Oct. 17, 1967 H. R. McKELVIE 3,347,760

METHOD OF ELECTROPOLISHING METALLIC SECTIONS FOR BALLOON CONTROL RINGS AND THE LIKE

Filed March 7, 1967

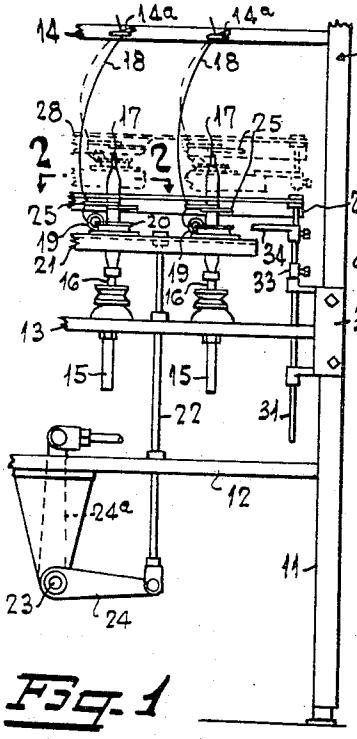


Fig. 1

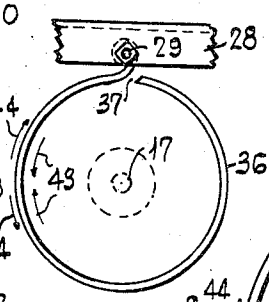


Fig. 2A

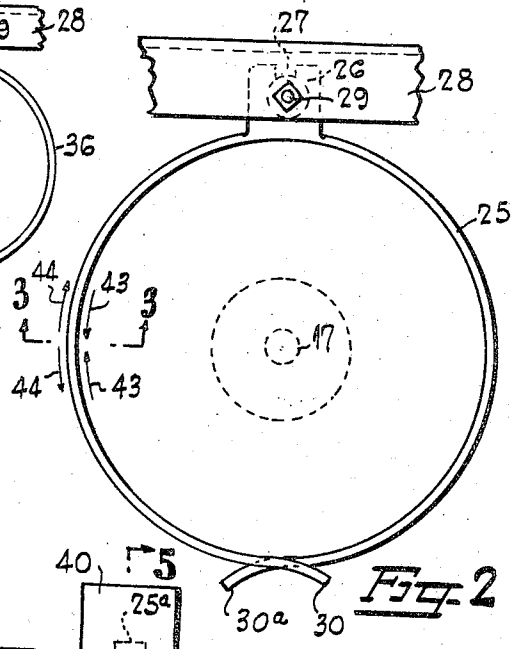


Fig. 2

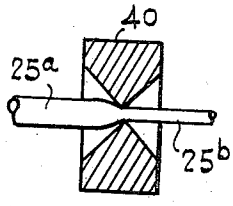


Fig. 5

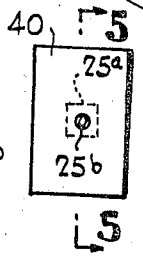


Fig. 4

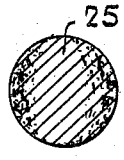


Fig. 3

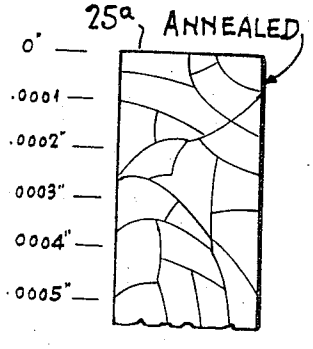


Fig. 6

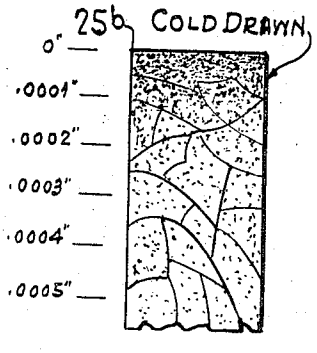


Fig. 7

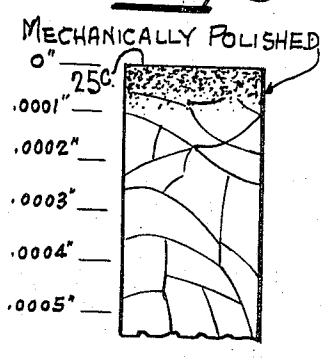


Fig. 8



Fig. 9

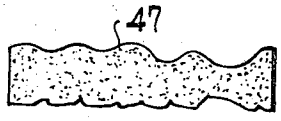


Fig. 10

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METHOD OF ELECTROPOLISHING METALLIC SECTIONS FOR BALLOON CONTROL RINGS AND THE LIKE

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12 Claims. (Cl. 204—140.5)

This invention relates to a method of electropolishing hard drawn metals, such as hardened stainless steel, cold drawn annealed steel, spring wire and the like, wherein the surface particles thereof have been severely damaged during manufacture by the reducing dies, or by the shaping of the reduced metal into an article of commerce, or by both. This application is a continuation-in-part of my copending patent application Ser. No. 361,335, filed Apr. 24, 1964, now U.S. Patent No. 3,316,703 in which a balloon control ring is used as one of the many examples of the present invention. The invention fills a long-felt need, especially where the metal must possess greater resistance to vibration and superior antifriction and wear-resistant properties.

The increasing spindle speeds of modern textile machinery, for example, coupled with highly abrasive fiber strands processed thereby, have introduced difficult friction, wear and vibration problems with respect to balloon control rings against which the strands slide while travelling at high speeds. The result has been a corresponding increase in strand breakage or ends down.

Balloon control rings are formed from wire in annealed condition and then electropolished or otherwise finished. Such rings, however, do not measure up to modern standards of durability, resiliency, resistance to vibration, and antifriction properties. A hard drawn metallic ring which is formed or shaped subsequent to electropolishing loses many essential surface properties on account of the excessive stresses produced on the concave and convex sides during formation. These excessive stresses further damage the surfaces thereby introducing friction, wear and vibratory problems during many uses of the metal.

It is therefore an object of this invention to provide a hard drawn metallic structural section having either a shaped or a linear configuration, and which is devoid of the above problems.

It is another object of invention to provide a metallic section of the class described characterized by greater durability, increased resistance to vibration, and by superior anti-friction and wear-resistant properties.

It is a further object of invention to provide a method of making balloon control rings which are made by first shaping or forming the ring from a drawn spring wire of the required hardness, removing from the outer ring surface the contaminated and severely damaged material resulting from the preceding wire drawing and ring forming steps to thereby expose a roughened but substantially undamaged outer ring surface, and finally electropolishing the roughened outer surface to the desired finish. By adopting this sequence of manufacturing steps, it is possible to avoid the expensive and difficult operation of tempering and hardening the ring after it has been shaped.

It is a still further object of invention to provide a method of making balloon control rings as set forth in the immediately preceding paragraph wherein the roughened outer ring surface is electro-polished by subjecting it first, to a solution which imparts an improved leveling action and then, to a second solution which imparts an improved root mean square, hereinafter referred to as "R.M.S."

Some of the objects of invention having been stated, other objects will appear as the description proceeds when

taken in connection with the accompanying drawings, in which,

FIGURE 1 is an elevation of one end of a spinning frame showing my improved anti-balloon rings mounted thereon;

FIGURE 2 is an enlarged plan view of the anti-balloon ring and taken along line 2—2 in FIGURE 1;

FIGURE 2A is a view similar to FIGURE 2 but showing a slightly modified form of ring;

FIGURE 3 is an enlarged cross-sectional view of the ring and taken along line 3—3 in FIGURE 2;

FIGURE 4 is a view showing a reduced metallic strand emerging from a die during a conventional metal drawing operation;

FIGURE 5 is a sectional view taken along line 5—5 in FIGURE 4;

FIGURE 6 is a sectional view schematically representing the outer surface layer of annealed steel;

FIGURE 7 is a view schematically representing the outer surface of cold drawn annealed steel and showing the deformation produced by the drawing operation at different depths below the surface;

FIGURE 8 is a view similar to FIGURE 7 and showing the deformation produced at different depths of mechanically polished annealed steel;

FIGURE 9 is a schematic representation of the outer surface of the annealed cold drawn steel when etched to remove the most severely damaged outer surface layer, and

FIGURE 10 is a schematic representation of the surface shown in FIGURE 9 after being electropolished.

Referring more particularly to the drawings, the numeral **10** broadly indicates one end portion of a conventional spinning frame comprising a vertically disposed end support **11** and horizontally disposed rails **12**, **13** and **14** extending from the latter. Rail **13** supports a plurality of bolsters **15**, each having a rotatable spindle **16** upon which a bobbin or strand holder **17** is removably mounted. During a spinning operation, a textile strand **18** is drawn downwardly from drafting rolls (not shown), through eyelet **14***a*, underneath ring traveler **19**, and onto the holder **17**.

The traveler **19** is mounted upon a spinning ring **20** concentrically disposed around the holder **17**, said traveler being adapted to slide at high velocities under the influence of strand **18**. Rings **20** are mounted in a horizontally disposed ring rail **21** which, in turn, is mounted for vertical reciprocatory movement relative to holders **17** by means of rod **22** slidably mounted in rails **12** and **13**. Rod **22** is actuated by means of levers **24** and **24***a* on shaft **23**.

The centrifugal force imparted to strand **18** as it moves at high speeds around the holder **17** causes the strand length between eyelet **14***a* and traveler **19** to swing outwardly and follow a path substantially defining the surface of a balloon. Heretofore, various types of balloon control rings have been devised to limit the extent of this outward travel of the strand, some of which resemble the shape of the present invention. With the attainment of higher spindle speeds in modern textile machines, however, such conventional control rings have been found deficient in that excessive strand friction, wear and vibration occurs, resulting in correspondingly greater breakage or ends down.

I have devised an improved balloon control ring **25** which overcomes the aforementioned problems for the reasons stated and in the manner set forth hereinafter.

Ring **25** is a spirally wound wire with opposite end portions **30** and **30***a* thereof overlapping one another in spaced relation to permit insertion of the strand, said overlapping portions being disposed at the front of the spinning frame in an easily accessible position.

The rear portion of ring **25** has a lug **26** integral therewith, which lug is provided with slot **27** (FIGURE 2). The ring **25** is adjustably secured to rail **28** by means of the slot **27** and a bolt **29** whereby the ring may be concentrically positioned relative to holder **17**.

Horizontal rail **28** and the rings **25** mounted thereon are supported for vertical reciprocatory movement relative to holders **17** by means of rod **31** vertically slidable in bracket **32** secured to end support **11**. The rail **28** and rod **31** are shown in lowermost bold-line position in FIGURE 1, at which time an adjustable collar **33** on rod **31** rests upon bracket **32**. The dotted line uppermost position of rail **28** occurs at the same time the spinning rail **21** moves to its uppermost dotted line position, the end portion of rail **21** engaging the laterally projecting end of an arm **34** as the rail moves upwardly, said arm being fixedly secured to rod **31**.

FIGURE 2A shows another type of control ring **36** which may be attached to rail **28** by means of bolt **29**. Ring **36** differs from previously described ring **25** in that all portions thereof lie substantially in the same plane and in the provision of a rearwardly disposed gap or opening **37** for threading the strand rather than a front opening. Rings **25** and **36** are typical of the forms or shapes which may embody the improved properties of the present invention.

In order to overcome the aforementioned problems, the rings **25** and **36** must be made of exceptionaly smooth and strong material. The use of spring steel of high tensile strength possesses distinct advantages over annealed steel because (a) spring steel springs back to its original shape when deformed, and (b) spring steel vibrates less under high pitched vibration of modern textile machinery. The rings are preferably made from stainless steel having a minimum tensile strength of 125,000 pounds per square inch. For austenitic 18–8 stainless steel, it is preferable to use full hard drawn material having a tensile strength ranging between 160,000 and 300,000 pounds per square inch. The core hardness should be between 23 and 56 Rockwell C.

Specifically, a suitable annealed steel **25***a* having an outer surface layer such as illustrated in FIGURE 6 may be employed as a starting material. Material **25***a* is cold drawn one or more time through a metal drawing die **40** (FIGURES 4 and 5) where it is reduced in a well known manner or to a strand **25***b* of smaller cross-section and greater hardness. During the reducting process, internal stresses beyond the elastic limit of the material are built up, especially near the outer surface as indicated at **47** in FIGURE 7. The outer surface is thus severely damaged and the structure of the stainless steel therebelow is changed. It will be noted in FIGURE 7 that the most severely damaged surface is less than .0001" deep as indicated by the density of shading although the grain size is fragmented to considerably greater depth, such as by metallic deformation resulting from rotation, slipping, bending, or fragment twinning of the crystals.

The above-described damaged outer surface, together with adjacent contamination, causes erratic aniodic corrosion when attempting to electro-polish the ring surface (see J. Wulff, Proceedings of Special Summer Conferences on Friction and Surface Finish, Massachusetts Institute of Technology, 1940, pp. 13–21).

The outer surface of cold drawn wire **25***b* is further deformed and fragmented when converted into the shape of a balloon control ring, at which time the inside annular concave periphery of the ring is subjected to excessive compressive stresses beyond the elastic limit of the material as indicated by arrows **43**. Similarly, the outside annular convex periphery of the ring surface is subjected to excessive tensile stresses as indicated by arrows **44**; however, the metallurgical damage to the outer periphery is relatively unimportant since it is not a wearing surface engaged by strand **18**. This further damage resulting from the shaping of the wire into a ring is illustrated in FIGURE 3 by stippled shading of the cross-sectional area.

It is important to note that the surface damage resulting from the ring shaping step alone is sufficient to render the ring unsuitable for its intended purpose, unless the damaged surface particles are removed prior to finishing. By performing or shaping the rings **25** or **36** from an unfinished cold drawn spring wire, rather than a finished wire, the objectionable damage from both the metal drawing and the ring shaping steps can be removed in one operation thereby exposing a rough, but substantially undamaged, outer surface of the proper resiliency and hardness to be electropolished. Moreover, the ring material can be tempered and hardened more easily when in a strand than when shaped into a ring.

The removal or cleaning of the objectionable damaged outer ring surface may be effected by etching and/or abrasive action. An example of a suitable etching solution is commercial muriatic or hydrochloric acid varying in concentration between the limts of 3 and 30%. The shaped rings are immersed in a solution at about 68 degree Fahrenheit for periods ranging from 2 to 10 hours, it being understood that the rate of removal varies with the duration of immersion.

The etching time for hydrochloric acid solutions can be reduced by increasing the temperature, if so desired.

Another type of etch that can be employed is the use of hot electropolishing solution, such as mentioned in the preceding paragraph. Any phosphoric acid, or mixture of phosphoric acid with other etching acid or acids, will etch stainless steel when using concentrations above 15% total acid. These solutions, maintained at a high temperature of approximately 200 degrees Fahrenheit, can etch stainless structural sections or rings more smoothly than the hydrochloric acid solutions. The solutions are effective at room temperature, but the action is so slow that it is not efficient. It is not necessary to apply current during the etching treatment.

The ring or structural section may be electropolished by making it the anode in a suitable solution with current or voltage adjusted to give conditions between etching on one hand and film growth or passivity on the other. The method and solutions in the Faust Patent No. 2,366,712 may be employed for electropolishing the etched or cleaned surface; however, the optimum mixtures which are successful in giving best polishing results are limited. I have one such optimum solution.

75% phosphoric acid
2 to 4% chromic acid
Voltage: 12 to 25
Current density: 1½ to 6 amperes per sq. in.
Temperature: 80 to 290 degrees Fahrenheit
Time: 5 to 20 minutes.

A properly cleaned or etched ring, prior to being electropolished, has an outer surface characterized by roughness, sharp edges and flaws as schematically illustrated in FIGURE 9 by reference character **46**. This rough surface may be electropolished in the above solutions to a satin finish produced at temperatures ranging from 80 to 120 degrees Fahrenheit, or to a bright mirror finish produced at temperatures ranging from 120 to 129 degrees Fahrenheit. The electropolishing removes the roughness and produces a smooth wavy surface finish **47** having a low coefficient of friction (FIGURE 10). Surface flaws and waviness are not critical factors as long as the roughness has been removed. More delicate yarns require the bright mirror finish produced at the higher temperature range.

Where the outer surface of the wire from which the control rings **25** and **36** are to be formed is mechanically polished, the metallurgical damage to the outer ring surface is similar to that produced by drawing, although to a lesser depth as indicated at **25***c* in FIGURE 8.

Likewise, when the mechanically polished wire is shaped into a balloon control ring, further damage will accrue to the outer periphery thereof. The cumulative damage from the mechanical polishing of the wire and from its subsequent formation into a ring can be removed in one operation as previously described to thereby expose a rough but substantially undamaged outer surface to be electropolished.

It has been found that a still better finish can be obtained by using two electropolishing solutions successively to treat shaped rings made from 18–8 stainless austenitic steel or equivalent. These solutions are substantially as given below:

First solution

56% phosphoric acid
7 to 17% chromic acid
Voltage: 12 to 25
Current density: 1½ to 6 amperes per sq. in.
Temperature: 80 to 200 degrees Fahrenheit
Time: 5 to 25 minutes

Second solution

75% phosphoric acid
2 to 4% chromic acid
Voltage: 12 to 25.
Current density: 1½ to 6 amperes per sq. in.
Temperature: 80 to 290 degrees Fahrenheit
Time: 1 to 5 minutes.

The first solution has the advantage of giving better leveling action by decreasing the waviness of the surface; whereas, the second solution gives a better R.M.S. surface finish as a supplement to the first solution. In other words, when using the second solution alone, the waviness causes the R.M.S. reading to irregularly approach 80 to 100 surface finish. When using the two solutions successively, the R.M.S. surface finish can be reduced to 3 or slightly higher.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. That method of making metal articles having a concavo-convex shape which comprises the steps of: forming a cold drawn spring wire of a predominantly ferrous metal composition into a ring while subjecting the inside annular metallic surface particles of the latter to compressive stresses in excess of their elastic limit, removing said excessively stressed particles to expose an underlying rough but substantially undamaged surface, and then electropolishing said underlying surface.

2. The method of claim 1 wherein said articles are balloon control rings for textile strands.

3. The method of claim 2 wherein said metal composition is stainless steel.

4. That method as defined in claim 3 wherein said surface particles are removed by mechanical means.

5. That method as defined in claim 3 wherein said particles are removed by mechanical and chemical means.

6. That method as defined in claim 3 wherein said particles are removed by etching with phosphoric acid.

7. That method as defined in claim 3 wherein said particles are removed by etching with a hot electropolishing acid solution having a concentration above 15%.

8. That method as defined in claim 3 wherein said section has a Rockwell C hardness ranging between 23 and 56.

9. That method as defined in claim 1 wherein said electropolishing step comprises: making said ring surface the anode in a solution consisting of approximately 75% phosphoric acid and from 2 to 4% chromic acid, and passing an electric current of a density of 1½ to 6 amperes and of a voltage of 12 to 25 through said solution.

10. That method as defined in claim 1 wherein said electropolishing step comprises: first, making said ring surface the anode in a solution consisting of approximately 56% phosphoric acid and from 7 to 17% chromic acid, and passing an electric current of a density of 1½ to 6 amperes and of a voltage of 12 to 25 through said solution to impart a leveling action to said surface, and second, making the ring surface the anode in a second solution consisting of approximately 75% phosphoric acid and from 2 to 4% chromic acid, and passing an electric current of a density of 1½ to 6 amperes and of a voltage of 12 to 25 through the latter solution.

11. That method as defined in claim 10 wherein said spring wire consists of stainless steel having a minimum tensile strength of about 125,000 pounds per square inch.

12. That method as defined in claim 10 wherein said spring wire consists of a hard drawn metal having a tensile strength ranging between 160,000 and 300,000 pounds per square inch.

References Cited

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ROBERT K. MIHALEK, *Primary Examiner.*