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PISTON

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Fig. 1.

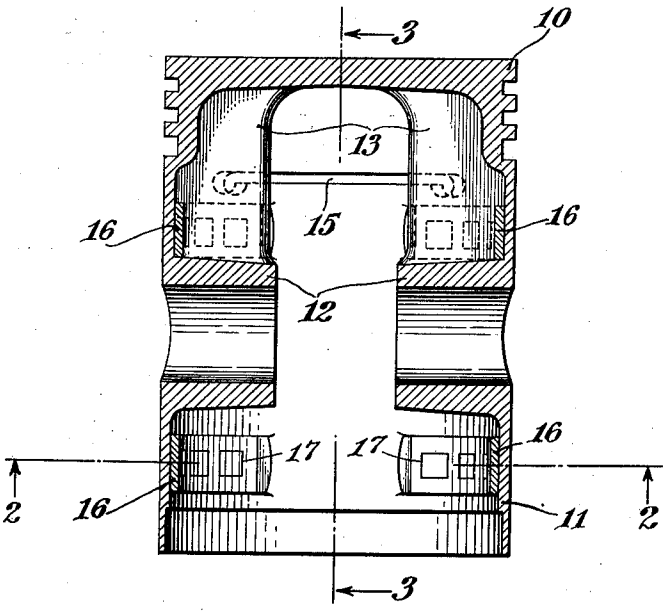


Fig. 2.

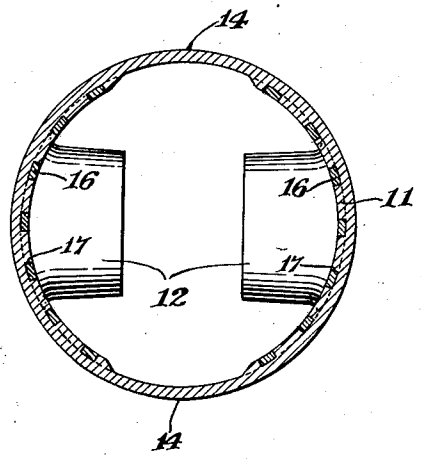
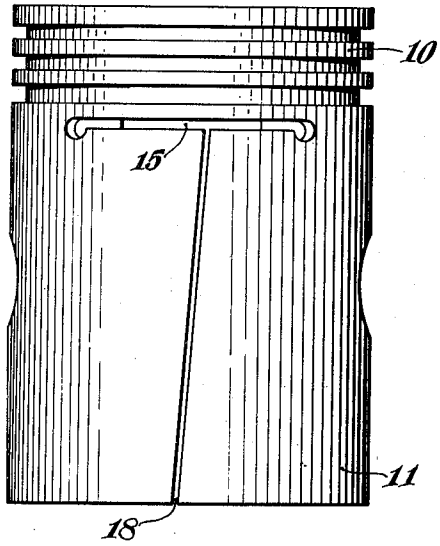


Fig. 7.



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Fig. 3.

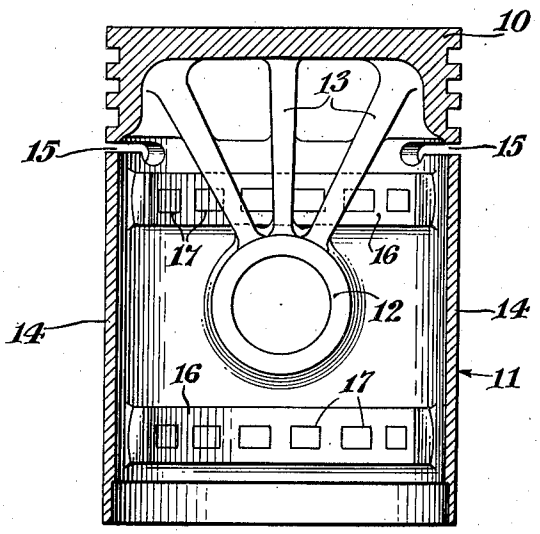


Fig. 4.

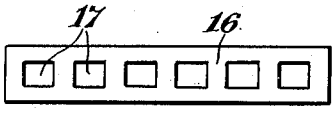


Fig. 5.

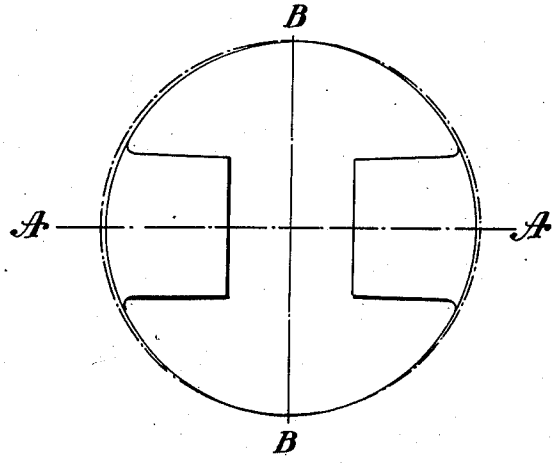
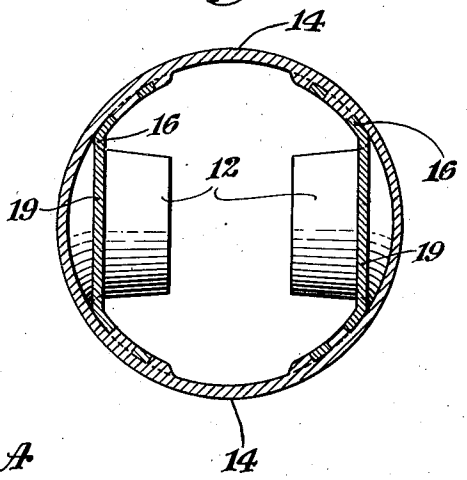


Fig. 6.



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Fig. 8.

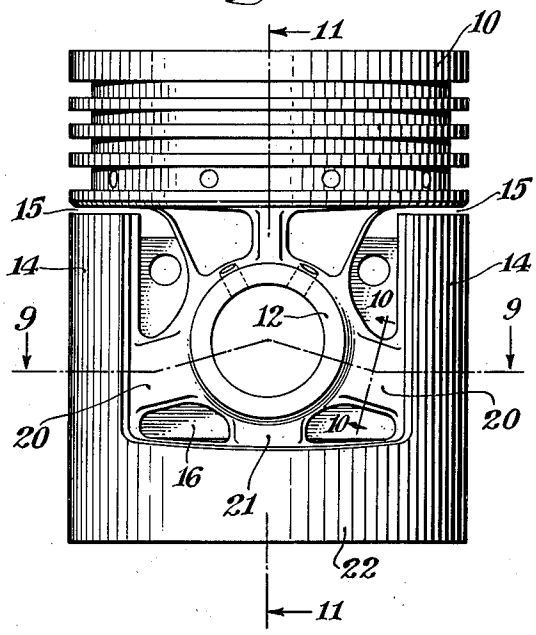


Fig. 9.

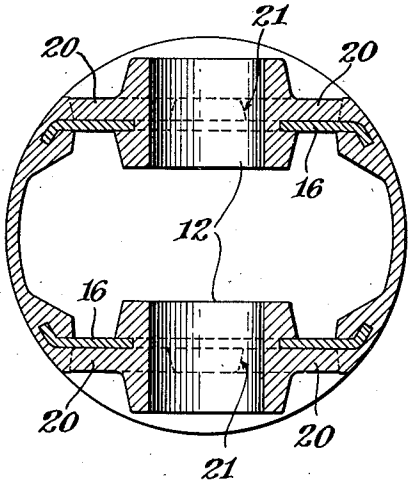
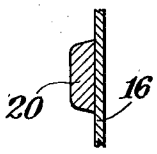


Fig. 10.



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Fig. 11.

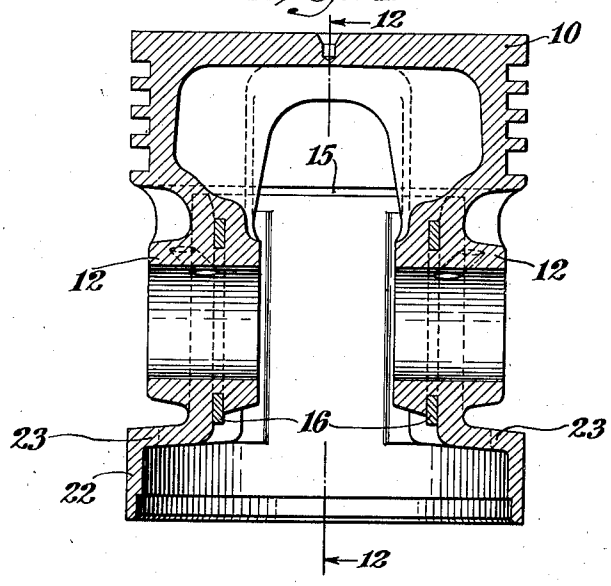
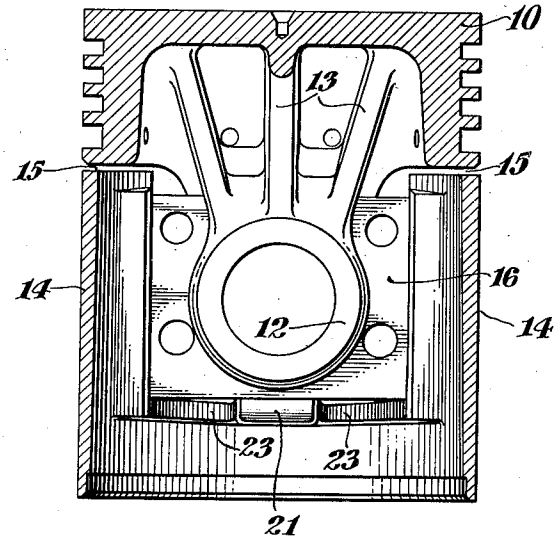


Fig. 12.



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Fig. 13.

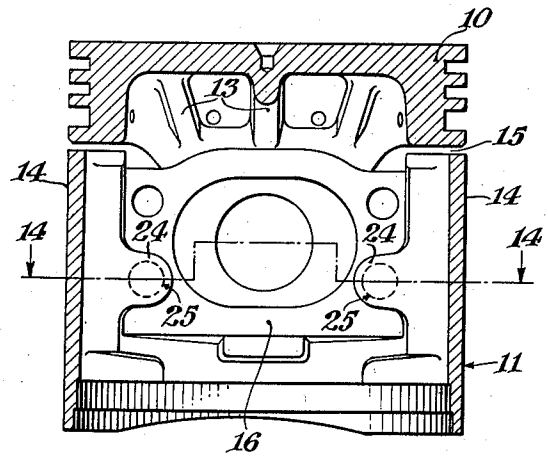
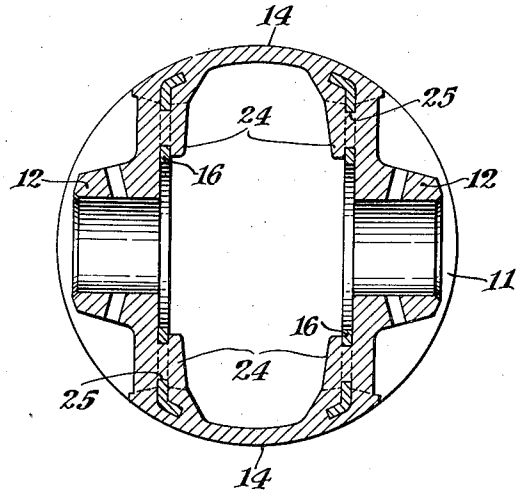


Fig. 14.



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UNITED STATES PATENT OFFICE

2,086,677

PISTON

Adolph L. Nelson, Detroit, Mich.

Application July 19, 1934 Serial No. 735,917

6 Claims. (Cl. 309—13)

This invention relates to an improved piston for internal combustion engines.

More particularly it provides a piston formed of light-weight material, such as an alloy of aluminum, and having an improved arrangement to control the expansion of the thrust faces of the piston.

This object is attained in the present invention by forming the skirt with an oval exterior shape when cold and including within the skirt a pair of thermostatic elements so arranged that under an increase of temperature they act to bend the skirt toward a substantially cylindrical shape.

In the preferred embodiment the thermostatic elements are formed of two members having unequal rates of thermal expansion, one of the members being of the same material as the skirt of the piston, and the other member being of a material having a lower rate of thermal expansion than the piston material. An increase of temperature causes these bimetallic thermostatic elements to bend due to the unequal expansion rates of the two members, and this bending of the thermostatic elements is utilized to bend the skirt from its oval shape when cold to an approximately cylindrical shape at the temperatures normally encountered under operating conditions in an engine.

This arrangement permits fitting the skirt so that when cold the load-carrying thrust faces have a close fit with the cylinder wall thereby preventing piston slap when the motor is cold. The self-bending action of the skirt caused by the thermostatic elements insures the thrust-faces having a suitable clearance with the cylinder wall when the motor is at normal operating temperatures, and prevents sticking of the piston should the skirt become heated to an abnormal temperature for any reason whatever.

These and other objects and advantages of the invention will become apparent as the description proceeds.

While preferred forms of the invention are disclosed herein for purposes of illustration, it should be understood that various changes may be made in the structure without departing from the spirit of the invention as hereinafter set forth and claimed.

In the drawings:

Fig. 1 is a vertical sectional view through a piston embodying the invention.

Fig. 2 is a cross-sectional view on line 2—2 of Fig. 1.

Fig. 3 is a sectional view on line 3—3 of Fig. 1.

Fig. 4 is a plan view of one of the inserts.

Fig. 5 is a diagram illustrating the expansion of the piston.

Fig. 6 is a view similar to Fig. 2 but showing a modification.

Fig. 7 is a side elevational view illustrating another modification.

Fig. 8 is a side elevational view of another species of the invention.

Fig. 9 is a sectional view on line 9—9 of Fig. 8.

Fig. 10 is a sectional view on line 10—10 of Fig. 8.

Fig. 11 is a sectional view on line 11—11 of Fig. 8.

Fig. 12 is a sectional view on line 12—12 of Fig. 11.

Fig. 13 is a view similar to Fig. 12 but showing a further modification.

Fig. 14 is a sectional view on line 14—14 of Fig. 13.

Light-weight materials, such as alloys of aluminum, have many advantages for use in constructing pistons, their chief disadvantage being the fact that they have higher coefficients of thermal expansion than cast iron, of which the cylinders are normally formed. The greater expansion of the aluminum creates a problem in the production of a satisfactory piston for automobiles because if the pistons are constructed like ordinary cast iron pistons and are fitted with sufficient clearance to avoid sticking when the motor is hot, they will cause such an objectionable piston slap when the motor is cold as to render the motor unfit for use in an automobile.

The present invention provides a solution of this problem by the use of a new principle, namely the curving property of thermostatic elements to produce a self-bending action of the skirt. The application of this principle yields a piston having very fine operating characteristics, as will appear from the following detailed description.

Referring first to the form of the invention illustrated in Figs. 1 to 7, the piston comprises a head 10 and a skirt 11, both formed of a suitable light-weight material, such as an alloy of aluminum. Piston pin bosses 12 are formed in the skirt, and the connection between the head and the bosses is strengthened by ribs 13.

The parts of the skirt adjacent diameter B (Fig. 5) at right angles to the axis of the piston pin bosses carry the main loads against the cylinder wall resulting from the angularity of the connecting rod, and these parts, which are usually referred to as thrust faces, are indicated by reference numerals 14. Because these thrust faces carry the loads the diameter B is the important

diameter that must have a proper fit in the cylinder bore at all temperatures encountered.

The first essential of this invention is that the skirt be given an oval exterior shape by any suitable method, preferably by grinding, the oval being disposed with its minor axis, A, coinciding with the axis of the piston pin bosses and with its major axis B at right angles to the axis of the pin bosses, as shown by the solid line of Fig. 5. The oval is preferably of the same size throughout the length of the skirt, or in other words, the skirt is not tapered from top to bottom.

The two thermostatic elements are disposed across the ends of axis A and are constructed so that as the temperature rises they bow outwardly, carrying the pin bosses outwardly and bending the skirt toward the cylindrical shape shown by the broken line of Fig. 5.

The head **10** is ordinarily the hottest part of the piston and hence expands more than the skirt. Contact of the head with the bore is prevented by giving the head a sufficient clearance and the thrust faces are isolated from the outward pull of the head by slots **15**.

To provide the bimetallic thermostatic elements arcuate inserts **16** are secured to the inner wall of the skirt. These inserts **16** are formed of some material such as ordinary steel having a lower coefficient of thermal expansion than the skirt material, and each insert extends along a boss-carrying wall of the skirt as shown in Fig. 2.

The inserts **16** are secured to the skirt in any convenient manner, the simplest way being to cast them within the skirt. In this species each insert is formed with a plurality of apertures **17** as shown in the plan view of Fig. 4, and the inserts are placed in the mold before the piston is cast. The piston mold is formed to permit the piston material to fill the apertures **17** and hold the inserts in place while bonding the ends of the inserts to the skirt wall.

Each insert **16** cooperates with the part of the skirt wall to which it is attached to form a bimetallic thermostatic element, the insert **16** forming the inner member and the skirt wall forming the outer member of the thermostatic element. Under an increase of temperature the outer aluminum member expands more rapidly than the inner steel member, and these unequal rates of expansion cause the middle part of the thermostatic element to bow outwardly, increasing its curvature. The combined action of the two oppositely arranged thermostatic elements causes a simple bending of the skirt from the oval shape shown in the solid line of Fig. 5 to the cylindrical shape shown in the broken line.

Obviously the outer member of the thermostatic element could be a separate piece of highly expansible material combined with the inner member to form an element which could be secured to the skirt in a suitable fashion, but for simplicity it is preferred to use the skirt material for the outer member.

In the construction illustrated in Figs. 1 to 4 a pair of thermostatic elements is located above the piston pin bosses, and a second pair is located below the piston pin bosses, but either the upper or the lower pair of inserts may be omitted in cases where the full action of the inserts is desired at only one end of the skirt.

The control provided by these thermostatic elements avoids the necessity for any vertical skirt slot, although a slot **18** may extend vertically through one of the thrust faces between the ends of the inserts as shown in Fig. 7 to take care of abnormal temperature conditions which may be encountered in faulty engine design.

Fig. 6 shows a modification in which the inserts instead of being completely arcuate have chordally extending parts **19**. In this form the ends of the inserts are bonded to the skirt wall, and the parts operate in the manner previously described.

Another embodiment of the invention is illustrated in Figures 8 to 12. In this form the inserts **16** are chordally extending plates with their ends anchored in the thrust faces, and the skirt wall is partly cut away around each pin boss, webs **20** of the skirt material extending along the outside of each insert. Here the inserts **16** and webs **20** form the inner and outer members, respectively, of the bimetallic thermostatic elements, and these elements operate as explained above to cause a simple bending of the skirt from its oval shape when cold toward a cylindrical shape as the temperature rises.

A vertical web **21** may connect each pin boss to the lower ring **22** of the skirt for reinforcing purposes, but this web does not interfere with the thermostatic bending of the skirt. The webs **20** and **21** perform an added function by conveying heat from the head to the skirt, whence it can be transferred to the cylinder wall.

It may also be desired to use a pair of arcuate flanges **23** to strengthen the lower part **22** of the skirt.

In the modification just described, the middle part of each insert **16** is cast within a pin boss. But in pistons embodying this invention the inserts are not relied upon to carry any of the thrust loads, and the inserts may be entirely free of the bosses as shown in Figs. 13 and 14. In this construction the insert merely extends along the inner side of the boss but its ends are anchored in the skirt in order to permit the thermostatic action. Whether the insert is cast into the bosses depends in any particular case on the length of the bosses and the position decided upon for the insert in view of the design of the connecting rod, etc.

Figs. 13 and 14 also illustrate that if desired ears **24** may extend inwardly and form bonds through holes **25** to hold the inserts tight against the webs **20**. These ears also reduce the amount of thermostatic bending since they shorten the effective length of the truly bi-metallic thermostatic element.

It has been mentioned that the diameter B is the important diameter to be considered, and the simplified diagrammatic sketch of Fig. 5 shows this diameter as remaining constant while the piston rounds up. In actual practice it is desired to give diameter B of the piston substantially the same rate of expansion as that of the cylinder bore so that the clearance between the ends of diameter B and the cylinder wall will remain substantially constant for all temperatures. This result can be achieved under the present invention by a proper co-ordination of the oval shape of the cold piston, and the materials and dimensions of the members of the bimetallic thermostatic elements. With this invention it is possible to form the inserts **16** of ordinary steel and obtain on diameter B a rate of expansion even lower than that of cast iron.

Since diameter A expands faster than the cylinder, the piston should be machined or ground so that this diameter will never have more than a very light contact with the cylinder wall even at abnormally high temperatures. Hence the

pistons should reach only an approximately cylindrical shape at normal operating temperatures, although the shape at these temperatures should come as close to cylindrical as the factor of safety will permit.

Upon starting a cold motor equipped with these pistons there will be no cold slap because of the small clearance at the ends of diameter B.

An important novel feature of this invention is that the skirt expansion is made practically independent of the head expansion on all diameters. In the past it has been customary to separate the upper ends of the thrust faces from the head by slots to keep the head from pushing the upper ends of the thrust faces outward. But the head has been left free to twist the upper ends of the pin bosses outward, and this movement of the bosses caused a detrimental twisting and distortion of the skirt. In the present invention the pin bosses are carried outwardly by the movement of the thermostatic elements independently of the head. This fact can be demonstrated by taking a single piston and heating it in any suitable manner until the head and skirt reach the same temperature. Under these conditions the expansion along the axis of the bosses is greater than that of the head, showing that the thermostatic action has carried the bosses outwardly even against the resistance offered by the head.

A further demonstration of the fact that the action of the thermostatic elements is very powerful and practically independent of other parts of the piston can be made by taking a piston of the type illustrated in Fig. 8, cutting the head off, severing the ties 21, and cutting vertical slots through the lower ring 22 below each pin boss. Under these conditions the expansion characteristics of the thrust faces are practically the same as for the original intact piston.

In normal operation of an engine the head is hotter than the skirt, and the higher temperature of the head practically balances the faster rate of expansion of the bosses, so that the head and bosses move out together, and there is no twisting of the bosses. This action permits an even and uniform bearing of the thrust faces on the cylinder wall.

Another important advantage of this invention is that the skirt is rendered self-correcting against excessive heat expansion. This feature results from the fact that the thermostatic elements perform their corrective function when they are subjected to an increase in temperature regardless of the source from which the heat comes, whether from an unduly high head temperature, a high oil temperature, or excessive skirt friction.

Thus through improper fitting a piston skirt may have an unusually hard bearing against the cylinder wall. This excessive friction may heat the skirt to a temperature higher than the normal temperature of the head. Ordinarily such frictional heat is self-aggravating, since the increased temperature causes increased expansion, which causes increased temperature, and so on to disaster. But by this invention any increased heat due to skirt friction merely causes the thermostatic elements to bend the skirt further toward cylindrical shape, thus relieving the excessive pressure on the thrust face, and since the generated heat expands the cylinder at about the same rate as the skirt, the skirt will wear in gradually without scoring.

In the preferred forms no vertical skirt slot is used, and the unslotted skirt has greater resistance to deflection under side thrust and to rocking in the bore. The increased stability of the piston gives better oil economy at high engine speeds and permits the rings to function properly without excessive wear.

For reasons explained above it is safe to fit the unslotted pistons of this invention in the bore with a very close fit on diameter B. In one test run pistons were fitted in a well-known make of automobile with less than a .0015 inch clearance and the car was run the second day up to above 80 miles per hour without the customary breaking in, showing that the engineers in charge of the test had confidence in the ability of the thermostatic control to prevent any difficulty due to piston expansion. On the third day top speed tests above 90 miles per hour were successfully completed.

By permitting extremely close fitting of an unslotted piston the invention provides for long piston life and freedom from taking a permanent "set" at a reduced size, in addition to increased power and operating economy.

The improved results are not limited to carefully controlled experiments, but the invention is such as to assure these results in commercial production and the full benefits can therefore be passed on to the public in the form of better piston performance and longer piston life.

I claim:

1. A piston comprising a head and a skirt both formed of material lighter in weight than cast iron and having a higher rate of thermal expansion than cast iron, the skirt being circumferentially continuous at its lower end and having piston pin bosses, the skirt also having circumferentially continuous thrust faces extending upwardly toward and terminating short of the head, the outer surface of the skirt being oval when cold, the short axis of the oval coinciding with the axis of the piston pin bosses and the long axis of the oval passing through the centers of the thrust faces, and a pair of bi-metallic thermostatic elements extending chordally of the piston with their opposite ends attached to the thrust faces, each bi-metallic element consisting of an innermost member and an outermost member, said outermost member being a web of the skirt material, said innermost member being a plate of material having a lower rate of thermal expansion than the material of the skirt, the middle portion of each bi-metallic element being connected to a piston pin boss, and the middle part of each bi-metallic element being adapted to bend outwardly under a rise in temperature, thereby bending the skirt toward cylindrical form and spreading the piston pin bosses independently of the expansion of the head as the piston warms up to operating temperature.

2. A piston as claimed in claim 1 in which the plates of the bi-metallic elements extend across the piston both above and below the axis of the piston pin bosses.

3. A piston as claimed in claim 1 in which the plates of the bi-metallic elements extend across the piston both above and below the axis of the piston pin bosses, and in which the webs forming the outermost members of the bi-metallic elements include parts that are narrower than the plates.

4. A piston as claimed in claim 1 in which a web extends downwardly from each pin boss to the lower continuous portion.

5. A piston comprising a head and a skirt both

formed of material lighter in weight than cast iron and having a higher rate of thermal expansion than cast iron, the lower end of the skirt being circumferentially continuous, piers extending downwardly from the head, piston pin bosses carried by the piers, circumferentially continuous thrust faces extending upwardly toward and terminating short of the head, the outer surface of the skirt being oval when cold, the short axis of the oval coinciding with the axis of the piston pin bosses and the long axis of the oval passing through the centers of the thrust faces, a pair of bi-metallic thermostatic elements extending chordally of the piston with their opposite ends attached to the thrust faces, each bi-metallic element consisting of an innermost member and an outermost member, said innermost member being a thin plate of material having a lower rate of thermal expansion than the material of the skirt and extending across the piston both above and below the axis of the piston pin bosses, said outermost member being a web of the skirt material extending horizontally from one thrust face to the other, parts of said web being narrower than said plate, each of the piston pin bosses being connected to the middle portion of a bi-metallic element, the middle portion of each bi-metallic element being adapted to bend outwardly under a rise in temperature, thereby bending the skirt toward cylindrical form as the piston warms up to operating temperature.

6. A piston as claimed in claim 5 in which each pier is continued downwardly and outwardly to join the continuous lower end of the skirt.

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