Dec. 11, 1962 K. G. HANN ETAL 3,068,353

METHOD OF AND APPARATUS FOR PROCESSING WIRE PARTICULARLY APPLICABLE TO WIRE FOR PRE-STRESSED CONCRETE CONSTRUCTION

Filed Oct. 7, 1960

6 Sheets-Sheet 1

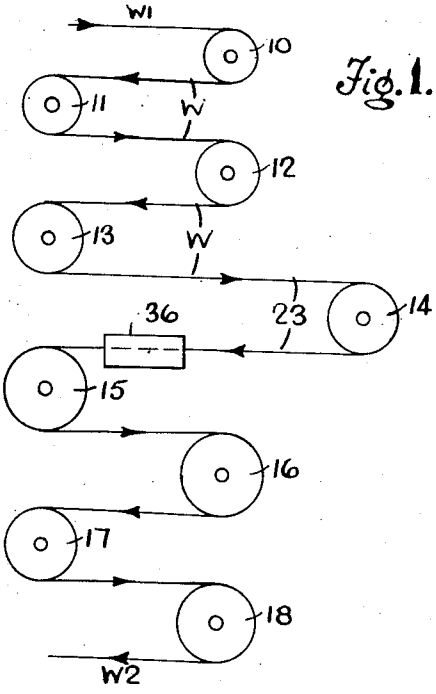


Fig. 1.

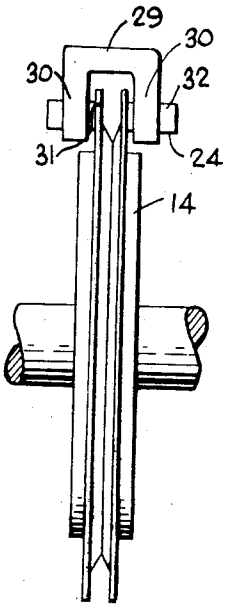
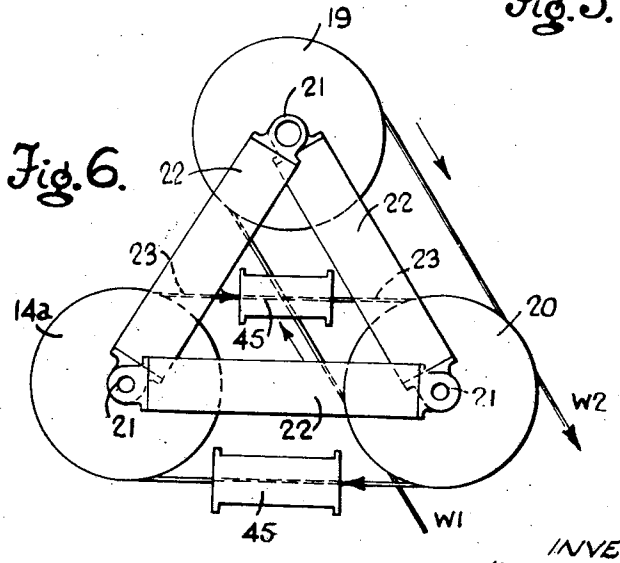


Fig. 5.

Fig. 6.



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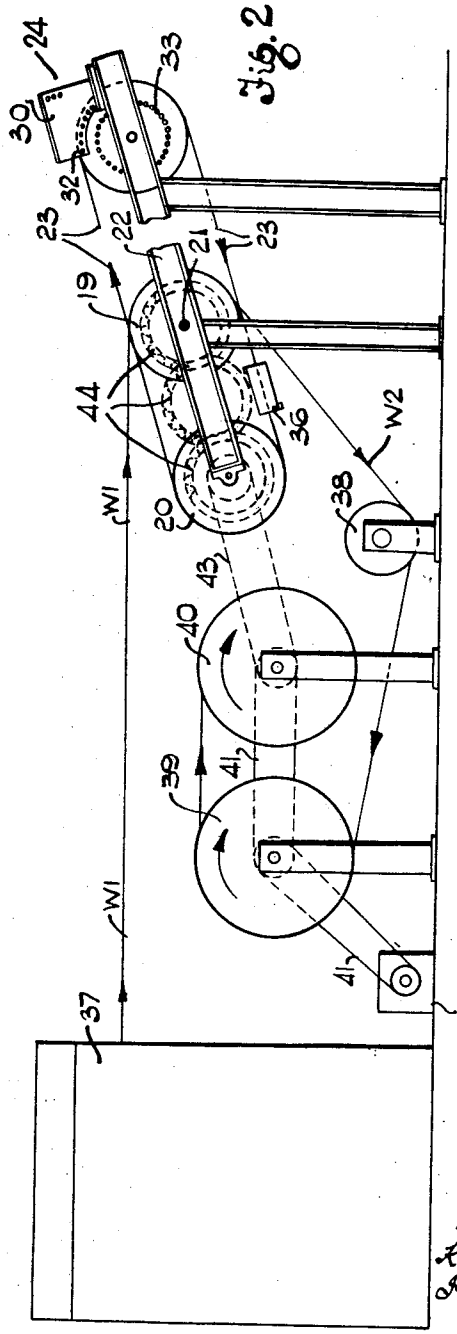
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Fig. 2



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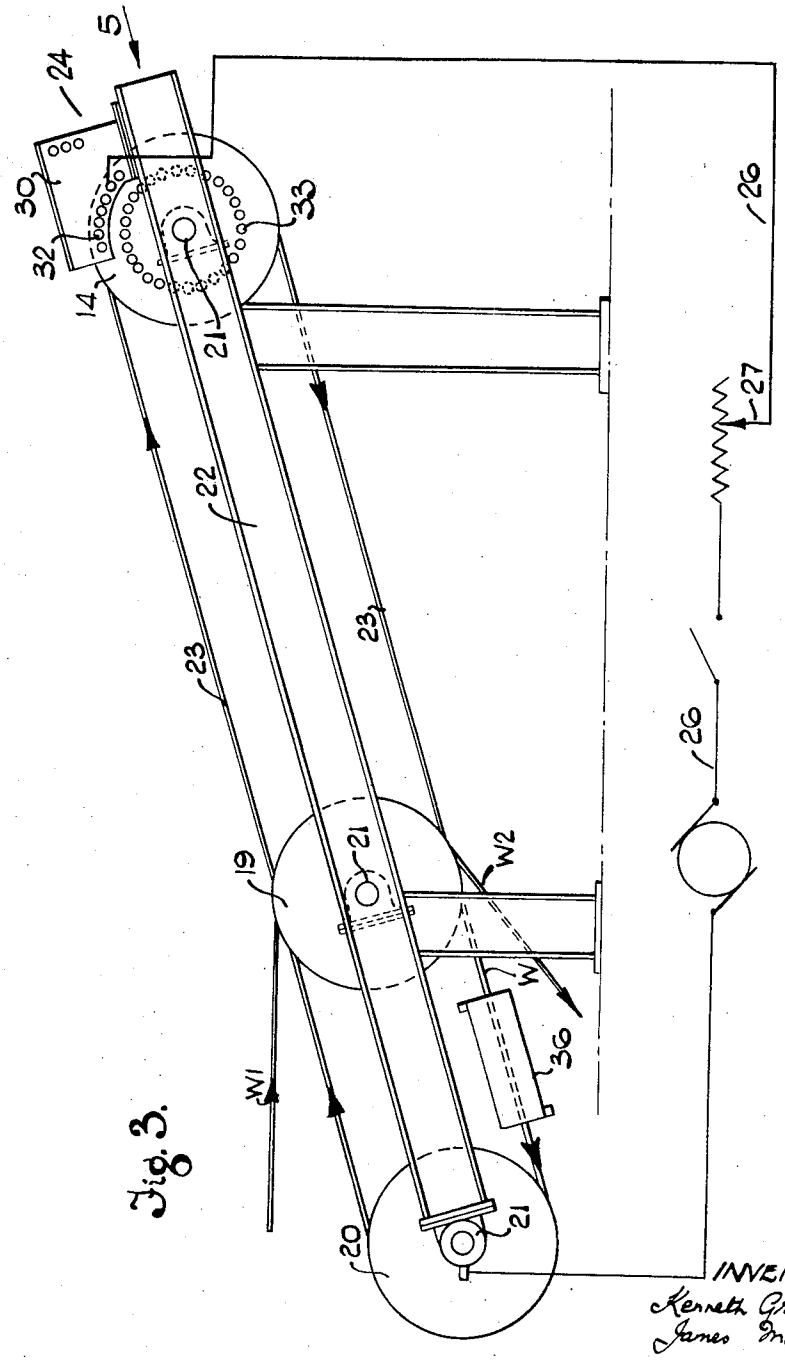


Fig. 3.

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METHOD OF AND APPARATUS FOR PROCESSING WIRE PARTICULARLY APPLICABLE TO WIRE FOR PRE-STRESSED CONCRETE CONSTRUCTION

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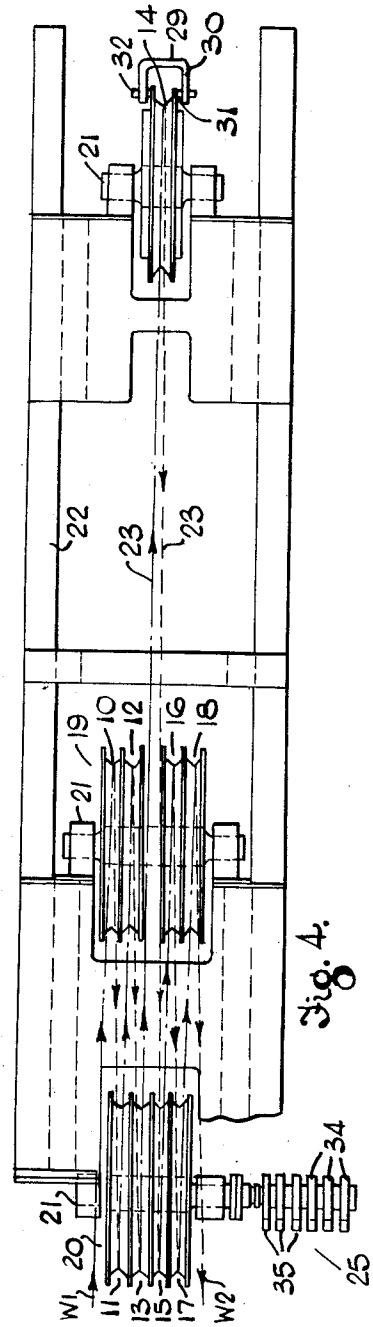


Fig. 4.

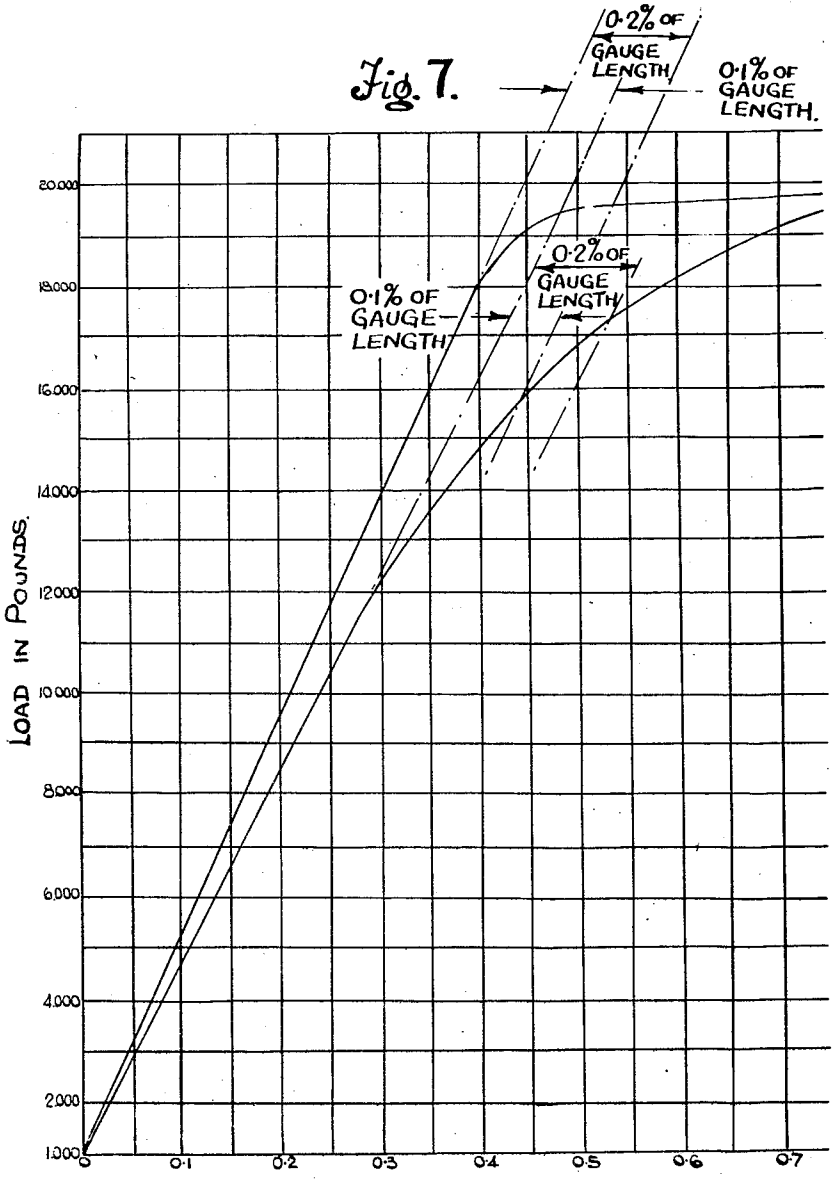
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METHOD OF AND APPARATUS FOR PROCESSING WIRE PARTICULARLY APPLICABLE TO WIRE FOR PRE-STRESSED CONCRETE CONSTRUCTION

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Fig. 7.



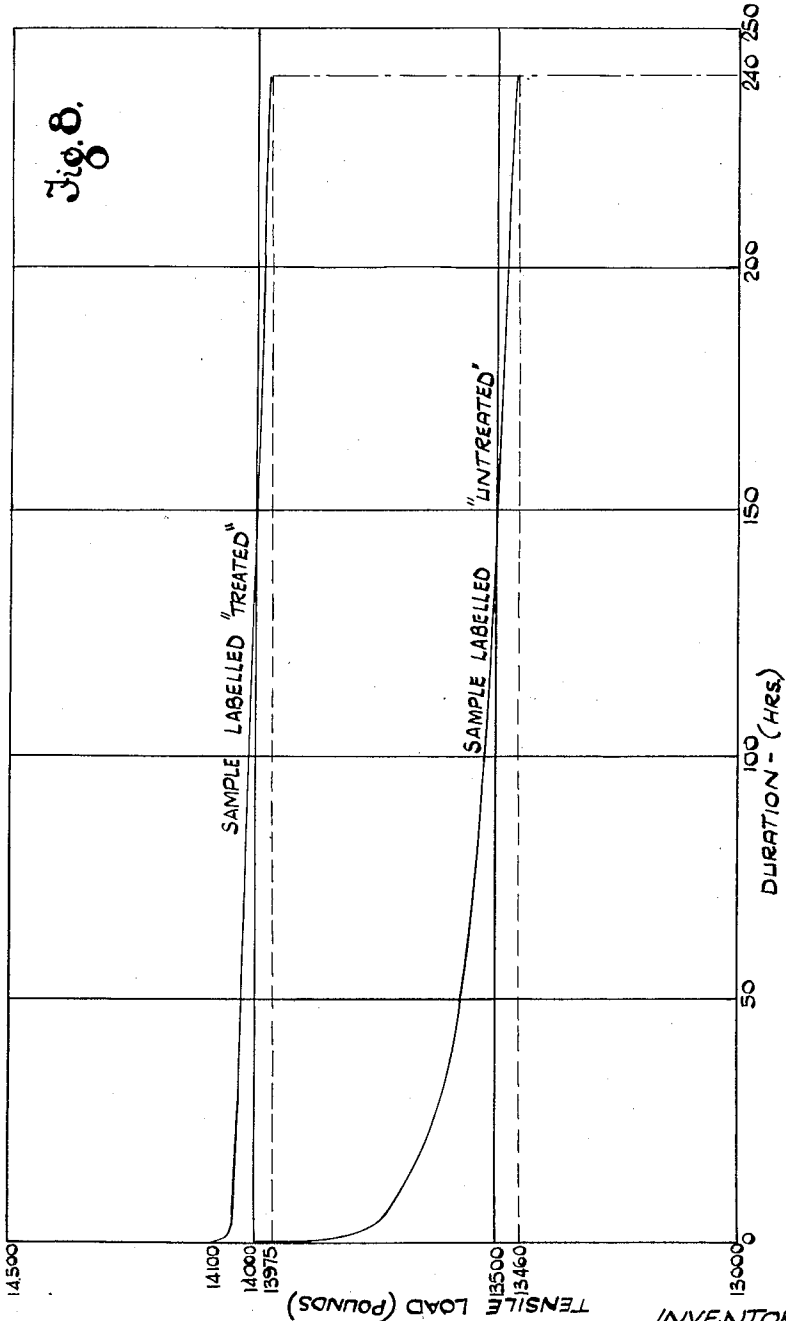
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METHOD OF AND APPARATUS FOR PROCESSING WIRE PARTICULARLY APPLICABLE TO WIRE FOR PRE-STRESSED CONCRETE CONSTRUCTION

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Fig. 8.



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METHOD OF AND APPARATUS FOR PROCESSING WIRE PARTICULARLY APPLICABLE TO WIRE FOR PRE-STRESSED CONCRETE CONSTRUCTION

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Filed Oct. 7, 1960, Ser. No. 61,268

Claims priority, application Great Britain Oct. 27, 1959

19 Claims. (Cl. 219—155)

This invention relates to a new or improved method of and apparatus for processing wire for the purpose of improving the same, both in respect of certain of its tensile properties and also in respect of its configuration as hereinafter more particularly explained.

The present invention is applicable both to wire in single lengths as well as to wire strand and wire rope. As is known, wire strand is formed by spinning a number of wires together around a central core, which core may be either a single wire or may be formed as a strand or length of fibre. A wire rope is a number of so formed wire strands, frequently six in number, spun together around a central core, which core may itself be a wire strand or a single length of wire.

For convenience in description the expression "wire" as employed in this specification is intended to include within its ambit wire strand and wire rope, in addition to embracing single lengths of wire.

The invention is particularly concerned with a new or improved method of and apparatus for improving the relaxation properties of wire, thereby rendering the wire particularly suitable for use in pre-stressed concrete construction.

Relaxation is a quantitative measure of the reduction in a predetermined tensile loading which, over a period of time, is requisite to prevent additional elongation of a length of wire which is being subjected to such predetermined tensile loading. The period of time referred to may be measured in multiples of ten minutes or in hours or days, dependent upon the desired accuracy of the relaxation test.

The relaxation property of wire is accordingly a measure of its utility in pre-stressed concrete construction in that in pre-stressed concrete the pre-stressing wires embedded in the concrete are thereby maintained at a constant length and measurement of the relaxation property provides indication as to the tensile load to which the concrete can safely be subjected under service conditions, i.e. after an extended period of time.

The improvement in the relaxation property of wire which, as hereinafter explained, can be obtained by the method and apparatus the subject of the present invention, in fact results in a consequential improvement in the elastic limit and of the percentage elongation of the wire when subjected to the usual tensile test.

The method and apparatus the subject of the present invention further enables wire strand and wire rope to be

produced in which, in the case of strand, the individual wires constituting the strand are formed to their designed helical shape in a particularly accurate manner and in the case of wire rope ensures that the strands forming the rope are similarly accurately formed to the desired helical shape so that a particularly perfect strand or rope is obtained so that when cut to length there is a complete or virtually complete absence of splaying of the cut ends, and the strand or rope can be cut without it being necessary to bind the same at either side of the point of severance.

The method and apparatus the subject of this invention further enables wire to be produced, whether in single lengths or as wire strand or wire rope, which is of particularly straight configuration, i.e. particularly free from slight kinks or other deviations from the straight.

These improvements in the shape of wire processed by the method and apparatus the subject of the invention, i.e. the aforementioned accurate helical shape in the case of strand or rope and markedly straight configuration in the case of a single length of wire or in the case of strand or rope, in addition to resulting in an article of specially high quality, renders the wire particularly suitable for use in pre-stressed concrete construction in that, under the continued tensile load there is the minimum of liability for the wire to elongate merely as a result of continued straightening of the wire or change in the position or shape of an imperfect helix of single length wire or strand, in the case respectively of wire, wire strand or wire rope.

In the specification of the prior United States patent application No. 431,965, now abandoned, of Kenneth Graeme Hann there is described and claimed a method of straightening cold drawn wire and the like formed of steel of the kind specified in such specification, comprising heating successive lengths of the wire or the like to a tempering temperature, of the steel concerned as defined in the prior specification, subjecting the wire or the like heated to such temperature to a tensile force acting in the direction of its length of magnitude sufficiently great as, having regard to the time during which each wire length is maintained at such temperature and the value thereof, as thereby to impart a permanent elongation to the wire or the like and effect a straightening in the form of the wire or the like without at the same time applying a tensile force sufficiently great to the wire as to effect failure of the wire under the applied tensile load.

In the prior specification there is particularly described an arrangement in which the tensile force which serves to straighten the wire is obtained by cold drawing the wire through a drawing die or between drawing down rolls, but we have also described in the specification a further method of applying the tension to the wire in which a length of previously drawn down wire is advanced from a feeding drum to a power driven capstan or block in which the feeding drum is provided with a brake or other means for retarding its rotation, so that the wire is subjected to tension in passing from the feeding drum to the capstan or block, the length of wire which is subjected to tension in this way being heated to the tempering temperature above referred to.

As described in the prior specification, such method serves to improve certain of the tensile properties of the wire in addition to improving the straightness of the wire but necessarily such improvements which are obtained will be dependent upon the strain produced in the wire, and in both of the particular arrangements described in the prior specification for applying the tension to the wire this strain is dependent on the tensile force actually applied, in the one case by the drawing tension and in the other case by the braking load applied to the feeding drum.

With either of these particular arrangements for carrying out the method the subject of the prior specification it is difficult to ensure that the tension applied is always the same, especially having regard to slight variations which may occur in the specified characteristics of the wire, and the diameter thereof, and it is therefore difficult accurately to control the maximum tensile stress developed in the wire so that it is difficult to control accurately the desired improvement in the tensile properties of the wire.

This difficulty is particularly marked where, as described in the prior specification, the wire is drawn through a die in that necessarily the die will be wearing slowly throughout its period of operation so that the tension thereby applied to wire of a given diameter will tend slowly to decrease until the die is renewed.

A further disadvantage of applying the tensile force to the wire by drawing it through a die is that it is obviously very difficult to apply such an arrangement to wire strand and wire rope.

Although the alternative described in the prior specification of producing the tension by braking means applied to the feeding drum can, without difficulty, be employed with wire in the form of strand, or rope, such an arrangement is subject to the disadvantage that the provision of such braking means involves a useless expenditure of power which is dissipated in heat at the brake and which power may well be as high as about sixty horse power in the case of wire strand of 1⅛ inch diameter.

The present invention has for its object the provision of a new or improved method of and apparatus for processing wire for the purpose above described, which method and apparatus avoids the disadvantages of the arrangements described in the prior specification aforementioned and at the same time is adapted to produce a wire which is characterised by particularly good relaxation properties and which is formed with a particularly high degree of accuracy in respect of the characteristics of straightness, and helical form in the case of strand or rope, as already described.

The present invention in its widest aspect comprises a method of processing wire for the purposes described, said method comprising applying to the wire a controlled predetermined strain by advancing the wire around a plurality of rotary members, each rotating at the same angular velocity but at progressively increasing diameter in the direction of wire advancement, and heating the successive predetermined lengths of the so strained wire to a temperature such as to produce a predetermined permanent elongation in the wire.

As the rotary members are rotating at the same angular velocity, it will be understood that the strain produced in a predetermined length of wire is dependent entirely upon the ratio between the smallest and largest diameter of the several rotating members of progressively increasing diameter in the direction of wire advancement and since this difference can be predetermined accurately, we can ensure by the present invention that the precise predetermined strain is produced in the wire and since the maximum temperature of the wire can, without difficulty, be maintained at any desired predetermined value, it is possible by the present invention accurately to control

the desired permanent elongation of the wire and thus the desired improvement in the relaxation characteristics of the wire under service conditions.

More specifically and preferably the present invention further comprises a method of imparting a permanent elongation to wire, said method comprising advancing the wire around a succession of rotary members, each rotating at the same angular velocity and which, in the direction of wire advancement, are of progressively increasing diameter so as to apply a predetermined strain to the wire, heating the so strained wire to a temperature such as to produce a desired predetermined permanent elongation in the wire, advancing the so elongated wire around one or a number of rotating members, and which member or number of members all rotate at the same angular velocity as that of the members of progressively increasing diameter, and which one member or at least the smallest diameter of the number of members around which the permanently elongated wire advances is of a diameter less than the maximum diameter of the rotary members around which the wire passes, such that the tension of the wire leaving the last of the succession of rotary members is the same as or not substantially greater than the tension of the wire advancing on to the first of said succession of rotary members.

In such preferred method it will be appreciated that the several rotary members are not subjected to any resultant torque and it is unnecessary to provide any power drive of any kind thereto, it being required merely to ensure that the tension of the wire passing on to the first rotary member is sufficient to prevent slip of the wire as it passes around the first of the several rotary members and it being further required merely to apply a sufficient tension to the wire leaving the last of the several rotary members as to ensure the continued advancement of the wire.

The tension in the wire leaving the last of the several rotary members may, as in the case of the tension in the wire passing on to the first rotary member, be quite small so that the method the subject of the present invention enables the wire to be processed for the purposes above described with the minimum expenditure of power. Necessarily, some power is required to overcome the frictional forces during the passage of the wire around the several rotary members as well as to overcome the frictional resistance to rotation of the members but the amount of power so absorbed is quite small.

This power may be supplied by means of some form of pulling device such as a power driven capstan or block which applies tension in the known manner to the wire leaving the last of the several rotary members and in this case the tension of the wire leaving the last of the several rotary members will be greater than the tension of the wire passing on to the first rotary member.

Alternatively, the power required to overcome the said frictional forces and resistance to rotation of the rotary members may be obtained by power driving the latter so that with the several members all rotating at the same angular velocity in this latter case the tension of the wire advancing on to the first of said succession of rotary members will be the same as the tension of the wire leaving the last of the succession of rotary members.

In the case where the wire is advanced around the several rotary members by applying tension to the length of wire leaving the last of the succession thereof, such tension will differ from the tension in the wire passing on to the first of said succession of rotary members by an amount herein defined by the expression "not substantially greater than," which amount corresponds to the force necessary to overcome the frictional forces above referred to in effecting rotation of the several rotary members and in advancing the wire therearound.

The heating of the wire in the method described may be effected by passing an electric heating current therethrough, for example, by advancing the wire in the form of a loop around a drum or pulley, which may constitute one of the rotary members referred to, this drum or pulley being connected to one part of the heating circuit, the arrangement being such that the current path is along each of the two lengths of wire forming the loop, i.e. passing on to and off this drum or pulley with the other end of the heating circuit connected to the remainder of the several rotary members.

Alternatively, the heating may be effected inductively by inducing a heating current in the length of wire which is subjected to the maximum tension, for example, by passing the length of wire to be heated through the opening or window of a transformer core carrying the primary winding, which would be connected to a suitable alternating current source.

The invention further comprises apparatus for carrying out the foregoing method, said apparatus comprising a plurality of rotary members, the periphery of which is adapted frictionally to engage with wire advanced successively around each of said members, said members being adapted to rotate at the same angular velocity but being of progressively increasing diameter in the direction of wire advancement so as to impart a controlled predetermined strain to the wire advancing around the last of said successively increasing diameter members, and means for heating the so strained wire to a temperature such as to produce a predetermined desired permanent elongation thereon.

The rotary members may each be mounted for rotation about separate axes and geared together so as to rotate at the same angular velocity but preferably a number of rotary members would be mounted on one of a number of common mutually parallel axes.

The apparatus in its preferred form would comprise a plurality of rotary members, the periphery of which is adapted frictionally to engage with wire advanced successively around each of said members, said members being adapted to rotate at the same angular velocity with some of said members being of progressively increasing diameter in the direction of wire advancement, so as to apply a progressively increasing strain to the advancing wire, means for heating to a controlled predetermined temperature a length of the wire which is subjected to the maximum strain so as to effect an elongation thereof under the tension produced in said length of wire by the applied strain, the arrangement being such that the so elongated wire is thereupon adapted to be advanced around the remaining of said rotary members, which remaining rotary members are of progressively decreasing diameter in the direction of wire advancement such that the tension of the wire leaving the apparatus is the same or not substantially greater than the tension of the wire entering the apparatus.

In this preferred arrangement the rotary members may be arranged in two sets, with each set mounted on an associated freely rotatable shaft, and the wire would, in its direction of advancement, be arranged to pass initially around a first member on one shaft, namely a first shaft, then around a member, namely a second member on the other, i.e. second shaft, then around a third member on the first shaft and so on from one set of members to the other, with the first, second, third, and each succeeding member of progressively increasing diameter so as to apply the desired maximum strain and associated maximum tension to the wire, the latter after being heated to the required temperature, similarly passing successively around the two shafts and their associated members

of progressively decreasing diameter in the direction of wire advancement until the wire finally leaves the apparatus.

The length of wire to be heated may be passed around a drum or pulley or other rotatable member mounted for free rotation about an axis spaced from the axes of rotation of the said rotary members of the progressively increasing and decreasing diameter above referred to so as to provide a loop of the requisite length for heating the wire to the required maximum temperature, which length is thus obtained irrespective of the spacing between the axes of rotation of the two sets of rotary members above referred to and their diameter.

Preferably all of the rotary members are constructed as grooved pulleys with the two sets of rotary members which rotate about respective shafts being each formed as a multigrooved pulley, with each pulley groove constituting one of the several rotary members referred to, with the grooves being formed to different diameter as above described.

Whatever arrangement is adopted, the diameter of the last of the series of pulleys or other rotary members will be greater than the diameter of the first of the pulleys or rotary members in the direction of wire advancement so as to allow for the elongation which has occurred in the wire by reason of the fact that the members are all rotating at the same angular velocity and a permanent elongation with an associated reduction in diameter of the wire has taken place so that the linear velocity of the wire leaving the apparatus will necessarily be somewhat greater than the linear velocity of the wire entering the apparatus.

One particular preferred method of and apparatus for carrying out the invention will now be described with reference to the accompanying drawings wherein:

FIGURE 1 is a diagrammatic view illustrating the principle of the method the subject of the invention.

FIGURE 2 is a side elevation depicting in diagrammatic form one preferred arrangement of apparatus for carrying out the method the subject of the invention specifically applicable to the production of wire strand.

FIGURE 3 is a side elevation of part of the apparatus depicted in FIGURE 2 illustrating the arrangement of the rotary members for applying the tension to the wire and the associated wire heating means.

FIGURE 4 is a plan view of the part of the apparatus which is depicted in FIGURE 3.

FIGURE 5 is a detailed view to an enlarged scale looking in the direction of the arrow **5** in FIGURE 3.

FIGURE 6 is a view similar to FIGURE 3 but showing an alternative form of apparatus.

FIGURE 7 is a graph illustrating the improvement in certain of the tensile properties obtained with one specific example of wire when subjected to the method the subject of the invention.

FIGURE 8 is a further graph illustrating the improvement in the relaxation properties of the same specific example of wire when subjected to the method the subject of the invention.

Referring firstly to FIGURE 1 of the drawings, the apparatus essentially comprises a number of rotary members which, in the direction of wire advancement, are successively designated **10**, **11**, **12**, **13**, **14**, **15**, **16**, **17** and **18**.

The members **10**, **12**, **16** and **18** are all constituted by separate V-section grooves of a single first pulley **19**, while rotary members **11**, **13**, **15**, and **17** are all constituted by the separate V-section grooves of a second single pulley **20**. The said grooves of the two pulleys **19** and **20** are referenced in FIGURE 3 to correspond with the rotary members **10**, **12**, **16**, **18**, and **11**, **13**, **15**, and **17** respectively

The first and second pulleys 19, 20, are supported for rotation by separate bearings 21 carried upon a supporting frame 22, so that the two pulleys can each rotate freely about spaced parallel axes.

The rotary members 10, 11, 12, 13 and 15 are, as hereinafter explained more specifically, of progressively increasing diameter so as to constitute strain applying members, while the rotary members 16, 17, and 18 are all of progressively decreasing diameter with the member 16 of a diameter less than the member 15 so as to constitute tension relieving members, as more particularly hereinafter explained.

The member 14 serves no part in applying the predetermined strain to the wire and serves merely to provide a convenient means for forming the wire into a loop 23 of relatively long length which is subjected to the predetermined maximum strain and which loop enables the so strained wire conveniently to be heated to the desired temperature to effect permanent elongation of the wire. The diameter of this member 14 is accordingly immaterial and it is mounted through bearing 21 from frame 22 for rotation about an axis separate from that of the two pulleys 19, 20, the member 14 being similarly formed as a pulley having only a single groove and being adapted in the arrangement shown in FIGURES 2 to 5 to be connected, as hereinafter more particularly described, to one side of an electric circuit so as to apply heating current to the two parallel lengths of wire in the loop 23 passing around this pulley. Conveniently this pulley 14 is electrically insulated from the pulleys 19 and 20, which are themselves connected to an earth or return lead of the electric circuit so that this pulley 14 constitutes a live pulley and will be so described.

In the preferred arrangement illustrated in FIGURES 2 to 5 of the drawings, which is specifically adapted for the processing of wire strand in accordance with this invention, the rotary members constituted by the grooves as above numbered of the two pulleys 19 and 20 have the diameter set out in Table I below:

TABLE I

Rotary member drawing ref. no.:	Diameter, inches
10	36
11	36.010
12	36.035
13	36.098
15	36.560
16	36.457
17	36.393
18	36.367

Thus, each of the five rotary members constituted by the pulley grooves 10, 11, 12, 13, and 15 are of progressively increasing diameter while the grooves 16, 17, and 18 are of progressively decreasing diameter.

The wire during its advancement passes around substantially one half of the circumference of each pulley groove so that slip will not occur between the wire and each pulley groove, i.e. the latter engage the wire frictionally and the advancing wire thereby causes the said rotary members to rotate in the direction of wire advancement, the wire in its direction of advancement passing first around pulley groove 10, then around pulley grooves 11, 12, 13, and pulley 14 and subsequently around pulley grooves 15, 16, 17, and 18. Since pulley grooves 10, 12, 16, and 18 are all provided on the one pulley 19, and grooves 11, 13, 15, and 17 are all provided on the one pulley 20 so that the wire is passing backwards and forwards from one pulley to the other as above described, and in the manner illustrated, the two pulleys 19 and 20 must necessarily rotate at the same angular velocity, provided that slip does not occur between the wires and the pulley grooves and the pulley groove diameters above referred to are selected so that in practice slip should not occur.

The wire which is being advanced in cold state around each of the four pulley grooves 10, 11, 12, 13, will be subjected to a progressively increasing strain by reason of the absence of slip between the wire and the pulley grooves, and the progressively increasing diameter of these pulley grooves which are all rotating at the same angular velocity. Thus a progressively increasing tension will be applied to the wire as it passes around these progressively increasing diameter pulley grooves.

Pulley groove 15 has a diameter greater than that of pulley groove 13, the difference in diameter being substantially greater than the difference between pulley groove 10 and pulley groove 13 and the substantially greater difference in diameter serves not only to apply some additional strain to the wire in passing from pulley groove 13 to pulley groove 15, but also and more importantly allows for the permanent increase in length per unit length of wire passing from pulley groove 13 to pulley groove 15 consequent on the heating of the wire whilst under tension during its passage from pulley groove 13 around live pulley 14 back to pulley groove 15.

The above referred to progressively decreasing diameter of pulley grooves 16, 17, and 18 in this order serves progressively to reduce the strain and the associated tensile stress in the wire as it passes from pulley groove 15 around these three further pulley grooves 16, 17 and 18.

The foregoing progressive reduction in pulley groove diameter is in fact so chosen as to ensure that the tension in the length of wire leaving the last of the several pulley grooves, namely pulley groove 18 is not substantially greater than the tension in the wire passing on to pulley groove 10.

At the same time the above specified difference in diameter between the successive pulley grooves, having regard to the permanent elongation produced in the heated length of wire passing from pulley groove 13 to pulley groove 15, is so chosen as to ensure that the wire remains taut as it passes around each of the various pulley grooves, i.e. there is a complete absence of slip between the wire and the several pulley grooves around which it passes.

In order to ensure absence of slip, it is in fact necessary that during the passage of the wire around pulleys of successively increasing diameter, the ratio of the tensions in the wire passing off and passing on to a given pulley should not exceed a predetermined value, which in practice is approximately 2.5 in the case of steel wire, where, as illustrated, the angle of wrap of the wire around each pulley groove is approximately 180° and the groove angle, i.e. the angle between the opposed sides of each pulley groove, is 60°, which is a typical value for grooved pulleys.

This figure of 2.5 is derived from the known formula for ratio of tensions, i.e.

$$\frac{T_1}{T_2}=e^{\mu\sigma}/\sin\frac{\alpha}{2}$$

where:

e is the exponential function.

μ=co-efficient of friction between wire and pulley groove, in practice about .16 in the case of steel wire, rope, or strand, with a steel pulley.

σ=radian angle of wrap corresponding to 180° in the arrangement described.

α is the pulley groove angle aforementioned.

As already stated, the tension of the wire leaving the pulley groove 18 will be slightly greater than the tension

of the wire passing on to pulley groove **10**, the difference in tension being absorbed in the frictional forces required to rotate the three pulleys **14**, **19** and **20**, as well as in frictional losses between the wire surface and the pulley grooves, and the power absorbed in advancing the wire through this said apparatus is accordingly very small.

The tension relieving members constituted by the pulley grooves **16**, **17**, and **18**, which are of progressively decreasing diameter, all have a diameter, including the last of these pulley grooves, in the direction of wire advancement which is greater than the diameter of pulley grooves **10**, **11**, **12**, and **13**, and this increase in diameter, as in the case of pulley groove **15**, corresponds to the permanent elongation which is produced in the heated loop of wire **23** during its passage from pulley groove **13** to pulley groove **15**.

Brush gear **24**, **25**, is provided for supplying current to the pulleys **14** and **20** respectively, this brush gear being connected to the electric circuit indicated diagrammatically at **26** in FIGURE 3, which electric circuit may incorporate a variable resistance **27** or some other known arrangement for varying the current supplied.

As shown in FIGURE 5 the brush gear **24** supplying the current to pulley **14** comprises a channel section brush carrier **29** shaped to arcuate configuration, the sides **30** of which embrace part of the rim **31** of the pulley **14** and these brush carrier sides have mounted thereon a number of closely spaced brushes **32** which contact with opposite faces of the pulley rim **31**.

Since the temperature to which the loop of wire **23** is heated is relatively high, means may be provided for reducing the heat loss by thermal conduction through pulley **14** to its bearings **21** and associated supporting frame **22**. Such means comprise the provision between the rim **31** of pulley **14** and the centre of a large number of closely circumferentially spaced through holes **33**, which serve to reduce the cross section of metal between the heated rim **31** and the centre part of the pulley.

The brush gear **25** for supplying the current to the pulley **20** is substantially conventional, consisting of a series of slip rings **34** and associated brushes **35** sufficient in number, having regard to the high current denity.

Alternatively, if desired brush gear similar to brush gear **24** can be employed for supplying the current to pulley **20**.

The apparatus further includes a cooling device in the form of a water quenching bath or tube **36** for cooling the end of the loop **23** of wire as it passes from pulley **14** on to the groove **15** of pulley **20**, this cooling device, as illustrated, taking the form of a tube through which water is circulated in the known manner. This cooling device serves to prevent undesirable overheating of the two pulleys **19**, **20**, around which the heated wire passes in turn, as well as to ensure that the wire is cold or nearly cold before passing around pulleys **20** and **19**. If the wire were still hot while passing around these two pulleys, it would tend to assume a permanent curved configuration corresponding to the curvature of these two pulleys.

Preferably the cooling water circulates through the tube **36** in a direction opposite to the direction of advancement of the heated wire therethrough.

FIGURE 2 shows in diagrammatic form the manner in which the wire in the form of wire strand is advanced through the apparatus. The strand is formed continuously in a stranding machine **37**, which may be of known form, and which, in any event, forms no part of this invention, the wire as it emerges continuously from the stranding machine constituting the length of wire W1 which passes on to the first groove **10** of pulley **19**.

The wire strand, after passing around the several grooves of the pulleys **19**, **20**, and after passing around the pulley **14** as already described, then advances as length W2 over guide pulley **38** and then wraps through several turns around a power driven capstan or block **39**, which serves to apply the tension to the wire for advancing it around the pulleys **20** and **14**, the wire finally advancing on to wire winding drum **40**, on which it is coiled. Thus the wire is continually pulled under tension through the apparatus.

The capstan or block **39** and drum **40** are power rotated through transmission means **41** of conventional form driven from electric motor **42** or other suitable power source.

Instead of advancing the wire strand around the several pulley grooves by applying tension thereto by means of the power driven capstan or block **39**, the two pulleys **19** and **20** may be power rotated by providing a power drive, as indicated in dotted outline at **43** in FIGURE 2, the power drive being through transmission means **41** from motor **42** to pulley **20** and in order to distribute the torque loading thereby applied to the wire so as to advance it around the pulleys, the pulley **20** may, as shown in dotted outline at **44** in FIGURE 2, be geared to the pulley **19**, namely by the three inter-meshing identical spurwheels **44** so that the power transmitted from the motor **42** is supplied equally to each of the two pulleys **19**, **20**.

In this alternative arrangement the length of wire W2 would pass direct from guide pulley **38** to winding drum **40**.

As a further alternative, the gearing **44** between the two pulleys **19**, **20**, may be provided even though rotation of the pulleys is effected by the tension of the wire in the length W2 leaving the pulleys; as such gearing together of the two pulleys **19**, **20**, may, under certain conditions of operation, be found advantageous in ensuring absence of slip between the wire and the pulleys **19**, **20**.

The manner in which the method of increasing the resistance of wire to creep as performed by means of the foregoing described apparatus will be generally apparent from the foregoing description of the apparatus. A length of wire, generally indicated at W, is passed around each of the pulley grooves **10**, **11**, **12**, **13**, in turn, in the manner diagrammatically indicated in FIGURE 1, the wire where it passes on to the first of these pulley grooves being designated W1, and as will be appreciated from an examination of FIGURES 1 and 3, the wire passes around substantially one half of each of these pulley grooves in passing from one groove to the next.

The length of wire in the form of the long substantially parallel sided loop **23** now passes from pulley groove **13** around pulley **14** and back to pulley groove **15**, which is on the same pulley **20** as that of pulley groove **13** so as to provide two equal lengths of wire which are simultaneously heated by the passage of the heating current from live pulley **14** to return or earth pulley **20**, and the wire in this loop **23** is accordingly heated to the desired temperature for obtaining the desired permanent elongation of the wire, the wire being heated progressively at a substantially uniform rate as it passes at a constant velocity from pulley groove **13**.

Finally, after passing around pulley groove **15**, the wire passes around the pulley grooves **16**, **17**, and **18** of progressively decreasing diameter, which serve to relieve the tension as already described, the length of wire as it leaves the apparatus, namely from groove **18** of pulley **20**, being designated W2.

In each of the aforementioned drawing figures the direction of advancement of the wire at any particular position in the apparatus is indicated by the arrows.

If desired, the wire can pass between the pulleys **19** and **20** in figure of eight fashion, i.e. referring to FIGURE 3 of the drawings, the wire can advance from the lower

side of pulley 19 to the upper side of pulley 20 and from the lower side of pulley 20 to the upper side of pulley 19. Such an arrangement provides an angle of wrap between the wire and the pulleys greater than 180°, and thus reduces the liability of the wire to slip in relation to the pulleys so as thereby to permit of an increased difference in tension in the wire as it passes successively from one pulley groove to the next, but involves a greater axial spacing between adjacent pulley grooves to prevent the lengths of wire fouling one another, than is necessary in the arrangement actually illustrated in FIGURE 3 in which the angle of wrap is 180°.

The maximum temperature to which the wire is heated will be the temperature of the wire immediately before it enters the cooling tube 36 and this maximum temperature may be adjusted by varying the heating current by means of the variable resistance or other adjusting means 27.

This maximum temperature is carefully predetermined by suitably adjusting the current flow in accordance with the following factors, namely:

(*a*) The composition of the material constituting the wire.

(*b*) The nature of the wire, i.e. whether it is solid wire or is in the form of wire strand or rope.

(*c*) The diameter of the wire.

(*d*) The rate of advancement of the wire through the apparatus, the effect of increasing this rate, keeping other factors constant, being to decrease the maximum temperature and the contrary effect being obtained by decreasing the rate of advancement.

(*e*) The required relaxation characteristic of the wire under the desired tensile loading.

As applied to wire formed of high tensile steel, to which the present invention is primarily applicable, i.e. wire formed of medium or high carbon or alloy steel, the temperature will be a tempering temperature within the tempering range of the steel in question, i.e. within the range of temperature to which such steel must be heated after a quenching operation for the purpose of improving the ductility characteristics of the steel.

This temperature is, of course, below the lowest transformation point in the iron/carbon diagram and in the case of medium or high carbon steel having a carbon content within the range of .35% to .9% the tempering temperature would be within the range of 220° C. to 500° C. and preferably within the range 250° C. to 380° C. In the case of certain alloy steels the upper limit of the aforesaid temperature range may be as high as 600° C.

As an example of the improvement in resistance to creep under tensile loading which is obtained by the method the subject of the present invention as applied to wire strand reference is made to the following test carried out with wire strand consisting of 7 wires formed from carbon steel having the following composition:

	Percent
C	0.73
Si	0.169
S	0.033
P	0.028
Mn	0.610

Fe and impurities in insignificant amount remainder.

The arrangement and diameter of the wires forming this wire strand were as follows:

1 core wire	.126".
6 wires helically wound around the core wire, the diameter of these 6 wires being each	.122".
Aggregate cross sectional area of the 7 wires	0.0826 sq. inches.
Nominal diameter of this strand	⅜".

A length of this wire was then passed through an apparatus of the specific form above described in which the various pulley grooves each as above described had the specific diameters above specified, and in no subjecting this wire to the method the subject of this invention the following measurements were taken:

Maximum tension in strand, lbs.	8600 lbs.
Maximum tension as percentage of breaking load	40.5%.
Heating current	900 amperes.
Voltage difference between live pulley and earth pulley	13 volts.
Heating power	11.7 kilowatts.
Linear velocity of wire through apparatus	19 feet per minute.
Maximum temperature of wire	320° C.

Two samples of the foregoing wire were taken, one sample being of the wire subjected to the method the subject of this invention is the specific manner above described, this sample being labelled "Treated." A second sample of the foregoing wire was taken, which was not subjected to the method the subject of this invention, this other sample being labelled "Untreated." These two samples were then subjected to a tensile test in which the extension in inches over a length of fifty inches was observed. Particulars of this test are set out in the following Table II:

TABLE II

Load applied in pounds	Extension in inches on a length of 50 inches	
	Sample labelled "Untreated"	Sample labelled "Treated"
1,000	Zero	Zero
1,500	.013	.012
2,000	.024	.024
2,500	.037	.036
3,000	.049	.049
3,500	.063	.063
4,000	.077	.075
4,500	.092	.085
5,000	.105	.096
5,500	.117	.108
6,000	.130	.119
6,500	.142	.131
7,000	.156	.142
7,500	.169	.153
8,000	.183	.164
8,500	.196	.173
9,000	.210	.185
9,500	.222	.197
10,000	.235	.209
10,500	.250	.219
11,000	.265	.231
11,500	.282	.242
12,000	.299	.254
12,500	.315	.265
13,000	.331	.277
13,500	.347	.288
14,000	.364	.300
14,500	.385	.312
15,000	.407	.322
15,500	.430	.334
16,000	.456	.346
16,500	.480	.358
17,000	.510	.370
17,500	.545	.383
18,000	.584	.397
18,500	.629	.415
19,000	.634	.436
19,500	.749	.475
20,000	.849	.902
20,500	.951	

	Untreated	Treated
Maximum load, in pounds	21,120	21,100.
Total extension on 50 inches at fracture.	1.47"=2.94%	2.82"=5.64%
0.1% proof stress, pounds	15,600	19,500.
0.2% proof stress, pounds	17,100	19,600.
Calculation of modulus of elasticity:		
Range of stress, pounds	1,000 to 11,000	1,000 to 11,000.
Extension on gauge length of 50 inches, inch	0.265	0.231.
Modulus of elasticity, pounds per sq. inch.	22,840,000	26,200,000.

The results set out in the foregoing table are also plotted as the two curves of the graphs depicted in FIGURE 7, this being a load extension graph wherein the righthand curve is the untreated sample and the lefthand curve is the treated sample.

From these curves and the foregoing Table No. II it will be seen that the treated sample subjected to the method the subject of this invention is characterised by a very much higher elastic limit, namely corresponding to an applied load of just under 18,000 lbs. as compared with the elastic limit of the untreated sample corresponding to an applied load of a little over 10,000 lbs.

In addition, up to a load of 19,500 lbs. the treated sample showed an appreciable reduction in extension on the gauge length of 50", as compared with the untreated sample.

It is evident from the results set out in Table II and on the graphs of FIGURE 7 that a significant improvement in the tensile properties of the wire is obtained by processing the wire in accordance with the method the subject of this invention.

Referring now to FIGURE 8, there is here depicted the relaxation property of the treated sample having the data above specified as compared with that of the untreated sample above specified. This relaxation test was carried out with further samples of the same wire strand as that which was subjected to the tensile test above described except that in subjecting the wire to the method the subject of this invention the maximum temperature of heating of the wire was somewhat higher, namely 375° C.

A sample of this so treated wire strand, together with a further sample of an otherwise identical untreated wire strand was subjected to an initial tension equal to 70% of the ultimate stress of the wire strand, namely to an initial tension in each case of 14,100 lbs. and the tension was progressively reduced in each case so as to maintain the strand at a constant length and readings were taken at intervals of every few minutes of the so applied tension for a period of 240 hours; the temperature conditions being maintained constant throughout the period of the test, namely at 20° C., which was considered to be representative of ambient temperature in concrete prestressing wire under conditions of service.

The results are plotted on the graph forming FIGURE 8 wherein the upper curve corresponds to the treated sample and the lower curve corresponds to the untreated sample, i.e. the sample which was not subjected to the method the subject of the invention.

As will be seen from this figure, the tests produced the results set out in Table III below, namely:

TABLE III

Type of sample	Reduction in tensile loading from initial loading of 14,100 lbs. after 240 hrs., length of sample kept constant, lbs.	Percentage reduction in tensile loading, length of sample kept constant
Treated	125	.89
Untreated	640	4.54

The difference between the two samples is substantially, the percentage difference after 240 hours, amounting to no less than 3.65% reduction in tensile loading.

The rapid and quite substantial loss of tensile properties during the first 50 hours of the test in the case of the untreated sample and the very small loss of tensile strength of the treated sample during this same period will be readily observable from FIGURE 8. In addition, careful examination of the slope of the two curves over the period 150 to 240 hours shows clearly that for the same constant length of sample, the untreated sample is suffering a reduction or relaxation of tensile property at a rate appreciably higher than is the case with the treated sample so that the percentage difference of 3.65% measured after a period of 240 hours will progressively increase over a longer period of time.

In FIGURE 6 there is depicted a modification of the apparatus shown in FIGURES 2 to 5 wherein the wire is heated inductively to the desired temperature instead of connecting it to opposite sides of a resistance heating circuit as in the arrangement above described.

In this modified construction there are two pulleys **19**, **20**, corresponding precisely to the pulleys **19**, **20**, of the construction already described and provided with similar pulley grooves of progressively increasing and thereafter progressively decreasing diameter.

Corresponding to the live pulley **14** is a third pulley **14**, around which the wire passes from and back to pulley **20** in like manner to the arrangement previously described.

These three pulleys are conveniently arranged at each of the apex of an equilateral triangle and are supported in such position by frame members **22** which are also arranged equilateral triangle fashion at each of two opposite sides of the apparatus, the frame members **22** supporting bearings **21** for the multi-grooved pulleys **19**, **20**, constructed as already described, and also supporting a bearing **21** for the third pulley **14**, and around which pulley **14** a single loop **23** of the wire to be heated passes in like manner to the preceding construction.

The three pulleys **19**, **20**, and **14** are each mounted for free rotation in like manner to the preceding construction, the wire passing around grooves on pulleys **19** and **20** of successively increasing and successively decreasing diameter in the manner already described.

With this modified arrangement depicted diagrammatically in FIGURE 6 the two lengths of wire in the loop **23** each pass through a current inducing transformer of known form, depicted diagrammatically at **45**, the arrangement being such that the two lengths of wire in the loop **23** which passes around pulley **14** and which is subjected to maximum tension is heated inductively in the known way to the required temperature.

It is important in this induction heating method that the loop **23** should be of low resistance and this is therefore made quite short, with a total length of the order of about three or four feet at the most so as to reduce to a minimum the dimensions of the iron core of the transformer **45**, and the triangular disposition of the three pulleys facilitates the provision of a loop of this relatively short length with corresponding low electrical resistance, while this triangular disposition of the pulleys also provides a space within the so formed triangle for the transformer.

It is, of course, possible to heat the loop by the conventional high frequency induction heating method in place of the particular arrangement depicted in FIGURE 6.

Although the present invention is particularly applicable to the processing of wire for use in reinforced concrete construction, it should, however, be understood that the invention is applicable also to the processing of wire for other purposes, for example, to wire rope for use in the construction of suspension bridge cables, while the invention is applicable merely to the case where it is required to produce wire of particularly straight configuration as well as to produce wire strand or wire rope in which the helical form of the wire or strand is of a particularly perfect configuration as above described.

Still a further advantage of the present invention is that is provides a convenient substitute for the existing cold stretching operation on wire strand or wire rope so as to preclude initial stretching under service conditions. At present this operation is carried out to an increasingly common extent on a very long strand or rope pre-stretching bed, which is a relatively expensive and inconvenient arrangement, the necessity for which is avoided by the processing of the strand or rope by the method the subject of the present invention.

What we claim then is:

1. A method of processing wire for the purpose described, said method comprising advancing the wire around

a succession of peripherally grooved rotary members with the wire engaging between opposite sides of said grooves, with each member rotating at the same angular velocity and which rotary members, in the direction of wire advancement, are of progressively increasing diameter so as to apply a predetermined strain to the wire, heating the so strained wire to a temperature such as to produce a desired predetermined permanent elongation in the wire, cooling the so elongated wire, advancing the so elongated wire around one or a number of peripherally grooved rotating members with the wire engaging between opposite sides of said grooves, and which member or number of members all rotate at the same angular velocity as that of the members of progressively increasing diameter, and which one member or at least the smallest diameter of the number of members around which the permanently elongated wire advances is of a diameter less than the maximum diameter of the rotary members around which the wire passes, such that the tension of the wire leaving the last of the succession of rotary members is the same as or not substantially greater than the tension of the wire advancing on to the first of said succession of rotary members.

2. A method according to claim 1 wherein the heating of the wire is effected by advancing the wire in the form of a loop around a rotary member forming one part of an electric heating circuit wherein the current flows along each of the two lengths of wire forming the loop and which pass on and off the said rotary member forming part of said heating circuit.

3. A method according to claim 1 wherein the wire is heated inductively by inducing a heating current in the length of wire which is subjected to the maximum tension.

4. Apparatus for processing wire for the purpose described, said apparatus comprising a plurality of peripherally grooved rotary members the two sides of which grooves are adapted frictionally to engage with opposite sides of a length of wire advanced successively around each of said members, said members being adapted to rotate at the same angular velocity with some of said members being of progressively increasing diameter in the direction of wire advancement, so as to apply a progressively increasing strain to the advancing wire, means for heating to a controlled predetermined temperature a length of the wire which is subjected to the maximum strain so as to effect an elongation thereof under the tension produced in said length of wire by the applied strain, means for cooling the so heated and elongated wire the arrangement being such that the so elongated and cooled wire is thereupon adapted to be advanced around the remaining of said rotary members, which remaining rotary members are respectively of progressively decreasing diameter in the direction of wire advancement such that the tension of the wire leaving the apparatus is the same or not substantially greater than the tension of the wire entering the apparatus.

5. A method of processing wire for the purpose described, said method comprising advancing the wire around a succession of peripherally grooved rotary members all rotating at the same angular velocity, with the wire engaging frictionally between opposite sides of each groove, with the diameters of the peripheral grooves of said rotary members increasing progressively and thereafter decreasing progressively in the direction of wire advancement, to apply a progressive increase in tension followed by a progressive decrease in tension to the advancing wire, subjecting a predetermined length of wire passing from the last but one to the last of the succession of rotary members of progressively increasing diameter, to a heating operation and heating said predetermined length of wire to a temperature such as to produce a predetermined permanent elongation of the wire under the tension so applied to said length, and cooling said heated wire before its passage on to said grooved member of largest diameter.

6. A method of processing wire strand or wire rope formed of medium or high carbon or alloy steel for the purpose of increasing the resistance of the wire to creep under tensile loading, said method comprising advancing the strand or rope around two sets of peripherally grooved rotary members, with the several members in each set connected together to rotate at the same angular velocity with the strand or rope in its direction of advancement passing around a member of each set in turn with the diameters of the peripheral grooves of said rotary members of the two sets increasing progressively and thereafter decreasing progressively in the direction of strand or rope advancement to apply a progressive increase in tension followed by a progressive decrease in tension to the advancing strand or rope such that the tension in the strand or rope leaving the last of the succession of rotary members is not substantially greater than the tension of the strand or rope advancing on to the first of said rotary members, engaging the strand or rope frictionally between opposite sides of each groove of each of the several members around which it passes, subjecting to a heating operation a predetermined length of strand or rope passing from a rotary member of one set to a rotary member of another set, which rotary members are respectively the last but one and the last of the succession of rotary members of progressively increasing diameter, by said heating operation heating said predetermined length of strand or rope to a temperature such as to produce a predetermined permanent elongation of the strand or rope under the tension so applied to said length of strand or rope, and cooling said heated strand or rope before its passage on to said rotary member of largest diameter.

7. Apparatus for processing wire for the purpose described, said apparatus comprising a plurality of peripherally grooved rotary members, the two sides of which members are adapted frictionally to engage with opposite sides of a length of wire advancing successively around each of said members in turn, said members being adapted all to rotate at the same angular velocity with the diameter of the peripheral grooves of said rotary members increasing progressively and thereafter decreasing progressively in the direction of wire advancement to apply a progressive increase in tension followed by a progressive decrease in tension to the advancing wire, means for heating a predetermined length of wire passing from the last but one to the last of the succession of rotary members of progressively increasing diameter, said heating means being adapted to heat said predetermined length of wire to a temperature such as to produce a permanent elongation of said length of wire under the tension applied thereto and means for cooling said length of heated wire before it passage around said peripherally grooved rotary member of largest diameter.

8. Apparatus according to claim 7 wherein in the direction of wire advancement alternate rotary members of successively increasing diameter and alternate rotary members of successively decreasing diameter are respectively arranged in one of two sets with the two sets mounted for rotation about one of two mutually parallel axes with the several rotary members of each set connected to one another so that said several members in each set are constrained to rotate together at the same angular velocity.

9. Apparatus according to claim 7 wherein in the direction of wire advancement alternate rotary members of successively increasing diameter and alternate rotary members of successively decreasing diameter are respectively arranged in one of two sets with the two sets mounted for rotation about one of two mutually parallel axes with the several rotary members of each set connected to one another so that said several members in each set are constrained to rotate together at the same angular velocity, and the diameters of said rotary members of progressively increasing diameter and the diameter of said rotary members of progressively decreasing diameter being such that the tension of the elongated wire leaving the apparatus

is not substantially greater than the tension of the wire entering the apparatus.

10. Apparatus for processing wire for the purpose described, said apparatus comprising a plurality of peripherally grooved rotary members, the two sides of which grooves are adapted frictionally to engage with opposite sides of a length of wire advanced successively around each of said members, said rotary members being arranged in two sets with the several members in each set mounted on an associated rotatable element so as to rotate therewith, said apparatus being further so arranged that the wire in its direction of advancement is adapted to pass alternately from a rotary member of one set to a rotary member of the other set, some of said members being of progressively increasing diameter in the direction of wire advancement so as to apply a progressively increasing strain to the advancing wire, means for heating to a controlled predetermined temperature a length of wire passing from the last but one to the last of the succession of rotary members of progressively increasing diameter and associated one with each of the two sets of members so as thereby to effect a permanent elongation of the heated wire under the tension produced in said length of wire by the applied strain, means for cooling the so heated and elongated wire, the arrangement being such that the so elongated and cooled wire is thereupon adapted to be advanced around the remaining of said rotary members, which remaining rotary members are respectively of progressively decreasing diameter in the direction of wire advancement such that the tension of the wire leaving the apparatus is the same or not substantially greater than the tension of the wire entering the apparatus.

11. Apparatus according to claim 10 wherein the two rotatable elements on which each of the two sets of rotary members are respectively mounted are connected together by gearing so that all of the rotary members comprised in the two sets are constrained to rotate at the same angular velocity.

12. Apparatus according to claim 10 wherein the two rotatable elements on which each of the two sets of rotary members are respectively mounted are connected together by gearing so that all of the rotary members comprised in the two sets are constrained to rotate at the same angular velocity, and one of said rotatable elements being connected to a power drive for effecting power rotation thereof independently of the tension in the wire leaving the apparatus.

13. Apparatus for processing wire for the purpose described, said apparatus comprising a plurality of peripherally grooved rotary members, the two sides of which grooves are adapted frictionally to engage with opposite sides of a length of wire advanced successively around each of said members, said members being adapted to rotate at the same angular velocity with some of said members being of progressively increasing diameter in the direction of wire advancement, so as to apply a progressively increasing strain to the advancing wire, a further rotary member mounted for rotation about an axis spaced from the axis of rotation of each of said peripherally grooved rotary members of successively increasing and successively decreasing diameter, said further rotary member being so positioned as to be adapted to have passed therearound that length of the advancing wire which is passing from the largest but one to the largest of the grooved members of progressively increasing diameter, means for heating to a controlled predetermined temperature a predetermined portion of said length of wire passing around said further rotary member so as to effect a permanent elongation thereof under the tension produced in said length of wire by the applied strain, means for cooling said heated and elongated wire before its passage around said grooved member of largest diameter and said remaining grooved rotary members around which the wire is adapted to pass being of progressively decreasing diameter in the direction of wire advancement such that the tension of the wire leaving the apparatus is the same or not substantially greater than the tension of the wire entering the apparatus.

14. Apparatus according to claim 13 wherein said further rotary member is connected to one part of an electric circuit, to the other part of which is connected the last but one and the last of said rotary members of successively increasing diameter, the arrangement being such that a heating current is passed along each of the two lengths of wire passing on to and off said further rotary member.

15. Apparatus according to claim 13 wherein means are provided for heating inductively the two lengths of wire passing on to and off the said further rotary member.

16. A method of processing wire for the purpose described, said method comprising advancing the wire around a plurality of sets of peripherally grooved rotary members with the several members of each set connected together to rotate at the same angular velocity and with the wire engaging frictionally between opposite sides of the grooves of each member with the diameter of the peripheral grooves of said rotary members increasing progressively and thereafter decreasing progressively in the direction of wire advancement to apply a progressive increase in tension followed by a progressive decrease in tension to the advancing wire, advancing the wire successively around a member of each set in turn, subjecting to a heating operation a predetermined length of wire passing from a rotary member of one set to a rotary member of another set, which rotary members are respectively the last but one and the last of the succession of rotary members of progressively increasing diameter, by said heating operation heating said predetermined length of wire to a temperature such as to produce a predetermined permanent elongation of the wire under the tension so applied to said length of wire and cooling said heated wire before its passage on to said rotary member of largest diameter.

17. A method of processing wire for the purpose described, said method comprising advancing the wire around two sets of peripherally grooved rotary members, with the several members in each set connected together to rotate at the same angular velocity with the wire in its direction of advancement passing around a member of each set in turn with the diameters of the peripheral grooves of said rotary members of the two sets increasing progressively and thereafter decreasing progressively in the direction of wire advancement to apply a progressive increase in tension followed by a progressive decrease in tension to the advancing wire such that the tension in the wire leaving the last of the succession of rotary members is not substantially greater than the tension of the wire advancing on to the first of said rotary members, engaging the wire frictionally between opposite sides of each groove of each of the several members around which it passes, subjecting to a heating operation a predetermined length of wire passing from a rotary member of one set to a rotary member of another set, which rotary members are respectively the last but one and the last of the succession of rotary members of progressively increasing diameter, by said heating operation heating said predetermined length of wire to a temperature such as to produce a predetermined permanent elongation of the wire under the tension so applied to said length of wire, and cooling said heated wire before its passage on to said rotary member of largest diameter.

18. Apparatus for processing wire for the purpose described, said apparatus comprising two sets of peripherally grooved rotary members, with the several members in each set connected together to rotate at the same angular velocity and so arranged as to permit of the wire in its direction of advancement passing around a member of each set in turn with the diameters of the peripheral grooves of said rotary members of the two sets increasing progressively and thereafter decreasing progressively in the direction of wire advancement to apply a progressive increase in tension followed by a progressive decrease in tension to the advancing wire such that the tension in the

wire leaving the last of the succession of rotary members is not substantially greater than the tension of the wire advancing on to the first of said rotary members, said peripherally grooved rotary members being adapted on opposite sides of each groove to engage frictionally, with the wire passing around the member, means for subjecting to a heating operation a predetermined length of wire passing from a rotary member of one set to a rotary member of another set, which rotary members are respectively the last but one and the last of the succession of rotary members of progressively increasing diameter so as to heat said predetermined length of wire to a temperature such as to produce a predetermined permanent elongation of the wire under the tension so applied to said length of wire and means for cooling said heated wire before its passage on to said rotary member of largest diameter.

19. Apparatus for processing wire for the purpose described, said apparatus comprising two sets of peripherally grooved rotary members, with the several members in each set connected together to rotate at the same angular velocity and so arranged as to permit of the wire in its direction of advancement passing around a member of each set in turn with the diameters of the peripheral grooves of said rotary members of the two sets increasing progressively and thereafter decreasing progressively in the direction of wire advancement to apply a progressive increase in tension followed by a progressive decrease in tension to the advancing wire such that the tension in the wire leaving the last of the succession of rotary members is not substantially greater than the tension of the wire advancing on to the first of said rotary members, said peripherally grooved rotary members being adapted on opposite sides of each groove to engage frictionally, with the wire passing around the member, a further rotary member mounted for rotation about an axis spaced from the axis of rotation of said two sets of rotary members, said further rotary member being so positioned as to be adapted to have passed therearound that length of the advancing wire which is passing from the largest but one to the largest of the grooved members of progressively increasing diameter, and means connecting to one side of an electric heating circuit the largest but one and the largest of said grooved rotary members of progressively increasing diameter, means connecting said further rotary member to the opposite side of said circuit so as to pass a heating current along the lengths of wire respectively passing on to and off said further rotary member so as to heat the same to a predetermined temperature and effect a permanent elongation thereof under the tension produced in said length of wire by the applied strain, and means for cooling said heated and elongated wire before its passage around said grooved member of largest diameter.

References Cited in the file of this patent

UNITED STATES PATENTS

1,023,316	Hurwitz	Apr. 16, 1912
1,669,743	Elder	May 15, 1928
1,954,678	Meissner	Apr. 10, 1934
2,060,400	Nieman	Nov. 10, 1936
2,479,353	Hansell	Aug. 16, 1949
2,502,005	Hansell	Mar. 28, 1950
2,589,283	O'Grady	Mar. 18, 1952

FOREIGN PATENTS

415,824	Germany	July 1, 1925