Sept. 15, 1959 D. M. ENDRES ET AL 2,904,377

SPACER AND EXPANDER FOR PISTON RINGS

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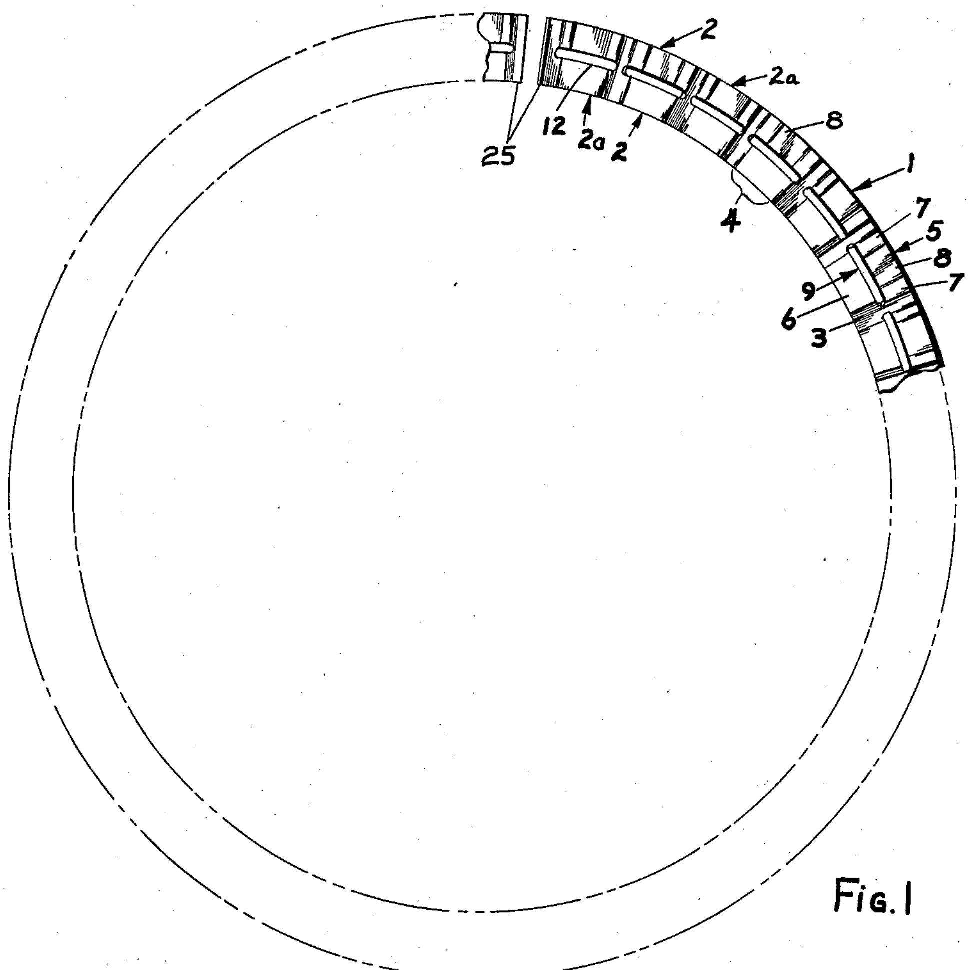

Fig. 1

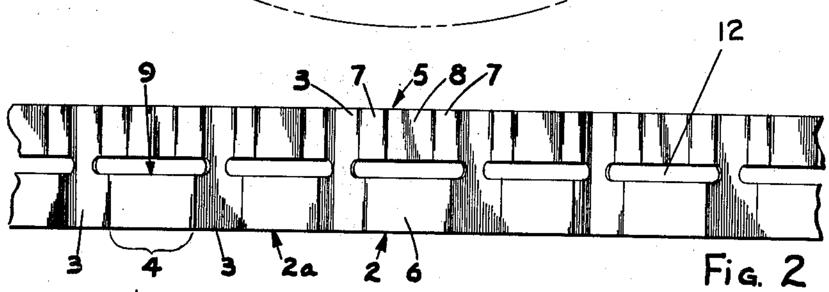

Fig. 2

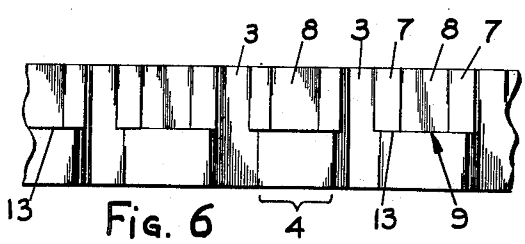

Fig. 6

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SPACER AND EXPANDER FOR PISTON RINGS

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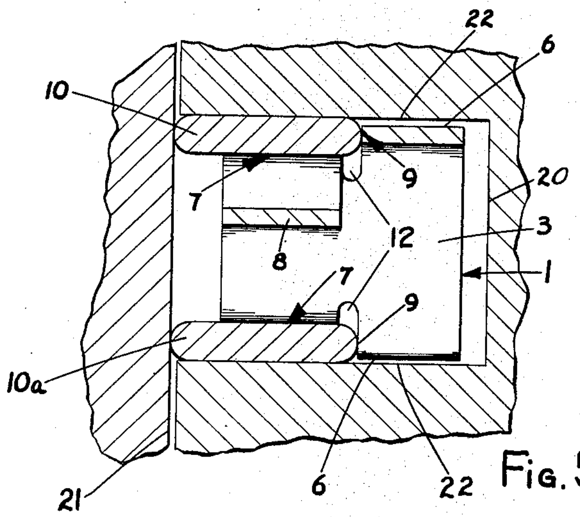

Fig. 5

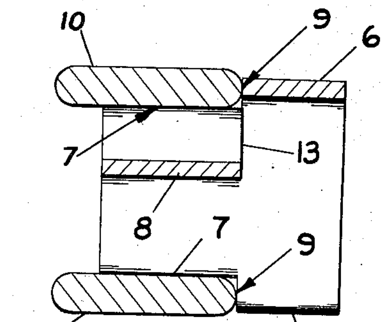

Fig. 7

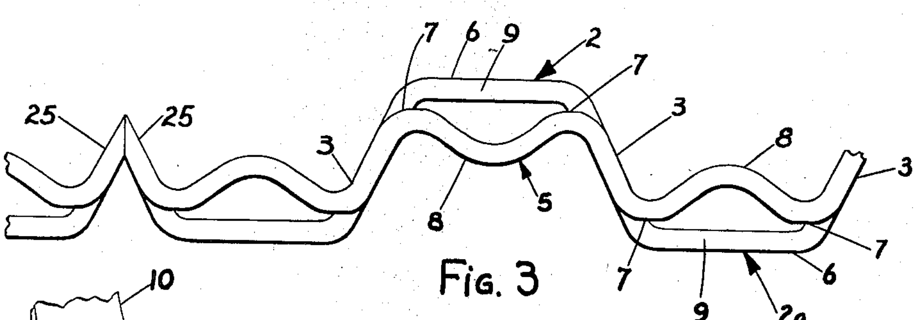

Fig. 3

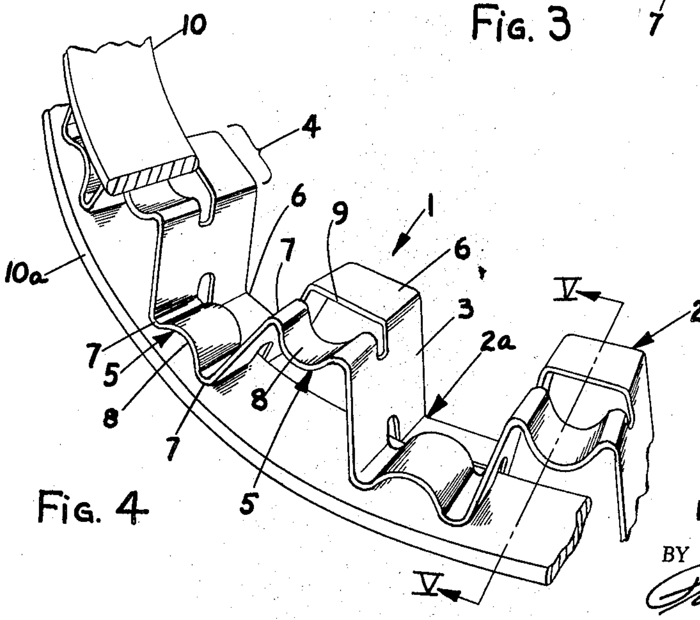

Fig. 4

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SPACER AND EXPANDER FOR PISTON RINGS

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9 Claims. (Cl. 309—40)

This invention relates to piston rings and more particularly to the type consisting of an upper and a lower rail supported and spaced by an expander.

Since piston rings must effect a seal to prevent the escape of high temperature, high pressure gases in one direction and the escape of lubricant in the other direction, it is essential that they be accurately fabricated to close tolerances. The high cost of the material utilized, particularly for the rails, makes it not only desirable but an economic necessity that the dimensions of the ring be such as to use a minimum of material. It is also desirable wherever possible, to substitute less costly materials and to eliminate such expensive processes as high temperature heat treating. It is also desirable to eliminate this latter process to avoid rejections due to warpage as result from high temperature heat treatment.

This invention provides a piston ring overcoming many of these objections. The design of the expander is such that while it is formed into a complex configuration it may be made from a high carbon, hard material such as a spring steel. This permits the use of work hardening materials requiring only low temperature heating to relieve stresses. The incident of warpage as a result of this type of heat treating is minor compared to that resulting from high temperature heat treatment processes.

This invention provides an expander affording firm, uniform support for the inner edges of the rails, thus, positively urging the rails outwardly against the cylinder walls. The design of the expander adapts the ring to occupy a higher proportion of the ring groove depth even though the rails themselves are of lower radial wall. This combination provides a ring of greater ease of installation and one which when installed positively safeguards against tipping of the rails or of the ring as a whole. Further, by using a narrower material for the rails the overall cost of the ring is reduced.

This expander design assures uniform spacing pressure against the side of the rails and thus firm and proper seating of the rails against the sides of the ring groove.

The openness of the ring design reduces clogging due to carbon deposits.

The use of a narrow material for the rails produces a flexible rail. This is particularly desirable because the added flexibility of the rail permits it to more readily conform to and follow the cylinder walls. Thus, it will more quickly adapt itself to the cylinder walls during the initial break-in period and thereafter will make a closer fit with them, effecting a tighter seal.

These and other objects and advantages of this invention will be understood by those acquainted with the design, manufacture and use of piston rings upon reading the following specification and the accompanying drawings.

In the drawings:

Fig. 1 is a plan view of the expander with the rails removed showing a portion of the expander in phantom.

Fig. 2 is a fragmentary plan view of the expander laid out in a straight line.

Fig. 3 is an enlarged front elevation view of a fragment of the expander.

Fig. 4 is a fragmentary, oblique view of the ring showing portions of the rails.

Fig. 5 is a sectional elevation view of the ring seated in the ring groove of a piston, taken along the plane V—V indicated in Fig. 4.

Fig. 6 is a fragmentary plan view of a modified construction for the spacer-expander.

Fig. 7 is a sectional elevation view corresponding to Fig. 5 but showing the modified construction of Fig. 6.

In executing the objects and purposes of this invention, there has been provided a piston ring consisting of a pair of split rails supported and held in spaced relationship by a sheet metal combination spacer-expander of such shape that it alternately contacts opposite rails. The outer portion of the expander ring provides side seats for the rails while the inner portion provides a backing support for the rails and occupies the inner portion of the ring groove. Each of the rail seats is depressed away from the rails and has a loop or saddle to receive the metal displaced in the formation of the rail seat. The portions of the expander extending between the rails are inclined to the rails to create, when the expander is circumferentially compressed, a camming action against the rails, forcing them to seat against the sides of the ring groove.

Referring specifically to the drawings, the numeral **1** (Fig. 4) indicates a spacer-expander, formed from an elongated, metallic ribbon of metal. This ribbon is provided with a plurality of spaced, longitudinally aligned slots **12**. These are preferably radiused at each end and may be formed by any suitable method such as punching. This strip is crimped, forming it into a series of generally U-shaped loops with alternate loops opening in opposite directions and the legs of each loop being common to the legs of the next adjacent loops. Thus, there are a plurality of loops **2** extending in one direction and a plurality of alternate loops **2a** extending in the opposite direction.

The sides or legs **3** of the loops are inclined for purposes which will appear more fully hereinafter. The expander **1** is formed into an annulus. The ends **25** of the spacer-expander ring may have various designs. It is important, however, that these ends be capable of effecting a firm abutment with each other when the ring is seated in the ring groove (Fig. 3). When the ring is installed, they must not be capable of telescoping past each other even though the installer exercises little care in making the installation.

Each of the loops has a web connecting the legs **3** forming a flat crown **4** of substantial length. Each of the crowns **4** is divided by one of the slots **12** into an outer seat portion **5** for the rails and an inner retainer portion **6** providing structural continuity for the expander. That portion of the expander ring which is inward of the slots **12** and including the retainer portions **6** constitutes generally the spring portion of the structure. That portion of the expander ring outwardly of the slots **12** and including the seat portions **5** constitutes generally the spacer portion of the structure. These two portions, while separated at the crowns by the slots **12**, are integral at the legs **3** of the loops **2** and **2a**. The seat portions **5** are necessarily of sufficient radial width to provide adequate support for the rails.

The seat portions **5** each provide a pair of contact areas **7** for the rails. Between the contact areas **7**, the seat portions **5** are looped toward the median line of the ring, creating a saddle **8**. The contact areas **7** are offset from the crowns **6** toward the median line of the ring a distance equal to a portion of the thickness of the rail. Since the ring is formed from a single ribbon of metal, the offsetting of the contact areas **7** and of the material between them reduces the total circumferential length of the outer portion of the expander ring. In order to utilize the same length of metal in each of the seat portions **5** as is utilized in the retainer portions **6**, the central area of each seat portion is formed into the saddle **8**, the depth and size of which is exactly that necessary to give the rail seat the same total length of material as that in the crown **6**. Thus, the material in the rail seat is neither compressed nor stretched in the forming of the expander ring.

The offsetting of the seat portions **5** of the expander ring toward the median line of the expander ring causes the outer edge of the retainer portions **6** to form a stop abutment **9** for the inner margin of the rail.

Seated on each side of the expander are rails **10** and **10***a*. The rails are radially wider than the seats **5** and thus project radially beyond the expander. Each rail normally consists of an annulus of high carbon, spring steel or other suitable material. The inner and outer margins of the rails are generally rounded.

Modification

The spacer-expander structure illustrated in Figs. 6 and 7 is identical to that illustrated in Figs. 1–5 except the slot **12** is omitted and a sheared slit **13** is substituted. In this type of structure, the ribbon is simultaneously crimped, slit and the outer seat portion **5** formed. It will be recognized that these operations need not necessarily be simultaneously executed but they are adapted to this type of fabrication. The functional differences between the pre-slotted and the shear-slit type structures will be enlarged upon subsequently.

Fabrication of the ring

To fabricate the expander ring, a ribbon of suitable material such as a high carbon steel is selected. Such steels as SAE 1060, SAE 1075, SAE 1095 or a stainless steel are suitable materials for the expander ring. The recitation of these steels is merely illustrative of the type of materials suitable for use in connection with this invention but the invention is not to be considered in any way limited to such materials. For the spacer-expander, as illustrated in Figs. 1–5, the ribbon of material is first passed through suitable punching or blanking equipment to form the slots **12**. Preferably, care is taken in this operation to assure clean severance of the metal, eliminating burrs and rough edges which could become accumulation points for carbon or stress concentration points which might lead to accelerated fatigue failure.

The slotted ribbon is then passed through crimping dies which form the loops **2** and **2***a*. These dies simultaneously form the rail seats **5**. As the rail seats **5** are formed, the material displaced by the offsetting of the seats is formed into the saddles **8**. The saddles **8** are of such length that they receive all the displaced material.

In this operation, care is taken to avoid the stretching or compressing of the material so that the total length of material in both the inner and outer portions of the expander ring, after it has been formed, remains identical with that of the ribbon of material before processing. Thus, a minimum of internal stress is created in the material. The minor stresses created normally may be relieved easily by low temperature annealing. This type of heat treatment seldom results in distortion and that which occurs is minor. Further, since the material is merely bent or formed and is not caused to flow within the ribbon itself, it may be a high carbon, hard steel. This may eliminate the necessity for post forming hardening by high temperature heat treatment or in the case of non-hardenable materials, by surface hardening processes such as nitriting. The necessity for limiting the ribbon stock to ductile materials is eliminated.

After the crimped or formed ribbon has been stress relieved, it is coiled and cut to ring length. The rails **10** and **10***a* are split and are assembled to the spacer-expander ring simply by seating them over it. While one particular process for forming the ring has been described, it will be recognized that other processes may be used within the scope of this invention so long as they employ the principle of re-positioning the material rather than of causing it to flow within the ribbon itself.

Operation

The expander ring **1** is so designed that, when seated in the ring groove **20** of the piston (Fig. 5) with the rails **10** and **10***a* bearing against the cylinder wall **21**, the expander will be compressed circumferentially, causing circumferential deflection. In so doing, the tabs or terminals **25** at the end of the ring are caused to tightly abut and the circumferential pressure thus created will tend to change the angle of inclination of the legs **3**. Under circumferential compression, the legs **3** will assume a position somewhat more nearly normal to the rails **10** and **10***a*. In so doing, the perpendicular spacing between the ring seats **5** will be increased on opposite sides of the expander, forcing the rails **10** and **10***a* out against the sides **22** of the ring groove. This effects desirable side sealing between the sides of the rails and the sides of the groove. It also accomplishes several other desirable effects.

The firm, steady side pressure exerted by the expander against the rails urges them to seat against the groove sides **22** thus automatically seating the whole piston ring properly in the groove. This action is sufficiently positive that even though the ring is carelessly installed, it cannot tip within the groove but must so seat that the rails are normal to the cylinder walls **21**. This eliminates one of the big problems in the installation of piston rings since a tipped or misaligned ring of this type results in improper sealing and may cause serious damage to the cylinder walls.

The positive side pressure exerted by this expander ring also holds the rails firmly against being tipped as the piston reciprocates with relation to the cylinder walls. This is also important.

A substantial portion of the rail side is supported yet the points of contact are narrow and spaced apart, thus creating a high percentage of openness. This prevents the clogging of the ring due to accumulation of carbon. This, again, is a serious problem in piston rings because highly closed rings tend to clog, interfering with their function and destroying their sealing qualities. Yet sufficient side support must be given the rail to prevent displacement due to its reciprocation along the cylinder walls.

The structure of the rail seats is important for another reason. To maintain effective sealing contact between the rails and the cylinder walls the rails must be free to move radially as they follow the cylinder walls. Accordingly, minimum friction between the rails and the spacer-expander is essential. The small area of the rail contacts **7** is advantageous in this respect. The small area involved facilitates the maintenance of a film of lubricant over the area. The existence of the saddle **8** provides access for the lubricant to the contact areas. In the construction employing the slot **12**, the lubricant supply to the saddle area is improved by the increased ability of the lubricant to flow into the saddle area from the inner side. Further, the slot **12** creates a sufficient passage to permit lubricant to reach the contact areas **7** from the inner edges of the areas.

Because of the design of this spacer-expander ring, the tendency of the rails **10** and **10***a* to tip is positively resisted since the loops cannot decrease in height except by a spreading of the legs **3**. This latter is prevented by the abutment of the ends of the ring. The only other way in which the rails could become displaced is by buckling of the sides **3**. The use of high carbon steels in the making of the expander ring assures sufficient strength in the expander ring to eliminate all possibility of this.

The use of the slot **12** is preferred to the slit arrangement illustrated in Figs. 6 and 7. The slots, since they are formed prior to crimping, may be made of sufficient length to extend a short distance down the sides **3**. They can thus be made to terminate at a point of low stress concentration rather than at a point of high stress concentration.

The radial width of the expander may be increased so that it substantially fills the ring groove **20** with only sufficient space remaining between it and the bottom of the ring groove to account for expansion and contraction as the temperature of the unit varies, and general clearance. By occupying a greater proportion of the depth of the groove, the stability of the piston ring against cocking or tipping is substantially increased.

This design of ring offers an advantage that is not apparent in any rings known at the present time. The trend today is to make the piston rings of larger diameter. With the larger diameter the depth of the piston groove is also proportionately increased. All rings known at the present time experience a decrease in stiffness or a reduction of tension when they are made to fit a deeper groove. The design of our ring overcomes this difficulty. When the ring diameter is increased and the groove depth, consequently, increased, our ring design also increases in tension. As a matter of fact, this design of ring almost automatically maintains a constant unit pressure for any diameter; and this is done without increasing the stresses in the spring.

The shoulders **9** provide positive backing for the rails **10** and **10***a*. When the ring is circumferentially deflected, the tendency of the ring to expand radially causes these shoulders to press against the rails, urging them outwardly against the cylinder walls **21**. Thus, the resiliency of the rails themselves need not be relied upon alone to create good bearing with the cylinder walls. This outward pressure is exerted uniformly all around the ring, assuring an effective seal with the cylinder walls. The use of narrower materials for the rails increases their flexibility and allows them to conform more readily to the cylinder walls. This reduces the required break-in period and assures a tighter fit throughout the life of the piston ring.

From the above it will be seen that this invention provides a piston ring having many of the advantages that other ring designs have attempted to accomplish. Further, it combines these advantages in a single piston ring which is easier to install, of greater efficiency in operation and greater economy in fabrication.

While there has been described a preferred embodiment of this inventioon together with a modification thereof, it will be recognized that other modifications as incorporate the principle of this invention are to be considered as included in the hereinafter appended claims unless these claims by their language expressly state otherwise.

We claim:

1. An annular split expander for a piston ring comprising: said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having an end portion and a pair of legs; said end portions intermediate the radial inner and outer margins thereof being slit; those sections of said end portions radially outward of said slits being offset toward the median line of said expander to form generally U-shaped saddles; a rail contact area on each side of each of said saddles.

2. An annular split expander for a piston ring comprising: said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having an end portion and a pair of legs; said end portions intermediate the radial inner and outer margins thereof being slit; those

sections of said end portions radially outward of said slits being offset toward the median line of said expander to form generally U-shaped saddles; a rail contact area on each side of each of said saddles; the combined lengths of said rail contact area and of said saddles being substantially the same as the length of the adjacent radial inner section of said end portion.

3. An annular split expander for a piston ring comprising: said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having an end portion and a pair of legs; said end portions intermediate the radial inner and outer margins thereof being slit; those sections of said end portions radially outward of said slits being offset toward the median line of said expander to form generally U-shaped saddles; a rail contact area on each side of each of said saddles; the combined lengths of said rail contact areas and of said saddles being substantially the same as the length of the adjacent radial inner section of said end portion; said legs being inclined to said end portions whereby circumferential compression of said expander will cause sideways separation of said seat portions.

4. An annular split expander for a piston ring comprising: said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having an end portion and a pair of legs; said end portions intermediate the radial inner and outer margins thereof being slit; those sections of said end portions radially outward of said slits being offset into generally U-shaped saddles extending oppositely from said loops; the ends of said saddles being depressed from the radial inner portions of said end portions; the length of said saddles being substantially equal to the length of said end portions.

5. An annular split expander for a piston ring comprising: said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having a circumferentially extending slot in its end portion dividing said end portion radially into spaced inner and outer sections the ends of said slots being radiused; said outer section having a pair of rail seats offset from said inner section toward the median line of said expander; a saddle between said seats extending oppositely from said loops.

6. An annular split expander for a piston ring comprising: said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having a circumferentially extending slot in its end portion dividing said end portion radially into spaced inner and outer sections the ends of said slots being radiused; said outer section having a pair of rail seats offset from said inner section toward the median line of said expander; a saddle between said seats extending oppositely from said loops; the combined lengths of said rail seats and of said saddle being substantially equal to the length of said inner section.

7. An annular split expander for a piston ring comprising: said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having a circumferentially extending slot in its end portion dividing said end portion radially into spaced inner and outer sections the ends of said slots being radiused; said outer section having a pair of rail seats offset from said inner section toward the median line of said expander; a saddle between said seats extending oppositely from said loops; the combined lengths of said rail seats and of said saddle being substantially equal to the length of said inner section; the sides of said loops being inclined to said end portions whereby circumferential compression of said expander will cause sideways separation of said end portions.

8. A piston ring assembly comprising: a resilient ex-

pander; said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having an end portion divided circumferentially into an inner section and an outer section; said outer section having a pair of rail seats offset from said inner section toward the median line of said expander; a saddle between said seats extending oppositely from said loops, said saddles being generally U-shaped; a pair of rails, one on each side of said expander; each of said rails seated on the adjacent ones of said rail seats.

9. A piston ring assembly comprising: a resilient expander; said expander having a plurality of generally U-shaped loops; alternate ones of said loops being oppositely directed; each of said loops having an end portion divided circumferentially into an inner section and an outer section; said outer section having a pair of rail seats offset from said inner section toward the median line of said expander; a saddle between said seats extending oppositely from said loops; a pair of rails, one on each side of said expander; each of said rails seated on the adjacent ones of said rail seats; said rails being thicker than the offset of said rail seats from said inner sections; the outer margins of said inner sections forming shoulders bearing against the inner margins of said rails; the sides of said loops being inclined to said end portions whereby circumferential compression of said expander will cause sideways separation of said end portions and of said rails.

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