June 7, 1949. L. E. ENDSLEY ET AL 2,472,288

PISTON

Filed Jan. 26, 1948 2 Sheets-Sheet 1

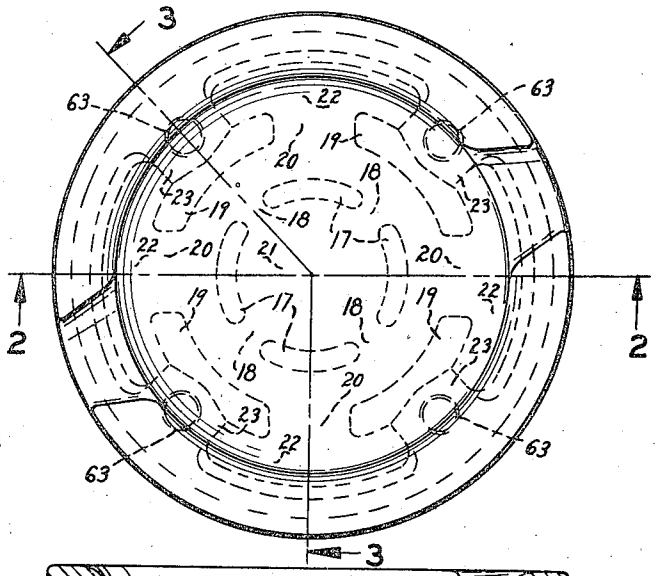


FIG. 1

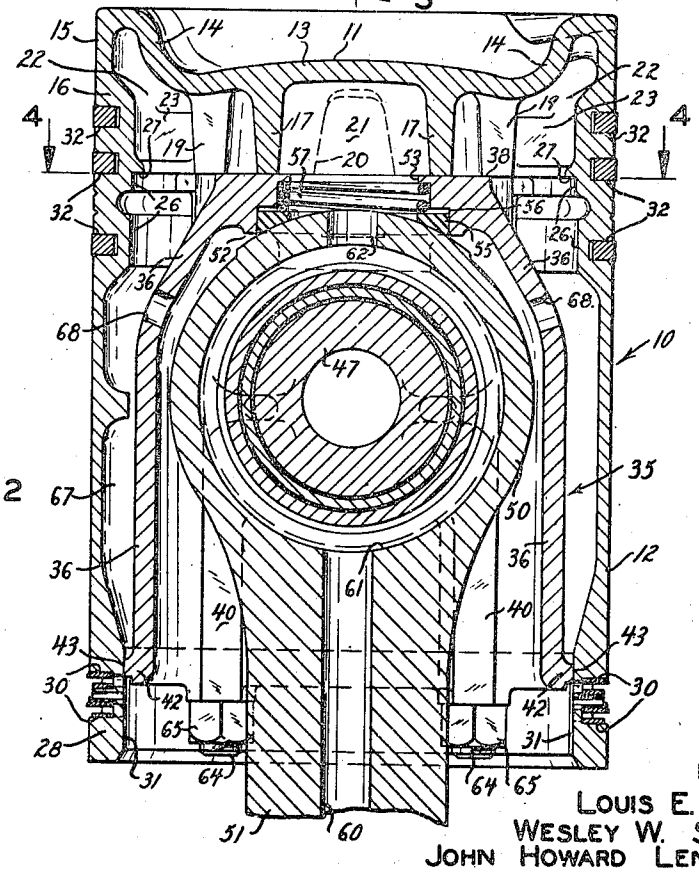


FIG. 2

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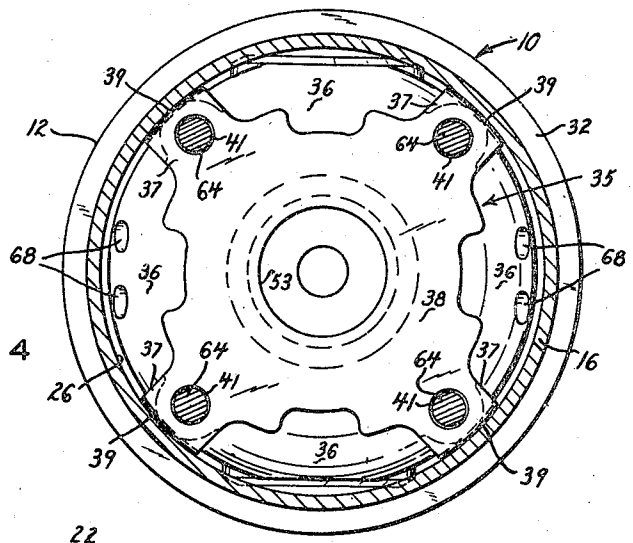


FIG. 4

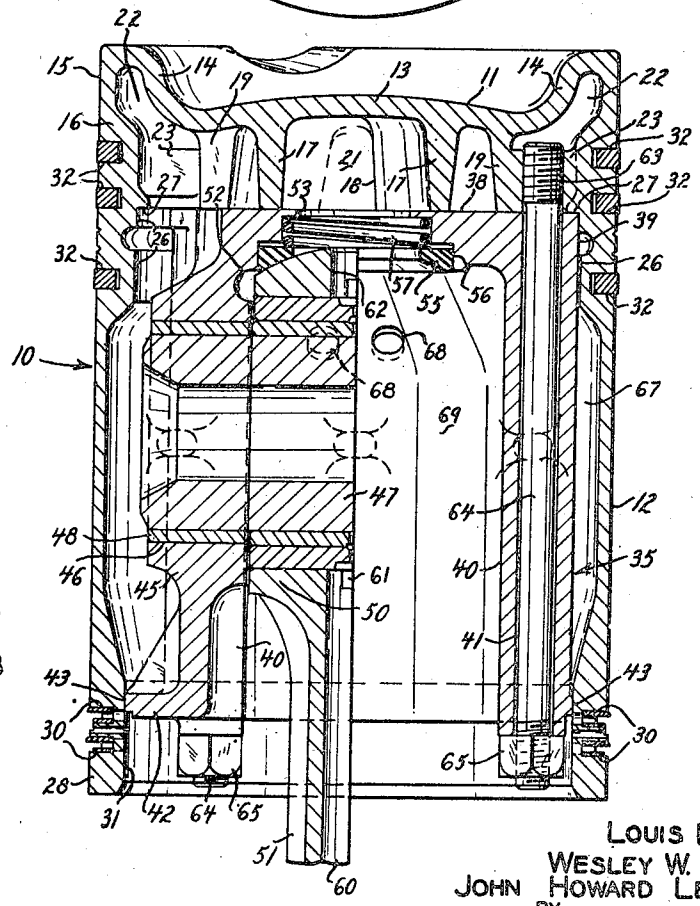


FIG. 3

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2,472,288

PISTON

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Application January 26, 1948, Serial No. 4,244

3 Claims. (Cl. 309—16)

1

This invention relates to pistons for internal combustion engines, and is particularly directed to the improvements in the construction of and provisions for cooling the piston.

The present invention has as a general object the provision of an improved piston construction and one that will better withstand heavy duty loads and high and changeable temperature conditions.

In its more specific aspects, the objects hereof are to provide an improved piston body which will posses structural characteristics enabling its greater resistance to mechanical loads and thermal expansion forces, and to provide a piston insert unit which is constructed for cooperation in combination with the piston body to direct a cooling medium into the critical areas of the piston body or crown and to retain a quantity of such cooling medium in condition for forceable circulation onto the critical areas during piston operation by reason of the inertia forces incident to piston motion.

Another object of the invention resides in the construction of a piston body having an improved crown portion which will be substantially free of load and thermal stresses and which is provided with internal and depending strut elements arranged to distribute the forces incident to piston operation and provide an improved means whereby the circulation of a cooling medium may be more intimately directed over the critical area to carry off the heat imparted to the crown and adjacent portion of the piston.

Other objects of the present invention will appear from the following detailed description of a single preferred embodiment, reference being had to the accompanying drawing, wherein:

Fig. 1 is a top plan view of the piston showing in dotted outline the arrangement of depending struts;

Fig. 2 is a sectional elevation through the piston and insert assembly, as seen at line 2—2 of Fig. 1;

Fig. 3 is a further sectional elevation taken along line 3—3 in Fig. 1 and wherein portions of the insert and connection rod assembly are omitted to show additional details;

Fig. 4 is a sectional view taken at the top plane of the piston insert member as indicated at line 4—4 in Fig. 2, and wherein further details of the assembly are shown to advantage.

The preferred embodiment of the invention includes a piston body 10 having a crown portion 11 and a skirt portion 12, these portions being cast integrally. The piston crown 11 is characterized

2

by a central area 13 of spherical and convex form and a peripheral area 14 of a concavo-convex form which rises above the spherically convex central area and is joined at its outer margin with the skirt portion, specifically with the cylindrical crown wall 15 thereof above the relatively thickened ring boss 16. In the formation of the piston crown, a series of inner and outer strut members are integrally cast at the under surface to extend axially of the piston. The inner series of struts 17 are arcuate in transverse section and are spaced to form slotted openings or ports 18 therebetween. In the present construction shown by Figs. 1 and 2, the inner struts 17 are four in number and a similar number of slot-like ports 18 are provided therebetween. The outer series of struts 19, also arcuately formed in transverse section, are located substantially opposite and in symmetrical relation with the slot-like ports 18 and are spaced to form a second series of slot-like ports 20 therebetween. Thus the inner and outer series of struts and slot-like ports, there being four in each series, are relatively staggered or angularly off-set, each with the others, to define a plurality of tortuous passages between the central pocket or chamber 21 defined in the under surface of the spherically concave crown 13 by the struts 17 and the outer or peripheral cavities 22 formed adjacent the under surface of the concavo-convex crown periphery 14.

The outer cavities 22 in the crown portion of the piston body 10 are defined in part by adjacent strut members 19, the outer cylindrical wall 15 adjacent the crown, and by radially directed boss formations or webs 23 which are integrally formed with and connect the struts 19 and the thickened zone of the ring boss 16. These webs 23 are free of any connection with the piston crown wall portion 14 (see Fig. 3) so that the flexibility in this wall portion is insured. Since each of the webs 23 is free of contact or connection with the crown wall portion 14, it will appear that each of the cavities 22 is in communication with the two adjacent cavities to form a complete passage about the upper margin of the crown between the cylindrical wall 15 and the crown wall 14 of concavo-convex configuration.

The lower end of each of the strut members 17 in the inner series and of the strut members 19 in the outer series are machined off to a common planar relation. At the time of this machining the lower zone of the ring boss 16 is internally machined to provide a cylindrical surface 26 which is concentric with the axis of the piston

body 10, and an annular shoulder or abutment 27 is also formed with its axially directed face located in the common plane of the struts 17 and 19. The cylindrical surface 26 and annular shoulder 27 provide a seat for the upper end of the piston insert or connecting rod bearing carrier later to be described.

The piston skirt 12 is characterized by its substantially symmetrical and relatively thin wall construction which extends below the ring boss 16 and terminates in a thickened end portion 28 adapted to carry oiling rings in suitable ring grooves 30. The inner surface of this thickened end 28 of the piston skirt is machined to provide a cylindrical surface 31 having a diameter substantially equal to that of the upper cylindrical seat 26. The ring boss 16 adjacent the upper end of the piston body is also machined to provide external grooves 32 for suitable compression rings.

Referring to Figs. 2, 3 and 4, the present improvements in piston construction may be seen to include an insert member 35 comprising a unitary cast body of generally cylindrical shape (Fig. 4) in plan. The upper portion of this insert body 35 is provided with inwardly and upwardly curved wall portions 36 separated at four equally spaced zones by boss projections 37, the latter projections extending into an upper, planar top surface 38 having the symmetrical marginal contour clearly indicated in Fig. 4. Each of the projections 37 is formed with a cylindrical outer surface 39 which is made accurately to fit in the piston body seat defined by the cylindrical wall 26 and annular abutment 27 (Fig. 3). In the forming of the insert body 35, a longitudinal boss or column element 40 is provided below each projection 37, and these column elements are axially drilled to form stud-receiving openings 41 which open through the top surface 38 of the insert. The lower end of the insert body 35 is formed with an annular and radially directed flange 42 having its outer face 43 machined to a true cylindrical form suitable for effecting a close sliding fit with the adjacent surface 31 on the piston skirt end portion 28 (Figs. 2 and 3).

Additionally, the insert body 35 is provided at diametrically opposite sides with an enlarged boss 45 (one being shown in Fig. 3) which is suitably bored out at 46 to form a bearing surface for the hollow gudgeon pin 47. This pin works in a bushing 48 fitted to the bore 46 in the insert boss 45. The space between these insert bearing bosses 45 forms the slot to receive the upper end bearing 50 of the usual connecting rod 51. The connecting rod bearing 50, through suitable bushings, has a working fit with the central portion of the gudgeon pin 47, and the upper end of this connecting rod bearing projects into a recess 52 formed at the under side of the central area of the insert body 35. In Figs. 2 and 3, the central area of the insert top face 38 is apertured at 53 to afford communication between the cavity 21 in the under side of the piston crown 11 and the recess 52 in the insert body 35. Means for sealing the recess 52 from the rest of the insert area therebelow is provided in the form of a sealing ring element 55 having a spherically formed lower face which seats against the adjacent face of the connecting rod, as shown in Figs. 2 and 3. This sealing ring is held in position in a shouldered recess 56, and by the force of a compression spring 57, the spring bearing on the ring and against a flange adjacent the aperture 53 in the upper wall 38 of the insert.

In conjunction with the above described details, the connecting rod 51 is longitudinally drilled to provide an oil supply passage 60 leading from a suitable connection at the crankshaft (not shown) to the internal annular oil groove 61 formed in the bearing 50. This groove 61 extends completely around the gudgeon pin and communicates with the insert recess 53 through the axial port 62 in the upper end of the connecting rod.

When effecting assembly of the piston 10 and the insert body 35, after the insert and connecting rod are fully assembled as shown, the piston is positioned over the insert such that the cylindrical surface 39 at the upper end of the insert engages in the piston seat defined by surfaces 26 and 27, and the lower surface 43 at the insert flange 42 engages with the cylindrical surface 31 at the lower end 28 of the piston skirt. The piston and insert are relatively rotated until the stud receiving passages 41 of the insert line up with the threaded apertures 63 (Figs. 1 and 3) in the piston webs 23 adjacent the outer series of struts 19. When this is accomplished the holding studs 64, there being four such elements, may then be inserted and threaded up in the apertures 63, and the clamping nuts 65 threaded on the lower projecting end of the studs. The nuts 65 are turned up to secure the piston and insert in final assembly and to bring the top surface 38 of the insert into abutment with each of the struts 17 and 19 dependingly carried by the under surface of the piston crown 11.

The piston skirt portion 12 and the adjacent walls 36 of the insert are relatively spaced and thereby coact to form an annular piston skirt chamber 67 which is closed at its bottom by the insert flange 42 and is in open communication with the outer cavities 22 in the piston head end or crown by way of the passages formed between the upper curved insert wall 36 and the cylindrical surface 26 of the piston between the insert projections 37. The resulting chamber 67 is provided with a plurality of outlet ports 68 (Fig. 2) located at a predetermined position above the closed bottom zone of the skirt chamber 67 and in the curved portion of the insert wall 36. These ports 68 (Figs. 3 and 4) are grouped in pairs at diametrically opposite zones of the insert and open from the chamber 67 to the interior 69 of the insert body 35.

When in service operation the interior of the piston, and particularly the internal surfaces of the crown 11, annular wall 14 and upper cylindrical wall 15 are bathed by a volume of oil supplied through the connecting rod passage 60 under pressure from the engine system. This cooling oil flows around the gudgeon pin 47 to the upper port 62 by way of the groove 61, and is forceably directed into the crown recess 21 where it can impinge upon the central crown surface and then flow radially outwardly and about the inner series of struts 17 and outer struts 19 to the cavities 22. The oil then flows into the annular chamber 67 and a quantity thereof is always contained by this chamber, the excess passing through outlet ports 68 to the interior space 69 of the insert body 35 for return to the engine crankcase and recirculation in the usual manner.

As an incident to the rapid reciprocatory motion of the piston and insert assembly, the cooling oil in the skirt chamber 67 will be forceably projected into the cavities and wall areas of the piston crown portions during the outward

movement of the piston and made to wash these surfaces and absorb the heat transmitted from the combustion side at an accelerated rate. During opposite, inward piston movement, the heated oil will be dashed into the cooler portions of the piston chamber 67 where it may reject the heat to the adjacent walls. During this alternate process of cooling oil movement between the hot crown zone and cooler skirt zone of the piston, a certain quantity of the oil will pass back to the crankcase through ports 68 and a fresh stream will be supplied under pressure from the port 62 in the upper end of the connecting rod 51 to the central crown chamber 21 defined by the inner series of strut members 17. Thus a constantly changing body of cooling oil will be maintained in the piston and constantly at work absorbing and carrying away the heat taken in by the piston at the combustion side of the crown area. The changing directions of piston movement and the rapid changes in the acceleration thereof cause the body of the cooling oil retained in the piston skirt chamber to slosh back and forth between the hot and cooler zones of the piston with a turbulent and rapidly flowing action which greatly enhances the rate of heat transfer to this cooling medium. The volume of cooling oil retained in the piston and that which has been found to produce the best cooling effect is equal substantially to one-half of the total volume of the chambered area defined between the piston body and the insert. Therefore, the over flow ports 68 are located at a zone such that this optimum volume of oil is trapped in the piston skirt chamber 67. This assures the presence of some cooling medium during the engine starting periods when the supply from the engine is building up to its normal pressure. Thereafter, the rate of supply at port 62 will be compensated by the over flow at ports 68 to maintain the desired volume in the chambered areas of the piston.

Considering, now, the structural features and advantages of the present improvements, it can be appreciated that the thrust loads on the piston crown 11 will be absorbed by the strut members 17 and 19 and passed into the upper face 38 of the insert for distribution throughout the latter and into the connecting rod 51 with a minimum of highly stressed areas. The lateral thrust or side loads on the piston body are principally concentrated at the annular zones or bands defined by the thickened upper ring boss 16 and the similarly thickened lower ring boss 28 of the skirt. These loads are then transmitted to the insert body 35 over the large bearing areas of the spaced projections 37 seated against the surface 26, and at the flanged surface 43 fitting the skirt wall 31. It is further to be noted, that in the axial assembly of the insert and piston, the axially directed securing studs 64 act only in tension and distribute such tension forces between the bottom of the insert body 35 and the thickened upper piston ring boss 16 and adjacent webs 23. Considered together the structural characteristics of the present piston and insert assembly relieve the piston crown portions of all but the necessary axial loads incident to the forces produced upon combustion of the fuel.

As a consequence of this preferred construction, the spherically convex crown 13 and the adjacent annular concavo-convex crown wall 14 are free to expand and flex with the rise of temperature on the combustion side, and are not restrained in any manner by the axial and side loads or forces created as an incident to normal piston

reciprication and accompanying oscillatory movement of the connecting rod. With a piston crown configuration having the gradually curved areas shown in Figs. 2 and 3, it will be possible to maintain the critically stressed zones so substantially below the rupture stress values as to preclude crown wall failure normally caused by fatigue and constriction thereof. The concave wall 13 and concavo-convex wall 14 of the piston crown are admirably suited to the necessary flexing during operation of the piston without concentrating stresses at any particular point or zone.

The above description given in connection with the accompanying drawing is characteristic of the presently preferred piston construction, but it is to be understood that certain changes and modifications may be made herein without materially departing from the spirit and intended scope of the annexed claims.

What is claimed is:

1. In a piston, a body having a crown and a skirt portion, said crown portion being formed with a central area of spherically convex form and an adjacent peripheral area of concavo-convex form integrally united at its outer margin with said skirt portion, an inner and outer series of strut members integrally formed with and depending from said crown portion, the strut members of the outer series being staggered relative to the inner series and being connected with said skirt portion at a zone below the concavo-convex area of said crown portion, whereby the said areas of the crown portion are unrestrainedly free to expand, contract and flex as a result of the thermal and mechanical forces incident to piston operation, and an insert member disposed in said body to bear against said skirt portion at axially spaced zones and to contact said strut members, said insert member having a recess opening inwardly of said inner series of strut members and through which a cooling fluid may enter the crown portion of the body for flow across the said crown areas and between and around said inner and outer series of strut members to carry off the heat imparted thereto during piston operation.

2. In a piston, a body having a crown portion and a skirt portion, said crown portion being formed with a spherically convex central area and a concavo-convex peripheral area extending axially above the central area and integrally united with said skirt portion at its outer margin, a plurality of strut members, each of arcuate form in transverse section, formed on and depending from said crown portion, said strut members being arranged in an inner and outer series to provide slot-like ports therebetween, the ports of one series being angularly off-set relative to the ports of the other series, an insert member disposed in said body to bear at one end against said strut members, the opposite end of said insert having a sliding fit in the skirt portion whereby a skirt chamber is formed between the skirt and insert, ports opening from the skirt chamber to the interior of said insert between the ends thereof, and said insert having a recess opening toward the central area of said crown portion to direct a cooling fluid onto the convex area of said crown, said off-set strut ports directing the cooling fluid outwardly in radial and circumferential paths toward the concavo-convex area of said crown and into said skirt chamber, the cooling fluid retained in said skirt chamber in excess of that passing through said insert ports being dashed back and forth in said chamber and crown portion due to inertia forces incident to piston operation.

3. A piston as defined in claim 2, and further characterized in that the volume of cooling fluid retained in said skirt chamber below the level of said insert ports is equal substantially to one-half of the volume of the skirt chamber and the space in said body crown portion.

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