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PISTON FOR A HIGH PERFORMANCE INTERNAL COMBUSTION ENGINE

Filed April 20, 1961 2 Sheets-Sheet 1

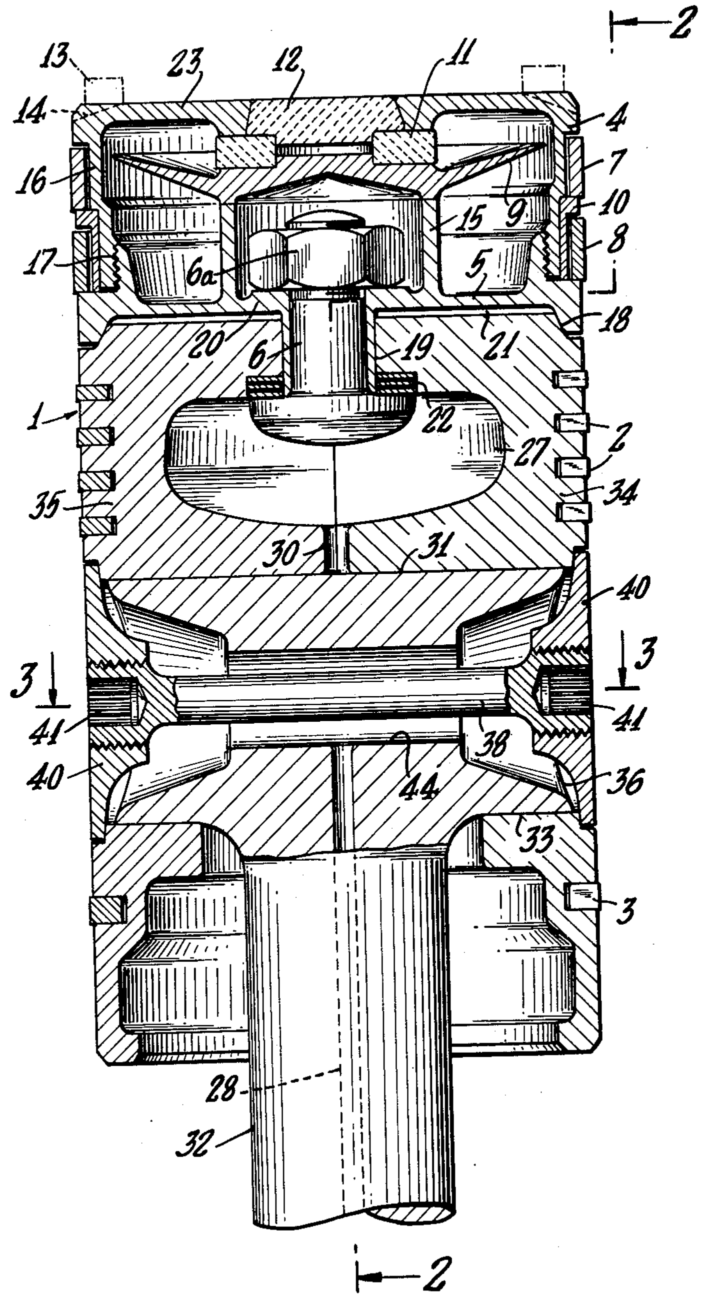

FIG. 1

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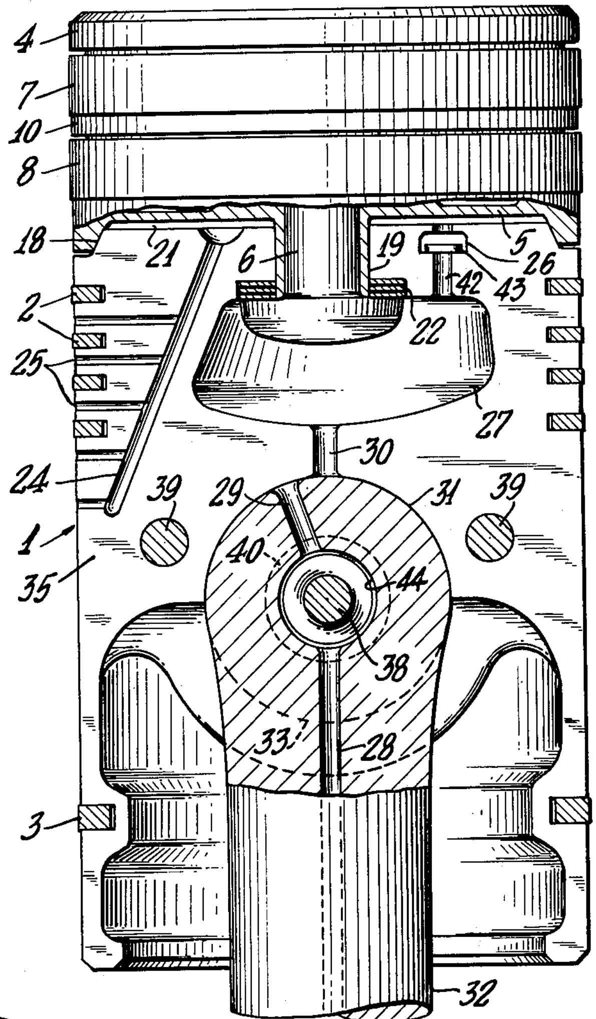

FIG. 2

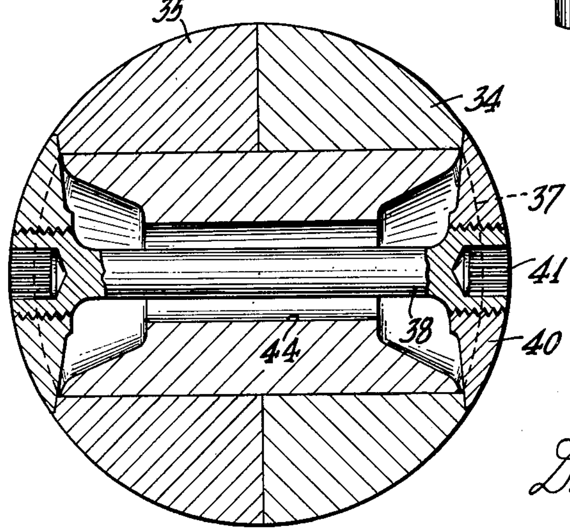

FIG. 3

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PISTON FOR A HIGH PERFORMANCE INTERNAL COMBUSTION ENGINE

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16 Claims. (Cl. 123—41.38)

This invention relates to improvements in pistons for internal combustion engines, and more particularly to an improved piston especially suited for high temperature, high pressure engines where torques of up to four times above those developed in ordinary engines are encountered.

Under such operating conditions, conventionally designed pistons are unable to withstand the increased pressures and temperatures of operation. As the torque is increased the mean effective pressure developed within the cylinder is proportionately increased and the heat developed within the firing chamber increases to such a point that conventional pistons would fail. The flow of such a large amount of heat through the piston top, the piston walls and over the piston rings to the cylinder walls would require such a large temperature gradient between the heat receiving surface of the piston and the cooled outside cylinder wall that the temperature level at the hot spots would exceed the limits that could be tolerated by the lubricating oil, the surface of the piston, the rings and the cylinder walls.

Pistons of conventional design, as regards the forces applied to the piston-pin which connects the piston to the connecting-rod, and the lateral pressure between the piston and cylinder walls, are already operated near their tolerable limits and cannot withstand pressure increases up to four times above normal.

One feature of my invention is a novel piston crown member secured to the upper end of the piston, which I have found will permit operation at such elevated temperature and provide a wide margin of safety. The crown comprises a thin base plate which supports a heat reflecting member contained in a thin hollow cylindrical cover. This construction, as will be described in detail hereinafter, includes an oil pumping arrangement which operates on each power stroke to deliver fresh oil to the outer surface of the piston for lubricating and cooling the sliding surfaces.

Another feature of my invention is the use of a connecting-rod having an integral cross-pin which provides a much greater bearing surface area than the conventional arrangement and thus gives rise to a better distribution of these increased driving forces.

A further feature is that I construct my piston body of two symmetrical half cylinders, which permits installation of the connecting-rod member and facilitates machining of the internal cavities of the piston member. The two halves of the piston body are connected together by a novel tie-bolt arrangement passing through the center of the connecting-rod pin.

These and other features of my invention will now be described in reference to the drawings illustrating a preferred embodiment and in which:

FIG. 1 is a longitudinal sectional view of the piston and crown assembly taken along a plane passing through the axis of the connecting-rod pin;

FIG. 2 is a view on line 2—2 of FIG. 1, showing the inner face of one of the two piston sections with the crown member in position to illustrate the details of the oil circulation and lubrication system; and

FIG. 3 is a horizontal cross-sectional view of the piston taken along lines 3—3 of FIG. 1 to illustrate the connecting-rod bearing arrangement.

In the drawings, the body **1** of the piston is of cast, forged or pressed aluminum alloy or of cast or forged iron. The piston body **1** is constructed of two symmetrical portions **34** and **35**, each having a semi-circular cross-section. FIG. 2 shows the inner surface of one of these two portions **35** to illustrate the interior arrangement of oil ducts to be described later, FIG. 1 being a longitudinal sectional view of the assembled halves taken on a plane passing through the axis of the connecting-rod pin. The piston body **1** is equipped with conventional piston rings **2** and, if desired, one or more oil rings **3** fitted into channels machined into the finished body.

The outer end of the piston body is capped by a heat resistant hollow cylindrical crown member **4** which is made of heat resistant material such as chromium alloy steel, and it is attached by screw threads **17** to an upwardly extending portion of plate **5**. The parts **4** and **5** may be tightly interconnected by applying a spanner wrench to crown lugs **13** formed integral with the crown **4**, which lugs are later removed by machining, or recesses **14** may be machined into the crown to receive lugs of a pronged spanner wrench. Plate **5** is a dual purpose member in that it provides for heat expansion compensation between the crown and the piston proper and it is also an elastic membrane serving as an oil pumping diaphragm to be described hereinafter in more complete detail. Plate **5** is connected to the body **1** by a central threaded bolt **6** which passes through a downwardly extending extension **19** of plate **5**, and by a nut **6***a* on the upper end of the bolt. The head of bolt **6**, at its lower end, is spring loaded by a biasing element in the form of a spiral spring washer **22** to permit slight axial movement of the members arising from thermal expansion, or from the explosive impact during firing.

The outer surface of the crown **4** is fitted with solid, not split, piston rings **7** and **8** which prevent the combustion gases of excessive pressure and tempertaure from reaching the piston body. A spacer ring **10** separates the two rings **7** and **8**. The small clearance provided between the crown rings **7** and **8** and the crown itself is such that there is little heat conduction directly from the crown to the ring. The gas pressure passing the upper land of the crown to the inner side of ring **7** acts radially outward, expanding to a predetermined degree this elastic ring, while pressing downwardly on the ring's upper shoulder. This prevents the gases from passing down between ring **7** and the cylinder wall and between ring **8** and the insert **10**. Rings **7** and **8** are normally in running contact with the cylinder wall but, when expanded by the gas pressure, the contact pressure of these rings against the cylinder wall is increased. By virtue of this contact with the cylinder wall, radiant heat from the crown **4** is conducted directly to the cylindrical wall which, in turn, is cooled externally by any of the well-known means of liquid or forced air cooling. The sealing action of ring **7** creates a large gas pressure drop in the running clearance space between the piston and cylinder wall above the ring. Although ring **7** is highly effective, ring **8** is provided to further reduce the gas pressure and temperature to which the conventional piston rings are exposed.

If a chromium plated aluminum cylinder is used, the clearance between piston body **1** and the cylinder may be kept very small under any condition of engine load, as the expansion of the members, due to the heat, can be held approximately equal for both piston and cylinder if the alloys are selected with proper consideration for the mean temperature differences of the two parts during the cooling process.

In high performance engines of this general type, that portion of the head of the piston directly in line with the combustion flame is subjected to momentary periodic temperatures above 4000° F. This spot is generally located at the geometric center of the piston head. To protect the piston crown member from these destructive temperatures, I have provided the top surface of the crown with an insert **12** of heat-resistant material having a low heat conductivity factor. Suitable material for the insert **12** is ceramic material such as aluminum oxide. An annular member **11**, also of the same low heat conductivity material, is positioned beneath the insert **12** and rests in an annular recess in the upper surface of a heat radiation shield **9**. The latter is supported by an annular upwardly extending flange **15** of the plate **5**, this flange surrounding a recess for nut **6***a*. The insert element **12** restricts heat transfer by conduction between the crown **4** and the heat reflector **9**, which is of highly polished low heat conductivity material. The ceramic inserts **11** and **12** and the heat reflector **9** are maintained in position by the compressive relationship between the crown **4** and the plate **5**.

During operation of the engine, only a small portion of the heat developed at the top of the piston crown may reach the piston body **1** by direct conduction. This is because the conductive path from the head of the crown is through the thin skirt **16**, which inserts a high thermal resistance in the transfer path, to the lower plate **5** via the screw threads **17** (which also present a transition resistance) and from plate **5** to the piston **1** via the outer annular flange of plate **5** where the parts meet, and also via the central portions **19** and **20** of plate **5** and bolt **6** where they come into contact with the body of the piston. If desired, bolt **6** can be made hollow to reduce heat conduction through it. Heat transfer from the head **23** of the crown **4** by radiation to the lower inside skirt portion **16** of the crown, to the plate **5** and to the end of the bolt **6** and its respective nut, are greatly reduced by the inserted heat reflector **9**. The heat reflector **9** may be a single body as shown, or it may comprise two or more axially spaced plates to improve its reflection efficiency.

The arrangement shown is highly efficient and it has been proven by experiment that not more than 1% of the heat, released in the cylinder by fuel burned in the combustion chamber above the crown, reaches the body **1** of the piston, and also it has been determined that plate **5** assumes an equilibrium temperature quite close to that of the body **1**.

The piston body **1** is of unique design in that it is constructed in two halves **34** and **35** which are united into one unit by a bolt **38** passing through the center of the piston-pin portion of connecting-rod **32**. In high performance engines of the type operating at about four times the normal mean effective pressure, the conventional connecting-rod and piston-pin arrangement does not present sufficient bearing surface to withstand the increased loading forces.

In FIG. 1 the novel arrangement of the connecting-rod **32** is shown having an integral wrist pin **31** formed thereon, which pin extends transversely of the rod and is slightly shorter in length than the diameter of the piston. In the conventional design, however, the connecting-rod is generally formed with an enlarged transverse ring portion, or eye, through which a separate pin is passed. In the conventional design the upper bearing surface of the piston must be cut away at the center to allow for movement of the enlarged end of the connecting rod which reduces the available bearing surface. In my arrangement, on the other hand, the upper bearing surface of the piston body **1** is continuous and unbroken save for a small oil duct **30**, to be discussed later. I have also shaped the outer ends of the cross-pin or wrist pin **31** to conform to the surface contour of the piston **1**, as shown at **36** of FIG. 1 and by the dotted line **37** of FIG. 3, to increase the vertical bearing surface area to the maximum amount. This configuration results in a bearing arrangement well able to withstand driving forces greatly in excess of conventional systems. The lower bearing surface of the cross-pin **31** does not carry the increased load and therefore need not exceed, in area, the conventional design.

As was previously stated, the piston body is made from two portions **34** and **35**, each having a semi-circular cross-section. A view of the inner surface of one of these portions is shown in FIG. 2. One of the piston halves is fitted with locating pins **39** while the mating half, not illustrated, is fitted with corresponding recesses to prevent lengthwise separation of the portions during assembly or operation. Each piston section is machined, in accordance with FIG. 2, to have a cavity **27** for receiving the head of the bolt **6** and to function as an oil circulation cavity for cooling and lubricating the piston body. There is an oil duct **42** leading upward from cavity **27** to the head of the body **1** which includes an enlarged cavity **26** enclosing a check valve disc **43**. The body **1** also includes duct **24** slopping downward from the head of the body and having horizontal branches **25** leading to the outer surface of the body directly beneath the respective piston rings **2**.

Oil is introduced into the piston, under pressure, through duct **28** in the connecting-rod **32** and thence into the space **44** within the cross-pin **31**. The oil then travels out through the duct **29** in the cross-pin (FIG. 2) to the cavity **27** via duct **30**. The oil travels from cavity **27** through duct **42**, check valve **43** and cavity **26** to the space **21** between the head of the piston body and the bottom of the crown base plate **5**. The surplus oil is then conducted from space **21** through the sloping duct **24** to the horizontal ducts **25** just below each of the piston rings **2**.

During operation of the engine, the inner part **20** of crown base plate **5**, being of thin metal, forming a resilient diaphragm, is deflected downwardly, in oil-can fashion, upon each explosion in the cylinder at the start of the power stroke. At this instant the oil duct **29** in the cross-pin **31** is out of alignment with oil duct **30** in piston body **1** (FIG. 2), thereby sealing off the oil reservoir cavity **27**, and the check valve **43** is seated to prevent passage of oil back to the cavity **27** from the space **21** between the crown and piston head. Thus, the downward deflection of plate **5**, acting on the surplus oil in the space **21**, forces oil from the ducts **25** onto the cylinder wall directly ahead of the piston rings **2** of the piston to provide an oil cushion between the moving parts. When the explosive force on the crown subsides, the base plate **5** returns to its normal or undeflected position due to its own internal elastic spring action. During the restoration of plate **5** to its original shape and position, it reduce the pressure in space **21** and acts to draw oil into this space from reservoir **27** by way of check valve **43**.

The two sections **34**—**35** of the piston body **1** are secured together at the top by the compressive action of the downwardly-extending internally-beveled flange **18** of the lower crown plate **5** on the upper externally-beveled edge of the piston body **1**, as caused by the securing means **6**—**6***a*. To insure that the piston body is held securely in one piece, a double-headed bolt **38** is passed through the hollow center **44** of the piston-pin **31**. As shown in FIG. 1, both ends of the bolt **38** are threaded, with each threaded end being of a different screw pitch to obviate the requirement for additional means to prevent the assembly from becoming separated. The nuts **40**, which are tightened on the threaded ends of bolt **38** to hold the assembly together, are machined on their outer surfaces to conform to the cylindrical surface of the piston, as may be seen in FIG. 3. The enlarged end portions of the tie-bolt **38** have centrally located countersunk splined socket holes **41** to receive a splined wrench. These keyways or socket holes could equally well be in the form of "Allen Head," "Bristo-Head" or other well-known type of socket shape.

As stated above, the threads of the ends of the tie-bolt **38** differ in pitch but have identical thread direction, that is, both right-hand or both left-hand threads. If the original machining is accurately performed and if the nuts **40** are held in the correct position for engaging the threads, bolt **38** will be in the correct axial position on each reassembly of the parts, and the nuts will be properly oriented in the surface of the piston. The nuts **40** could be countersunk slightly at the surface of the piston if it is so desired.

It will be apparent that the thin part **20** of crown plate **5** is spring loaded by the spring washer **22** surrounding the hollow extension **19**, this spring washer being compressed between the head of the connecting means or bolt **6** and an overlying internal shoulder of piston body **1**. Consequently, the crown **4—5** continues to be held securely in position on piston body **1** even when the thin part **20** is deflected downwardly under the explosion impact (through flange **15**), as previously described.

The duct or channel **28** in piston connecting-rod **32** may be supplied with oil from the usual high pressure lubricating system (not shown) of the engine, as through a passage at the inner end of rod **32** communicating with an oil supply under pressure in the crank housing. The outer passage **29** in the rod and the admission passage **30** to cavity **27** can be positioned so that the oscillating motion of the rod provides for oil admission during the upward stroke of the piston but seals channel **28** in the center-point (FIG. 2) and downward phase of the motion during which the check valve **43** is held seated by the pumping action of plate **5** incident to its downward deflection. However, a duplicate of the channeling **24—25** can also be arranged at the opposite side of the piston, either when the engine is reversible and high gas pressures act at the opposite angle of the connecting rod **32**, or when the gas pressures during the compression stroke are so high that such extra lubrication of the piston is desirable or necessary. In this case, oil passages **29—30** may be arranged for oil admission at the greater rod angles of piston positions nearer the outer center-point where low gas pressures prevail.

I claim:

1. A heat buffer crown for a piston for high temperature internal combustion engines, which comprises a base member, said base member being adapted to physically contact the piston over only a minor portion of its surface to minimize heat transfer by conduction, means for interconnecting said base member and the piston, a heat reflecting element supported by said base member, a heat insulating element supported by said heat reflecting element, and a hollow cylindrical cover enclosing said elements and releasably connected to said base member.

2. A heat buffer crown as in claim 1, wherein the interconnecting means include a yieldable biasing element operable to urge the crown against the piston.

3. A heat buffer crown as in claim 1, wherein the cover has a cylindrical skirt portion having a peripheral recess therein, and an endless sealing ring disposed within said recess.

4. A heat buffer crown for a piston for high temperature internal combustion engines, which comprises a hollow cylindrical body having opposite deflectable end walls and a cylindrical side wall, one of said end walls having a flexible diaphragm portion and a peripheral spacing flange engagable with the piston to hold said diaphragm portion in spaced relation to the piston, means extending centrally from said diaphragm portion for securing said body to the piston, and displaceable means disposed in said body and through which said diaphragm portion is deflectable by deflection of the opposite end wall.

5. A heat buffer crown according to claim 4, in which said displaceable means include a heat reflecting element.

6. A heat buffer crown according to claim 4, in which said displaceable means include a heat insulating element.

7. A heat buffer crown according to claim 4, in which said displaceable means include heat reflecting and heat insulating elements.

8. A heat buffer crown according to claim 4, in which said cylindrical side wall has an external circumferential recess, the crown comprising also a sealing ring in said recess.

9. A heat buffer crown according to claim 4, in which said opposite end wall has a skirt forming said side wall, the skirt having a threaded connection with said one end wall at the region of said peripheral flange.

10. A heat buffer crown according to claim 4, in which said opposite end wall has a skirt forming said side wall, the skirt having a threaded connection with said one end wall at the region of said peripheral flange, said skirt also having an external circumferential recess, the crown comprising also a sealing ring in said recess.

11. A piston assembly for high compression internal combustion engines, which comprises a piston body, said piston body including two semi-cylindrical sections, a connecting rod at one end of said body pivotally connected thereto and having a hollow wrist pin rotatably disposed within cylindrical bearing cavities of both piston sections, a transverse tie-bolt having threaded end portions disposed to pass through said hollow wrist pin, and locking nuts on said threaded end portions holding said body sections together, the hollow of the wrist pin forming an annular chamber around the bolt, the ends of said chamber being closed by the nuts, the piston body having an oil channel leading from the wrist pin for delivering lubricating oil to the side wall of the assembly, the connecting rod having an oil supply passage leading to said chamber, and the wrist pin having a passage positioned to communicate with said channel in a predetermined angular position of the rod relative to the piston body.

12. A piston assembly for high temperature internal combustion engines which comprises a cylindrical piston body adapted for connection at one end to a connecting rod, a cylindrical heat buffer crown at the other end of said body, said crown including a hollow cylindrical member, said crown and said body being in heat conducting contact with each other over only a minor portion of their contiguous surfaces, whereby heat conduction between said crown and body is minimized, connecting means securing said crown and body together and a highly polished low heat conductive heat reflecting shield mounted in said hollow cylindrical member and extending generally transversely of the piston body.

13. A piston assembly for high temperature internal combustion engines which comprises a cylindrical piston body adapted for connection at one end to a connecting rod, a cylindrical heat buffer crown at the other end of said body, said crown and body having interengaging peripheral surfaces and spaced opposing surfaces extending radially inward from said peripheral surfaces to define a space, and connecting means disposed centrally of the piston assembly and surrounded by said space for securing the crown and piston body together at said peripheral surfaces, in which said connecting means include a yieldable biasing element urging said peripheral surfaces together to accommodate different thermal expansions of different parts of the assembly.

14. A piston assembly for high temperature internal combustion engines which comprises a cylindrical piston body adapted for connection at one end to a connecting rod, a cylindrical heat buffer crown at the other end of said body, said crown and body having interengaging peripheral surfaces and spaced opposing surfaces extending radially inward from said peripheral surfaces to define a space, and connecting means disposed centrally of the piston assembly and surrounded by said space for securing the crown and piston body together at said peripheral surfaces, in which the piston body includes

two longitudinal sections, said interengaging peripheral surfaces including a bevelled internal surface of the crown and a bevelled external surface of the body surrounding said internal surface, whereby said sections are held together by the connecting means through said bevelled surfaces.

15. A piston assembly for high temperature internal combustion engines which comprises a cylindrical piston body adapted for connection at one end to a connecting rod, a cylindrical heat buffer crown at the other end of said body, said crown and body having interengaging peripheral surfaces and spaced opposing surfaces extending radially inward from said peripheral surfaces to define a space, and connecting means disposed centrally of the piston assembly and surrounded by said space for securing the crown and piston body together at said peripheral surfaces, in which the crown includes a resilient plate diaphragm partly defining said space and adapted to flex toward said body under an explosion impact transmitted through the crown from the end thereof remote from said body, said body having an oil receiving cavity and a passage leading from said cavity to said space, the assembly comprising also a check valve in said passage to prevent flow from said space to the cavity, the assembly having an oil discharge passage leading from said space through the side wall of the piston assembly, whereby the diaphragm is operable by said flexing to force oil from the space through said discharge passage and to draw oil from the cavity into said space upon return movement of the diaphragm away from said body.

16. A piston assembly for high temperature internal combustion engines which comprises a cylindrical piston body adapted for connection at one end to a connecting rod, a cylindrical heat-buffer crown at the other end of said body, said crown and body having interengaging peripheral surfaces and spaced opposing surfaces extending radially inward from said peripheral surfaces to define a space, and connecting means disposed centrally of the piston assembly and surrounded by said space for securing the crown and piston body together at said peripheral surfaces, in which piston assembly the crown includes a resilient plate diaphragm partly defining said space and adapted to flex toward said body under an explosion impact transmitted through the crown from the end thereof remote from said body, said body having an oil-receiving cavity and a passage leading from said cavity to said space, the assembly comprising also a check valve in said passage to prevent flow from said space to the cavity, the assembly having an oil discharge passage leading from said space through the side wall of the piston assembly, whereby the diaphragm is operable by said flexing to force oil from the space through said discharge passage and to draw oil from the cavity into said space upon return movement of the diaphragm away from said body.

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