July 7, 1942. J. S. DONALDSON 2,289,251

PISTON

Filed Feb. 8, 1938

Fig. 1

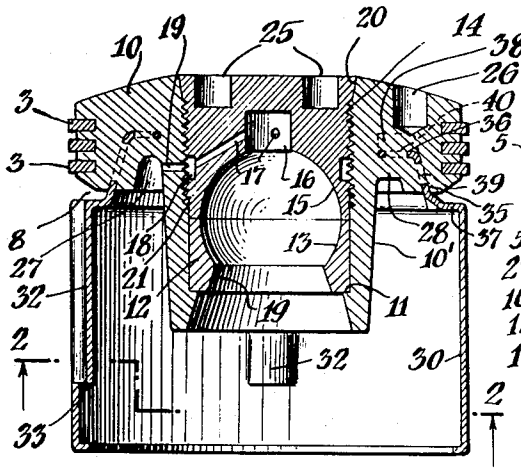


Fig. 3

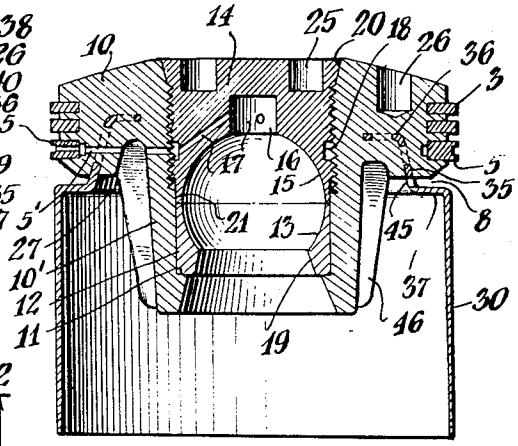


Fig. 2

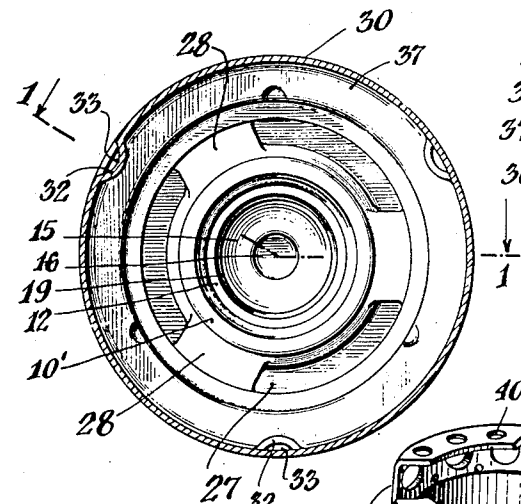


Fig. 4

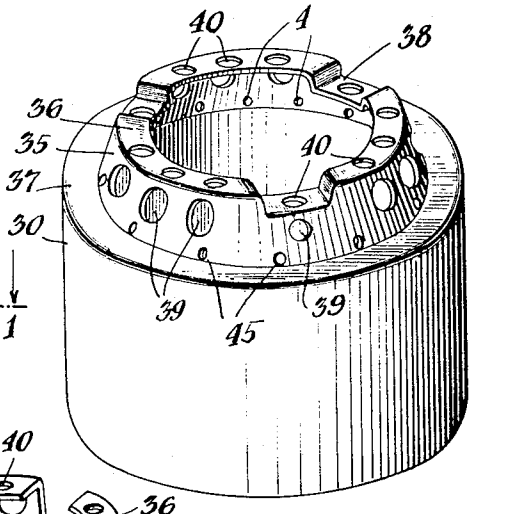
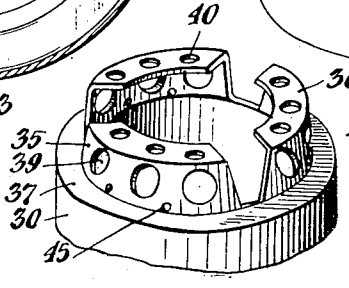


Fig. 5



INVENTOR

John Sherman Donaldson

BY

Arthur J. Kurtz

his ATTORNEY

UNITED STATES PATENT OFFICE

2,289,251

PISTON

John Shearman Donaldson, St. Albans, N. Y., assignor to Donaldson Piston Corporation, New York, N. Y., a corporation of New Jersey

Application February 8, 1938, Serial No. 189,328

5 Claims. (Cl. 309—14)

This invention relates to pistons, and more especially to pistons for internal combustion engines. Pistons made in accordance with this invention are of relatively light weight and highly efficient, of low oil consumption, easily serviced because of the ease and quickness with which they can be removed, and of comparatively low manufacturing cost, and have excellent wearing qualities.

Pistons for internal combustion engines as commonly made comprise a ring-carrying head portion at the combustion end of the piston, together with a skirt portion, and means for connecting the piston to the upper end of the connecting rod. The head portion with its ring section is guided and held in alignment by the skirt as the piston reciprocates in the cylinder. The skirt should, therefore, be securely attached to the head portion of the piston and be rigid under all operating conditions, and should fit as closely to the cylinder wall as possible without causing harmful friction under all engine operating temperatures.

Cylinders of internal combustion engines are usually made of cast iron and are either water-cooled or air-cooled. In order to make pistons as light as possible they are commonly made of metals or alloys which are light and strong but which usually also have high coefficients of expansion. The transfer of heat during engine operation from the combustion chamber through the piston to the cooled cylinder wall affects the temperature of the piston skirt and resulting expansion. Due to the construction of the piston with resulting high temperature of the skirt during operation, it has been necessary heretofore in fitting the pistons to allow for a greater expansion of the piston skirt than that of the cylinder wall by making the outside diameter of the skirt sufficiently less than that of the internal diameter of the cylinder, or by slotting the skirt, to avoid the danger of the skirt, due to its greater expansion, expanding enough to fit so tight in the cylinder as to seize or become frozen thereto during the operation of the engine. The difficulty due to expansion of the piston skirt has been increased by the fact that for the commonly used wrist-pin connection between the piston and the connecting rod, substantial bosses are provided on opposite sides of the piston skirt for journaling the wrist pin, and these relatively heavy masses of metal conduct heat from the head causing dangerous and unequal expansion and contraction at different parts of the skirt.

By the present invention the necessity of large clearances between the piston skirt and the cylinder and the necessity of slotting the skirt is avoided, and a light-weight piston having a circumferentially continuous, or solid, skirt which may be fitted more closely in the cylinder than has heretofore been found possible, is hereby provided. Also, a piston is provided, the head portion of which, including the part carrying the connecting rod bearing, may be die-cast of comparatively light-weight metal which may be a metal having a relatively high coefficient of expansion, such, for example, as an alloy containing a large percentage of magnesium known as Dow metal. The skirt is made of thin, rolled or otherwise worked, comparatively hard and fine-grained wear-resisting metal such as steel or other suitable strong wear-resisting material which can be made to have a smooth low-friction surface. Passing of oil from below the piston rings to the combustion space of the cylinder above the piston is kept at a minimum; and a ball-and-socket connection is most desirably provided between the piston and the connecting rod, this having the advantage of avoiding the necessity of having heavy masses of high heat conducting material connected to the piston skirt, which cause unequal expansion and contraction of the skirt.

To these ends, a piston embodying the features of the invention, in the form now considered best, has its head portion cast of a light-weight metal, with its connecting rod bearings of the same or other suitable metal, carried independently of the skirt. It has a thin tubular skirt of strong, hard, wear-resisting, smooth-surface material, preferably a suitable steel or steel alloy, the coefficient of expansion of which is not much greater and may be somewhat less than that of the cylinder and which also has the property of expanding without assuming an oval shape. The skirt proper is spaced axially from the ring-carrying part of the head and is spaced radially from the bearings carrying part of the head, and is securely and rigidly connected to the head by having an extension or neck of reduced diameter embedded in the ring carrying part of the cast head and having a plurality of holes therein through which the cast metal extends. The skirt may have an inwardly extending flange at its lower end for greater rigidity and strength, and it may also have oil relieving holes therethrough.

Instead of the more commonly used wrist-pin connection between the piston and the connecting rod, the connection is most desirably of the ball-and-socket type, a ball on the end of the

connecting rod being seated between upper and lower bearing members carried by a downwardly extending central tubular body portion of the piston head. This central body portion serves to conduct heat away from the top part of the head and dissipate it to the splashed-up crankcase oil, thus enabling the skirt, which is connected to the top part of the head, to be kept at a lower temperature. Heat dissipating fins are desirably provided on the central body portion for the purpose of increasing the conduction of heat from the top part of the head.

Because of the form and construction of the head and the manner in which the skirt is connected thereto, the conduction of heat from the head to the skirt is largely reduced; and because of the free access of splashed crankcase oil to the inside of the skirt, comparatively good cooling of the skirt is secured. The maximum operating temperature of the skirt is thus reduced; and because of this, together with its comparatively low coefficient of expansion, the skirt may be fitted with a much closer clearance than has heretofore been found practical with the so-called solid skirts. It has been found that pistons made according to this invention having circumferentially continuous skirts of plain carbon steel about $\frac{1}{32}$ of an inch thick may be fitted with a clearance of less than .0005 of an inch for each inch of diameter without causing any trouble as the result of skirt expansion.

The hard dense wear-resisting metals of which the skirts are most desirably made are comparatively heavy, but they are also correspondingly strong, and because of this, and of the fact that the skirt, to which the connecting rod is not directly connected, is free from injurious operating strains and stresses set up through the connection between the piston and the connecting rod, the skirt can safely be comparatively thin, and, therefore, comparatively light. The skirt is mainly an alignment element. The head portion of the piston, including the bearings-carrying part, may be, and most desirably is, made of a light weight alloy so that the piston as a whole will be very light and strong.

The invention thus provides a light weight piston having a solid skirt which may be exceptionally close fitting and with a smooth wear resisting cylinder engaging surface of low friction.

Because of the close fit of the piston skirt in the cylinder bore and its smooth surface and wear-resistance, and the comparatively light weight of the piston as a whole, a much improved and more efficient operation of the engine through a long period of use is obtained. The ring-carrying part of the piston is accurately guided, and cocking of the piston with resulting piston slap and uneven wear and rounding of the piston rings with resulting passing of oil and loss of vacuum and compression and power are almost, if not completely, eliminated. It is well known that with the pistons commonly in use there is comparatively great loss of engine power due to cocking of the pistons and the resulting ring and piston failure, and that this loss of power is aggravated by the passing of an excessive amount of oil which in turn results in carbon formation, causing further loss of power and, in extreme cases, preignition.

The invention will be more fully understood from a detail description in connection with the accompanying drawing, in which:

Fig. 1 is a vertical section through an approved illustrative embodiment of the invention taken along the line 1—1 of Fig. 2;

Fig. 2 is a sectional view taken on line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 1 showing a modification;

Fig. 4 is a perspective view of the skirt; and

Fig. 5 is a perspective view on a smaller scale showing a modification of the skirt.

Referring first to Figs. 1 and 2, the head portion of the piston is of cast metal and comprises an annular top part 10 which is peripherally grooved for holding the piston rings, and which as shown has three ring grooves for holding three compression rings 3, and a downwardly extending central body portion or part 10', which when the piston is to be connected to the connecting rod by a ball and socket joint, as shown, is a tubular part the bore of which extends upward through the top of the piston head, and which is of substantially smaller diameter than the skirt. Near its lower end this tubular body part 10' has an inside shoulder 11 on which is seated an annular lower bearing member 12 which fits in the bore of the tubular body part and the inner surface 13 of which is spherically curved to fit the ball on the end of a connecting rod (not shown) to which the piston is to be connected. The opening in the bottom of the bearing member is of sufficient size to permit the necessary oscillation of the connecting rod. Above the bearing member 12 the bore of the tubular body part 10' is threaded to receive a threaded upper bearing member 14 which has a spherically curved bearing surface 15 to engage an upper half of the connecting rod ball when seated on the lower bearing member. An oil pocket 16 extends upward from the top of the bearing surface 15, and crankcase oil splashed up within the piston will pass through passages 17 in the wall of the tubular body part to a circumferential oil groove 18 and thence through passages 19 to the pocket 16, only one of the passages 17 being shown. The bearing member 13 is of such depth or vertical length that when screwed down into position its top surface is substantially flush with the adjacent surface of the top part 10, which may be somewhat convex as shown.

This removable bearing member has an annular portion 20 of its peripheral surface, most desirably at the top thereof as shown, without threading and slightly tapered downwardly, and a corresponding portion 21 of the bore into which the bearing member is screwed is also without threading and tapered downwardly and inwardly at an angle slightly less than the angle of the tapered portion of the bearing member, and the relative diameters of these two tapered surfaces are such that the tapered surface 20 of the bearing member will come into engagement with the upper part of the tapered surface 21 of the bore before the bearing member has been screwed down to its position of adjustment on the lower bearing member. When the upper bearing member has been screwed down to its seated position the tapered surfaces 20 and 21 are so tightly wedged together that the upper bearing member is thereby securely locked and held against any unintended loosening as the result of vibration, and, also, a seal is provided against any possible introduction of carbon from the top of the piston to the connecting rod bearing surfaces. This locking and sealing feature of the piston shown, which is not part of the present invention, is more fully described and claimed

in my application Serial No. 51,782, filed November 27, 1935.

The upper bearing member has two wrench pin sockets 25 and the top part 10 of the head also has wrench sockets 26, preferably three, of which one is shown in Fig. 1, for turning the bearing member and holding the piston when the bearing member is being inserted or removed. An annular groove 27 is formed in the lower side of the part 10 of the head, for the purpose of making the head as light as possible, with ribs 28 at intervals across the groove, there being three such ribs as shown although there may be a different number.

The top part 10 and tubular body part 10' of the head are formed as a single casting and may be of a light weight metal or alloy which may, for example, be an alloy containing a very large percentage of magnesium. Such metal has a coefficient of expansion somewhat higher than aluminum and much greater than the coefficient of expansion of steel. This metal can be cast or die cast, and is sufficiently strong for its purpose and is highly wear-resisting when oiled. The head is of such form that it may readily be die cast.

The skirt 30 is a thin tubular skirt made of strong, hard, wear-resisting smooth-surface material, preferably steel or a suitable steel alloy, having a coefficient of expansion not substantially greater than that of the metal of which the cylinder in which the piston is to be used is made. Medium carbon steel having a wall thickness of about $\frac{1}{32}$'' has been found suitable for pistons of about 3'' in diameter. The coefficient of expansion of such steel is only slightly greater than that of cast iron of which the cylinder blocks of internal combustion engines are usually made. Regardless of the way the skirt is formed, it should most desirably be of rolled metal or metal otherwise worked or metal having characteristics of worked metal, such as centrifugally cast tubing, because of the greater density and strength of worked metal.

The skirt element or part of the piston comprises the circumferentially continuous skirt proper 30 and a reduced upper end or neck portion 35 having an inwardly extending flange 36 at its upper edge, which parts 35 and 36 are embedded in the top part 10 of the cast head. The neck 35 is connected to the skirt proper by a flat web or flange 37 extending inward from the upper edge of the skirt. It is most desirable to make the skirt 30, flange web 37, neck 35 and flange 36 of a single integral piece of material, rather than to make the skirt and neck of separate pieces suitably welded or otherwise secured together either before or after the neck is cast in the head.

The neck 35 and its flange 36 are most desirably and for greatest strength and rigidity circumferentially continuous as shown in Fig. 4, but much of the advantage of the construction, and a strong rigid connection between the head and skirt, may be secured by making the neck and flange discontinuous, having openings therein which divide the neck and flange into a plurality of spaced portions as shown by Fig. 5. When so formed, the neck and flange should be of thicker material than is required when they are circumferentially continuous. As shown in Fig. 5, the web or flange 37 should, most desirably, be circumferentially continuous even when the neck and flange are discontinuous.

When the flange 36 is circumferentially continuous, it has, most desirably, a plurality of equally spaced depressed portions 38 extending across the flange, the number of these depressions 38 corresponding to the number of thickening ribs 28 in the top part 10 of the head, and the skirt element is positioned with relation to the head so that the position of the depressions 38 circumferentially will correspond to the positions of the ribs, the principal purpose of the ribs 28 being to provide a sufficient thickness of metal below these depressed portions of the flange 36. The wrench sockets 26 of the head part 10 are best located above the depressions 38 and ribs 28 because of the greater depth of metal at these points.

The neck 35 has a suitable number of through openings or holes 39 formed therein, and flange 36 has also a suitable number of holes 40 therethrough. The neck 35 and flange 36 should have these holes whether they are circumferentially continuous as shown in Fig. 4 or circumferentially discontinuous, divided into a plurality of spaced portions as shown in Fig. 5. When the neck and flange are circumferentially continuous and the flange has the depressed portions 38, each such depressed portion 38 has, most desirably, one of the holes 40 therein, and one of the holes 39 in the neck is located just below each of the depressions 38, the holes below the depressions being smaller than the other holes 39. These holes 39 and 40 are provided in order that when the head is cast about the skirt neck and flange, the head metal will flow through these holes so that the neck and flange will thereby be very firmly and securely anchored in the top part of the head, and also, that the portions of the head between which the neck and flange extend will be strongly bonded together. The skirt is thus not only firmly and securely anchored in the part 10 of the head, but will not become loosened because of differences in expansion of the head metal and skirt metal under the temperature changes to which they are subjected.

The skirt, including its reduced portion or neck, may be formed in any suitable way. It may be spun from a flat piece of sheet metal, but, most desirably, it is formed from a piece of tubing of suitable size and thickness for the skirt proper, the reduced portion comprising the flanged neck and connecting web being spun or pressed or otherwise formed to the desired shape to produce a one-piece skirt element. Seamless tubing is the best for the purpose, but suitable welded tubing may be used. Although the skirt proper is shown as without openings other than the oil discharge openings of Figs. 1 and 2, a suitable degree of skeletonizing of the skirt would not change its characteristic of being circumferentially continuous or not circumferentially continuous as the case might be.

As shown in Figs. 1 and 2, the skirt 30 has its wall deformed inwardly to form a plurality, three as shown, of channels 32 extending downward from the upper edge of the skirt, shown as parallel to the axis of the skirt and ending a short distance from the bottom of the skirt. These channeled or bent-in portions 32, by taking up to some degree circumferential expansion of the skirt, serve to relieve pressure on the cylinder wall of an over-tight fitting piston. Each of the grooves 32 terminates in an oil discharge hole 33, so that oil reaching the space 8 between the ring-carrying part of the head and the top of the skirt will flow downward through the grooves

32 and be discharged through the holes 33 to the space inside the skirt. The skirt 30 is also shown in these figures as provided with an internal flange at its lower edge for increasing its strength and rigidity.

In the modification shown in Figs. 3 and 4, the skirt 30 is not provided with an internal flange at its lower end as in Figs. 1 and 2, but terminates in a flangeless end having most desirably the usual oil wiping edge; and, instead of the grooves 32 and holes 33 of Figs. 1 and 2, oil holes 45 are provided at the bottom portion of the extension 34 of the skirt to permit oil to pass from the annular space 8 into the space inside of the skirt. The central tubular part 10 of the head is also provided with a plurality of heat-dissipating fins 46 of which two are shown in Fig. 3. Fig. 3 also shows the head as being provided with two compression rings 3 and an oil ring 5 of any suitable kind, instead of three compression rings and no oil ring as shown in Fig. 1. The usual oil discharge passages 5', of which one is shown in Fig. 3, extend inward from the oil ring groove.

The skirt, whether flanged at its lower end or not, may be tapered downward in wall thickness as shown in Fig. 3 without sacrifice of desired strength and rigidity. The skirt may readily be so tapered in wall thickness when stamped or drawn to final shape, and when so shaping the skirt the operation is facilitated by so tapering it.

The skirt stays in alignment under the severest conditions of operation and remains comparatively cool and effectively prevents the piston from cocking to one side.

What is claimed is:

1. An element for a piston, comprising a cylindrical skirt portion and a circumferentially continuous neck portion of reduced diameter having an inwardly extending flange, said flange having a plurality of spaced transverse depressions therein.

2. An element for a piston, formed of a single piece of hard, wear-resisting, smooth-surface material and comprising a thin circumferentially continuous cylindrical skirt portion and a circumferentially continuous neck portion of reduced diameter flanged at its upper end and having a plurality of holes therein, said flange having portions offset axially.

3. A piston, having a circumferentially continuous thin skirt, the skirt wall being deformed inwardly to form a plurality of expansion-take-up channels extending downwardly from the upper edge of the skirt, said channels terminating short of but near the lower edge of the skirt.

4. A piston, having a circumferentially continuous thin skirt, the skirt wall being deformed inwardly to form a plurality of expansion take-up channels extending downwardly from the upper edge of the skirt, said channels terminating short of but near the lower edge of the skirt and having oil discharge openings therein.

5. A piston, comprising a cast ring-carrying head portion and a circumferentially continuous thin skirt of hard wear-resisting smooth surface material from the upper edge of which an integral circumferentially continuous connecting part extends upward and inward, the upper portion of such connecting part, which is of substantially less diameter than the skirt, extending into and being embedded in the head portion and having a plurality of holes therein through which the head metal extends, the only contact between the head portion and the skirt and connecting part being at said embedded portion of the connecting part, the skirt having its upper edge circumferentially continuous and spaced axially from the head portion, and the connecting part being flanged at its upper edge and its flanged part having a plurality of spaced depressed portions therein.

JOHN SHEARMAN DONALDSON.

CERTIFICATE OF CORRECTION.

Patent No. 2,289,251. July 7, 1942.

JOHN SHEARMAN DONALDSON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 5, for the word "discontinuous" read --continuous--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 18th day of August, A. D. 1942.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)