United States Patent

Cronstedt

[15] **3,704,695**

[45] **Dec. 5, 1972**

[54] **VALVE CONSTRUCTION FOR VARIABLE COMPRESSION RATIO PISTON**

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[73] Assignee: **Teledyne Industries, Inc.,** Los Angeles, Calif.

[22] Filed: **July 2, 1970**

[21] Appl. No.: **51,934**

[52] **U.S. Cl.**.....**123/78 B,** 123/48 B

[51] **Int. Cl.**.....**F02b 75/04**

[58] **Field of Search**.....123/78 B, 48 B

[56] **References Cited**

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3,407,791	10/1968	Saarinen et al.	123/78 B
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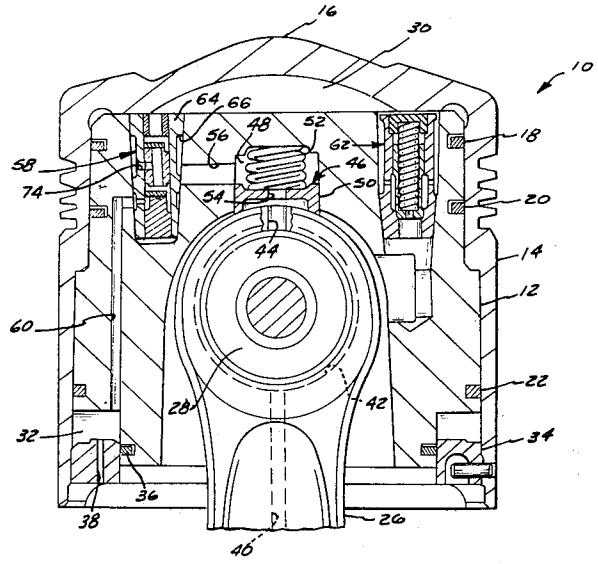
Primary Examiner—Wendell E. Burns

Attorney—Hauke, Gifford and Patalidis

[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 connected to the lower chamber for discharging a controlled quantity of oil therefrom. The supply valve and discharge valve assembly are each preferably formed with a conically shaped exterior surface that mates with a similarly shaped hole within the inner piston member for retaining the valves therein. The supply valve is formed with a separate seat spool which is inserted into a bore formed through the supply valve body and welded in place.

1 Claim, 5 Drawing Figures



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SHEET 1 OF 2

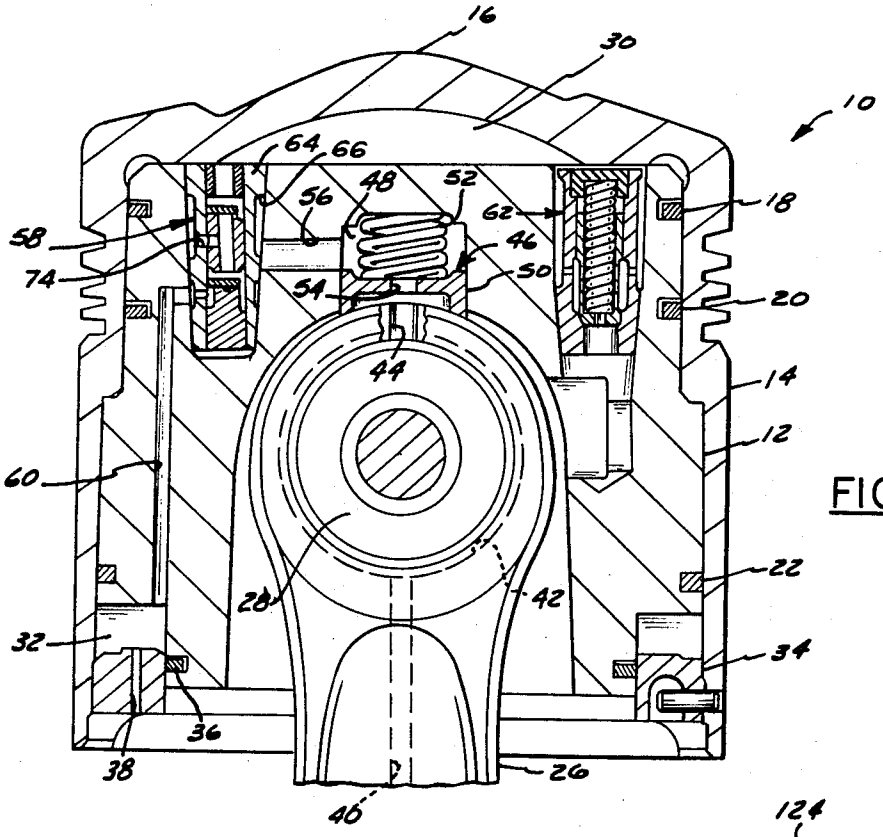


FIG-1

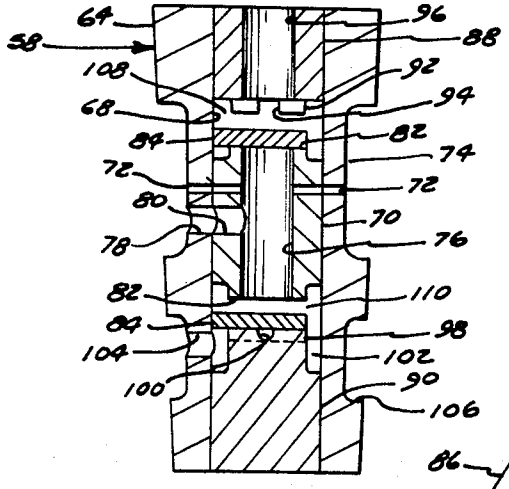


FIG-2

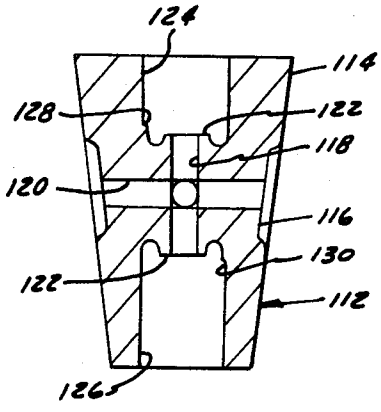


FIG-4

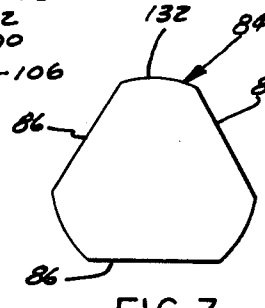
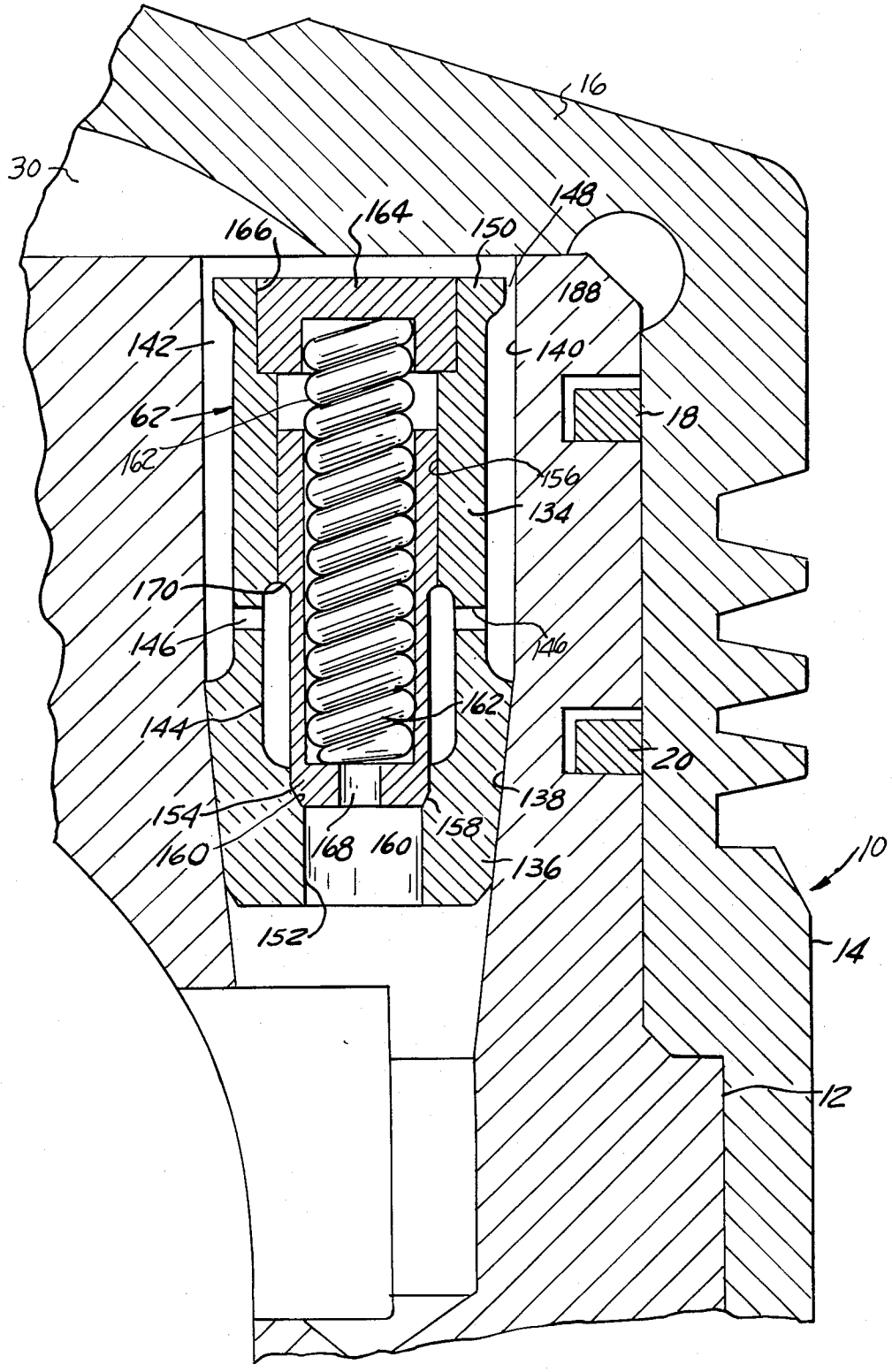


FIG-3

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FIG. 5


16
30
148
164
166
150
188
142
140
62
18
162
156
134
170
146
146
144
162
20
154
138
160
168
160
158
136
10
152
14
12

VALVE CONSTRUCTION FOR VARIABLE COMPRESSION RATIO PISTON

BACKGROUND OF THE INVENTION

1. 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.

2. 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; 3,417,779; 3,418,982; 3,450,111; 3,450,112 and 3,450,113 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 members which form upper and lower variable volume chambers adapted to contain a substantially 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.

Heretofore the supply valve means included an elongated housing bored inwardly a portion of its length from either end with valve surfaces formed on the housing at the inner end of each bore. The construction resulted in difficult and costly machining operations.

SUMMARY OF THE PRESENT INVENTION

The present invention provides means for eliminating these problems. Such means takes the form of a new and improved construction for the supply valve means. The supply valve means includes an outer housing having a conically shaped exterior surface that mates with a similarly shaped hole within the inner

piston member for retaining the valve. The outer housing includes a bore formed therethrough along its axis of elongation. A separate valve seat spool is inserted into the bore and positioned in the desired location and electron beam welded in place. The seal spool is completely finished prior to its insertion into the bore.

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 supply valve of the present invention;

FIG. 2 is an enlarged view of the supply valve illustrated in FIG. 1;

FIG. 3 is an enlarged view of the valve plate used in the supply valve of FIG. 1;

FIG. 4 is an enlarged view of a prior art supply valve; and

FIG. 5 is an enlarged fragmentary view of structure 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 sealing ring **36** 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 annular member **34** 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**. The movement 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 between the valve assembly 58 and 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, which forms the outer housing of the valve 58, 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.

As can best be seen in FIG. 2 the member 64 is formed with a central bore 68 which extends therethrough parallel to the axis of elongation of the member 64. A separate seat spool 70, generally tubular shaped, is inserted into the bore 68 and is located in the desired position. Once positioned, the spool 70 is secured in place as by electron beam welding as at 72.

The member 64 is further provided with an external annular groove 74 which registers with the passage 56 (FIG. 1) and communicates with an axial passage 76 formed in the spool 70 by way of a pair of aligned radially extending ports 78 and 80 formed in the member 64 and the spool 70, respectively. Valve seats 82 are formed at each end of the axial passage 76 and are adapted to be engaged by valve plates 84. As can best be seen in FIG. 3, the valve plates 84 are preferably in the form of flat circular discs provided with chordially removed portions 86 so that they assume a substantially triangular shape in plan. This shape is preferred to aid in centering the plates while permitting oil flow past the periphery of the plates.

The member 64 is provided with an upper stop member 88 and a lower stop member 90, which are preferably press-fitted within the bore 68. The upper stop member 88 is provided with a downwardly extending cylindrical portion 92 having a plurality of arcuately removed sections 94 and encompassing an axial passage 96 so that when the valve plate 84 is adjacent the portion 92, fluid flow from the axial passage 76 flows around the valve plate 84 and through the removed sections 94 and the passage 96 to the upper chamber 30. The lower stop 90 is formed with an upstanding cylindrical section 98 having arcuately removed sections 100 and surrounded by an annular space 102 which is connected with a radially extending port 104. The port 104 registers with an external annular groove 106 which registers with the passage 60 to (FIG. 1) the lower chamber 32.

The stop members 88 and 90 are spaced from the valve seats 82 so that chambers 108 and 110 are formed, providing an area for the valve plates 84 to move freely between the position closing the axial passage 76 when in a position engaging the valve seats 82 to a position spaced from the seats to allow fluid flow from the passage 76.

Referring to FIG. 4, the prior art valve 112 includes a conically shaped member 114 provided with an external annular groove 116 which communicates with an axial passage 118 formed in the member 114 by way of a plurality of annularly spaced ports 120. Valve seats 122 are formed at each end of the through passage 118 and are adapted to be engaged by valve plates, which are preferably in the form of flat triangular shaped disks as shown in FIG. 3. The ends of the member 114 are formed with extended cylindrical bores 124 and 126 which are provided with stop members for the valve plates. Due to misalignment, warpage and other normal problems in the machining operation, variations in the diameters as at 128 and 130 result. The variations as at 128 and 130 are normally disposed slightly closer to the opening of the bores 124 and 126, respectively, than the valve seats. Thus, referring to FIG. 3, it is necessary to chamfer the valve plates at the three corners 132. Furthermore, it is necessary to chamfer the valve plates on both sides to eliminate incorrect or upside down assembly.

Thus, the new design of the supply valve shown in FIG. 2 eliminates the variation in diameters as at 128 and 130 and, therefore, eliminates the need to chamfer the valve plates, reducing the cost of the supply valve assembly. Finally the spool 70 may be completely finished prior to its insertion into the bore 68, making the finishing of the valve seats to the desired precision a much easier job.

As the invention has thus far been described and assuming that the combustion chamber pressure is below the predetermined maximum valve 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 84 will cause the lower valve plate 84 of the supply valve assembly 58 to move upwardly against the lower valve seat 82 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 **84** will cause the upper valve plate **84** of the supply valve assembly **58** to move to the upper position against the stop member **88** 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 **12** and the inner member **14**. 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.

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.

Referring to FIG **1**, and FIG. **5** the discharge valve assembly **62** preferably comprises a generally cylindrical valve casing **134** having a conically shaped lower end **136** press fitted into a conical hole **138** formed on the lower end of a bore **140** provided in the inner member **12** with its axis parallel to the axis of piston **10**. The lower end of the bore **140** is open to discharge oil from the valve assembly **62** to the engine crankcase. The upper end of the bore **140** opens into the chamber **30**. The conical end **136** of the valve assembly **62** may be wedged into the conical hole **138** of the bore **140** 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 **142** is provided between the cylindrical portion of the casing **134** and the bore **140**. The chamber **142** is connected to an annular chamber **144** formed within the casing **134** by means of a plurality of horizontal openings **146**. The chamber **142** communicates with the chamber **30** through a narrow annular passage **148** formed between the bore **140** and a radially extending flange **150** formed around the casing **134** adjacent its top surface. Communication between the chamber **144** and a central discharge passage **152** of the casing **134** controlled by a valve member **154** of the barrel poppet type. The valve member **154** is slidably mounted in a bore **156** coaxial with the discharge passage **152** and bore **140** so that the direction of opening and closing of the valve member **154** is parallel to the direction of the piston travel. The lower end of the valve member **154** has a frusto-conical surface **158** adapted to seat against a conical surface **160** formed in the casing **134** at the junction of the bore **152** and chamber **144**. A compression coil spring **162** is disposed within the hollow interior of the valve member **154** and extends upwardly therefrom into a spring retainer cap **164** press-fitted into an annular recess **166** formed in the casing **134**. The lower end of the valve member **154** has a hole **168** formed therein for venting fluid pressure in the spring chamber to the downstream side of the valve **154**. The valve member **154** is formed with an external annular shoulder **170** on which the oil pressure in chamber **144** acts to lift the valve member against the force of the spring **162**.

During engine operation, oil passes from the upper chamber **32** through the narrow annular passage **188** formed between flange **150** and bore **140** to the horizontal openings **146** provided in the casing **134** and into the chamber **144** formed in the valve assembly **62**. Excess pressure acts upon the surface **170** disposed within the chamber **144** to open the valve **154**.

It is apparent then that a substantial improvement has been described for reducing the cost of manufacturing a supply valve for use in variable compression ratio piston engines such as those disclosed in the aforementioned patents.

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, means defining a first and second chamber, said chambers varying oppositely in volume with respect to relative movement of said members, means for discharging 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; means disposed with said inner member for supplying a pressure fluid to said chambers, said means including a supply valve carried by said inner member with opposite ends of said supply valve respectively connected to said chambers and valve plates disposed to automatically open and close communication between said supply valve and said chambers, the improvement comprising: said supply valve consisting of an elongated conically shaped outer housing disposed within a bore formed in said inner member, said outer housing having a cylindrical, axial bore extending completely through said housing, a spool mounted in said axial bore in a position spaced from opposite ends thereof said spool having a cylindrical outer surface and an axial through bore, end surfaces of said spool intersecting said outer surface to form valve seats at each end of said through bore, a stop member mounted within said outer housing at each end of said axial bore and spaced from said valve seats and valve plates disposed within said axial bore intermediate said spool and said stop members to move between said valve seats and said stop members to open and close communication between said through bore and said chambers.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,704,695 Dated December 5, 1972

Inventor(s) Val Cronstedt

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 10, delete "FIG. 1" and after "60" insert --(FIG. 1)--.

Column 5, line 60, following "134" insert --is--.

Column 6, line 13, after "valve" (first occurrence), insert --member--.

Column 6, line 40, following "disposed", delete "with" and insert --within--.

Signed and sealed this 1st day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
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