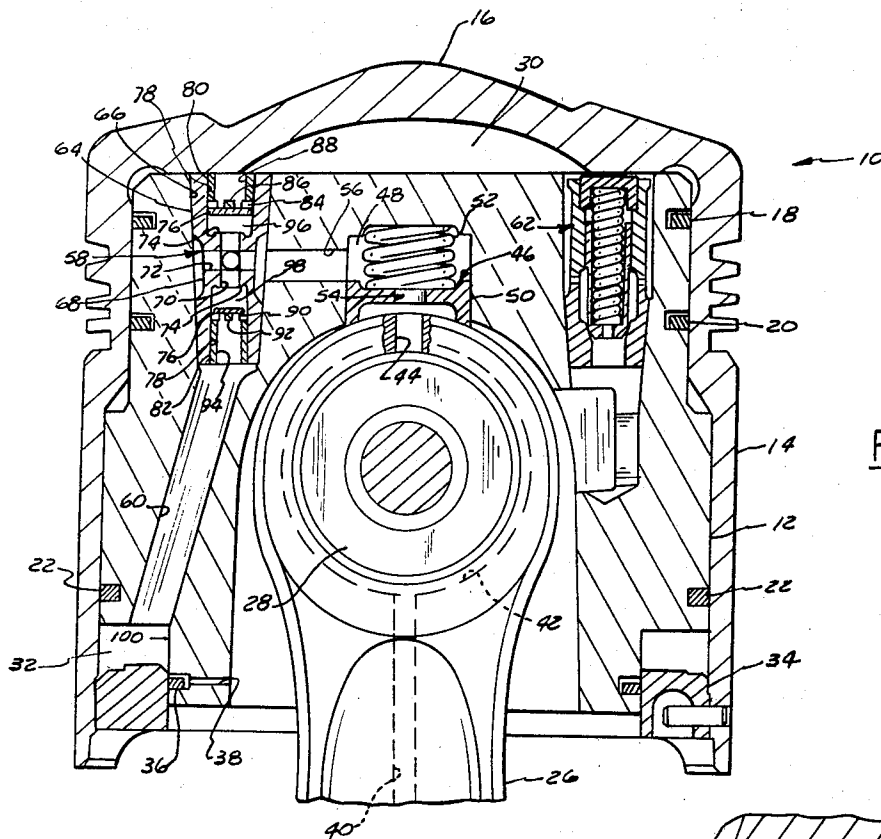


FIG-1

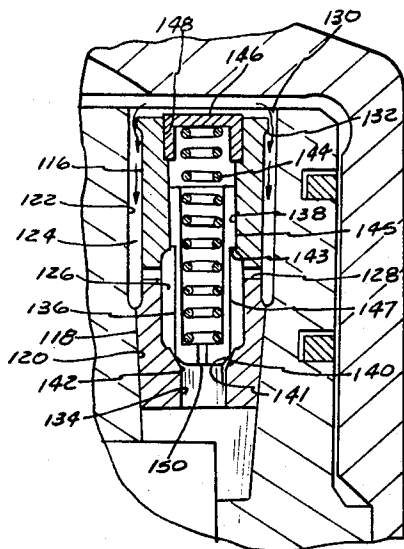


FIG-2

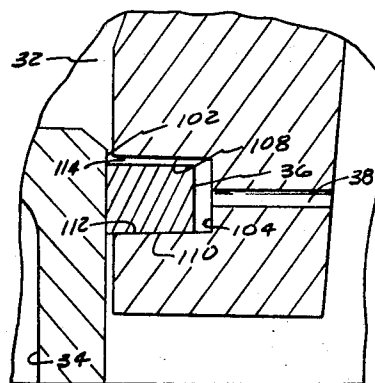


FIG-3

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VARIABLE COMPRESSION RATIO PISTON INCLUDING OIL FILTER MEANS

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to variable compression ratio engines and more particularly to improved hydraulic means for regulating relative movement of the two members which make up the pistons for such engines.

II. Description of the Prior Art

Heretofore various constructions have been disclosed for those engines designed to maintain a predetermined constant maximum combustion chamber pressure. One type of such engine has been disclosed in U.S. Pat. Nos. 3,156,162; 3,161,112; 3,185,137; 3,185,138; 3,303,831; 3,311,096; 3,403,662; 3,405,697; 3,405,698; 3,407,791; 3,417,739; 3,417,778; 3,418,982; 3,450,111; 3,450,112 and 3,450,113 as comprising two-part pistons for internal combustion engines in which an inner member or carrier is connected in the usual manner to the connecting rod and carries an outer member or shell which is adapted to move axially to a limited extent relative to the inner member. Clearance spaces are provided between the top and bottom ends of the inner and outer member which form upper and lower variable volume chambers adapted to contain an incompressible fluid such as the oil from the lubrication system of the engine. By regulating the flow of oil to and from these chambers the movement of the outer member relative to the inner member in response to piston reciprocation and combustion chamber pressure is controlled for varying the clearance volume of the cylinder in which the piston reciprocates so that the compression ratio of the engine will be automatically regulated until a predetermined maximum combustion pressure is achieved.

In these types of constructions, inlet supply valve means are provided for directing the oil from the lubrication system of the engine to the upper chamber when it is expanding and to the lower chamber when that chamber is expanding. The supply valve means includes means for closing these chambers when they are contracting so that the oil in the chambers acts as a hydraulic lock preventing the parts from expanding or contracting except to the extent allowed by a controlled rate of leakage permitted from the lower chamber through a fixed restricted orifice and from the upper chamber by means of a discharge valve assembly operable to open the upper chamber to crankcase atmosphere when pressure in that chamber becomes excessive.

It is essential to the proper operation of the engine that the discharge valve assembly close completely upon the predetermined combustion chamber pressure being restored and that the fixed restricted orifice be maintained open. Heretofore impurities within the lubrication system of the engine have at times found their way into the discharge valve assembly to maintain the valve in its opened position and into the fixed restricted orifice to block the passage of fluid therethrough. Furthermore, heretofore the discharge valve assembly and the supply valve have been retained within the inner member by threaded members and seals which tended to fail due to the high oil pressures and reciprocating forces present.

SUMMARY OF THE PRESENT INVENTION

The present invention provides means for eliminating these problems. Such means takes the form of a narrow annular passage formed between the inner member and the body of the discharge valve assembly upstream of the valve and its seat for filtering out impurities from the fluid before they reach the valve and its seat. Such means also includes a narrow annular passage formed between the lower chamber and the fixed restricted orifice for filtering the fluid before the fluid passes through the orifice. The annular passages prevent impurities in the fluid from entering the discharge valve and becoming wedged between the valve and its seat to maintain the valve in its open position and from entering the restricted orifice and blocking the passage of fluid therethrough. Furthermore, the

discharge valve assembly and the supply valve are formed with conically shaped valve bodies for retaining the valves within the inner member.

BRIEF DESCRIPTION OF THE DRAWINGS

The description refers to the accompanying drawings wherein like reference characters refer to like parts throughout the several views and in which:

FIG. 1 is a longitudinal cross-sectional view of a piston assembly embodying the construction of the present invention;

FIG. 2 is an enlarged view of a discharge valve assembly illustrated in FIG. 1; and

FIG. 3 is an enlarged fragmentary view of the restricted orifice illustrated in FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawings for a more detailed description of the present invention, a preferred variable compression ratio piston 10 is illustrated in FIG. 1 as comprising an inner member or piston pin carrier 12 carrying on its outer surface an outer member or shell 14. The outer member 14 has a crown 16 which serves as the head of the piston 10 and which forms a movable wall of the lower boundary of the combustion chamber of the engine. Inner member 12 is axially slidable within and with respect to the outer member 14 and is provided with rings 18, 20 and 22 which engage the inner surface of the outer member 14 and provide an essentially fluid tight seal between these surfaces. The inner member 12 is connected to the crank shaft (not shown) of the engine by a connecting rod 26 and a wrist pin 28 in the conventional manner. Thus the inner member 12 is movable axially between fixed upper and lower limits in the manner of a conventional piston, while the outer member 14 can move axially upwardly and downwardly relative to the inner member 12 within limits which will be presently described. An upper variable volume chamber 30 is formed intermediate the upper surface of the inner member 12 and the lower surface of the crown 16. A lower variable volume chamber 32 is formed intermediate the lower surface formed by an annular recess in the lower end of the inner member 12 and by the upper surface of an annular member 34 fixed to the outer member 14. A filtering and sealing ring 36, the construction of which will be presently described prevents fluid leakage from the lower chamber 32 intermediate the adjacent surfaces of the inner member 12 and the member 34. A restricted orifice 38 of a fixed diameter is formed in the inner member 12 and provides communication between the chamber 32 and the crankcase of the engine.

The member 34 and the lower surface of the crown 16 defining the upper chamber 30 provide the limits of axial movement of the outer member 14 relative to the inner member 12 is automatically controlled by regulating the flow of essentially incompressible fluid into and out of the chambers 30 and 32. The control fluid preferably comprises oil supplied to the piston 10 from the usual pressurized lubricating oil supply of the engine by a passage 40 in the connecting rod 26. The passage 40 preferably connects with an annular groove 42 circling the wrist pin 28 and leading to an outlet 44. A slipper collector assembly generally indicated at 46 is disposed in a cavity 48 formed in the inner member 12 and comprises a cap member 50 urged by a spring 52 into sliding, sealing contact with the connecting rod 26. The cap member 50 is provided with a vertical opening 54 and collects the oil discharged from the outlet 44 to direct it through the opening 54 to the cavity 48. Oil is fed from the cavity 48 to the upper and lower chambers 30 and 32 by way of a passage 56 connected with the chamber 48 and connecting to the upper chamber 30 and the lower chamber 32 through a supply valve assembly generally indicated at 58. A passage 60 formed in the inner member 12 communicates the lower end of the valve assembly 58 with the lower chamber 32. Oil is discharged from the upper chamber 30 to crankcase atmosphere by way of a pressure regulating discharge valve assembly 62, which will be described in more detail as the description proceeds.

The supply valve 58 preferably comprises a conically shaped member 64 mounted in a conically shaped bore 66 formed in the inner member 12. The member 64 is installed in the bore 66 by applying a downward axial force thereon, with the friction developed between the outer surface of the member 64 and the bore 66 providing a press fit which retains the member in place. It should be noted that this method of installing the member 64 provides a construction in which the oil pressure developed during normal engine operation within the chamber 30 produces a retightening force which is exerted upon the upper surface of the member 64, to aid in keeping the member seated.

The member 64 is provided with an external annular groove 68 which registers with the passage 56 and communicates with an axial passage 70 formed in the member 64 by way of a plurality of annularly spaced ports 72. Valve seat 74 are formed at each end of the through passage 70 and are adapted to be engaged by valve plates 76, which are preferably in the form of flat triangular shaped disks. The ends of the member 64 are formed with extended cylindrical bores 78 which have an upper stop member 80 and a lower stop member 82 preferably press-fitted therein. The upper stop member 80 is provided with a downwardly extending cylindrical portion 84 having a plurality of arcuately removed sections 86 and encompassing an axial passage 88 so that when the valve plate 76 is in the position as shown in FIG. 1, fluid flow from the axial passage 70 flows around the valve plate 76 and through the removed sections 86 and the passage 88 to the upper chamber 30. Similarly, the lower stop 82 is formed with an upstanding cylindrical section 90 having arcuately removed sections 92 and encompassing an axial passage 94 which registers with the passage 60 to the lower chamber 32.

The stop members 80 and 82 are spaced from the valve seats 74 so that chambers 96 and 98 are formed, providing an area for the valve plates 76 to move freely between the position closing the through passage 70 when in a position engaging the valve seats 70 to a position spaced from the seats to allow fluid flow from the passage 70.

As the invention has thus far been described and assuming that the combustion chamber pressure is below the predetermined maximum value which the piston is designed to maintain and that the upper and lower chambers 30 and 32 are both filled with oil, during the latter part of each upward stroke of the piston 10 at the end of the exhaust stroke and in the early part of each downward intake stroke, the momentum of the outer member 14 tends to move it upwardly relative to the inner member 12, thereby tending to expand the upper chamber 30 and contract the lower chamber 32. The resulting increase in oil pressure in the lower chamber 32 as well as the inertia forces acting on the valve plates 76 will cause the lower valve plate 76 of the supply valve assembly 58 to move upwardly against the lower valve seat 74 to close oil flow from the passage 56 to the lower chamber 32. This will produce a hydraulic lock between the members 12 and 14 by reason of the oil contained within the lower chamber 32, with the result that during each cycle of engine operation upward relative movement of the outer member 14 with respect to the inner member 12 will be regulated by the amount of oil permitted to escape from the lower chamber 32 by way of the orifice 38. Similarly the tendency of the upper chamber 30 to expand during upward movement of the piston and the effects of inertia on the valve plates 76 will cause the upper valve plate 76 of the supply valve assembly 58 to move to the upper position against the stop member 80 to open oil flow from the passage 56 to the upper chamber 30 to keep that chamber filled with oil.

The controlled discharge from the lower chamber 32 through the restricted orifice 38 then permits a gradual cyclic decrease in the volume of the lower chamber 32 and thus a corresponding increase in the volume of the upper chamber 30 to provide relative upward movement between the outer member 14 and the inner member 12. As the upper chamber 30 increases in volume, oil from the lubrication system is directed through the supply valve assembly 58 to the upper

chamber 30 to maintain that chamber in a filled condition. Thus, it is essential to the proper operation of the piston 10 that the restricted orifice 38 be maintained open for the passage of fluid therethrough. Referring to FIGS. 1 and 3, the member 34 is loosely fitted around the inner surface 100 of the chamber 32 for providing a passage 102 therebetween for the flow of oil from the chamber 32 to the orifice 38. An annular recess 104 is formed in the inner member 12 intermediate the passage 102 and the orifice 38 for receiving the filtering and sealing ring 36. The ring 36 maintains a close sliding fit with the member 34 for preventing the oil in the chamber 32 from flowing freely through the passage 102 to the engine crankcase. As illustrated in FIG. 3, the ring 36 is forced by oil pressure in chamber 32 against the lower surface 112 of an annular recess 104, thereby causing a seal between the lower surface 110 of the ring 36 and the surface 112, opening up a passage 114 communicating between the passage 102 and the orifice 38 to allow oil flow from the chamber 32 to the orifice 38. Thus, oil passing from the lower chamber 32 is directed through the passage 102 and through the narrow passages 114 to the orifice 38, where it is returned to the engine crankcase. It is apparent that metal chips or the like which might tend to block the orifice 38 are prevented by the filtering ring 36 from reaching the orifice 38 so that the danger of this happening is substantially reduced.

During the compression and power stroke, the gas pressure acting on piston crown 16 is transmitted to the inner member through the oil in upper chamber 30 creating a high oil pressure in this chamber. Whenever the gas pressure exceeds the selected upper limit, sufficient oil pressure is built up in the upper chamber 30 to open the discharge valve assembly 62 and release some of the oil from the chamber 30 allowing the outer member 14 to move downwardly relative to the inner member 12 and thus decreasing the compression ratio of the engine. In order for the above operation to occur, the discharge valve assembly 62, as shown in FIGS. 1 and 2, must be functioning properly and remain completely closed until the desired combustion chamber pressure has been achieved. It has been found, however, that sometimes foreign particles, such as metallic chips or the like, make their way to the discharge valve assembly and become wedged between the valve face and its seat and thus prevent the valve from closing completely. When this happens, of course, the discharge valve assembly 62 remains slightly opened discharging oil from the upper chamber 30 so that desired combustion chamber pressure can never be achieved.

To prevent this from occurring, the discharge valve assembly 62 has been modified from the construction previously provided. Referring to FIGS. 1 and 2, the discharge valve assembly 62 preferably comprises a generally cylindrical valve casing 116 having a conically shaped lower end 118 press fitted into a conical hole 120 formed on the lower end of a bore 122 provided in the inner member 12 with its axis parallel to the axis of piston 10. The lower end of the bore 122 is open to discharge oil from the valve assembly 62 to the engine crankcase. The upper end of the bore 122 opens into the chamber 30. The conical end 118 of the valve assembly 62 may be wedged into the conical hole 120 of the bore 122 to secure the valve assembly 62 in place with the aid of pressures developed in the chamber 30 as described heretofore with respect to supply valve 58.

A cylindrical chamber 124 is provided between the cylindrical portion of the casing 116 and the bore 122. The chamber 124 is connected to an annular chamber 126 formed within the casing 116 by means of a plurality of horizontal openings 128. The chamber 124 communicates with the chamber 30 through a narrow annular passage 130 formed between the bore 122 and a radially extending flange 132 formed around the casing 116 adjacent its top surface. Communication between the chamber 126 and a central discharge passage 134 of the casing 116 is controlled by a valve member 136 of the barrel poppet type. The valve member 136 is slidably mounted in a bore 138 coaxial with the discharge passage 134 and bore

122 so that the direction of opening and closing of the valve member 136 is parallel to the direction of the piston travel. The lower end of the valve member 136 has a frusto-conical surface 140 adapted to seat at corner 141 against a conical surface 142 formed in the casing 116 at the junction of the bore 134 and chamber 126. A compression coil spring 144 is disposed within the hollow interior of the valve member 136 and extends upwardly therefrom into a spring retainer cap 146 press-fitted into an annular recess 148 formed in the casing 116. The lower end of the valve member 136 has a hole 150 formed therein for venting fluid pressure in the spring chamber to the downstream side of the valve member 136. The valve member 136 is formed with an external annular shoulder 143 on which the oil pressure in chamber 126 acts to lift the valve member against the force of the spring 144.

During engine operation, oil passes from the upper chamber 30 through the narrow annular passage 130 formed between flange 132 and bore 122 to the horizontal openings 128 provided in the casing 116 and into the chamber 126 formed in the valve assembly 62. Oil pressure acts upon the surface 143 disposed within the chamber 126 to open the valve 136. Thus, it is apparent that metal chips or the like, which might tend to hold the valve member 136 in an upward unseated position, are prevented by the narrow annular passage 130 from reaching the valve corner 141 and its seat 142 so that the danger of the valve being held in the opened position is substantially reduced.

The area of the surface 143 is very accurately controlled by controlling the relative diameters 145 and 147 of the valve member 136. Furthermore, the area upon which the oil pressure in chamber 126 acts to lift the valve member 136 is unaffected by the wearing of the seat 142 during operation of the valve member 136, since the valve member 136 continues to seat at corner 141 regardless of the amount of wear of seat 142. This type of feature is essential to continued compression ratio regulation with extensive operation time.

It is apparent then that a substantial improvement has been described to insure efficient operation of variable compression ratio piston engines such as those disclosed in the aforementioned patents by providing new types of filtering means to insure the proper operation of the discharge valve and the restricted orifice and new means for mounting and retaining the valves within the inner member 12.

I claim:

1. In a variable compression ratio piston for an internal combustion engine having an inner member and an outer member movable relative to one another to vary the compression ratio of the engine, a control system for regulating movement of the members, comprising:

means defining a chamber variable in volume in response to relative movement of said members, said inner member having a bore opening to said chamber;

means for supplying a pressure fluid to said chamber; valving means for discharging fluid from said chamber and through said bore upon a predetermined pressure being produced within said chamber;

mounting means supporting said valving means within said inner member bore such that fluid from said chamber flows within a passage defined between the adjacent surfaces of said inner member bore and said mounting means before reaching said valving means; and

filter means disposed in said passage defined by said inner member bore and said mounting means for filtering fluid passing from said chamber through said passage to said valving means.

2. The piston as defined in claim 1, wherein said filter means comprises a flange formed on said mounting means and extending into said passage toward said adjacent surface of said inner member bore to reduce the effective flow area of said passage.

3. In a variable compression ratio piston for an internal combustion engine having an inner member and an outer member movable relative to one another to vary the compression

ratio of the engine, a control system for regulating movement of the members, comprising:

means defining a first chamber and a second chamber, said chambers varying oppositely in volume with respect to relative movement of said members;

means for supplying an essentially incompressible fluid to said chambers, means for discharging said fluid from said second chamber at a controlled rate and means for discharging fluid from said first chamber upon a predetermined pressure being produced therein; and

sealing means disposed on the discharge side of said second chamber between relatively moving portions of said members to prevent the passage of said fluid between said relatively moving portions of said members beyond said sealing means, said sealing means being spaced from one of said members to define an annular passage for filtering the fluid passing from said second chamber to said second chamber discharging means located in said inner member.

4. The piston as defined in claim 3, wherein said sealing means includes a ring carried in an annular recess formed in said inner member, said annular passage being formed between said ring and said inner member.

5. The piston as defined in claim 4, wherein the outer edge of said ring engages said outer member to form a fluid seal therewith.

6. The piston as defined in claim 3, wherein said first chamber discharging means is disposed within said inner member and includes valving means, fluid from said first chamber passing between adjacent surfaces of said inner member and said first chamber discharging means before reaching said valving means; and including

filtering means being carried by said inner member and said first chamber fluid discharging means along said adjacent surfaces thereof for filtering fluid passing from said first chamber to said valving means.

7. The piston as defined in claim 6, wherein said last mentioned filtering means comprises a radially extending annular flange formed on said first chamber fluid discharging means for forming an annular passage with said inner member to permit fluid passage therethrough.

8. The piston defined in claim 1 wherein said mounting means has a conically shaped outer housing disposed in a conically shaped bore formed in said inner member, the fluid pressure communicating with the outer housing urging said housing into said inner member bore for forming a press fit therebetween.

9. The piston as defined in claim 8, wherein said valving means includes said conically shaped outer housing.

10. The piston as defined in claim 8, wherein said means for supplying pressure fluid comprises a second valve means which includes said conically shaped outer housing.

11. The piston as defined in claim 1 wherein said passage is an annular passage, and said filter means comprises an annular flange formed on said mounting means and extending into said passage toward said adjacent surface of said inner member bore to reduce the effective flow area of said passage.

12. The piston defined in claim 1 wherein said valving means comprises a valve seat and a valve member for discharging fluid from said chamber through said valve seat upon a predetermined pressure being produced in said passage, said valving means further comprising resilient means for urging said valve member toward said valve seat, said valve member having a surface spaced from said valve seat and in communication with said pressure fluid in said passage for urging said valve member away from said valve seat to open communication therethrough.

13. In a variable compression ratio piston for an internal combustion engine having an inner member and an outer member movable relative to one another to vary the compression ratio of the engine, a controlled system for regulating movement of the members, comprising:

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means defining a first chamber and a second chamber, said chambers varying oppositely in volume with respect to the relative movement of said members;

means for supplying an essentially incompressible fluid to said chambers;

means for discharging said fluid from said second chamber at a controlled rate;

means for discharging fluid from said first chamber upon a predetermined pressure being produced therein, said first chamber discharging means being disposed within said inner member and including valving means, fluid from said first chamber passing between adjacent surfaces of said inner member and said first chamber discharging means before reaching said valving means;

filtering means carried by said inner member and said first

chamber fluid discharging means along said adjacent surface for filtering fluid passing from said first chamber to said valving means, said last mentioned filtering means comprising a radially extending annular flange formed on said first chamber fluid discharging means for forming an annular passage within said inner member to permit fluid passage therethrough; and

filter means disposed on the discharge side of said second chamber for filtering said fluid passing from said second chamber to said second chamber discharging means and including an annular passage communicating between said chamber and said second chamber discharging means.

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