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METHOD OF PRODUCING PISTON RINGS

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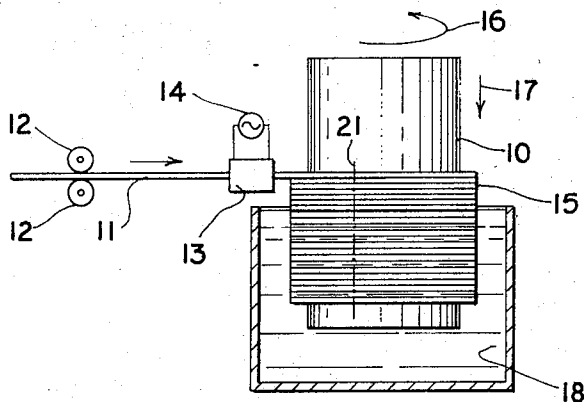


Fig. 1

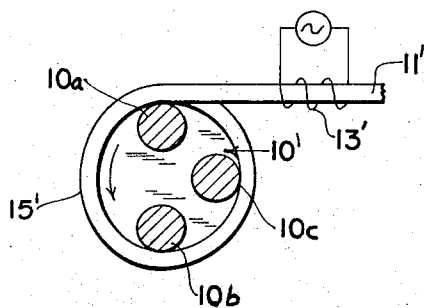


Fig. 2

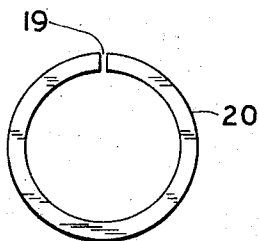


Fig. 3

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METHOD OF PRODUCING PISTON RINGS

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ABSTRACT OF THE DISCLOSURE

Method of producing piston rings wherein a coil body is formed by helically winding a plurality of successive turns of a steel wire having a generally rectangular cross-section on a support, the wire having substantially the following composition: carbon 0.3 to 1.5% by weight, chromium 1.0 to 25.0%, molybdenum 0.5 to 4.0% by weight and vanadium 0.1 to 2.0% by weight, the balance being substantially entirely iron; thereafter the wire is induction-heated upon the support to a temperature above the alpha-iron/gamma-iron transition temperature of said wire, is oil-quenched on the support to cool the body and is separated into turns by slitting of the coil in a generally axial direction.

The present invention relates to a method of producing metallic sealing elements of the type adapted to surround a slidable body while in sealing relationship with a juxtaposed member and, more particularly, to piston rings and the like.

In general, annular sealing elements of this type must have a well-defined and substantially uniform distribution of radial pressure to avoid undue wear of the relatively shiftable bodies as well as a high heat resistance and a considerable wear resistance. These characteristics are particularly important in piston rings adapted to be used in internal-combustion engines and the like, wherein they are subjected to high temperatures, high-velocity sliding motion and various bending and compressive stresses. It is thus essential that these elements be shape-retentive in their stationary states as well as during motion.

Heretofore piston rings and the like were produced by coiling a steel wire which was then cut and tensioned or stressed by interposing a spacer between the ends of the ring. The dimensions of the latter were then fixed by a heating treatment. The radial-pressure distribution of a ring produced in this manner was not wholly satisfactory. Difficulties were also involved in the use of noncircular forms about which the wire was wound by earlier techniques. For example, deformation of a highly resilient wire around the form was unable to overcome the tendency of the wire to spring back into its original condition unless high tempering temperatures were employed. These temperatures almost invariably resulted in substantial distortion of the ring.

It is an object of the present invention to provide an improved method of producing annular sealing elements and, particularly, piston rings of the aforescribed character which can be produced in a simple and inexpensive manner.

The present invention is based upon the discovery that, to a large measure, the composition of a steel wire or strip employed in the formation of a sealing element or piston ring will determine the suitability of the forming technique. More particularly, it has been found that an annular sealing ring can effectively be produced by winding a steel wire of suitable composition around a form, which can be a mandrel or a known three-roll coiling device in a plastically deformable state. This winding operation is followed by rapid hardening of the wire on the form to

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produce a coil body, the quick-hardening step preferably being carried out by rapid oil quenching immediately after the winding step. The turns of the coil body can then be severed therefrom (e.g. by axially slitting the coil) whereupon the individual rings with well-defined gaps can be subjected to an annealing step at a temperature much lower than the temperature employed for winding without distorting the ring to relieve any residual stresses and to increase its heat strength and wear characteristics. In addition, it is desirable, according to the invention, to case-harden the individual rings in a nitrogen atmosphere before the grinding and lapping thereof.

The apparatus for producing the rings may thus comprise induction-heating means for raising the temperature of the wire to one in which the latter is in a plastically deformable state the oil-quenching means being provided along the path of winding just forwardly of the heating means at the coil form.

An essential feature of the present invention resides in the use of a steel composition which is characterized by a carbon content between substantially 0.3 and 1.5% by weight, with the steel being heated to a temperature above the alpha-iron/gamma-iron allotropic transformation temperature. The latter generally lies above 750° C., although temperatures as high as about 1100° C. can be employed for steels with the higher carbon concentrations. Preferably, however, the heating temperature is upwards of the Ac₃ level (i.e. the Ac₃ temperature level upon a rise in temperature) or about 900° C.

Preferably, the steel also contains between about 1.0 and 24.0% chromium, 0.5 to 4.0% molybdenum and 0.1 to 2.0% vanadium, the balance being substantially entirely iron. If it is desired to increase the heat resistance of the ring, I have found that addition of about 1.0 to 5.0% nickel and/or 1.0 to 10.0% tungsten will produce optimum results. As a consequence of the rapid quenching the ring may comprise a large austenitic component and is quite adaptable to nitrogen case-hardening.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a diagrammatic view of an apparatus for producing piston rings according to the present invention;

FIG. 2 is a cross-sectional view showing the formation of noncircular coil bodies from above; and

FIG. 3 is a plan view of the sealing element.

In FIG. 1 there is shown a cylindrical mandrel 10 of noncircular cross-section about which is wound a flattened steel wire or strip 11 of rectangular cross-section. This strip is fed generally tangentially to the mandrel by a feed means, schematically illustrated as a pair of rollers 12, via an induction-heating coil 13 which is positioned just rearwardly of the mandrel 10. The high-frequency alternating current from a source 14 connected across coil 13, raises the temperature of the steel wire, which has the composition previously described, to a temperature above the alpha-iron/gamma-iron transformation temperature. As previously pointed out, the temperature is upwardly of 750° C. and may range to 1100° C. depending, of course, upon the carbon content. When the carbon-content is approximately 0.5% by weight, the heating temperature must be above, say, 800° C. while at a carbon content of 1% the temperature should exceed 850° C. It suffices to point out that optimum results are obtained when the temperature is above the Ac₃ level or about 900° C. for this type of steel. The steel is thus in a plastically deformable state with little or no tendency to spring out of the helical configuration of the coil body 15 formed on the mandrel. The latter can be rotated in the direction of arrow 16 and is displaced axially (arrow 17) into a bath 18 of cold quenching oil. The cooling on the

mandrel takes place so rapidly that complete hardening is immediately effective so that the coil body 15 retains its shape without outward spring. Since the mandrel 10 is noncircular, the individual turns of the coil body have the required radial pressure distribution.

The turns of the coil can be severed from the body and simultaneously provided with the necessary radial gap 19 (seen in the connection with the piston ring 20 of FIGURE 3) by an axial slotting operation carried out along the line 21 when the coil is still on the mandrel. Alternatively, the coil body 15 can be removed from the mandrel and cut out along markings which have previously been applied thereto along, say, line 21. To further improve the thermal and wear resistance of the hardened piston ring 20 thus produced, it can be subjected to an annealing process which can be carried out at exceptionally low temperatures. To obviate any possibility of distortion, the annealing process can be effected, for example, at a temperature on the order of several hundred degrees C. and even below this if prolonged periods are used. The annealing process can, however, be carried out in the course of a few hours at the most, if so required. Pressure should be applied to the ring in order to insure that it lies flat during the annealing step since it has a helical curvature imparted thereto during the winding step. A piston ring produced in accordance with this method will generally not require any finishing operation along its inner surface (i.e. that juxtaposed with the mandrel) so that only the usual grinding of its planar upper and lower surfaces in addition to a honing of its periphery need be carried out.

In FIG. 2 there is shown an arrangement wherein the coil body 15' is produced by winding the steel strip 11' helically about a support 10' consisting of three angularly but nonsymmetrically spaced rollers 10a, 10b, 10c so that a noncircular helix is formed. An induction coil 13' can be provided to heat the strip as it is wound upon the support.

The invention is believed to admit of many modifications within the ability of persons skilled in the art, all these modifications being considered included in the spirit and scope of the appended claims.

I claim:

1. A method of producing piston rings which comprises the steps of inductively heating a steel wire having the composition: carbon 0.3 to 1.5% by weight, chromium 1.0 to 2.5%, molybdenum 0.5 to 4.0% by weight and vanadium 0.1 to 2.0% by weight, the balance being substantially entirely iron to a temperature above the alpha-iron/gamma-iron transformation temperature of the steel; winding the inductively heated steel wire around a mandrel at a temperature above the alpha-iron/gamma-iron transformation temperature of the steel; cooling the wire on the mandrel by quenching; and removing the cooled wire from said mandrel.

2. The method of producing piston rings which comprises the steps of inductively heating a steel wire having the composition: carbon 0.3 to 1.5% by weight, chromium 1.0 to 2.5.0%, molybdenum 0.5 to 4.0% by weight and vanadium 0.1 to 2.0% by weight, the balance being substantially entirely iron to a temperature above the alpha-iron/gamma-iron transformation temperature of the steel; winding the inductively heated steel wire around a mandrel at a temperature above the alpha-iron/

gamma-iron transformation temperature of the steel; cooling the wire on the mandrel by quenching; removing the cooled wire from said mandrel in the form of solid rings; and case-hardening the ring thus formed in a nitrogen atmosphere.

3. A method of producing piston rings comprising the steps of forming a coil body by helically winding a plurality of successive turns of a steel wire having a generally rectangular cross-section on a support, said wire having substantially the following composition: carbon 0.3 to 1.5% by weight, chromium 1.0 to 25.0%, molybdenum 0.5 to 4.0% by weight and vanadium 0.1 to 2.0% by weight, the balance being substantially entirely iron, induction heating said wire upon said support to a temperature above the alpha-iron/gamma-iron transition temperature of said wire; oil quenching the coil body on said support to cool said body; separating the turns of said body by slitting said coil in a generally axial direction; and annealing the rings thus formed to relieve stress.

4. The method defined in claim 3 wherein the rings are case-hardened in a nitrogen atmosphere.

5. The method defined in claim 4 wherein said composition further includes at least one metal selected from the group which consists of nickel in an amount between 1.0 and 5.0% by weight, and tungsten in an amount between 1.0 and 10% by weight.

6. A method of producing piston rings comprising the steps of forming a coil body by helically winding a plurality of successive turns of a steel wire having a generally rectangular cross-section on a noncircular cylindrical mandrel, said wire having substantially the following composition: carbon 0.3 to 1.5% by weight, chromium 1.0 to 25.0%, molybdenum 0.5 to 4.0% by weight and vanadium 0.1 to 2.0% by weight, the balance being substantially entirely iron; induction heating said wire upon said mandrel to a temperature above the alpha-iron/gamma-iron transition temperature of said wire; oil quenching the coil body on said mandrel to cool said body; separating the turns of said body by slitting said coil in a generally axial direction; and annealing the rings thus formed to relieve stress.

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