

[54] METHOD AND APPARATUS FOR
MANUFACTURING SPLIT RETAINING
RINGS AND THE LIKE

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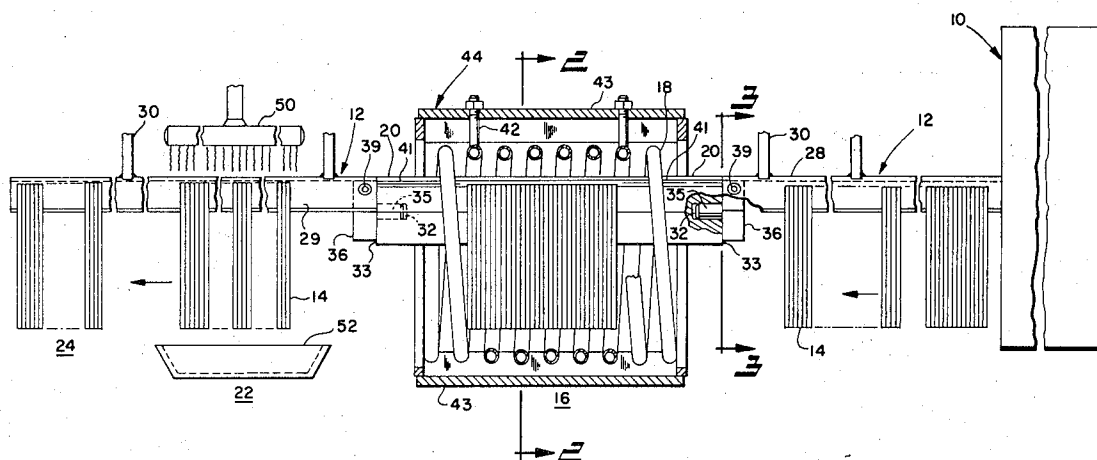
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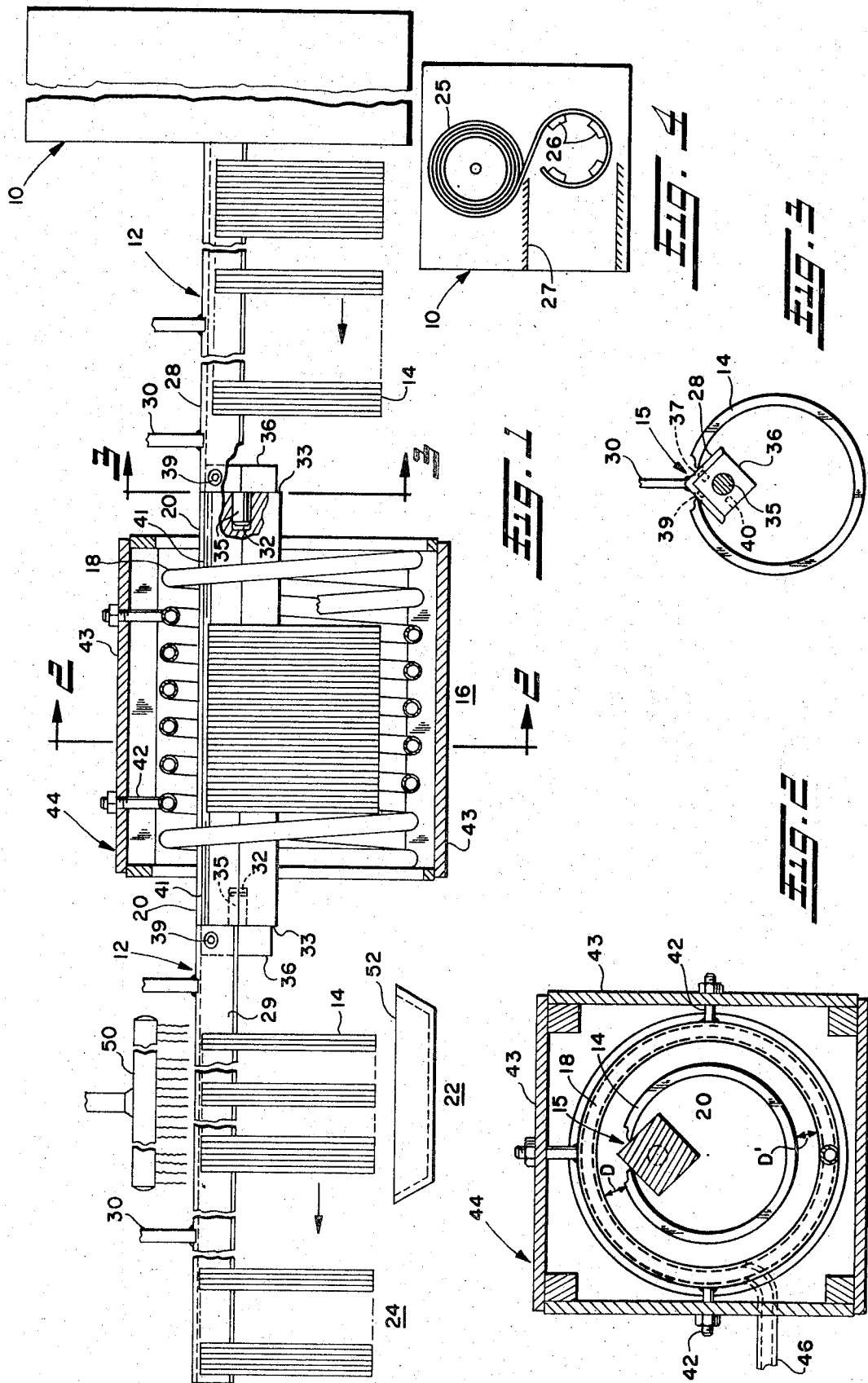
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[57] ABSTRACT

A method and apparatus is provided for manufacturing and packaging split retaining rings quickly and economically. The rings are initially formed from work-hardened, high carbon spring steel wire by a coiling machine and collected side by side into stacks on an especially configured suspended rod such that all ring gaps within each stack are aligned with one another. The ring stack is moved on the rod to an electrically non-conductive portion thereof which is encircled by an electrically conductive coil in spaced relation thereto. Alternating current is supplied to the coil whereby the ring stack is induction heated to a predetermined temperature and thus stress relieved. Each ring stack is then moved along the rod where it is cooled, oiled, inspected and wrapped; all operations being formed with the rings remaining in their stacked position on the rod.

18 Claims, 4 Drawing Figures





METHOD AND APPARATUS FOR MANUFACTURING SPLIT RETAINING RINGS AND THE LIKE

This invention relates generally to a method and apparatus for forming heat treating and packaging split retaining rings and more particularly to a method and apparatus for strain relieving the rings after they have been initially formed.

The invention is particularly applicable to a method and apparatus for processing generally circular, snap rings used in automotive transmissions, bearing retainers, and the like and will be described with particular reference thereto. However it will be appreciated by those skilled in the art that the invention has broader applications and can be used in processing split retaining rings of any shape or like products made from pre-tempered or hard-drawn, high carbon steel.

Heretofore snap rings have been initially formed from high carbon, hard-drawn steel by a coiling machine which bent and sheared the rings to approximate size. The rings were then assembled side by side into stacks and a plurality of stacks placed in a tank where they were degreased. The tank was then placed in a batch-type draw furnace where the rings were stress relieved by being heated to approximately 450° F for 2 hours. After heating the tank was removed from the furnace and the rings allowed to cool and inspected. The rings were then oiled, wrapped in stacks with each stack having the ring gaps aligned therein for customer assembly purposes and the wrapped stacks placed in shipping cartons.

The above described operation was extremely time consuming, both in the sense of the time required for stress relieving and in the time and labor spent in stacking and wrapping the rings. Additionally the furnace and tanks required excessive plant space. Furthermore because the rings shrink to close the ring gap during stress relieving and the shrinkage must be determined by trial and error, an excessive amount of time and wasted material was spent in establishing the heat time and temperature required when any new ring size was desired to be produced. Finally dimensional variations which occur during extended runs in any manufacturing process resulted in an entire batch of rings being scrapped or rejected before the process could be brought within control.

It is thus an object of the subject invention to provide an improved method and apparatus for forming, heat treating and packaging split retaining rings which overcomes all of the above-noted disadvantages while also providing means for continuously processing the rings in a straight assembly-line manner.

In accordance with the invention this object is achieved by providing a suspended, longitudinally extending, especially configured rod closely adjacent at one end to the coil forming machine. A detachable portion of the rod is formed of electrically non-conductive material which passes in predetermined spaced relation through an electrically conductive coil defined by a plurality of turns formed in a helix. The coil is electrically connected to a motor generator which supplies alternating current at predetermined frequency to the coil.

When the hard-drawn wire is initially formed into approximate ring shape by the coiling machine, the rings are automatically longitudinally positioned, side by

side, onto the suspended rod until a stack of rings of predetermined length is achieved. The shape and configuration of the suspended rod is such that all rings in each stack have their ring gaps longitudinally aligned with a portion of the rod which extends above the gap while a portion of the rings extends below the rod. The ring stack is moved along the suspended rod and positioned on the non-conductive rod portion encircled by the coil whereupon the stack is heated by induction until properly stress relieved. Markings may be scribed on the rod for a visual gauging technique to assure control of the process as the ring gap closes to a specified dimension when the rings are heated. The ring stacks are then moved along the rod to an oiling station where the rings are cooled by compressed air and soaked in oil to prevent corrosion. Following this operation, the rings are moved to the end of the rod whereupon selective ones are accurately gaged and the ring stack easily wrapped as an assembly for shipping.

It is thus another object of the subject invention to provide a method and apparatus for forming split retainer rings which utilizes induction heating for stress relieving the rings.

The invention may take physical form in certain parts and arrangement of parts a preferred embodiment of which will be described in detail herein and illustrated in the accompanying drawing which forms a part hereof and wherein:

FIG. 1 is a longitudinal, partially schematic, elevation view of the apparatus employed in the subject invention;

FIG. 2 is an end view of the induction heating arrangement of the subject invention taken along Line 2—2 of FIG. 1;

FIG. 3 is a detailed view taken along Line 3—3 of FIG. 1 showing the construction of a portion of the apparatus; and

FIG. 4 is a schematic illustration of the coiling machine employed with the present invention.

Referring now to the drawing wherein the showings are for illustrating a preferred embodiment of the invention only and not for the purpose of limiting same, there is shown in FIG. 1, a schematic arrangement of a coiling station 10 (FIG. 4), and a longitudinally extending suspended rod 12 adjacent the output end of the coiling station 10 and adapted to receive a plurality of rings 14 spaced side by side in stacks thereon. Positioned along the rod is stress relieving station 16 defined by an electrically conductive coil 18 and an electrically non-conductive portion 20 of the suspended rod. Spaced from the heating station 16 on rod 12 is an oiling station 22 and a wrapping and inspection station 24 on rod 12 is spaced from oiling station 22.

Cold-rolled, work-hardened, carbon spring steel wire of composition between AISI C-1060 and C-1095 is provided for forming the rings 14 of the subject invention by the coiling station 10 (FIG. 4). Alternatively the rings could be formed from pre-tempered, cold work-hardened carbon spring steel or certain grades of stainless steel, all of which shall hereafter be referred to as spring wire. As known by those skilled in the art, coiling station 10 includes spring steel wire wrapped around a spool 25, which wire is pulled from the spool into a coiling machine 26 where the wire is sheared and formed in the approximate shape of a snap ring 14 having a predetermined ring gap 15 between opposed sheared ends. As each ring is formed it is upended and

slides down a mandrel 27 whereby the rings are moved onto the suspended rod 12. The rings collect side by side until a stack of predetermined length is formed which stack is then processed as a unit. In the preferred embodiment, the stack length has been set at 10 inches which has been established to meet end user packaging requirements for ease of handling.

Rod 12 is shown in FIG. 1 to be of three-piece construction and includes a first 90° angle-iron portion 28 adjacent coiling machine 10, a second 90° angle-iron portion 29 at the opposite rod end and an intermediate non-conductive rod portion 20 having a square-shaped, cross-sectional configuration with exterior side dimensions equal to the outside surface dimensions of right angle portions 28,29. Rod 12 is suspended by a plurality of standoffs 30 which are secured only to the apexes of the first and second right angle portions 28,29. The intermediate rod portion 20 has a centrally drilled hole 32 in each end face 33 of the intermediate portion. Each hole 32 receives, in pressed fit relation, a trunnion 35 of a square-shape support block 36 which block is sized to fit within the interior configuration of each right angle portion 28,29 whereby rod portion 20 is secured between angle portions 28,29. Each support block 36 is secured to its respective first and second angle portion 28,29 by a threaded fastener 37 (FIG. 3) applied to one of two countersunk holes 39 drilled on opposing sides of each angle portion 28,29 and received in threaded engagement in one of two threaded bores 40 formed in opposing sides of the rectangular support block 36. The position of the countersunk holes 39 in the angle portions 28,29 and the threaded bores 40 in the support blocks 36 permit the non-conductive rod portion 20 to be rotated in sequential 90° increments so that anyone of its apexes can be placed at the top of the rod 12. Because non-conductive rod portion 20 is preferably constructed of a ceramic material which is relatively expensive, the aforementioned mounting means permits long life of the rod before it must be replaced as a result of wear occurring to its surfaces from sliding contact with the rings 14. Additionally, longitudinally extending lines 41 at predetermined distances may be scribed on selective surfaces of the non-conductive rod portion 20 for a purpose to be explained hereafter.

The stress relieving station 16 of the subject invention is shown in FIG. 1 to encompass the non-conductive portion 20 of suspended rod 12. Extending around a segment of the non-conductive portion 20 in predetermined spaced relation thereto is a hollow conductive copper coil 18 which is formed in a helix of axial length at least as great as the ring stack length. The tubing thickness, the spacing between coils and the inside diameter of the tubing will be specified hereafter. The conductive coil 18 is suspended relative to the bar 12 by a plurality of threaded studs 42 (FIG. 3) brazed to the coil and which extend through and fasten to wall surfaces 43 of a rectangular box-like structure 44. The rectangular structure 44 is an open-ended shield made of electrically non-conductive material such as wood or teflon and is fixed against movement by being fastened to a fixed structure (not shown). Two ends 46 of the conductive coil 18 extend through the rectangular structure 44 and are secured to a motor generator of the radio-frequency type. The coil ends 46 are also fixed to a source of coolant supply, such as wa-

ter, which is circulated through the coil for heat-cooling purposes.

Positioned along a segment of angle portion 29 and remote from stress relieving station 16 is an oiling station 22 and spaced from oiling station 22 at the end of angle portion 29 is a wrapping and inspection station 24. Oiling station 22 is defined by a hollow cylindrical rod 50 which is positioned a predetermined distance above suspended rod 12. At the bottom of hollow cylindrical rod 50 are a plurality of fine holes through which compressed air is blown for cooling the heated ring stack. Positioned a predetermined distance below suspended rod 12 and directly beneath cylindrical rod 50 is an oil trough 52 whereby each stack of rings 14 can be oiled to prevent corrosion prior to wrapping and after being cooled by the air from cylindrical rod 50. Alternatively, oil could be mixed with the air supply from the cylindrical rod 50 and an oil mist sprayed on the ring stack positioned under the rod whereby the rings will be simultaneously cooled and oiled.

OPERATION

The basic operation of the subject invention is to process each stack of rings individually by moving same along suspended rod 12 so that each stack of rings is heated to stress relieve same, cooled, oiled, inspected, and wrapped while the timing of the line is such that as each stack is wrapped another stack is formed in coiling machine 10. Movement of each stack of rings along the rod could be done manually or alternatively could employ U-shaped fixtures made of an electrically non-conductive material such as teflon which would draw each stack of rings along the bar by some mechanical arrangement (not shown).

Following the initial ring forming operation by coil machine 10 as described above and the completion of a stack of rings, the ring stack is moved along the rod to stress relieving station 16. With the ring stack axially centered within the conductive coil 18, current of predetermined frequency and amperage supplied to the coil 18 inductively heats the ring stack to a stress relieving temperature which has been determined to be within the range of 450° to 700°F for the ring material specified above. As the ring is thus heated, the ring gap, which may be of any dimension from one-sixteenth inch to a distance slightly less than the diameter of the ring, closes and the ring shape uniformly contracts while the stresses within the steel are relieved. Each ring stack is thus independently controlled by heating to a predetermined temperature. When this temperature has been reached the coil current is automatically cut off and the ring stack moved to oiling station 22. While the heat time has been accurately predetermined for any given ring size, the rod markings 41 indicating ring gap dimensions serve as a quick visual check means to assure that the process remains in control.

It is believed that the use of induction heating for stress relieving retaining rings which are split is new in the art. During experimentation with this concept, several parameters which are essential to the successful operation of the stress relieving operation and several parameters which effect the optimum design of the process have been recognized.

Of critical importance to the successful induction heating of the ring stack is the fact that the ring gap 15 of each ring within the stack must be aligned with one another so that the gap formed by all the rings in the

stack is not closed by any one ring. It has been found that if the latter situation exists those ring portions which traverse the gap would be heated to a higher temperature than those ring portions which do not traverse the gap and this would result in non-uniform heating. This was found to occur even if the rings within the stack were so orientated that alternative rings would have their ring gaps disposed at top and bottom sides of the rod respectively. Thus even if the output of the motor generator was substantially reduced to prevent the intensive rapid heat buildup within the stack, the stress relieving operation would be unacceptable because those ring portions which traversed the ring gaps would be locally heated excessively. Another critical parameter of the subject invention resides in the fact that an electrically non-conductive material must be interposed between relatively small ring gaps to prevent any tendency of the secondary circuit generated within the ring stack from arcing between the gap. Thus it has been found that if the induced current within the ring arced between the gap which arcing is dependent upon the gap size and humidity, a heating result similar to that occurring from the misalignment of the rings would likewise occur. In connection with the two aforementioned critical parameters, it should be noted that the intermediate portion 20 of rod 12 by virtue of its rectangular shape not only automatically aligns the ring gap 15 of each ring within the stack when the rings are transferred thereto but also is constructed so that its apexes extend beyond the thickness of each ring to prevent any tendency of the induced current to arc over the ring gap. With an electrically non-conductive material interposed between the ring gaps, induction heating without arcing has been accomplished with a ring gap as small as one-eighth inch. With such small ring gaps, a thin strip of electrically non-conductive material such as teflon could be inserted on the bar.

Investigation has also indicated that while uniform heating is obtained simultaneously at the outside and inside diameter of the ring stack, uniform heating at the top and bottom of the ring stack would not occur if the rings are exactly centered within conductive coil 18. Allowances should be made for the gap or open portion of the ring. Thus it has been discovered that the distance from the outside diameter of the ring to the inside diameter of the coil at the top or open portion of the ring designated as "D" in FIG. 2 must be greater than the distance from the outside diameter of the ring to the inside diameter of the coil tubing at the bottom portion of the ring designated as "D'". Furthermore experimentation has indicated that the differential in distances i.e. $D-D'/D$ should be established within the approximate range of 5 to 15 percent. Still another critical parameter is the fact that each ring in the stack must be in side-by-side contact and disposed axially within the conductive coil 18. It has been observed that if a number of rings within the stack were axially separated from the remaining rings in the stack, to in effect give two stacks of rings at different masses, that the heating effect would be different between the "two stacks" even if both "stacks" were disposed entirely within the axial length of the conductive coil.

Those parameters which are believed to effect the optimum design of the induction heating of the ring stack include the output of the motor generator, the time that the ring stack is heated and the construction

of the conductive coil, both in itself and also as the coil construction effects different ring sizes positioned therein. Good stress relieving results having been experienced with the use of a 15 k.v.a. radio-frequency generator with a frequency range between 500—540 Kilo-hertz and a varying amperage draw between $1\frac{1}{2}$ – 4 amps. When such a generator has been employed, it has been found necessary, at times, to employ a dummy ring at each axial end of the ring stack to permit the actual end rings in the stack to be identically heated as those within the stack middle. However it has been found that the use of 20 k.v.a. radio-frequency generator eliminated the need for the dummy rings at the stack ends. With either generator employed it has been found that the stress relieving time of the ring stacks could vary between 5 and 120 seconds depending upon the amperage setting as defined above and the coil construction as will be defined hereafter. Thus the speed of the line is established by the time it takes the coil machine 10 to form a stack of rings. However, it is desired to heat the ring stack to stress relieve over the longer range of the time limit, to assure uniform heat distribution while maintaining gap shrinkage and size variations at a minimum.

Also effecting the heating of the ring stack is the size and shape of the conductive coil. Briefly, the less number of coil turns the more power required from the generator to heat the stack. On the other hand if the number of coils are increased for a given stack length beyond a minimum spacing therebetween, an electrical interference between adjacent coils will occur. Good results have been obtained when the O.D. of the copper tubing employed has been three-eighth inch or alternatively one-half inch with a minimum spacing between turns of one-half inch although it is believed an absolute minimum spacing between coils of one-fourth inch could be employed. Finally the diameter of the tubing effects the heating of the ring stack in that the smaller air gap, the distance between I.D. of the tubing and O.D. of the ring hereinbefore defined as D and D', the quicker the ring stack heats or the smaller the current required to heat the stack. However, this effect is dependent upon the mass of the ring stack within the coil because a smaller ring mass requires less current draw even though the air gap be larger than that for a larger mass ring stack. Thus ring stacks having outside diameters which ranged between $2\frac{1}{4}$ inches and $7\frac{3}{4}$ inches having been adequately heated by a 9 inch I.D. coil with the same radio-frequency generator.

With the establishment of the above-noted parameters as indicated, split retaining rings have been stress relieved as thoroughly and as uniformly as that of the prior art. However, the processing time, the set-up time, the plant space utilized, etc. have been drastically reduced when compared to the old method while the quality control of the entire operation has been markedly improved.

Following the stress relief operation, each ring stack is moved to the cooling or oiling station and then to the packing and inspecting station as hereinbefore noted. Inspection occurs by separating the first and last rings from each stack prior to wrapping and gaging same with "GO" and "NO GO" gages.

The invention has been described with reference to preferred embodiment. Obviously, modifications and alterations will occur to others upon reading and understanding the specification. It is my intention to in-

clude all such modifications insofar as they come within the scope of the present invention.

It is thus the essence of the invention to provide a method and apparatus for forming split retaining rings which employ an induction heating and apparatus for stress relieving the rings.

Having thus defined my invention, I claim:

1. A method for making stress relieved split retaining rings and the like from spring wire comprising the steps of:

permanently forming said spring wire into the shape of said split ring having a gap between opposed ends;

positioning a plurality of said rings into generally vertical side-by-side contact with the gaps on the tops thereof to form a generally horizontally extending stack of rings;

transferring said stack onto a supported horizontally extending rod having an upwardly extending generally inverted "V" shaped projection in cross section for receipt within said gaps for simultaneously aligning each ring in said stack on said rod so that each ring gap is aligned with one another;

moving said stack onto a non-conductive portion of said rod within an electrically conductive coil; and

applying alternating electric current at predetermined frequencies for a sufficient time to said coil to heat said stack of rings to a predetermined temperature whereby said rings are uniformly stressed relieved and said gaps are closed to a predetermined dimension.

2. The method of claim 1 further including the step of visually gaging the closing of said ring gaps by aligning said gaps with horizontally extending markings on said rod.

3. The method of claim 2 wherein the minimum time of heating is at least 5 seconds.

4. The method of claim 1 further including the steps of transferring said stack on said suspended bar to a second station and cooling said stack at said second station.

5. The method of claim 4 further including the steps of

moving said stack to a third station on said rod; wrapping said stack in a protective coating; and removing said stack from said rod.

6. The method of claim 5 further including the step of removing selective rings from said stack and gaging same at said third station.

7. The method of claim 1 wherein said rod is of a generally polygonal cross section and said upwardly extending inverted "V" shaped projection is an upwardly extending corner of said cross-sectionally polygonal rod.

8. The method of claim 7 wherein said rod is of generally rectangular cross section.

9. The method of claim 1 wherein said rod is of generally triangular cross section and said upwardly extending inverted "V" shaped projection is an upwardly extending apex of said triangle.

10. Apparatus for stress relieving a plurality of split retaining rings and the like formed from spring wire, said rings being placed vertically side by side to form a horizontally extending ring stack of predetermined length with the gaps in said rings being oriented to-

wards the top of said stack, said apparatus comprising:

a horizontally extending, suspended rod of non-conductive material having a uniform, horizontally and upwardly extending generally inverted V-shaped projection for receiving a stack of rings suspended on said rod in predetermined orientation with said gaps receiving said projection therein so that the gaps between opposed ends of each ring is aligned with one another;

a conductive coil encircling said rod and said stack of rings in predetermined spaced relation, said conductive coil defined by a plurality of turns formed in a helix and of length at least equal to the length of said stack; and

motor generator means for applying alternating current of predetermined frequencies to said coil for heating said stack of rings to a predetermined temperature.

11. Stress relieving apparatus as defined in claim 10 wherein

the ring gap portion of said stack is positioned further away from the interior of said coil than the ring portion diametrically opposed to said gap portion.

12. Stress relieving apparatus as defined in claim 10 wherein said rod has a plurality of longitudinally-extending scribed lines over selective surfaces thereof for visually gaging the closing of said ring gap during heating.

13. Stress relieving apparatus as defined in claim 11 wherein:

said suspended rod is rectangular in cross section, said projection is an upwardly extending corner of said cross-sectionally rectangular rod, and said rod has a centrally located bore at each axial end face; and

indexing means including a trunnion thereon press-fitted into each bore for rotating said rod in 90° increments.

14. Stress relieving apparatus as defined in claim 10 wherein

intersecting exterior surfaces of said rod define rod apexes and the included angle of said apex being predetermined so that said apex extends beyond said ring gap.

15. Apparatus for forming split-retaining rings and the like from spring wire comprising:

forming means for bending and shearing said spring wire into the shape of said split ring, each split ring having a gap between opposed sheared ends greater than that desired for a finished ring;

a longitudinally extending suspended rod having a stress relief station positioned thereon, said rod having an uniform, longitudinally and upwardly extending apex for receiving said gaps in aligned relation;

said stress relief station defined by said rod having a non-conductive portion extending therealong, a plurality of said rings placed side by side with gap openings aligned positioned on said non-conductive portion of said rod, a conductive coil encircling said non-conductive rod portion and said stack of rings and defined by a plurality of turns formed in a helix, said coil axially extending a distance at least equal the length of said stack of rings, and motor generator means for supplying al-

ternating current to said coil for heating said stack of rings.

16. Ring forming apparatus as defined in claim 15 further including said suspended rod having a cooling station and a wrapping station position thereon and cooling means for cooling said ring stack by compressed air.

17. Ring forming apparatus as defined in claim 16 further including visual gaging means on said non-conductive rod portion for determining the closing of said ring gap during heating.

18. Ring forming apparatus as defined in claim 16

wherein said rod includes

a first right angle portion adjacent said forming means, a second right angle portion at the opposite end of said rod and said non-conductive portion inbetween said first and second portions, said non-conductive portion having a general cross-section configuration with intersecting side surfaces defining apexes and said side surfaces of same dimension as exterior surfaces of said angle portions, said apexes extending beyond the ring gap of said rings in said stack.

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