Dec. 22, 1970 K. G. HANN ET AL 3,548,624

APPARATUS FOR PROCESSING WIRE AND THE LIKE

Filed Feb. 20, 1968 6 Sheets-Sheet 1

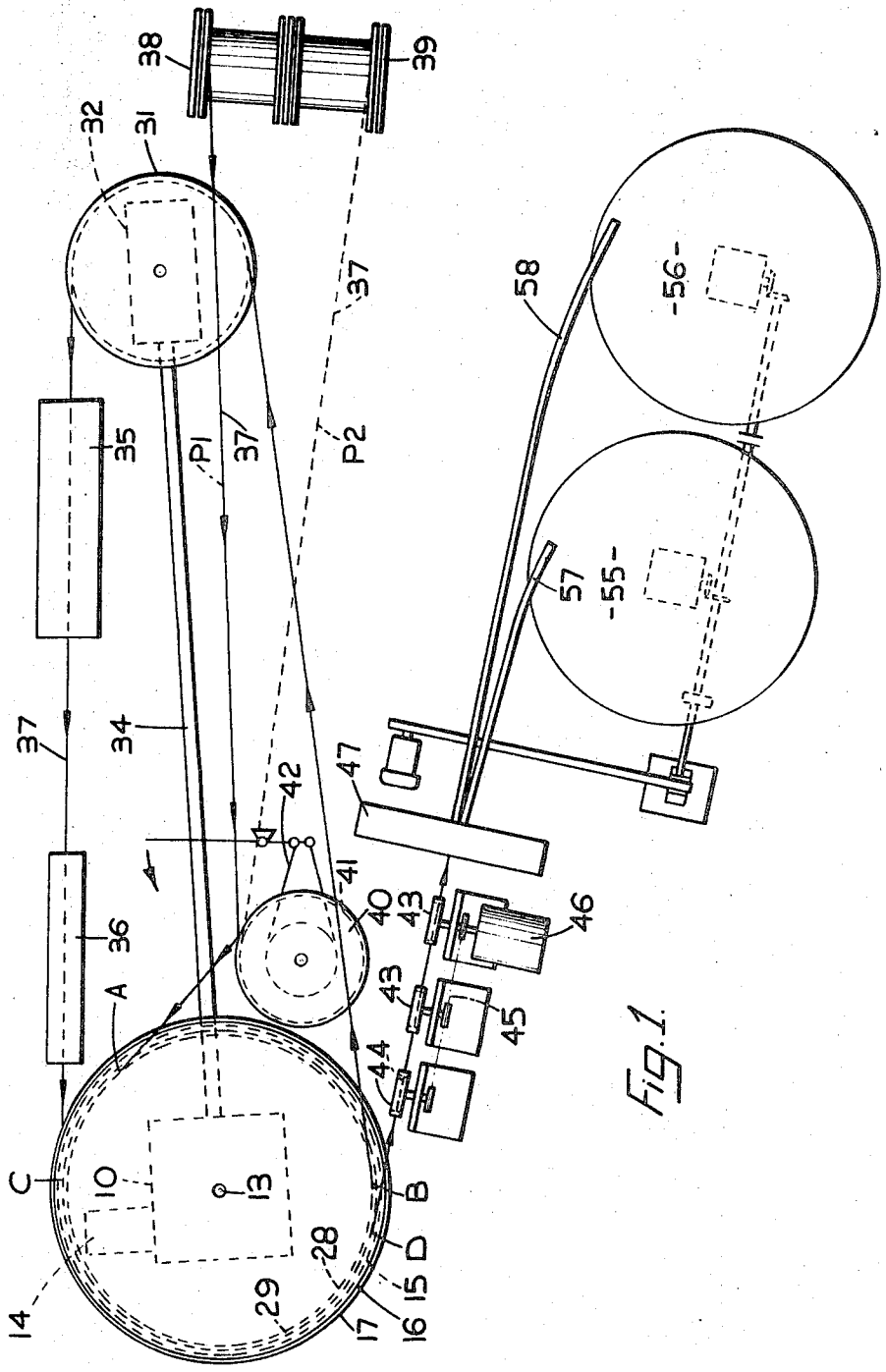

Fig. 1.

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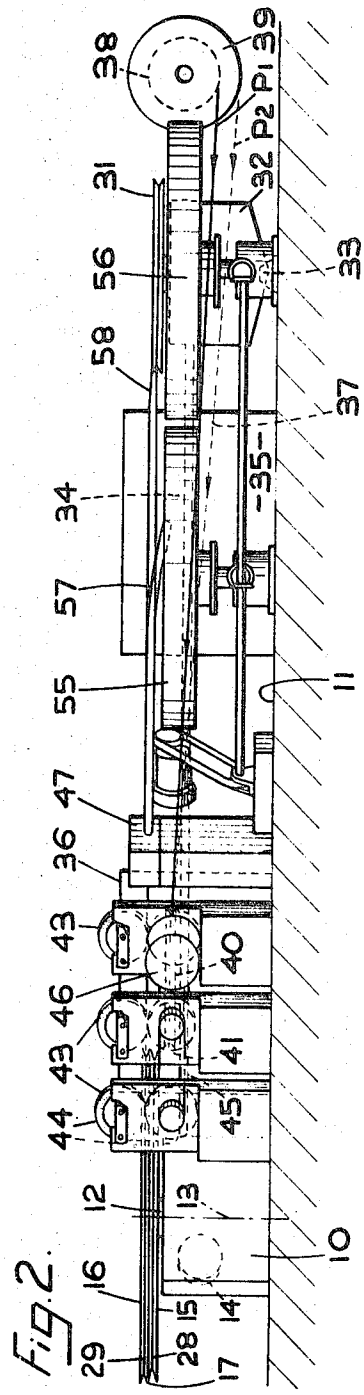

Fig. 2.

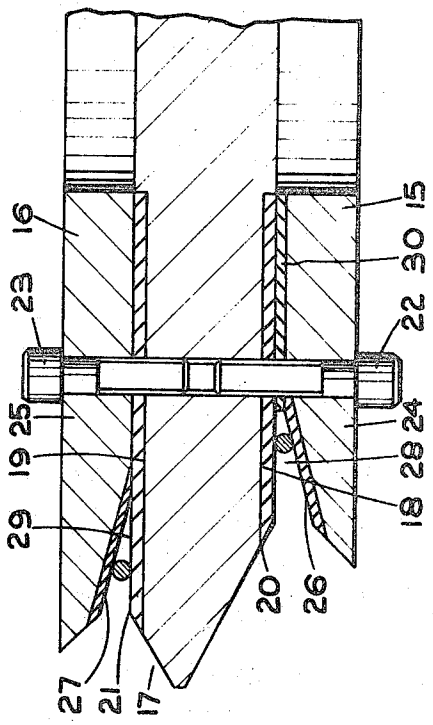

Fig. 3.

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APPARATUS FOR PROCESSING WIRE AND THE LIKE

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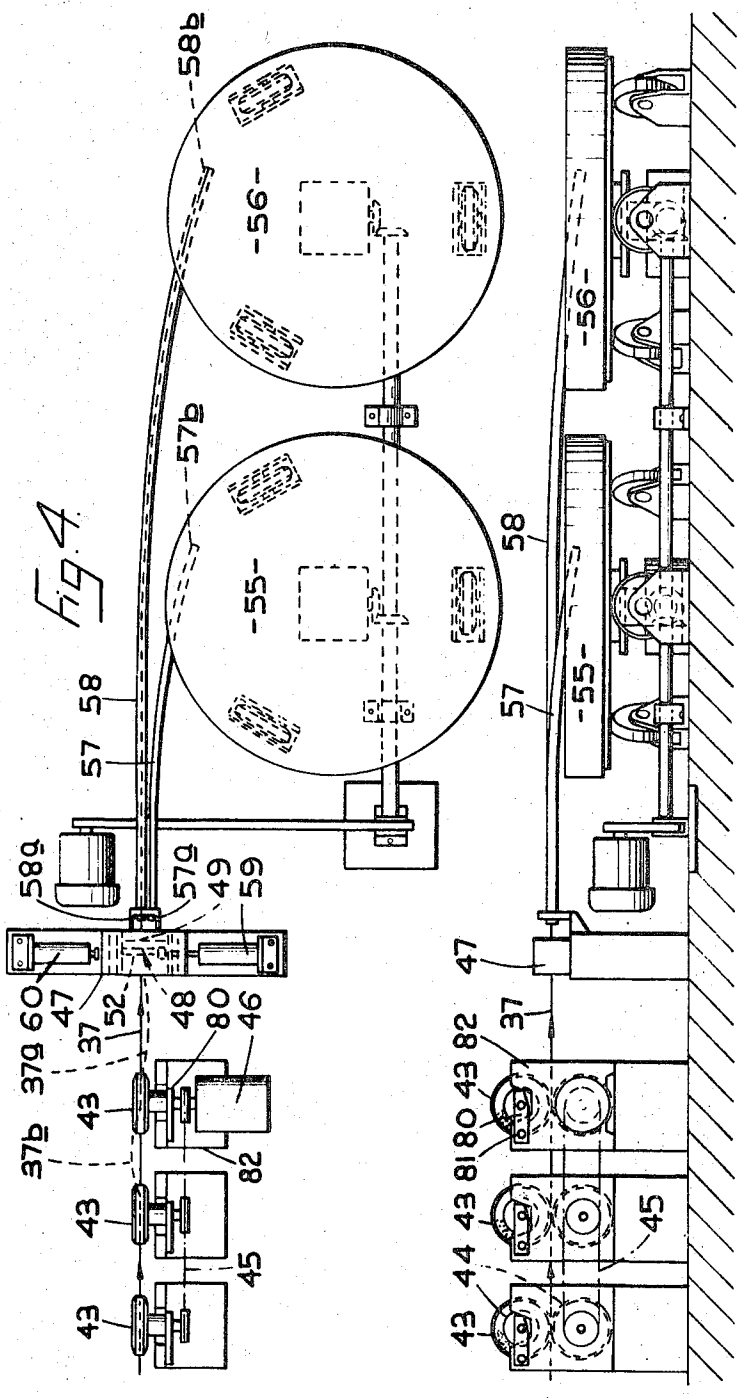

Fig. 4

Fig. 5

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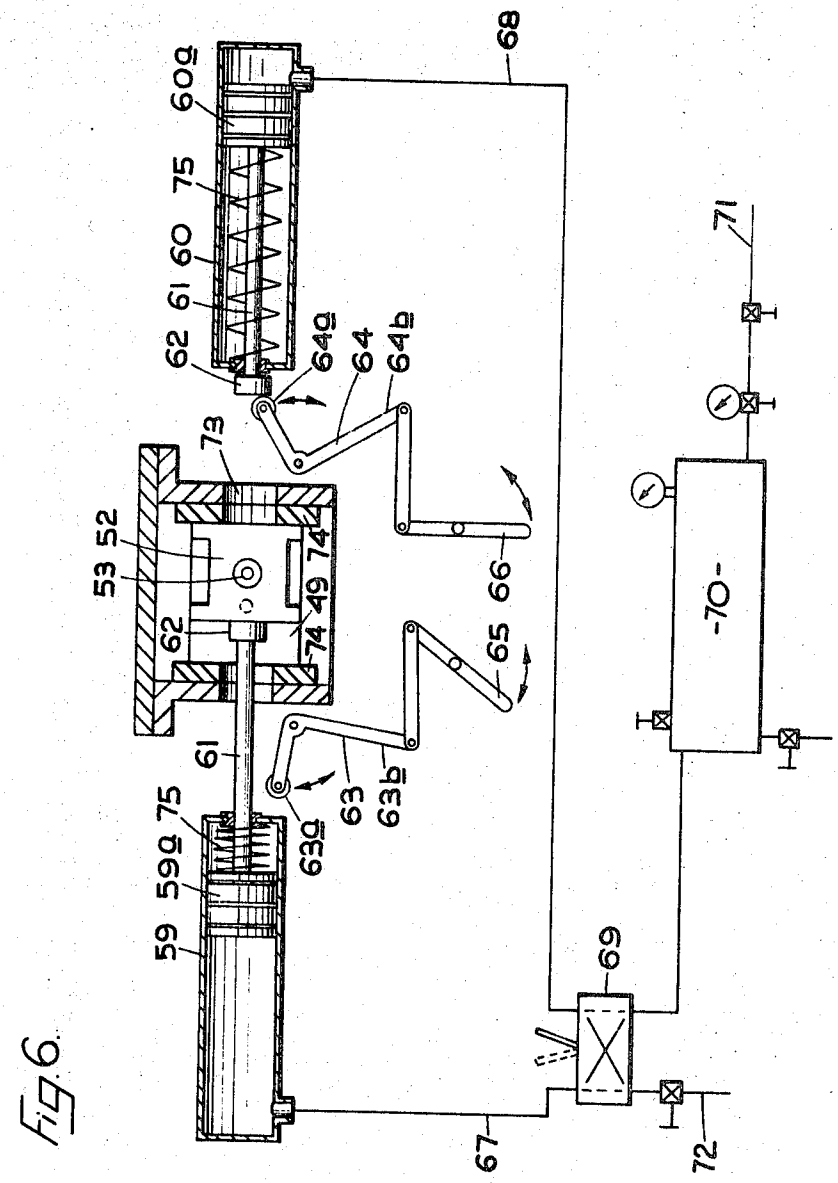

Fig. 6.

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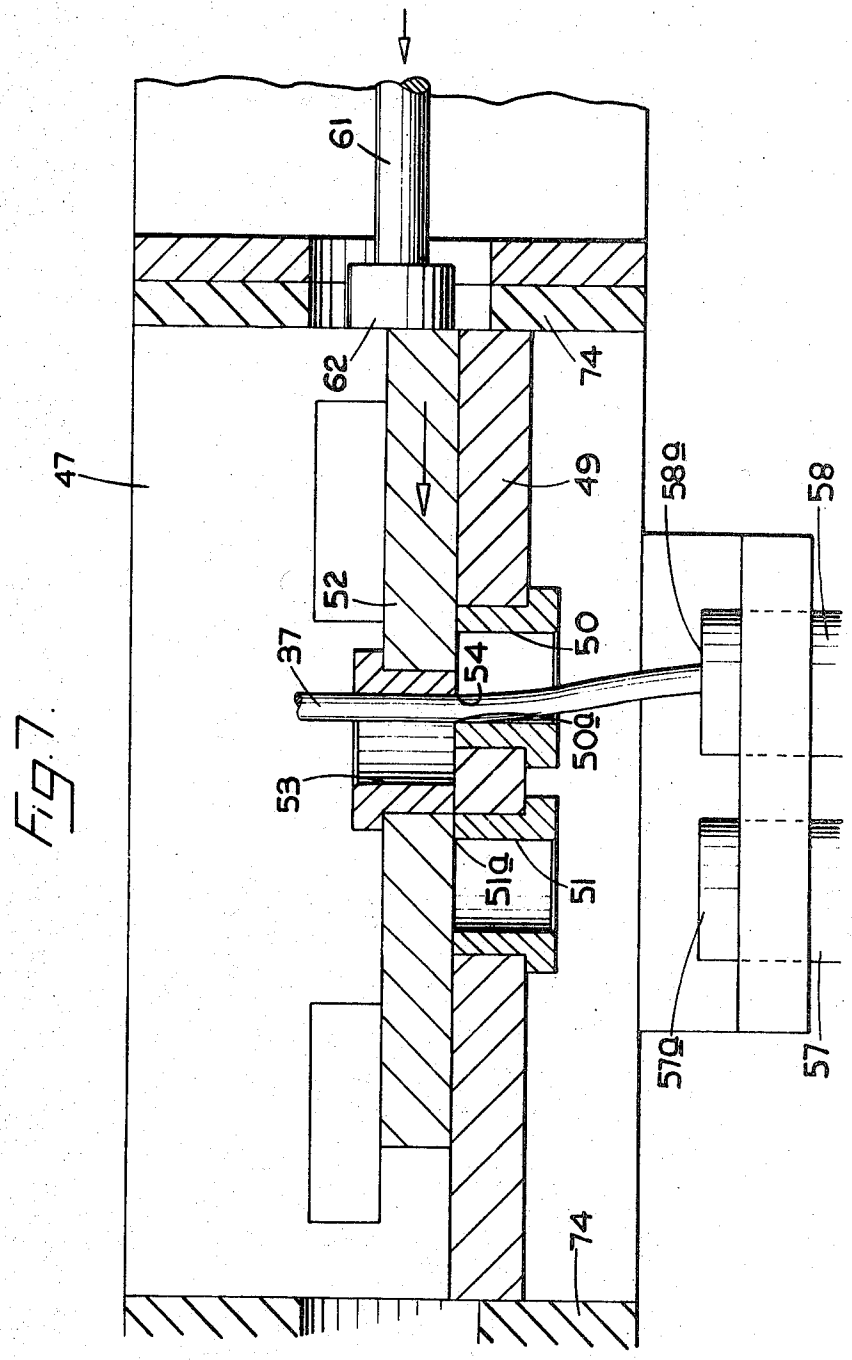

Fig. 7

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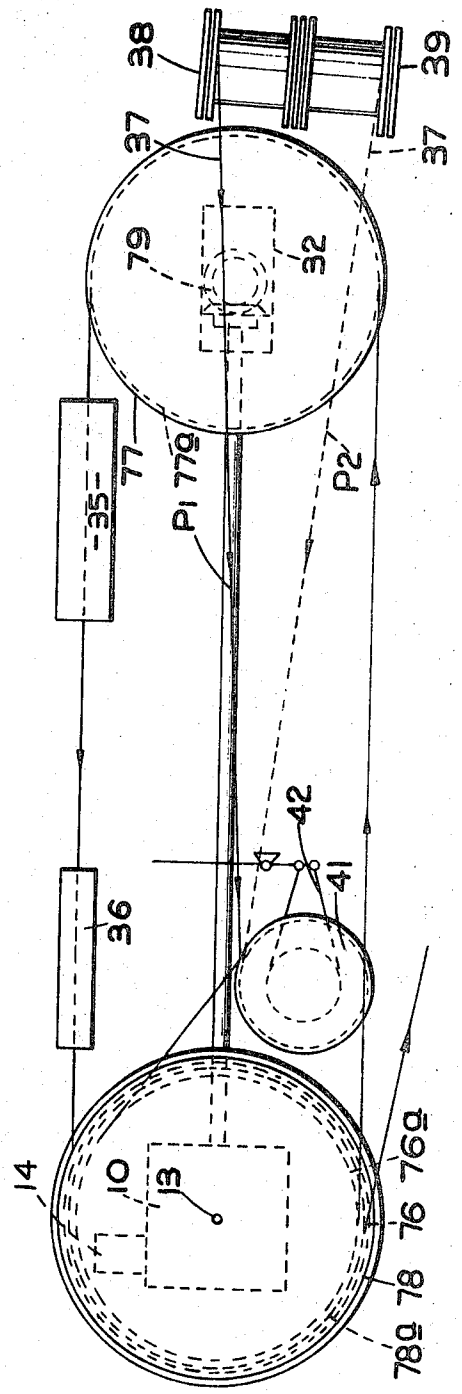

Fig. 8

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Patented Dec. 22, 1970

3,548,624

APPARATUS FOR PROCESSING WIRE AND THE LIKE

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Claims priority, application Great Britain, Feb. 24, 1967, 8,809/67
Int. Cl. B21f 9/00
U.S. Cl. 72—129 12 Claims

ABSTRACT OF THE DISCLOSURE

Method of and apparatus for effecting controlled permanent stretching of metal wire, strand or rope, by passing the same around a number of V-groove pulleys of different diameter, coupled together to rotate at the same angular velocity, with the V-grooves having a groove angle of not more than 30°.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates to a new or improved method of and apparatus for effecting controlled permanent elongation, so as to increase the resistance to continued elongation under sustained tensile loading, of flexible elongated metal elements of the type herein called the "type described," which are formed in wire, strand or rope. The invention is especially applicable to effecting such controlled elongation of steel elements of the type described, more particularly wire of medium and high carbon also alloy steel for use in engineering structures of various kinds, for example, in bridge construction, or as pre-stressing elements in concrete structures. The effect of permanently elongating the element in the manner described herein being particular in the case of steel elements to so change the structure of the metal as well as to so raise the elastic limit as to increase substantially the creep resistance or relaxation property of the element, i.e. resistance to continued elongation when subjected to a sustained tensile loading over a long period of time as in the case of a pre-stressing element for a concrete or like structure.

(2) Description of the prior art

The invention is concerned with a method and apparatus for the purpose referred to in the preceding paragraph, which is of the kind herein called "the kind specified," in which the metal element of the type described is advanced around a plurality of rotating members and which rotate at the same angular velocity, each provided with a peripheral V groove which receives and frictionally grips the advancing element, with the diameter of the several V grooves differing from one another so as to increase progressively in the direction of element advancement to hereby apply a predetermined strain and tension to the advancing element, applying sufficient tension to the length of element leaving the V groove of largest diameter to maintain the element in gripping engagement therewith, with successively advancing lengths of element passing to the rotating member having the largest diameter V groove, and which are subjected to the maximum strain and tension, being heated to a predetermined temperature such as to attain such a controlled permanent elongation of the element as to increase the creep resistance of the element.

In the specification of our prior Pat. No. 3,068,353, we have described a method and apparatus of the kind specified in which a large number, eight in all, of peripherally V-grooved rotating members are employed; namely five such members, the diameters of the grooves of which increase progressively in the direction of advancement of the element to apply thereto a progressively increasing strain and tension up to the predetermined maximum value, and three such members, the diameters of the V grooves of which are less than that of the last successive member of progressively increasing diameter and which diameters further decrease progressively in the direction of element advancement to reduce progressively the tension applied to the advancing element; and the rotary members being arranged in two sets, with the two sets being mounted for rotation in side by side spaced apart relationship with the elongated element passing alternately from one set to the other in its direction of advancement. In such prior method and apparatus the angle between the two sides of the V groove of each rotary member was the customary angle for V groove pulleys, namely 60°.

Although such method and apparatus is extremely effective in producing in a closely controlled manner the required permanent elongation per unit length of element, it entails the following disadvantages:

(1) Before any part of the element can be subjected to the operation of the apparatus, a sufficient portion of the entire length of the element, namely at the forward end thereof in the direction of element advancement, must be fed into the apparatus as completely to extend around those rotary members which serve progressively to decrease the tension in the element, which portion necessarily cannot be subjected to the required combination of heat and tension, and the same applies in respect of that portion of the element which is constituted by the rear end thereof in the direction of element advancement as this passes around the rotary members of progressively increasing diameter during the feeding of the last part of the entire length of the element through the apparatus.

Thus both the front and rear portions and which in practice have a length several times the circumferential length of a single rotary member are not subjected to the required combination of heat and tension and are therefore scrap. As each rotary member may have a peripheral diameter of between about 1 and 1.5 metres, the wastage of element per length of element, allowing for the distance between the two sets of rotary members which the element has to traverse in passing from one rotary member to the next, is of the order of 35 to 50 metres which is a substantial amount of waste.

(2) By reason of the relatively large number of V-grooved rotary members required and their arrangement in two sets each set comprising several rotary members and each set having its own rotational mounting, all of which rotary members must be formed to a high degree of accuracy, the apparatus described in the prior specification is expensive.

The present invention has for its object a new or improved method of and apparatus of the kind specified, in which the proportion of scrap in a given length of element arising from the reason above mentioned, is substantially reduced, and which effects an important economy in the cost of the apparatus for a given output.

SUMMARY OF THE INVENTION

The present invention is based upon our discovery that by reducing the angle between the sides of the V grooves of the rotary members from the hitherto customary value of 60°, which is the value obtaining with the arrangement of the prior specification, to a substantially smaller value not exceeding 30°, the same maximum strain and thus the same maximum tension and controlled elongation can be

developed in an elongated element of a given cross sectional shape and area with a substantially fewer total number of rotary members, which can accordingly be arranged in a single set, and without it being necessary to provide any V-grooved rotary members of progressively decreasing diameter in the direction of element advancement. Indeed in many applications of this invention only two V-grooved rotary members are necessary.

Accordingly the present invention comprises a method of the kind specified for effecting a controlled permanent elongation and improved creep resistance of a flexible elongated metal element of the type described, said method being characterised in that the elongated element is advanced under tension onto and around each of a plurality of peripherally V-grooved rotary members comprising not more than three such members in all, and that the angle between the two sides of each V shaped groove of the several rotary members is not more than 30°, but is large enough to ensure that the two sides of each V shaped groove have mere wedging engagement with the metal element and that the rotary member of largest peripheral diameter is the last of said V groove rotary members around which the elongated element passes in its direction of advancement.

By the expression "large enough to have mere wedging engagement" is meant that the angle between the two sides of each V shaped groove must not be so small as to produce a crushing or like deformation of the metal element within the groove so as undesirably to damage the same. Usually such angle must not be less than about 8° for this reason.

The invention further comprises apparatus for carrying out foregoing method into effect.

As compared with the method and apparatus the subject of our prior patent, the present invention provides the following important advantages:

(1) a substantial reduction in the amount of scrap in respect of each complete length of elongated metal element, which is permanently elongated by the method and apparatus of this invention. In particular, as there are no V-grooved rotary members for progressively reducing the applied tension, an important scrap saving can be effected in respect of the forward end of the length of elongated element.

Also, although there must still be some scrap in respect of the rear end of the length of elongated element passing around the rotary members of progressively increasing diameter, such scrap length will be much less as the number of rotary members of progressively increasing diameter is reduced.

(2) The reduction in the total number of V groove rotary members enables an important economy to be effected in the construction cost of an apparatus of a given output for the same size and properties of the element concerned.

The foregoing advantages are obtained without any sacrifice at all in the closely accurate control of the maximum strain and tension and thus of the desired elongation which is a characteristic of the method and apparatus the subject of our prior specification above mentioned.

The above advantages are particularly significant where, as is preferred, only two V-grooved rotary members, namely first and second members, are employed and connected together to rotate together about a common axis, with the second member having the largest diameter.

In this preferred form of the method and apparatus, there is no scrap wastage arising from the lengths of element passing from one to the other of two sets of rotary members, as in the prior arrangement earlier described. Also the disposition of the two V-grooved rotary members as a single set mounted for rotation together about a common axis effects a further economy in the construction cost.

A particularly satisfactory arrangement so we have found, is that in which the angle between the two sides

of each V groove is within the range of 12° to 20°. With an angle of less than 12° there is some risk of damage to the surface of the element by crushing, although in general such risk is not serious until the angle is less than about 8°. With an angle of more than 20°, the frictional grip arising from the wedging engagement with the element begins significantly to be reduced.

Indeed the most satisfactory arrangement in our experience is one in which the foregoing angle is 15°. This provides the maximum frictional grip on the element, particularly where this is a single strand of wire of circular form in cross section, consistent with not making the V groove so deep as would be the case with smaller angles as to be so costly in manufacture as to commence to offset the saving referred to under advantage (2) above.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is considered to be primarily applicable to effecting controlled elongation of metal elements in the form of a single strand of wire, in particular, medium or high carbon steel or alloy steel wire and one preferred apparatus for carrying out the method of this invention as applied to medium and high carbon steel wire, will now be described with reference to the accompanying drawings, wherein:

FIGS. 1 and 2 are respectively, a plan view and side elevation of the apparatus;

FIG. 3 is a cross sectional view to an enlarged scale of the two V groove rotary members of the same construction;

FIGS. 4 and 5 are respectively, plan views and side elevations to an enlarged scale of certain parts of the same apparatus depicting certain details of the construction, which for clarity, have been omitted from FIGS. 1 and 2;

FIG. 6 is a diagrammatic view depicting the pneumatic system in controlling the operation of shears for cutting the wire into lengths;

FIG. 7 is a sectional view to an enlarged scale of part of the wire cutting shears;

FIG. 8 is a plan view of part of the apparatus depicted in FIG. 1, showing a modification.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, the apparatus illustrated in FIGS. 1 to 7 comprises a base **10** carried rigidly on floor **11** and supporting for rotation in bearings **12** a vertical shaft **13**, power driven from electric motor **14**. The upper end of shaft **13** carries a pair of connected together first and second rotary members **15**, **16**, respectively. These, referring to FIG. 3, are constituted by central pulley member **17** the hub of which is fixed to shaft **13** to rotate therewith. As shown in FIG. 3, opposite side faces **18**, **19** of pulley member **17** are flat and mutually parallel, with the diameter of the peripheral edge **20** of face **18** being less than that of the corresponding edge **21** of face **19**. To each of these faces **18**, **19** are secured by a number of circumferentially spaced bolts **22**, **23**, rings **24**, **25** respectively, which at positions near each edge **20** and **21** and opposite to faces **18**, **19** are formed with chamfered faces **26**, **27** respectively.

Each of these chamfered faces **26**, **27** is inclined at an angle of 15° away from the corresponding pulley member face **18**, **19** to provide therebetween a V groove **28**, **29**, respectively, with chamfered face **27** at a great radial distance from the axis of rotation of pulley member **17** than face **26**. Thus the diameter of groove **28** is less than that of groove **29** and its effective diameter is further reduced in relation to that of groove **29** by packing strip **30** disposed between ring **24** and pulley member face **18**, so that V groove **28** is adapted to grip the wire at a position nearer its base or apex than is the case with groove **29**, so as by such reduction in the diameter of groove **28** relative to groove **29** to increase the strain produced in the wire.

Also insofar as the bolts **22**, **23** are removable the pack-

ing strip **30** can be removed or replaced by one of a different thickness. Also the same or a different packing strip can thereby readily be inserted between ring **25** and face **19**. The effect of the foregoing is respectively to vary the effective size, i.e. wire gripping diameter of grooves **28**, **29**, in accordance with the desired strain to be developed.

The larger diameter groove **29** is disposed horizontally above groove **28** and is horizontally aligned with idle pulley wheels **31** provided with the usual 60° angle peripheral V groove and mounted for free rotation about a vertical axis through bearings not shown in mounting **32**, supported from floor **11** through trunnion pivot **33**, the axis of which is perpendicular to the vertical plane containing the axes of rotation of pulley member **17** and idle wheel **31**. A steel thrust tube **34** extends with its central axis lying in such plane from the upper end of mounting **32** to the upper end of rigid base **10**. This tube **34** serves to take the thrust on mounting **32** of the tension produced as described below in the wire passing from groove **28** to groove **29** around idle wheel **31**. Insofar as tube **34** is made in an elastic metal, i.e. steel, it will elastically deflect in proportion to the tension in the wire and the pivotal support **33** of idle wheel mounting **32** permits of this deflection being observed and of the wire tension being measured by suitable known apparatus for that purpose if required.

The idle wheel **31** is spaced horizontally away from the pulley member **17** by a sufficient distance which measured at the centres and for a diameter of member **17** of the order of 3 metres and an idle wheel diameter of about 1⅔ metres may be a distance of about 8 metres. Thus there is ample space to accommodate between wheel **31** and member **17** an induction heater **35** of known form for heating to the required temperature to effect permanent elongation, successive lengths of advancing wire at maximum tension, while such space can also accommodate water quenching bath **36** for cooling the wire after heating to a temperature low enough to ensure that on subsequent reeling it will not take a permanent set in coiled configuration.

The length of wire **37** to be permanently elongated is fed into the apparatus above described, along one or the other of wire paths P1, P2 from one or the other of corresponding supply reel **38**, **39**, respectively, each supported for rotation above aligned horizontal axes and provided with the usual brake for keeping taut the length of wire in paths P1 or P2. The arrangement permits of the wire being fed from a second reel, e.g. reel **39**, as soon as the first reel, e.g. reel **38**, is exhausted and of the latter being replaced meanwhile by a full reel.

The length of wire from each of these two reels passes around brake wheel **40** mounted for rotation in a horizontal plane aligned with that of lower lesser diameter V groove **28** constituting first rotary member **15**. This brake wheel has a peripheral wire engaging V groove **41** with an angle between the sides less than the customary angle, namely 30° to enable a substantial braking torque to be applied to the wire passing around the bake wheel from an associated brake **42** of known form. Thus the length of wire which passes around nearly the entire circumference of the V groove **41** of brake wheel **40** and thence to power rotated first rotary member groove **28** is caused to advance onto groove **28** under appreciable tension which may be as high as about 500 kilos at a wire speed of 100 metres per minute. Thus the wire is brought into tight gripping engagement with V groove **28** at the position A in FIG. 2 where it enters such groove. Thus at such position there will be no slip at all between the wire and the groove **28**.

The length of wire **37** passes around about three quarters of the circumference of first rotary member **15** provided by lesser diameter groove **28**, being pulled into the apparatus by the power rotation of member **15** from motor **14**. The length of wire then leaves groove **28** at position B and passes direct to and around idle wheel **31** from which it advances through the induction heater **35** by which it is heated to a temperature within the range of 220° to 500° C. in the case of a carbon steel wire, the maximum temperature being as high as 600° C. in the case of an alloy steel wire. The precise temperature to which the wire is heated depends on the particular steel composition and the required permanent elongation of the wire measured as a percentage of its original length. In the case of a carbon steel having a carbon content within the range of .6% to .85% the heating temperature is preferably within the range of 250° C. to 380° C., where a permanent elongation within the range of 2% to 5% is desired.

The wire, after being heated by the induction heater **35** to the temperature above specified, is then passed through the water quenching bath **36** so as to be cooled to a temperature such that the tension applied to the wire is now below the elastic limit of the wire, it being of course understood that the elastic limit falls with increase in temperature. Thus the wire will not assume a permanently curved configuration on subsequent reeling.

The wire now passes at position C into the V groove **29** of power rotated second rotary member **16**, at which position the wire **37** is in tight gripping engagement with the two sides **19**, **27** of this V groove and around which the wire passes for substantially one half of the circumference of this second rotary member **16**, leaving the same at position D.

As a result of the selection of the maximum angle between the two sides of each V groove **28**, **29** of the corresponding rotary members **15**, **16**, to be not more than 30° as opposed to the hitherto customary 60°, which angle is 15° in the arrangement illustrated, it is possible to make the diameter of second rotary member **16** so much larger than that of rotary member **15** as thereby to produce up to at least a 5% permanent increase in the length of a medium or high carbon steel wire passing from rotary member **15** to rotary member **16** without slip occurring between the wire and the corresponding grooves **28**, **29** at the position A, C, respectively, at which the wire first engages with the rotary members **15**, **16** in advancing therearound. To ensure absence of slip at positions A and C it is further necessary that substantial tension is applied both to the length of wire passing onto the smaller diameter rotary members **15** at position A and also as described below, to the length of wire leaving the larger diameter rotary member **16** as to maintain the wire passing around such rotary member **16**, as shown through substantially half the circumference thereof, in frictional gripping engagement with member **16**.

The foregoing absence of slip at positions A and C and the above described permanent elongation of the wire is further ensured in accordance with this invention by the sides of the V grooves being relatively inclined at the small angle of not more than 30° and preferably between 12° and 20°; thus producing a particularly large wedging pressure on the surface of the wire in engagement therewith so as to increase substantially the frictional resistance to slip between the wire and the V grooves at the positions A and C, without at the same time crushing or deforming the wire to damage it as would be the case if the said angle were too small, i.e. less than about 8°.

Preferably, the diameter of second rotary member **16**, i.e. of the wire gripping part of groove **29**, is made so much larger than that of first rotary member **15**, i.e. of the wire gripping part of groove **28**, as to produce a strain, controlled precisely by the selected difference in the two diameters, amounting to 4% in the length of wire passing from rotary member **15** to rotary member **16**. The resultant tension in the wire which may be within the range of 2000 to 4500 kilos dependent on the wire diameter and composition, will result in a permanent elongation of the wire of nearly the same value as the strain produced by the difference in diameter above mentioned. The value of the permanent elongation will be somewhat less than the

value of the strain by reason of some elastic contraction of the wire after leaving groove **29**.

The effect of heating to the temperature above specified the steel wire when under the tension above specrified, is to so alter the physical structure of the metal as not only merely to permanently elongate the wire but also to increases substantially its subsequent resistance, particularly at room temperature, to creep under sustained tensile loading.

Necessarily for the wire to be strained in the above way the two rotary members including their respective V grooves must be connected together as above described, so as to rotate at the same angular velocity.

Although there is no slip between the wire and each groove **28**, **29** at positions A and C and although this condition obtains over part of the length of each groove with which the wire is in frictional engagement in advancing beyond positions A and C, as the length of wire advancing around each groove **28**, **29** approaches nearer to the positions B, D, respectively at which the wire leaves the groove it will commence to creep in relation to the groove. Such creep will be in a forward direction relative to groove **28** under the tension resulting from the strain produced in passing from groove **28** to groove **29**, and in a backward direction relative to groove **29**, since the tension in the wire leaving groove **29** at position D will be very much less than that at which it enters the groove at position C.

After the wire leaves the larger diameter rotary member **16** at position D it passes between a plurality of power driven pairs of draw-off wheels **43**, which serves to apply sufficient tension to the length of wire leaving the V groove **29** at the position D as to maintain such gripping engagement between the rod and the V groove that no slip occurs at the position C.

For this purpose each pair of draw-off wheels **43** may be provided with a peripheral inflated pneumatic rubber tyre **44** with the axes of rotation of the two wheels in each pair being so relatively disposed that the treads of the two tyres are in pressure engagement with one another over a distance of several centimetres in a direction along the length of the wire advancing therebetween. Thus, each pair of power driven wheels **43** can apply quite substantial tension to the length of wire leaving the larger diameter rotary member **16**, which tension may be of the order of about 200 kilos at position C.

At least two pairs of such draw-off wheels **43** are necessary in order to take care of joints between successive advancing lengths of wire and ensure that when a joint between such length is between two pairs of wheels **43**, the foremost length continues to be power advanced to the reeling mechanism.

Preferably to ensure the provision of sufficient tension in the wire leaving the larger diameter rotary member, three pairs of these wheels are provided, as shown in FIG. 5 of the drawings and these are all driven at the same angular velocity through the gear drive diagrammatically depicted at **45** from a common power source **46**.

After passing between the three pairs of draw-off wheels **43**, the wire then advances to a cut-off device **47** comprising pneumatically operated shears **48** of known form, the construction of which is shown in general in FIG. 4 and in more detail in FIGS. 6 and 7.

Thus, referring to FIGS. 6 and 7, the shears comprise a stationary die plate **49** provided with a pair of transversely spaced apart holes **50**, **51**, for the passage therethrough of the length of advancing wire **37**. Mounted for rectilinear sliding movement on this stationary die plate **49**, is cut-off die **52**, having a wire receiving and guiding hole **53**, the inner edge **54** of which adjacent to fixed die **49** is adapted to coact with the adjacent edge **50***a*, **51***a*, respectively, of either of the two holes **50**, **51** in severing the length of wire advancing through the holes **50** and **51** respectively, to power wire rotated coiling units **55**, **56** of known form.

The arrangement ensures that as soon as one coiling unit, e.g. **55**, is fully wound, the wire can then be severed by the reciprocatory movement of cut-off die **52**, so as to bring its hole **53** from a position previously in register with one of the two stationary die holes, e.g. hole **50**, into a position now in register with the other stationary die hole **51**, severing the length of wire during such movement of the cut-off die.

Thus, the free end of the fresh length of wire necessarily within guiding hole **53** is at once directed to that stationary die hole which is associated with the at present empty coiling unit, in this case coiling unit **56**, permitting of the already wound coil on coiling unit **55** being removed ready for a fresh length of wire as soon as coiling unit **56** is filled.

For this purpose, in association with each of the two coiling units **55**, **56**, is a tubular wire guide **57**, **58**, respectively, one end **57***a*, **58***a*, respectively, being aligned with stationary die holes **50**, **51**, with the other end **57***b*, **58***b*, respectively, directed to the corresponding coiling unit **55**, **56**.

The movable cut-off die **52** is reciprocated by a pair of pneumatic rams **59**, **60**, between two extreme positions, in which its wire receiving hole **53** is completely aligned with stationary die hole **50** in the one position and with stationary die hole **51** in the other position, the cut-off die advancing between these two extreme positions through two intermediate wire cut-off positions one of which is depicted in FIG. 7.

The piston rod **61** of each of these rams **59**, **60**, is not connected to the movable cut-off die **52**, but is adapted to displace die **52** by impact engagement therewith after the piston rod has been displaced by a distance sufficient for it to acquire a certain velocity and kinetic energy. For this purpose as shown in FIG. 6, the outer end of each piston rod is provided with a striking head **62** which is normally spaced away from but adapted for impact engagement with the adjacent end of the movable die.

A pair of detent members **63**, **64**, associated with rams **59**, **60** respectively, are provided for releasably retaining each ram piston rod in turn in its retracted position, as shown in FIG. 6 in the case of ram **60**. Each detent member embodies a detent head **63***a*, **64***a* respectively, and mounted on a bell crank lever **63***b*, **64***b* respectively, and connected through linkage to a corresponding control handle **65**, **66**.

The cylinder of each ram **59**, **60** at the end thereof furthest from the associated piston rod is connected to pipe **67**, **68** respectively, leading to manually operated change over valve **69** of known form, and displaceable into one or the other of two positions in which in manner known per se, it connects one or the other of the two pipes **67**, **68** in turn to high pressure air supply reservoir **70** supplied with air under pressure through air line **71**, with the other of the two pipes being simultaneously connected to low pressure pipe **72** exhausting to atmosphere.

The arrangement permits by displacement of valve **69** into one or the other position, of each ram **59**, **60** being pressurised to the maximum working pressure with its associated piston rod locked in the retracted position by the corresponding detent member, i.e. the rod of ram **60** with the parts in the position shown in FIG. 6. Thus as soon as the detent member is displaced into the release position (e.g. as shown for ram **59** in FIG. 6), by the operator's actuation of the corresponding control handle **65**, **66**, the associated ram piston rod is projected to bring its striking head **62** through adjacent stationary die opening **73** into sudden impact engagement with the adjacent end of movable die **52** to displace this suddenly and very rapidly in a small fraction of a second from one position to the other relative to stationary die plate **49**. Such rapid movement of die **52** is permitted by the fact that when one ram is pressurised by operation of valve **69**, the other ram is connected by the valve to low pressure pipe **72** so as not to resist the movement of die **52**. Die plate **49** is provided with rubber or other resilient cushioning strips **74** and the ram pistons **59***a*, **60***a* are provided with shock absorbing springs **75**, whereby the

impact of the foregoing rapid movement of die **52** is cushioned.

The above described arrangement facilitates the continued advancement of the wire through the apparatus during its periodical severing by die **52**. Thus for a wire speed through the apparatus of 100 metres per minute, the speed of displacement of the movable die **52** by the impact effect described may be so great that the advancing wire is only advanced about 4 cms. through the apparatus while the severed end thereof is stationary during its transference by die **52** from one to the other of die holes **50**, **51**. Such small linear advancement of the flexible wire is taken care of by momentary and slight bowing of the length of wire between the foremost pair of draw-off wheels **43** and the shears **48**, as depicted at **37***a* in FIG. 4 and also by some slip between the wire and such foremost pair of wheels **43** to permit between the latter and middle pair of wheels **43** of slight further bowing as depicted at **37***b*.

Thus, the arrangement provides for the continued advancement of the wire around the two V-grooved rotary members **15** and **16** during cut-off of the wire at intervals corresponding to the successive filling of each of the two coiling units.

The foregoing wire cut-off operation in the arrangement described could be controlled manually by an operator, who at the commencing of coiling into one of the two coiling units would first actuate valve **69** to pressurise the ram ready for displacing die **52** into position for supplying the other coiling unit and as soon as the one coiling unit was full would actuate the control handle **65**, **66** respectively, for releasing the piston rod of such already pressurised ram.

The V-grooved rotary members **15**, **16** need not rotate about the same axis and up to three such members in all may be provided. Such an arrangement is shown in FIG. 8 in which three rotary members **76**, **77**, **78** are provided, each having the above described small angle peripheral V groove **76***a*, **77***a*, **78***a* respectively, with the diameters of the grooves increasing in the direction of advancement of the wire **37** as denoted by the arrows, with members **76** and **78** of smallest and largest diameter respectively connected together to rotate at the same angular velocity about a common axis in like manner to members **15**, **16** of the preceding construction. Member **77** occupies the position of idle wheel **31** of the preceding construction and is connected to members **76** and **78** by gearing **79** of known form to rotate at the same angular velocity as that of members **76** and **78** so that a progressively increasing strain and tension is applied to the wire, successive lengths of which at maximum tension are heated and permanently elongated in like manner to the arrangement earlier described.

If desired, as shown in FIG. 5 the upper of the two wheels **43** in each pair may be mounted on arm **80** pivoted at one end at **81** to supporting frame **82** so that the upper of the two wheels **43** in each pair is mounted for limited up and down movement against suitable, e.g., resilient loading so as to permit of the upper wheel momentarily moving upwardly to provide for the passage of thimbles or other locally enlarged joining means between successive lengths of advancing wire in the case where a number of lengths of wire are connected together before advancing through the apparatus depicted in FIGS. 1 and 2.

The mode of operation of the apparatus described in the various drawings, FIGS. 1 to 7 inclusive and FIG. 8, will, it is believed be clear from the foregoing description and further description is accordingly considered unnecessary.

What is claimed is:

1. Apparatus for effecting a predetermined permanent elongation of a flexible elongated metal element when heated to an elevated temperature, by the application thereto of a controlled tension, wherein said apparatus comprises an arrangement for developing the whole of said controlled tension and concurrent predetermined permanent elongation in a single loop of the heated element, said arrangement consisting of the provision of first and second power rotated tensioning pulleys each having a peripherial V-grove, in which is accommodated less than a single turn of the element advancing around said first and second pulley grooves at the beginning and end respectively of said single tensioning loop. means for maintaining the peripheral linear velocity of the second pulley groove greater than that of the first pulley groove by an amount requisite to develop in the single loop the whole of the controlled tension and predetermined permanent elongation of the element, and each of said two V-grooves having their respective two sides relatively inclined at an angle which is not greater than 30°, but large enough to wedge without crushing the element which is within each groove.

2. Apparatus according to claim **1** and wherein the element after permanent elongation, is reeled, characterised by the provision of a pair of reeling devices and means adapted during the continued advancement of the permanently elongated element, to sever this as soon as one reeling device is full and to direct the end of the element immediately to the rear of the position of severing to an empty reeling device so as to maintain the continued advancement of the element through the apparatus.

3. Apparatus according to claim **2** wherein the severing means comprises a stationary die provided with a pair of die openings each leading to one of the two reeling devices and a moving die mounted for reciprocatory movement over the stationary die between two extreme positions, in each of which an opening in the moving die is in register with one or the other of the two openings in the stationary die, with the edge of the moving die opening, which is adjacent to the stationary die, being adapted to coact with the adjacent edge of the two openings in the stationary die and sever the element as the stationary die moves from one to the other of its two extreme positions.

4. Apparatus for effecting a predetermined permanent elongation of a flexible elongated metal element when heated to an elevated temperature, by the application thereto of a controlled tension, wherein said apparatus comprises an arrangement for developing the whole of said controlled tension and concurrent predetermined permanent elongated in a single loop of the heated element, said arrangement consisting of the provision of first and second power rotated tensioning pulleys each having a peripheral V-groove, means for guiding successively advancing lengths of said element around said first pulley and thereafter around said second pulley so that at all times less than a single turn of the element is accommodated within said first and second pulley grooves at the beginning and end respectively of said single tensioning loop, means for applying to the successive lengths of metal element entering into engagement with the first pulley and moving out of engagement with the second pulley tension sufficient to prevent slip between the element and the first and second pulleys at the positions of entry and disengagement respectively, and means for maintaining the peripheral linear velocity of the second pully groove greater than that of the first pulley groove by an amount requisite to develop in the single loop the whole of the controlled tension and predetermined permanent elongation of the element, and each of said two V-grooves having their respective two sides relatively inclined at an angle which is not greater than 30°, but large enough to wedge without crushing the element which is within each groove.

5. Apparatus according to claim **4** wherein the means for applying sufficient tension to the length of element moving out of engagement with the second pulley, comprise a plurality of pairs of power driven wheels which grip the element frictionally and which are so disposed in relation to the severing means as to permit of the element temporarily assuming a bowed configuration consequent

on the momentarily stopping of its advancement at the position of severing, the arrangement permitting of the continued advancement of the element around the V-grooved rotary members.

6. Apparatus according to claim **5**, wherein each pair of gripping wheels is provided with pneumatic friction gripping tyres at their respective peripheries, with the tyres of the two wheels in each pair in pressure contact with one another so as to grip the element over a predetermined length during its passage between the two wheels of each pair.

7. Apparatus according to claim **6**, characterised in that the two wheels in each pair are mounted for rotational movement about horizontal axes spaced one above the other with the upper wheel in each pair mounted for limited vertical movement in relation to the lower wheel against loading means, for the purpose specified.

8. Apparatus according to claim **1** wherein the first and second pulleys are connected integrally together to rotate about a common axis with the second pulley having a peripheral diameter larger than that of the first pulley.

9. Apparatus according to claim **1** wherein the angle between the two sides of each V groove is within the range of 12° to 20°.

10. Apparatus according to claim **4** wherein the angle between the two sides of each V groove is within the range of 12° to 20°.

11. Apparatus according to claim **2** wherein the severing means comprises a stationary die provided with a pair of die openings each leading to one of the two reeling devices and a moving die mounted for reciprocatory movement over the stationary die between two extreme positions, in each of which an opening in the moving die is in register with one or the other of the two openings in the stationary die, with the edge of the moving die opening, which is adjacent to the stationary die, being adapted to coact with the adjacent edge of the two openings in the stationary die and sever the element as the stationary

die moves from one to the other of its two extreme positions and means are provided for reciprocating the die in each of two opposite directions by a pair of oppositely acting fluid pressure actuated rams the free end of the associated piston rod of which is adapted for impact engagement at velocity with the adjacent end of the moving die, means being provided for releasably retaining each piston rod in turn in a retracted position out of engagement with the moving die and means for admitting fluid under pressure to the ram of each so retracted pistion rod in turn to effect on subsequent release of each of said retracted piston rods successive displacement of the die in opposite directions.

12. Apparatus according to claim **5** wherein each pair of gripping wheels is provided with pneumatic friction gripping tyres at their respective peripheries, with the tyres of the two wheels in each pair in pressure contact with one another so as to grip the element over a predetermined length during its passage between the two wheels of each pair, and the two wheels in each pair are mounted for rotational movement about horizontal axes spaced one above the other with the upper wheel in each pair mounted for limited vertical movement in relation to the lower wheel against loading means.

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