Nov. 25, 1958 H. WURZEL 2,861,824

RETAINING RINGS

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FIG. 3

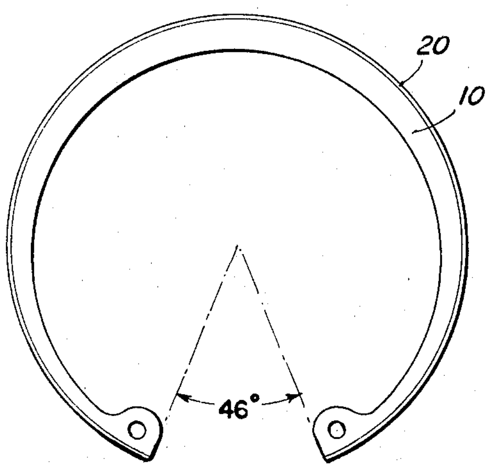
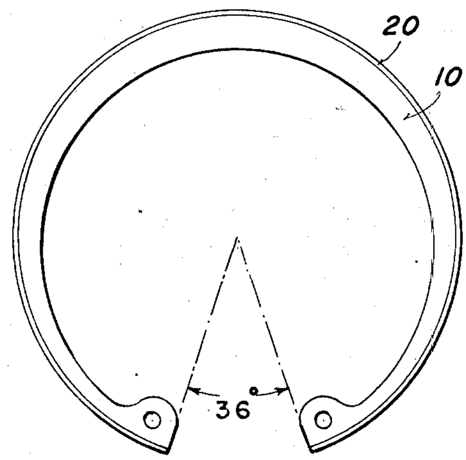


FIG. 4



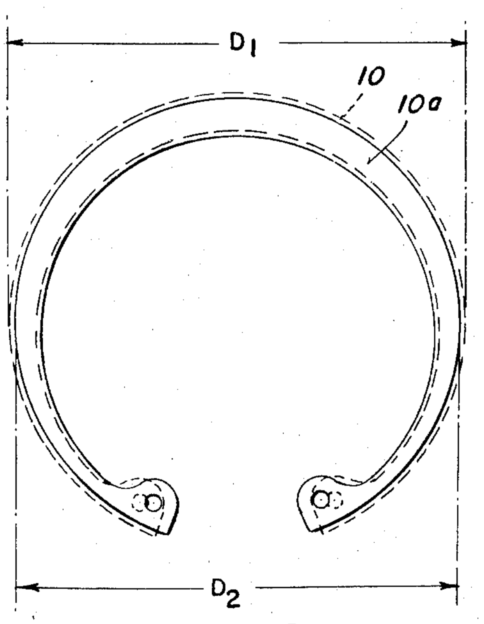


FIG. 6

FIG. 5

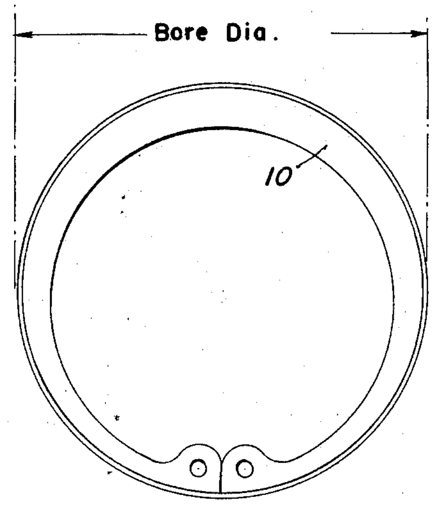


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FIG. 1

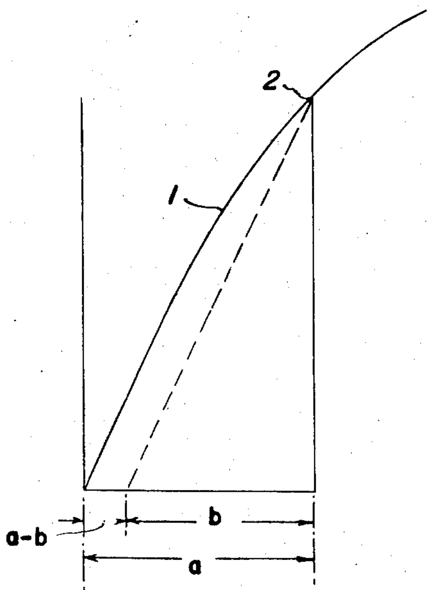


FIG. 2

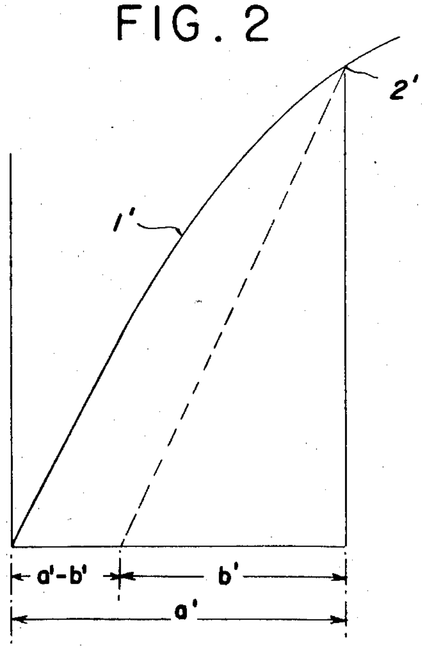


FIG. 7

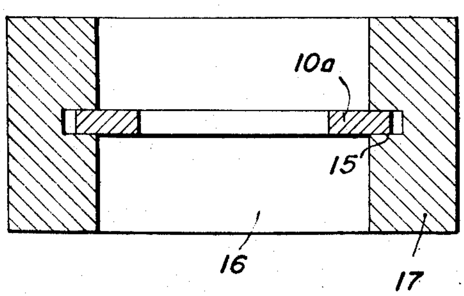
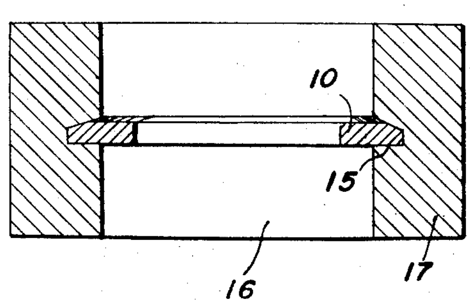


FIG. 8



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RETAINING RINGS

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1 Claim. (Cl. 287—52)

This invention relates to improvements in retaining rings of the type adapted to form an artificial locating shoulder on a shaft or in the bore of a housing, and more particularly to an improved internal retaining ring and an assembly incorporating such a ring.

It is well known from the Heiermann Reissue Patent No. 18,144, dated August 4, 1931, and later patents issued to the assignee of the present application to construct elastically deformable internal retaining rings as a split or open-ended spring-ring body having section height (radial width) which decreases progressively from the middle section to the free ends and with a width of gap between said free ends enabling said rings to be compressed to an outside diameter less than the bore of the housing in which the ring is to be assembled, whereby the ring may be inserted in the bore to the axial position of the groove in which the ring spring-seats itself when released. In the design of such an elastically deformable ring the width of the gap as well as the maximal section height of the ring (which latter as explained in patent to Heimann No. 2,574,034, dated November 6, 1951, and corresponding British Patent No. 685,982, dated January 14, 1953, is derived from the formula

$$\frac{p}{1-p}=\frac{s}{E}\cdot\frac{D}{h})$$

and the depth of the groove in which the ring is to be released have to be so dimensioned that the maximal permissible working stress to which the ring is exposed is not exceeded. At the same time it is highly desirable that this working stress be chosen as high as possible, that is to say, up to the yield strength of the material of the ring, thereby to provide the greatest possible height in the ring shoulder, on the one hand, and in the depth of the groove, on the other.

The aforesaid allowable working stress of such a ring depends on the characteristics of the ring material, especially on its hardness which, in turn, depends on the heat treatment to which it is subjected in being rendered springy. As the heat treatment cannot be maintained absolutely constant, it frequently happens that the ring, even though the width of its gap has been calculated correctly with respect to section height, ring diameter and yield strength of the material, takes on a permanent set when compressed for the first time, after which, on being released, it does not regain its original gap width and original free diameter. Any loss in free ring diameter is of course highly objectionable because it decreases the pressure grip of the ring against the bottom of its groove, and hence the ring possesses less than its theoretical security. Furthermore, it may happen that a ring which has suffered a loss in free diameter as aforesaid, upon being released into the deepest groove for which it is designed, i. e. a groove having the proper calculated depth plus the maximum necessary tolerance, no longer abuts the groove bottom but, instead, seats loosely in the groove, thus failing to make full use of the groove depth in resisting thrust loads. Obviously,

such an undesirable condition is the more frequent the more sensitive the ring material is to heat treatment.

Stated broadly, a main object of the invention is to eliminate the possibility of ring insecurity as results from an internal ring having taken on an unwanted permanent set as aforesaid, both in the ring-to-groove bottom attachment, and also in the ring assembly as a whole.

A more particular object of the invention is the provision of an internal retaining ring characterized, prior to its initial compression into a housing bore, for example, by a free diameter (and a corresponding width of gap) which is larger than the free ring diameter and gap width of a standard elastically deformable ring ascertained by calculation to be the correct diameter and gap width for the particular intended ring application, by an amount such that, consequent to its initial compressing, the ring will take on a predetermined permanent set, but only to the degree that the ring does not become smaller in terms of free diameter and width gap than the calculated or standard ring.

Another object of the invention is the provision of an internal retaining ring characterized as aforesaid and which yields the further advantage that the depth of the seating groove for said ring may be increased to a certain amount as results from the fact that the groove diameter may be enlarged up to the diameter of the ring after it has taken on a permanent set. This is a particular feature of advantage with small rings of .75″ down to about .25″, because such small rings are particularly prone to being permanently set so that, previously, groove depth and thrust load had to be kept within rather small limits.

Yet another object of the invention is the provision of a retaining ring initially having an enlarged free diameter and gap width as compared to a standard calculated ring, as aforesaid, and which is further characterized in that its groove-seating (outer) edge is beveled according to United States patent to Bluth No. 2,509,081, dated May 23, 1950, which with the present application is commonly owned. As is disclosed in said patent, such beveled rings engage their groove more or less deeply, according to the play between the ring and machine part to be located by the shoulder formed thereby, with the maximum play which such beveled rings may take depending on their free diameter which, according to the present invention, reaches the full calculated optimum only after the first compression thereof.

The above and other objects and features of advantage of an internal retaining ring according to the present invention will appear from the following detailed description, in which reference is had to the accompanying drawings, in which—

Fig. 1 is a stress diagram graphically illustrating the conventional (standard or computed) ring dimensioning;

Fig. 2 is a similar view illustrating ring dimensioning according to the invention;

Fig. 3 is a plan view of a ring according to the invention having enlarged free diameter and gap width as compared to the conventional ring, i. e. a ring of the invention prior to being permanently set by its first compression;

Fig. 4 shows the ring of Fig. 3 after having been compressed and released for the first time, as results in the ring taking on a predetermined permanent set;

Fig. 5 shows the same ring compressed before entering the bore of a housing;

Fig. 6 is a comparative view illustrating a ring with conventional dimensions shown in full lines, and a ring with dimensions according to the invention in dotted lines, the latter after the first set;

Fig. 7 is a section through a ring assembly comprising a housing having a bore, a groove in the housing bore, and a conventional ring with permanent set seated in the groove; and

Fig. 8 shows the same assembly but incorporating a ring according to the invention.

First discussing some of the theoretical considerations involved in the design of an improved internal retaining ring of the invention, reference is had to Figs. 1 and 2 wherein numeral **1** (Fig. 1) designates the stress curve of a conventional internal retaining ring dimensioned according to standard calculations which graphically illustrates the stress conditions in the ring plotted against the progressively closing positions of the gap as abscissae, and numeral **2** designates the maximal tension *s* in the middle section of the ring when the gap is completely closed, it being assumed that the yield strength of the material of the ring has been exceeded to a certain degree consequent to full closing of the gap. Upon release of the ring to its groove, the gap of course opens up again, but not to its original width *a*, but, rather, to a lesser value *b*. That is to say, the ring has taken on a permanent set *a*—*b* in its first assembly.

Fig. 2 graphically depicts the stress conditions existing in a ring according to the invention, again against the progressively closing positions of the gap as abscissae. The original gap has a width *a'* greater than gap-width *a* as aforesaid, and it will be noted also that the tension *s'* (designated at **2'**) in the ring middle section is, according to the stress curve **1'**, greater than *s* aforesaid when the gap is completely closed. When released, the ring opens up again, but only to the lesser value *b'*, so that, here again, a permanent set *a'*—*b'* takes place. However, since the stress *s'* is substantially greater than the stress *s*, the new gap width *b'* is also larger than *b* aforesaid. More particularly, according to Fig. 2, said new gap width is approximately equal to the original gap *a* of the conventional (standard) ring illustrated in Fig. 1.

The course and slope of the stress curve **1'** (Fig. 2) also shows that by increasing the original gap of conventional internal retaining rings by approximately 30–50%, and the free diameter of said rings to about 11–12% of their bore diameter as compared with 9–10% for the conventional rings, there is achieved the desirable effect that, after the first set of the herein proposed internal spring retaining rings as results when their ring ends are brought together, the final or residual gap is substantially equal to the original gap of conventional rings. It is to be observed, however, that the gap width may not be increased to an excessive degree because a one-sided distortion may then occur due to the possibility that the ring arms are not perfectly symmetrical.

Translating the above theoretical considerations into ring structure, reference numeral **10** (Fig. 3) illustrates an internal retaining ring according to the invention which, as usual, comprises an open-ended ring body whose inner and outer edges are preferably eccentric, with the eccentricity being in direction such that the ring body has progressively decreasing section height (radial width) from its middle section to its free ends, which latter may be formed as radially-inwardly protruding apertured ears **11**, **12**, substantially as shown. According to the invention such a ring body has a wider gap between its open ends than the gap with which conventional internal retaining rings of corresponding size are provided. That is to say, a ring of the invention is shown to have a gap width of 46° (approximately 12.8% of the ring circumference) prior to its being initially compressed in first assembly thereof as against 36° (or 10% of the ring circumference) with the conventional internal retaining ring as previously designed. However, as seen in Fig. 4, when the present ring is compressed as by bringing its ends together as in Fig. 5, thus to reduce external ring diameter to slightly less than the diameter of the housing bore in which the ring must be inserted and shifted along in assembly, the ring takes on a permanent set which decreases the gap but not to below 36°. Thus, the ring upon being sprung into its groove (provided, of course, that the depth of the groove is such as to permit the ring to release to its free diameter) has gap width corresponding to the gap width of the conventional ring before it has taken on its permanent set consequent to being first assembled in its groove.

Referring to Fig. 6, such compares in one view a ring according to the invention, after it has taken on its predetermined permanent set, with a known retaining ring before the latter has acquired a set consequent to first compression thereof in assembly. As can readily be seen the ring **10** as herein proposed (shown in dotted lines) has, after setting, a somewhat wider gap than that of the conventional ring **10***a* prior to its having been permanently set, and similarly the free diameter D^1 of the herein ring, after it has taken on a permanent set, is also slightly greater than the free diameter D^2 of the conventional ring before it has been set by its first compression.

The functional differences present between the herein proposed and conventional rings in their respective assemblies will also be clear upon analysis of Figs. 7 and 8, in which reference numeral **10***a* (Fig. 7) indicates a conventional ring seated in a groove **15** provided therefor in the bore **16** of a housing **17**. If the ring **10***a* is to have pressure grip on the bottom of the groove **15**, it must not of course take on a permanent set to an amount such that its outer diameter becomes smaller than the groove bottom diameter. Therefore, if such a requirement is to be met, the groove can have limited depth only, because otherwise the permanent set which the ring takes in being assembled in said groove results in its outer or groove-seating edge being spaced from (as indicated) or, at best, having but non-pressure sliding contact with, the bottom of the groove **15**.

But if the outside diameter of a ring upon the latter being compressed in the bore **16** and released to the groove **15** is caused to remain as large as the outside free diameter of the conventional ring **10***a* before being assembled in said groove, the ring will pressure-grip itself against the bottom of a groove having full calculated depth. Such is intended to be illustrated in Fig. 8, wherein a ring **10** corresponding to the Fig. 4 ring is full-seated in the groove **15**. That is to say, the ring initially had diameter and gap width larger than calculated for the yield strength of the ring material and/or the depth of the groove **15** but it has taken on a permanent set in amount as effects reduction in said gap width and a corresponding reduction in said ring diameter to values resulting in the ring **10** seating in the full-depth groove **15** as calculated for the particular assembly. This means that the ring **10** has greater security than the ring **10***a* and also that it makes full use of the optimum calculated groove depth in resisting thrust loads.

The following numerical comparisons between the conventional and the present improved internal retaining rings are also offered as an aid in further disclosing the invention. Whereas the conventional ring with progressively decreasing section height has a gap width of approximately 36° (10% of the ring circle) and a section height calculated according to the yield strength for the particular section height, the improved ring of the invention has, for the same section height, a gap width of approximately 45–55° (or approximately 12–15% of the ring circle), so that in fully closing the ring the yield strength at the middle section of the ring is considerably exceeded. The free outer diameter of the improved ring according to the invention is correspondingly larger than the free diameter of the conventional ring, i. e. by about 2% for the stated gap width. That is to say, that whereas the original (free) diameter of the conventional ring exceeded the diameter of the housing bore by 9–10%, thus being approximately 1.1 of housing bore diameter, the original (free) diameter of the improved ring exceeds the housing bore diameter by 11–13%, or approximately 1.12+ of said housing bore diameter.

Preferably, the outer or groove-seating edge of the ring is beveled as at 20 in the manner disclosed in the commonly owned Bluth et al. Patent No. 2,509,081. As explained above, beveled rings according to said patent seat in their grooves more or less deeply in accordance with the play between the ring and the machine part being located by the ring, with the maximum play which the beveled ring may take up depending on its free diameter. Since according to the invention the free diameter of the ring 10 reaches its full calculated optimum upon the ring being first set, beveling of its groove-seating edge according to said Bluth et al patent enables said ring to take up a greater amount of end play than the conventional ring whose free diameter is reduced from its calculated optimum consequent to the first setting thereof.

Without further analysis, it will be appreciated that the improved internal retaining ring and assembly utilizing same as herein disclosed achieves the desirable objectives therefor outlined in the foregoing. However, as many changes could be made in carrying out the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

An internal spring retaining ring adapted for assembly in a groove provided therefor in a housing bore and there-

upon to form an artificial shoulder for axially locating a machine part in said bore comprising an open-ended ring body of spring material having a gap between its open ends enabling said ring body to be compressed in assembly, the section heights of the ring body decreasing progressively from its middle section to substantially its free end whereby the ring maintains circularity when compressed, the outer free diameter of said ring being approximately 1.12+ of the housing bore diameter and the width of said gap being approximately 12–15% of the outer circumference of the ring body, said ring body contracting to an outer diameter slightly less than the bore diameter when its free ends are brought substantially together and upon release following its first such contraction, expanding to an outer diameter which is less than its initial free diameter but substantially equal to the diameter of the circle of the groove bottom, the construction and arrangement being such that in said contraction the ring body takes on a slight permanent set by an amount such that its free diameter after release is not smaller than the initial free diameter of an elastically deformable ring having the same section heights and adapted for assembly in the same housing bore.

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2,560,917 Bebinger ______________ July 17, 1951

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