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de Montremy

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[54] **METHOD OF MANUFACTURING SEGMENTS FOR MOTORS, COMPRESSORS AND THE LIKE, MACHINE FOR APPLYING THIS METHOD AND SEGMENTS OBTAINED BY THIS METHOD**

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[51] **Int. Cl.** **B23p 15/06**

[58] **Field of Search** 29/156.6, 156.62; 277/216, 277/217

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[57] **ABSTRACT**

A metallic wire of spring steel is wound against a mandrel and cut to the desired length for the segment. The form of the mandrel is such that the track of the wire on the mandrel is an open skewed curve of which the perpendicular projection onto a plane parallel to the middle plane of the said curve comprises two end arcs which cross.

9 Claims, 6 Drawing Figures

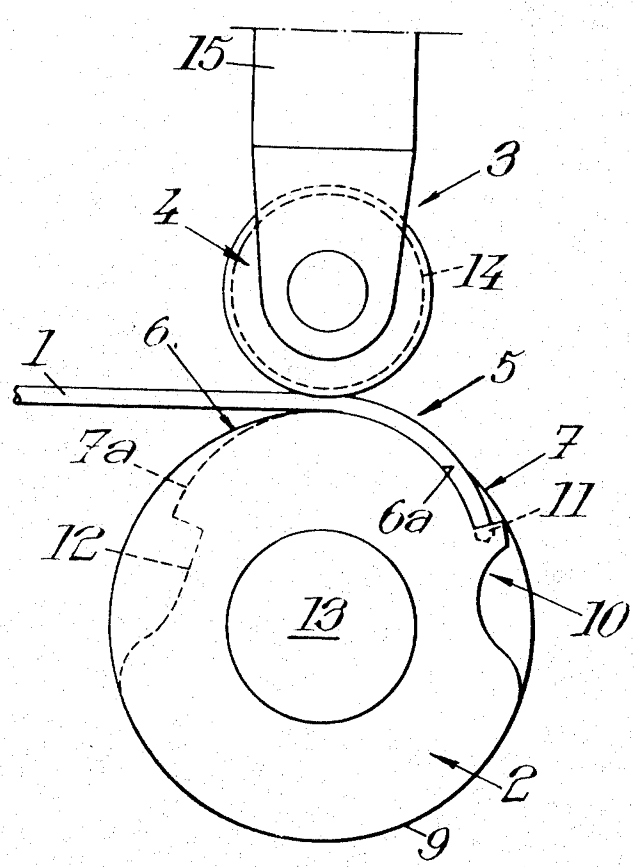


Fig. 1.

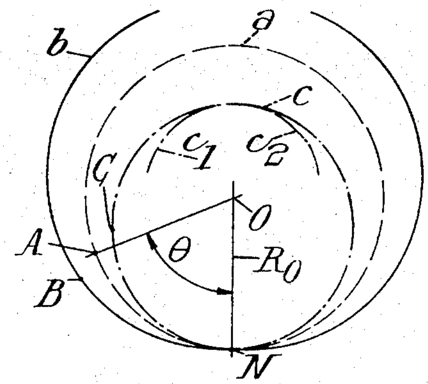


Fig. 2

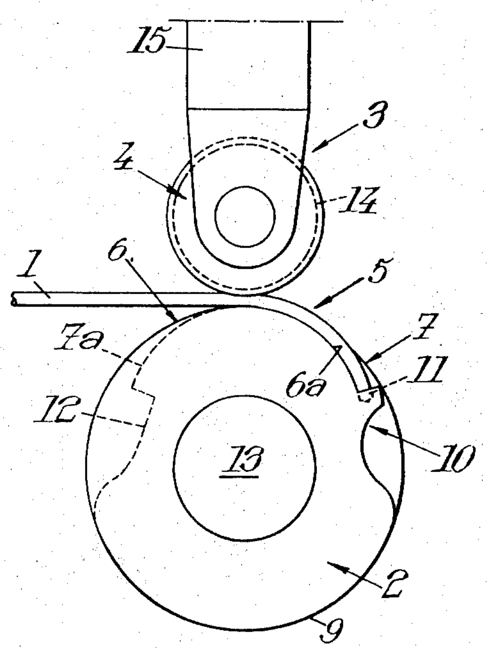


Fig. 3.

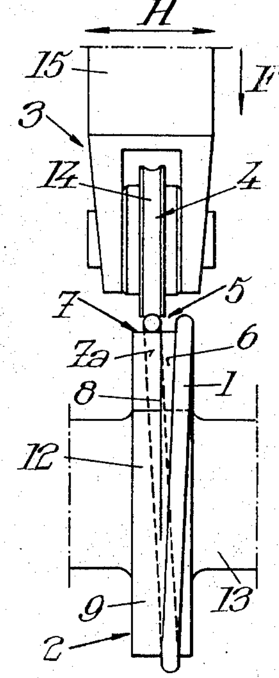


Fig. 4.

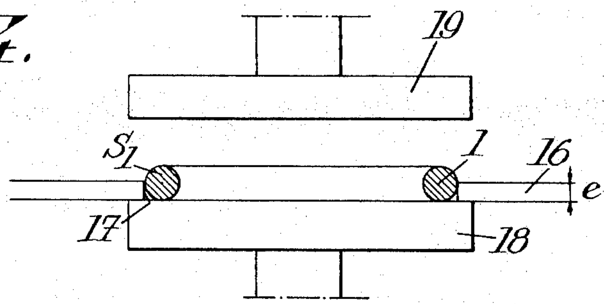


Fig. 5.

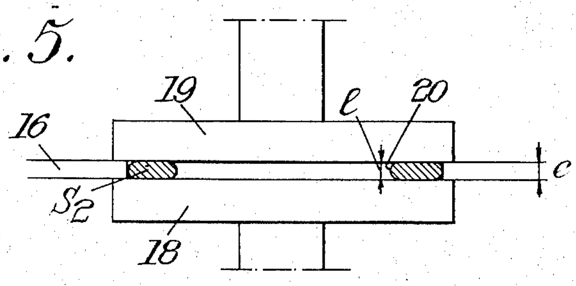
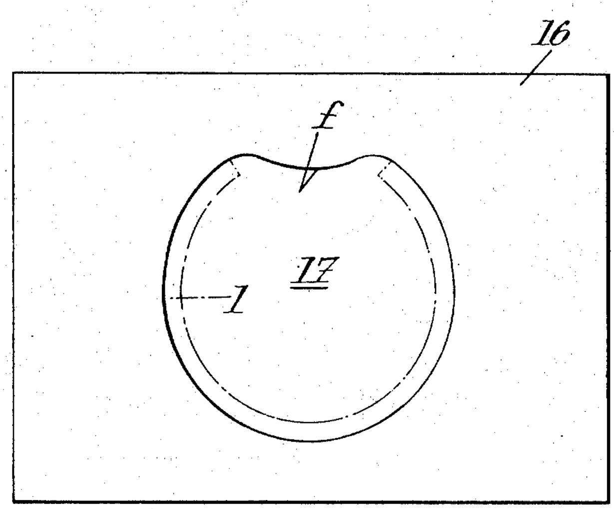


Fig. 6.



METHOD OF MANUFACTURING SEGMENTS FOR MOTORS, COMPRESSORS AND THE LIKE, MACHINE FOR APPLYING THIS METHOD AND SEGMENTS OBTAINED BY THIS METHOD

The invention relates to a method of manufacture of open ring-shaped segments for motors, compressors and the like.

The invention relates more particularly, but not exclusively, among these segments to piston rings for petrol piston engines or diesel engines.

Hitherto these segments were obtained by a casting method in the course of which the segment was molded to a predetermined shape. The crude segment thus obtained was then subjected to various machining operations before becoming a finished segment. The manufacturing production rate permitted by such a method is relatively low and the qualities of the product obtained vary to a great extent.

It is a particular object of the invention to provide a method of manufacturing open ring-shaped segments which does not have, or has to a less degree, the drawbacks mentioned above of the prior art.

According to the invention, a manufacturing method for open ring-shaped segments, for engines, compressors and the like, is characterised by the fact that a metallic wire is taken, this wire is wound against a mandrel of suitable shape and that the wire is cut to the desired length for the segment, the shape of the mandrel being such that, after winding, when the wire is cut, the average strand of the latter is extended, in the free state, over an open curve such that the said segment, after undergoing finishing treatments, when it is brought back to its nominal diameter, and when it is mounted around a piston housed in a cylinder, is adapted to exert, over the whole of its periphery, a constant specific pressure on the said cylinder, the track of the wire round on the mandrel being an open skewed curve, of which the perpendicular projection on a plane parallel to the middle plane of the said curve comprises two end arcs which cross, the ends of the arcs being situated in the concavity of the projection, inside the surface limited by the latter.

Preferably, the finishing treatments comprise a phase during which the wire is subjected, after having been withdrawn from the mandrel, to a pressing adapted to give a suitable shape to the transverse section of the wire and to render flat the middle line of the latter, and a phase during which the wire is subjected to a hot stabilizing treatment, adapted to eliminate the inner tensions and to give the segment its optimal metallurgical and mechanical charateristics.

Advantageously, the metallic wire used is spring steel wire of round, rectangular or square section.

The invention also relates to a machine for applying the method according to the invention.

This machine is characterised by the fact that it comprises a mandrel in the form of a drum, of which the peripheral portion comprises two cylindrical end zones staggered, with respect to one another, radially and along the axis of the said drum, and of which the apparent contours along the said axis are secants, the end of the contour of one zone being situated in the concavity of the contour of the other zone, the said end zones being connected between themselves by an intermediate cylindrical zone.

Preferably, the machine comprises at least one roller for winding the wire against the mandrel, the said roller being urged against the mandrel by elastic means and adapted to be moved along the axis of the said mandrel so as to cause, in the course of the winding of the wire, a displacement of the latter, along the said axis, by an amplitude such that one end of the wire is adapted to be urged against one of the end zones of the mandrel and that the other end of the wire is adapted to be urged against the other end zone of the mandrel, the latter and the roller being adapted to be displaced with respect to one another in a relative rotary movement.

The invention also relates to segments of open ring shape obtained by the application of the abovesaid method.

The invention consists, apart from the features mentioned above, in certain other features which are preferably used at the same time and which will be more explicitly considered below with regard to a preferred embodiment of the invention, which will now be described in more detailed manner with reference to the accompanying drawings, but which is in no way limiting.

FIG. 1 of these drawings, shows, in plan view, on one hand, the middle line, shown as a solid line, of a segment in the free state, on the other hand, in discontinuous line, the middle line of a segment brought back to its nominal diameter and, on the other hand, lastly, in mixed line, the middle line of a segment, in the course of manufacture by the method according to the invention, wound on the mandrel.

FIG. 2 shows, in elevation, diagramatically, a machine enabling the application of the method according to the invention, the various parts of the machine occupying a position corresponding to the beginning of the winding of the wire on the mandrel.

FIG. 3 is a view from the left with respect to FIG. 2, of the various parts of the machine occupying different relative positions from those shown in FIG. 2, the winding of the wire on the mandrel being practically completed.

FIG. 4 is a diagrammatic view showing the beginning of the pressing operation.

FIG. 5 shows similarly to FIG. 4, the operation of pressing proper.

FIG. 6, lastly, is a plan view of a matrix.

To manufacture a segment, according to the invention, procedure is as follows:

Starting with a metallic wire 1, preferably of spring steel wire, (FIGS. 2 and 3), this wire is wound against a mandrel 2 of suitable shape and the wire is cut to the desired length for the segment.

The shape of the mandrel 2 is such that, after winding, when the wire 1 has been cut and has undergone finishing treatments such as stamping and thermal treatment, the average strand of this wire extends in the free state along an open curve *b* (FIG. 1). This curve *b* is such that, when the segment is brought back to its nominal diameter, that is to say when the middle line of the said segment extends along the circumference *a* and the said segment is mounted around a piston (not shown) housed in a cylinder (not shown), the said segment, which has a tendency to be opened as a result of its elasticity, exerts over its periphery a constant specific pressure on the said cylinder.

The curve b is known and the radius of curvature ρ at a point B of this curve b is connected with the radius Ro of the circumference a by the formula:

$$1/Ro - 1/\rho = Mo\ (1 + \cos\theta)/EI$$

In this formula θ denotes the angle comprised between the radii joining the center O of this circumference a, respectively to the point N, also called point of flexion of the segment, and to the point A which corresponds, on the curve a to the point B of the curve b. Otherwise stated, the length of the arc of the curve $\breve{NB}$ is equal to the length of the arc of the curve $\breve{NA}$.

Mo denotes the bending moment at the point N of the segment when the middle line of this latter extends along this circumference a.

E denotes the modulus of elasticity or YOUNG's modulus of the material used.

I denotes the moment of inertia of the cross-section of the segment.

The track of the wire **1** wound on the mandrel is an open non-planar curve, of which the perpendicular projection, on a plane parallel to the middle plane of the said curve is represented by the curve c in FIG. **1.** The two end arcs c_1, c_2 of the curve c cross and the ends of these arcs c_1, c_2 are situated in the concavity of the curve c, inside the surface limited by the latter.

When the wire **1** has been wound on the mandrel **2**, that is to say when the middle line of the wire **1** has taken the shape of a skewed curve of which the perpendicular projection on a plane parallel to the middle plane of said left handed curve is the line c, and when this wire is relaxed, it takes up by itself, after finishing treatments, in the free state, a shape such that its middle line extends along the curve b. Under these conditions, when the segment formed by the wire is brought back to its nominal diameter, that is to say when the middle line of the said segment is extended along the circumference a, the segment will exert over the whole of its periphery a constant specific pressure on the surface that surrounds it.

The exact shape to be given to the mandrel **2** may be determined experimentally, but Applicant has established, on the basis of simplified hypotheses which will be considered below, formulae connecting the radius of curvature ρ at any point B of the line b, and the radius of curvature ρo of the line c at the point C corresponding to the point B. By point C corresponding to point B, must be understood a point C such that the length of the arc $\breve{NC}$ is equal to that of the arc $\breve{NB}$ (see FIG. **1**).

In the case were the cross section of the wire **1** which is used is circular, the radii of curvature ρo and ρ are connected by the following formula:

$$\rho = \frac{T\cdot\frac{\pi}{16}}{T\left(\frac{1}{\rho_0}-\frac{1}{\rho_{00}}\right)\left(\frac{\Omega_{t_E}}{8}-\frac{\sin 4\Omega_{t_E}}{32}\right)-\epsilon_E\cdot\frac{\sin^3\Omega_{t_E}}{3}}$$

where t_E = distance between the neutral strand and the first clamped strand:

$$t_E = \epsilon_E/(1/\rho o - 1/\rho oo)$$

with:

ϵ_E = relative elongation corresponding to the elastic limit of the wire

ρoo = radius of curvature of the blank of wire

T = distance between the neutral strand and the outer strand of the section considered

Ω_{t_E} = arc cos t_E/T

In the case where the wire used is a wire of square or rectangular, the radii of curvature ρo and ρ are connected by the formula:

$$\rho = 1/[K^3/\rho oo + 1/\rho o\ (1-K^3) - 3/2\cdot\epsilon_E\cdot(1-K^2)/T]$$

In this formula:

$$K = t_E/T$$

and the other letters have the same significance as for the preceding formula.

It must be noted however that these equations do not introduce the variable amount of strain which could exist in the wire **1** due to the fact of its method of manufacture. For this reason, the preceding formulae must not be considered as absolutely rigorous. It is possible to introduce corrective values, determined experimentally, tending to compensate the errors introduced by the simplifying hypotheses which have enabled these formulae to be established.

In addition, account is taken of the diameter of the wire, when the latter is circular, or of its dimensions, height and length, when this cross section of the wire is square or rectangular, for the determination of the profile of the mandrel.

The essential phase of the method according to the invention, which consists of winding the metallic wire **1** against the mandrel **2** can be effected by means of a machine **3**, shown diagrammatically in FIGS. **2** and **3** and which will now be described.

This machine **3** comprises the mandrel **2** and at least one roller **4** for winding the wire **1** against the mandrel **2.**

The latter has the shape of a drum of which the peripheral portion **5** comprises two end zones **6** and **7**, cylindrical, displaced with respect to one another radially and along the axis of the said drum. As can be seen on FIG. **2**, the apparent contours of the zones **6** and **7** along the direction of the axis of the drum, which axis is perpendicular to the middle plane of the track of the wire **1** on the mandrel and parallel to the generatrixes of the cylindrical zones **6** and **7**, are analogous to the arcs of the curve c_1, c_2 of FIG. **1**; the apparent contours are therefore secants and the apparent contour of the end *7a* of the zone **7** is situated in the concavity of the contour of the other zone **6**, whilst the apparent contour of the end *6a* of the zone **6** is situated in the concavity of the contour of the zone **7.** It will be noted that the concavitites of the zones **6** and **7** are turned in the same direction. The zones **6** and **7** are axially adjacent so that the peripheral surface of the mandrel **2** bears, over a fraction of its perimeter, a radial wall **8** (FIG. **3**) projecting which ensures the connection, in a radial sense, of the zones **6** and **7.**

The end zones **6** and **7** are connected between themselves by an intermediate cylindrical zone **9** of which the generatrixes are parallel to the axis of the mandrel of which the dimension, along the direction of this axis, is equal to the sum of the dimensions of the said end zones **6** and **7.** The cylindrical zone **9** ensures a peripheral continuous connection between the said end zones.

The zone 6 is intended to come into first contact with the wire 1 which is wound on the mandrel 2. Fixing means 10 for the end of the wire 1 have been therefore provided, on the mandrel 2, at the end of the zone 6, the enable the attachment of the free end of the wire 1. These fixing means comprise a shoulder projecting radially outwardly in the zone 6, in which shoulder is provided a housing 11 where the free end of the wire 1 is locked.

At the end of the other end zone 7, is provided a hook portion 12 (FIG. 2) returning radially towards the axis of the mandrel. This hook portion 12 facilitates the cutting of the wire 1, to the desired length, when this wire has been wound to the end of zone 7.

The mandrel 2 is mounted on a shaft 13 which can be rotated in a sense corresponding, in FIG. 2, to the clockwise direction.

The roller 4 comprises a groove 14 which serves to guide the wire 1. The groove 14 has a profile which corresponds to that of the cross-section of the wire 1. The roller 4 is mounted rotatably in a fork 15 on which elastic means (not shown) are adapted to act so as to push the roller 4 against the mandrel 2, in the direction of the arrow F (FIG. 3). Means (not shown) are also provided to displace the fork 15 and the roller 4 parallel to the axis of the mandrel 2 along the double arrow H (FIG. 3). The displacement of the roller 4 from the right towards the left of the FIG. 3 is necessary to enable the wire 1, on its winding, to become again in contact with zone 6 and then in contact with the zone 7. The movement of the roller 4 from the left towards the right of FIG. 3 is necessary so that the latter comes back into its initial position when the winding of the desired length is completed.

The wire 1 after having been wound on the mandrel 2 is cut to the desired length.

As regards the cross-section of the wire, especially if it is started from a wire of circular section, it must be given dimensions, height and width, corresponding to the use intended for the finished segment.

For this, the portion of the wire which has been wound on the mandrel and freed from the latter, is subjected to a pressing operation. A matrix 16 is used (FIG. 6) constituted by a plate of steel of which the thickness e (FIGS. 4 and 5) is equal to the thickness 1 of the segment once finished (FIG. 5). The plate 16 is cut out along an opening 17 of which the contour is identical to that of the wire 1, when the latter is freed after winding on a mandrel 2.

Naturally, the portion *f* of the contour of the opening 17 which corresponds to the zone comprised between the ends of the curve *b* of FIG. 1, has a shape determined essentially by practical considerations.

The matrix 16 is arranged between the plates 18 and 19 of a press, these plates being separated. The length of the wire 1, prior to being wound on the mandrel 2, is placed in the opening 17 of which the shape specified above is such that the contour of this opening does not exert any radial pressure on the wire 1. The approach of the two plates 18 and 19 is then actuated to obtain the shaping of the cross section of the wire 1. The plates 18 and 19 cause crushing of this until they come into contact with the matrix 16. It will be noted that the surface of the cross section of the wire 1 does not change and that the hatched areas S_1, S_2 of FIGS. 4 and 5, corresponding to the cross sections, are equal.

In the course of this stamping operation, the middle line of the wire 1 which, on winding on the mandrel 2 with axial displacement of the roller 4, had been rendered left handed, becomes flat.

After this stamping operation, the part is stabilized with heat, either in the shape that it occupies in the free state, or to the nominal diameter, that is to say when its middle line extends along the circumference *a* of FIG. 1. This stabilizing treatment enables the inner tensions due to stamping to be eliminated and to give to the finished segment its optimal mechanical characteristics.

It will be noted that after the stamping operation, when starting from a wire of circular cross section, the finished segment has externally, in the radial sense, a bulge portion 20 (FIG. 5) of which the transverse section is a convex curve, turning its convexity towards the centre of the segment. The radius of curvature of the transverse section of bulge portion 20 is substantially equal to the radius of the circular section of the wire initially used for manufacturing the segment.

The shape of the mandrel 2 is such that when the segment is finished and has undergone the finishing treatments constituted by stamping and thermal treatment, the middle strand of the segment extends, in the free state, along the curve *b* of FIG. 1.

To establish ideas, there will now be given three numerical examples valid for a steel wire of circular cross section of radius 1.2 mm, the steel used having a relative elastic elongation limit equal to $\epsilon_E = 0.009$ and the radius of curvature of the blank wire being equal to: $\rho oo = 235$ mm. Under these conditions:

$\rho = 92$ mm for $\rho o = 39.25$ mm
$\rho = 34.3$ mm for $\rho o = 22.75$ mm
$\rho = 41.6$ mm for $\rho o = 25.7$ mm

These results have been obtained experimentally by means of cylindrical mandrels of constant radius, the radii being respectively 39.25 mm, 22.75 mm and 25.7 mm. These results are applicable to a point of the cross section of a mandrel, such that the mandrel 2, which need not be of constant radius, but of which the radius of curvature of the section at the point considered is precisely equal to one of the values taken by ρo in the three numerical examples above.

The method according to the invention permits a high production rate for the segments and the operations of winding of the wire on the mandrel, cutting, and stamping can be done automatically.

The qualities of the segments obtained by this method vary little and have a small dispersion. In addition, the number of operations necessary for obtaining the finished segment is reduced.

The stamping operation can also be eliminated if the initial section of the wire is judiciously selected.

The section of the wire could be trapezoidal, with bevels.

I claim:

1. Method for the manufacture of segments in the form of an open ring for a motor, compressor or the like, said method comprising taking a metallic wire, providing a mandrel such that the track of the wire wound on the mandrel is an open skewed curve, of which a projection perpendicular to a plane parallel to the average plane of the said curve comprises two end arcs which cross, the ends of the arcs being situated, in projection, in the concavity of the projection, inside the surface limited by the latter, winding the wire against said mandrel, cutting the wire to the desired length for

the segment, the shape of the mandrel being such that, after winding, when the wire is cut, a middle line of the wire is extended, in the free state, along an open curve such that the said segment, after having undergone finishing treatments, when it is brough back to its nominal diameter and when it is mounted around a piston housed in a cylinder, is adapted to exert over the whole of its perimeter a constant specific pressure on the said jacket.

2. Method according to claim **1**, wherein the finishing treatments comprise a phase during which the wire is subjected, after being withdrawn from the mandrel, to stamping adapted to give a suitable shape to the transverse section of the wire and to render the middle line of the wire flat and the phase during which the latter is subjected to a hot stabilizing treatment, adapted to eliminate inner tensions and to give the segment its optimal metallurgical and mechanical characteristics.

3. Method according to claim **1**, wherein the metallic wire used is spring steel wire.

4. Method according to claim **1**, wherein the initial transverse section of the wire is circular.

5. Method according to claim **1**, wherein the initial transverse section of the wire is square or rectangular.

6. Method according to claim **1** wherein the mandrel is in the form of a drum of which the peripheral portion comprises two end zones, cylindrical, offset with respect to one another, radially and along the axis of the said drum, and of which the apparent contours along the said axis are secants, the contour of the end of one zone being situated in the concavity of the contour of the other zone, the said end zones being connected between themselves by an intermediate cylindrical zone.

7. Method according to claim **6** wherein the winding of the wire against the mandrel is effected by at least one roller, the said roller being urged towards the mandrel by elastic means and being moved along the axis of the said mandrel so as to cause, in the course of winding of the wire, displacement of the latter, along the said axis, by an amplitude such that an end of the wire is urged against one of the end zones of the mandrel and that the other end of the wire is urged against the other end zone of the mandrel, the latter and the roller being moved with respect to one another in a relative rotary movement.

8. Method according to claim **2** wherein said stamping is carried out on the wire after freely placing it in a matrix comprising a metallic plate of which the thickness is equal to the desired thickness for the finished segment, the said plate being cut-out along an opening of which the contour is identical with that of the wire when the latter is freed after winding on the mandrel.

9. Method according to claim **6** wherein the end zone which comes into first contact with the wire during winding includes fixing means for the end of the wire at the end of said end zone for attachment of the free end of the wire, comprising a radially outwardly projecting shoulder in said end zone, the shoulder being provided with a housing for receiving the free end of the wire, and wherein said winding is preceded by inserting a free end of the wire into said housing.

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