UNITED STATES PATENT OFFICE

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WORKHOLDER FOR PISTON RING
HEAT-TREATMENT

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In United States Letters Patent to Harry M. Brannberry, Reissue No. 23,014, there are disclosed piston rings formed of the steel alloy known as "Nitralloy N" which has substantially the composition .20-.27% C, .40-.70% Mn, .30 max Si, 1.10-1.40% Al, 1.00-1.30% Cr, .20-.30% Mo, 3.65-3.75% Ni, and the balance Fe. In one step of the manufacture of such rings they are heated in a nitrogenating atmosphere and, because of the nature and properties of the steel alloy, they grow in size. This growth is difficult to control and, unless properly controlled, causes the rings to warp and become irregular in contour, thus entirely ruining them.

My invention relates to the manufacture of such piston rings and has had for its principal object the provision of an apparatus for use in the manufacture of one or a plurality of such piston rings which will so hold the ring or rings during the heat treating operation as to control the radial pressures at the ends of each ring, whereby all growth of the ring during heat treating takes place in a direction away from the axis, i.e. radially outwardly thus permitting and causing the manufacture of a ring which is perfectly circular when in closed, operative position within a perfectly circular cylinder and exerting the desired radial pressure characteristics and which is not warped or otherwise deformed.

Other more particular objects, advantages and use of my invention will become apparent from a reading of the following specification taken in connection with the accompanying drawings which form a part thereof and wherein:

Fig. 1 is a broken away sectional view in elevation of a preferred form of furnace fixture especially adapted for practicing my improved nitriding method;

Fig. 2 is a plan view of the fixtures shown in Fig. 1;

Fig. 3 is an enlarged view showing to advantage the important manner in which the floating feather assembly cooperates with the free ends of the ring, including the positioning of the fulcrum or pivotal portions of the feather on the neutral axis of the ring to produce a ring having generally uniform radial pressures;

Fig. 4 is a view similar to that of Fig. 3, but showing a modified floating feather assembly having the pivotal supporting portions thereof engaging the opposed terminal surfaces of the ring at a position radially inwardly of the neutral axis of the ring, for producing a ring having low circularity and correspondingly low point pressures; and

Fig. 5 shows still another modified floating feather assembly having the pivotal supporting or fulcrum portions engaging the opposed terminal faces of the ring at positions radially outwardly of the neutral axis of the ring for producing a ring having high circularity and correspondingly high point pressures.

Generally speaking, a plurality of split rings 10 are arranged for support on base 11 and are held in engagement with each other and with the base by means of a weighted cover 12. This cover 12 functions to hold the rings 10 sufficiently tightly or snugly to prevent distortion of the flat sides thereof out of their normal plane while at the same time providing for axial movement thereof, which results from the growth of Nitralloy N rings. This pressure is sufficiently light to permit of the thorough penetration of the nitriding gases to all surfaces of the rings with the result that the thickness dimension of each of the rings gradually increases, depending on the length of time to which the rings are subjected to the nitriding atmosphere. Moreover, prior to nitriding and assembly in the fixture, the rings are provided on both sides with a surface of desired roughness to insure free access of the nitriding atmosphere to all surfaces of the ring so that all surfaces are substantially uniformly treated to achieve optimum radial characteristics and flatness. In practice, I have found that very satisfactory results are obtainable where 100 rings are included between the base 11 and the cover 12, and the cover given a weight of the order of from six to ten pounds. For example, I have successfully nitrided and shaped two Nitralloy N rings each having an outside diameter of 6.125"$, a thickness or width of 0.070"$ and radial dimensions of .150 and .170 inch respectively at the beginning and end of the nitriding process. It will be apparent that the cover member 12 may be held in the proper pressure engagement with the rings 10 by means of a spring instead of a weight, if so desired. However, I have found that the weighted cover arrangement is simple and gives particularly satisfac-
The thing of critical importance is the provision of means for holding the rings in snug sidewise engagement while at the same time allowing for the increase of thickness due to growth resulting from the nitrinding process and avoiding increasing the side pressure on the rings.

For the very important purpose of effecting the optimum shape or contour of the cylinder wall engaging surface of the ring, I have provided a special ring end control assembly indicated generally at 15 for properly spacing and controlling the terminals or free end portions of the ring during the nitrinding heat treatment. This end control assembly 15 functions to apply equal and tangential pressure to the spaced ends of the ring at the optimum positions of force application, while at the same time functioning to permit free floating of the ring ends about the positions of force application during the nitrinding heat treatment, and in addition provides for the radial outward movement of the spaced ends resulting from the elongation of the ring due to the growth thereof. The ring is thus relatively free to assume its optimum shape since the terminals thereof are truly floated by the control assembly 15.

Ring and control assembly 15 includes essentially a spacing feather 16 formed, on the opposite terminal portions thereof, with a pair of pivots or fulcrums 17, 17a preferably effecting line contact with the opposed terminal faces 19, 19a of the ring. This line contact extends generally parallel to the principal axis of the ring and is given a selected relative location with respect to the neutral axis 21 of the ring. In the case of the form of feather shown in Figs. 1 through 3, pivots 17, 17a are coincident with the neutral axis 21 of the ring to produce a circular ring terminal area resulting in substantially uniform radial pressures when confined to a cylinder. Located is spaced relation from fulcrums 17 and 17a are ring positioning shoulders 22, 22a for engaging and properly locating the inner periphery of the ring. Feather 16 is formed on the backside thereof with a guide channel 23 cooperating with a complementary guide 24 mounted on base 11 and providing for radial outward movement of feather 16 as elongation takes place in rings 10 resulting from the growth of the Nitralloy. It will be noted that a liberal tolerance is provided between the guideway 23 and the guide 24 in order to eliminate rigidity and provide for a true floating relationship. In addition, at symmetrically spaced positions there are provided guides 24a, 24b and 24c corresponding to guide 24 and cooperating with the inner periphery of rings 10 to assure that the rings are aligned in the pile or stack. With the ends of the rings in engagement with the feather there is a normal clearance or tolerance between the inner periphery of the rings and the respective guides 24a, 24b and 24c of the order of the .003" to .005", which has been found to be adequate provision for the necessary movement of the ring in taking the ultimate shape thereof due to the heat nitrinding treatment thus avoiding any influence on the newly assumed shape of the rings.

The guides 24a, 24b and 24c may be fastened to base 11 in the requisite adjusted position therefor for the particular size of ring being treated by means of suitable bolts 26. Radially extending guideways 27 are provided for facilitating the radial adjustment of guides 24, 24a, 24b and 24c.

Referring now to Fig. 4, it will be noted that the modified form of ring end control assembly 115 differs from that of Fig. 3 principally in the location of pivotal supports or fulcrums 117 and 117a. In this form of feather the fulcrum supports and spacing portions 117 and 117a are so positioned that with shoulders 112 and 112a in engagement with the inner peripheral surface of ring 10 the fulcums contact the ring inwardly of the neutral axis 121. The result of positioning the fulcums radially inwardly of the neutral axis 121 is to produce a finished ring having a low circularity including corresponding low point pressures. The exact distance of offset between the fulcums and the neutral axis can best be determined experimentally by trial and error, and will be controlled by the amount of point pressure desired, the same increasing as the offset distance relatively inwardly is increased.

Referring now to Fig. 5, it will be noted that the modified form of ring end control assembly 218 differs from that of the above figures in the location of the pivotal supports or fulcrums 217 and 217a. In this form of feather the fulcrum supports 217 and 217a are offset radially outwardly with reference to the neutral axis 221, with the result that there will be produced a ring having high circularity including correspondingly higher point pressures. As in the case of Fig. 4, the exact amount of offset can best be determined experimentally by trial and error method, the controlling factor being the value of point pressures desired, the same increasing as the amount of the offset is increased radially outwardly. Shoulders 222 and 222a function, as in the case of the above figures, to correctly position the inner periphery of the ring in order that the fulcums 217 and 217a will properly engage the inner terminal surface of the ring at the selected offset position.

While only certain ranges of positive point pressures are particularly applicable to internal combustion engines of current design, the several modifications above described clearly bring out the very fine and precise control over all forms of point pressure made possible by my improved arrangement including the spaced fulcums and their selected positioning with reference to the neutral axis of the rings.

In practicing the present invention, the fixtures of rings to be treated, which are initially circular in contour, are first installed in the fixture in the manner disclosed in Figs. 1 and 2, and with an end control assembly positioned between the spaced ends of the rings, this assembly being selected in accordance with the desired ring end characteristics including point pressures. As an example, I have successfully nitrinated and shaped Nitralloy N rings having an outside diameter when closed of 6.125", a thickness of .070" and radial dimensions of .150" and .170" respectively, spreading the ends thereof between the fulcums 217, 217a of a feather 215 separated by a distance of approximately 1.25" and 1.5" respectively, these fulcums being disposed radially outwardly of the neutral axis 221 approximately one-quarter of the distance between the neutral axis and the outer peripheral surface. This distance between fulcrums may, of course, be varied within the elastic limit of the piece to provide the particular radial pressure characteristics desired.

The complete assembly including the rings carried therein is exposed to a heat treatment in a
nitriding atmosphere for a selected period of time of the order of thirty to forty hours during which the rings are subjected on all the surfaces thereof to the nitriding atmosphere. I have found it to be especially advantageous to limit the nitriding temperature to a value considerably below the critical temperature of the Nitralloy N; which critical temperature is about 1300° F. More specifically, I have found that a range of temperatures between 950° to 1025° F. produces very satisfactory results. This is approximately 300° below the critical temperature required to completely normalize Nitralloy N. By the phenomenon that will be referred to as precipitation or dispersion hardening, there results a core having great hardness and high elastic limit surrounded by a case perfectly blended to the core through a transition zone of appreciable thickness. The entire section is sufficiently stress relieved during the nitriding cycle to effect a fundamental shaping of the ring, including the incorporation therein of radial point pressures held within very close limits. This dispersion hardening occurs in this relationship to temperature range and includes a gradual increase in the physical properties during the heating operation, it being noted that Nitralloy N is the only known steel possessing this very important characteristic. The physical properties of the core will increase from 28 to 30 Rockwell C to 39 to 44 Rockwell C with an accompanying tensile strength of the order of 200,000 to 250,000 p.s.i. During the time that the ring is absorbing the ammonia gases and is growing in length as well as in other dimensions, the piece becomes sufficiently stress relieved to permit it to assume the requisite fundamental double parabolic shape while freely floating about the end control assembly. This end control assembly is further effective, as above pointed out, to control the radial pressure pattern of the finished ring within close limits to meet any engine requirement by virtue of the fact that the tangential pressure is applied along localized lines extending generally parallel to the major axis of the ring and having a selected position of contact with the inner terminal faces of the ring ends with reference to the neutral axis of the ring.

It will thus be seen that rings of Nitralloy N steel can be mounted in my improved fixture and the ends thereof controlled by the floating feather with just enough weight upon their sides to hold them in close relationship while making ample provision for nitriding atmosphere penetrating to all surfaces thereof, with the result that a ring is obtained with more or less neutral conditions when removed from the fixture, the same being double parabolic in shape. This conforms with the fundamental law of stress, the round ring having the ends thereof spread apart and the feather or spacer inserted therein, being careful to stay within the elastic limits of the ring material. It will also be noted that the rings are unconfined exteriorly during the nitriding process and are thus permitted to grow without restraint, the floating feather exerting the aforesaid control and permitting a true floating relationship to exist.

By virtue of this phenomenon of dispersion hardening, it is believed that when permitting the ring to float freely during nitriding, the stress that is built up from opening the ring will be properly readjusted and relieved. By subjecting the rings to a nitriding heat, including particularly limiting the temperature to an appreciable value below the normalizing temperature of Nitralloy N, there results a setting of the ring to the desired double parabolic shape. The rings will have imparted thereto substantially the same free joint opening as the spacing between the fulcrums on the feather.

While I have disclosed my invention in connection with certain specific embodiments thereof it will be understood that this is by way of example rather than limitation, and that the scope of my invention is to be defined by the appended claims.

I claim:

1. A fixture for supporting and tensioning a split piston ring formed of an alloy having the composition 0.20–0.27% C, 0.40–0.70% Mn, 0.30 max Si, 1.10–1.40% Al, 1.00–1.30% Cr, 0.20–0.30% Mo, 3.25–3.75% Ni and the balance Fe, during heat treatment thereof in a nitriding atmosphere, comprising means for engaging the opposite side faces of the ring to support it, means adapted to be disposed between the ends of the ring to hold them apart and tension the ring and having edges respectively adapted to engage the end faces of the ring approximately perpendicularly to the opposite side faces thereof and other parts respectively adapted to engage the inner wall of the ring adjacent the end faces thereof, and means for preventing radial inward movement of said ring-tensioning means beyond its position in the un-heated condition of the ring while otherwise permitting free movement thereof.

2. A fixture for supporting and tensioning a split piston ring formed of an alloy having the composition 0.20–0.27% C, 0.40–0.70% Mn, 0.30 max Si, 1.10–1.40% Al, 1.00–1.30% Cr, 0.20–0.30% Mo, 3.25–3.75% Ni and the balance Fe, during heat treatment thereof in a nitriding atmosphere, comprising means for engaging the opposite side faces of the ring to support it, and means adapted to be disposed between the ends of the ring to hold them apart and tension the ring and having edges respectively adapted to engage the end faces of the ring approximately perpendicularly to the opposite side faces thereof and other parts respectively adapted to engage the inner wall of the ring adjacent the end faces thereof.

3. A device for holding apart the ends of a split piston ring formed of an alloy having the composition 0.20–0.27% C, 0.40–0.70% Mn, 0.30 max Si, 1.10–1.40% Al, 1.00–1.30% Cr, 0.20–0.30% Mo, 3.25–3.75% Ni, and the balance Fe, during heat treatment thereof in a nitriding atmosphere, comprising a body having identical ends adapted to engage the opposite end faces of the ring, each of said ends having an opening therein which in the operative position of the device between the ends of a piston ring extends through said body in a direction parallel to the axis of the ring and which is defined by an inner surface and an outer surface which is spaced from the inner surface in a direction away from the axis of the ring, the outer edge of said inner surface being adapted to provide a support for the inner wall of the ring adjacent the end face thereof, and the outer edge of the outer surface being adapted to engage the end face of the ring.

4. A device according to claim 3, in which the inner surface of each end opening of said body is longer than the outer surface in a direction parallel to a line extending between the ends of the ring whereby the outer edge of each of said
inner surfaces provides a support for the inner wall of the ring adjacent the end face thereof. 5. A device according to claim 3, in which said body has an inner face which is adapted to be positioned toward the axis of the ring when the device is in operative position between the ends of a piston ring, said inner face having a recess therein adapted to receive a fixed part of less width than said recess to prevent radial inward movement of said body beyond its position in the un-heated condition of the ring while otherwise permitting free movement thereof.

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