April 11, 1961 C. L. PETERSON 2,979,321

STRAND ANNEALING APPARATUS

Filed March 8, 1956 2 Sheets-Sheet 1

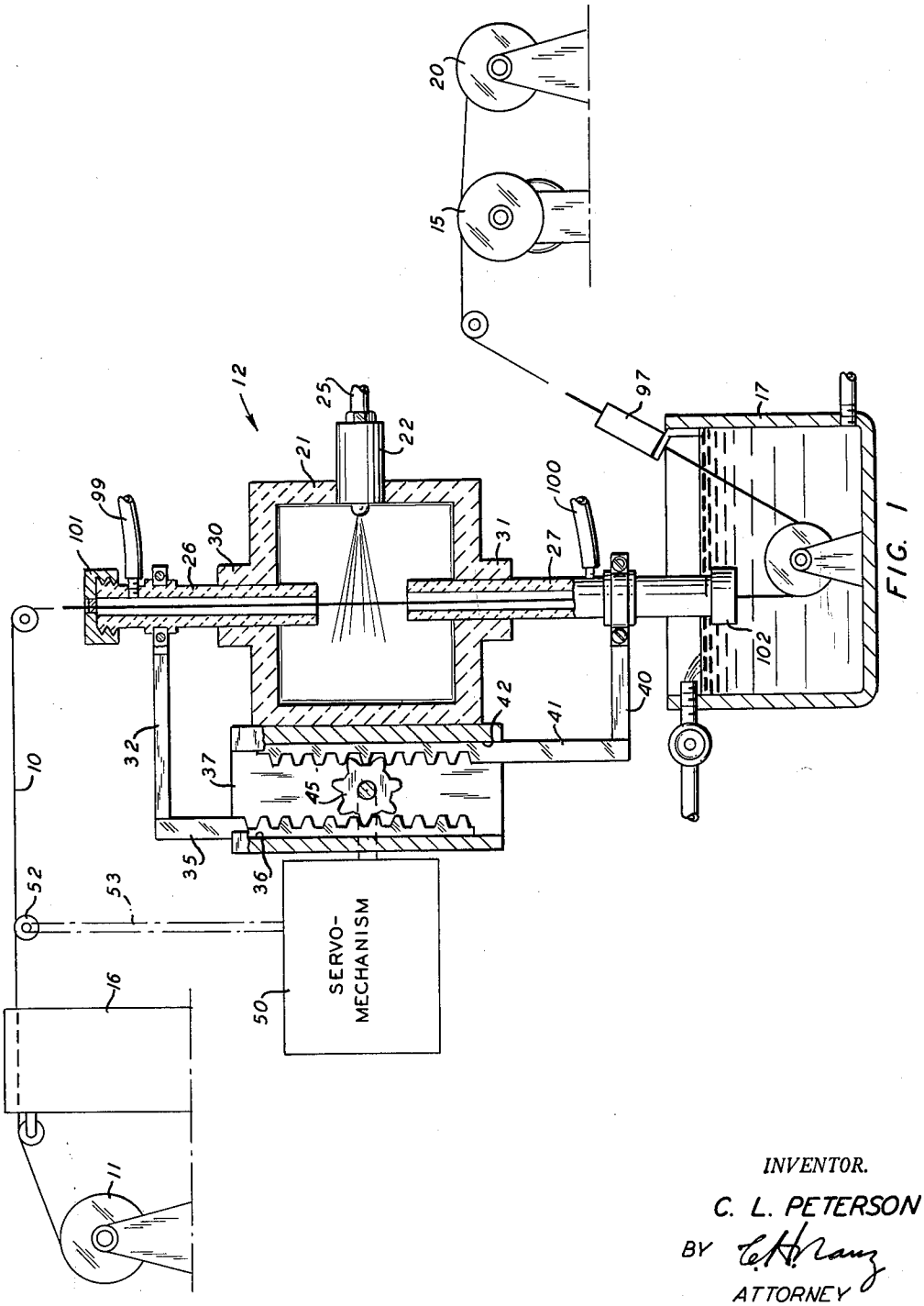


FIG. 1

INVENTOR.
C. L. PETERSON
BY E. H. Ramey
ATTORNEY

April 11, 1961 C. L. PETERSON 2,979,321

STRAND ANNEALING APPARATUS

Filed March 8, 1956 2 Sheets-Sheet 2

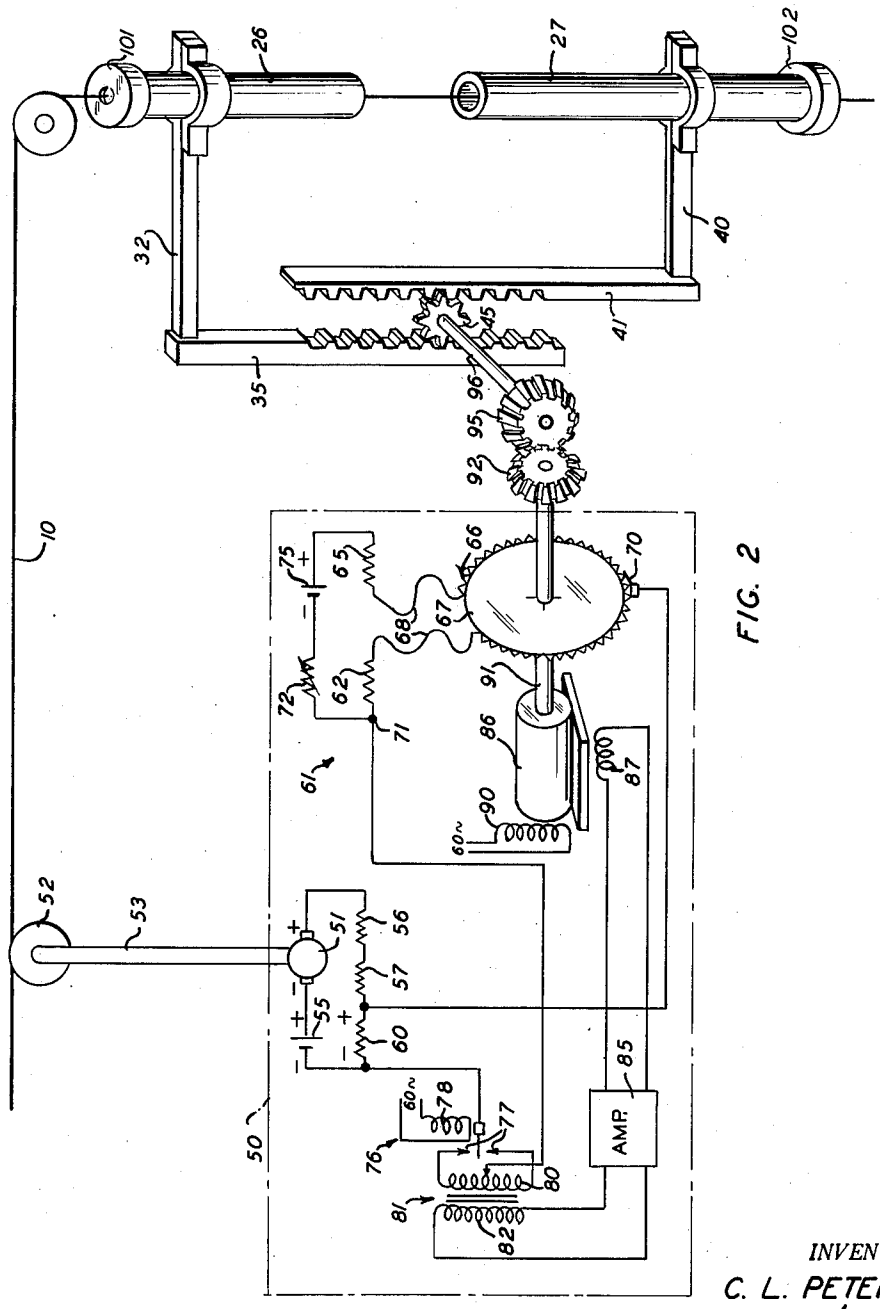


FIG. 2

INVENTOR.
C. L. PETERSON
BY
ATTORNEY

United States Patent Office 2,979,321 Patented Apr. 11, 1961

2,979,321

STRAND ANNEALING APPARATUS

Charles L. Peterson, Cicero, Ill., assignor to Western Electric Company, Incorporated, New York, N.Y., a corporation of New York

Filed Mar. 8, 1956, Ser. No. 570,239

10 Claims. (Cl. 263—3)

This invention relates to strand annealing apparatus, and more particularly to heat treating control systems for continuously annealing strands of indefinite length.

In the manufacture of electrically-conductive strands for use in the communications and other fields, the strands have drawing and other cold-working operations performed thereon before the desired products are obtained. As a result of permanent deformation of the strands by these cold-working operations, internal stresses remain therein which cause brittleness and may lead to yielding prematurely. These stresses may be dissipated by heating the strands to annealing temperatures, which are considerably below the range in which the strands soften. The annealed strands remain hard, but their elastic strength is improved by the annealing operation.

When it is desired to anneal a copper strand, for example, after a wire drawing operation, the strand is heated to a temperature in the order of approximately 800° F. to approximately 900° F. It is imperative that the strand be heated to a temperature that is no higher than this range since softening and possibly rupture of the strand may occur.

It is an object of this invention to provide new and improved strand annealing apparatus.

It is another object of this invention to provide new and improved heat treating control systems for continuously annealing strands of indefinite length.

A method illustrating certain features of the invention may include advancing a strand past a source of radiant heat and exposing incremental lengths of the strand to the heat source in proportion to the speed at which the strand is being advanced.

Apparatus illustrating certain features of the invention may include means for heating a strand to anneal it, means for normally advancing the strand continuously past the heating means and means for exposing incremental lengths of the strand to the heating means in proportion to the speed at which the strand is advancing.

A complete understanding of the invention may be had from the following detailed description of apparatus and methods forming specific embodiments thereof, when read in conjunction with the appended drawings, in which:

Fig. 1 is a diagrammatic, front elevation, partially in section, of apparatus embodying the invention for continuously annealing a strand of indefinite length, and

Fig. 2 shows a schematic diagram of a control circuit used in conjunction with the apparatus shown in Fig. 1.

Referring now to the drawings, and more particularly to Fig. 1, a strand **10** of copper, aluminum, or the like, to be annealed is advanced continuously from a supply reel **11** through an annealing apparatus, shown generally at **12**, by a suitably-driven capstan **15**. Work is performed upon the strand in a strand-working machine **16**, which may be, for example, a wire-drawing machine. After the strand **10** is annealed, it is passed through a quenching tank **17** and is taken up on a conventional take-up apparatus including a reel **20**.

The strand **10** is annealed when it is passed through a furnace **21** forming a part of the annealing apparatus **12**. A suitable combustible mixture is supplied at a constant rate to a radiant burner **22** in the furnace **21** through a supply pipe **25**. When ignited, the combustible mixture heats the strand **10** to the desired annealing temperature. The furnace **21** is so designed that a predetermined length of the strand **10** is exposed to the burner **22** when the strand is passing through the furnace at a predetermined maximum rate.

The strand **10** will travel at its predetermined maximum rate most of the time. However, when starting and stopping the strand, for example, to replace an exhausted reel with a full supply reel **11**, it is necessary to decrease the speed of the strand from its predetermined maximum speed to zero. This decrease in speed would cause the strand to become overheated if the strand were exposed to the radiant burner **22** at this time, and such overheating may cause undesirable softening of the strand or even the rupture thereof.

In order to prevent the strand **10** from being overheated during the periods when the strand is passing through the annealing apparatus **12** at less than its normal, maximum speed, two spaced, colinear protective tubes **26** and **27** are secured slidably within the upper and lower sides of the furnace **21** through suitable guides **30** and **31**, respectively. The tubes **26** and **27** may be made from a ceramic material or some other suitable heat-resistant material. One end of a bracket **32** is secured to the tube **26** near the upper end thereof. The other end of the bracket **32** is secured to the upper end of a rack **35**, mounted slidably within a guideway **36** formed in a housing **37** secured by suitable means (not shown) to the side of the furnace **21**. One end of a bracket **40** is secured to the tube **27** and the opposite end of the bracket is secured fixedly to the lower end of a rack **41**, also mounted slidably within a guideway **42** formed in the housing **37**.

Both of the racks **35** and **41** engage a pinion **45**. When the pinion **45** is rotated in a clockwise direction, as viewed in Fig. 1, the tubes **26** and **27** are moved apart so that predetermined lengths of the moving strand **10** are exposed to the radiant burner **22** within the furnace **21**. This is the desired condition when the strand **10** is advancing through the annealing furnace **21** at its normal, maximum rate. When the pinion **45** is rotated in a counterclockwise direction, the lower end of the tube **26** and the upper end of the tube **27** are brought together in abutting relationship to completely shield the strand **10** from the radiant burner **22**. This is the desired condition when the strand **10** is stationary, as it will be when an empty supply reel **11** is being replaced by a full reel. The tubes **26** and **27** can also be spaced apart any distance between these two extreme positions depending on the speed of the strand **10** through the annealing furnace **21**.

To automatically space the tubes **26** and **27** in accordance with the speed of the strand **10** by rotating the pinion **45**, a servomechanism **50** (Fig. 1) of a well-known type and responsive to the speed of the strand is provided. The servomechanism **50** causes the tubes **26** and **27** to completely shield the strand **10** when the strand is either not advancing or is advancing at such a slow rate that the strand will be damaged if exposed to the radiant burner **22** in the furnace **21**. The servomechanism **50** also causes proportionally-increasing incremental lengths of the strand **10** to be exposed to the radiant burner **22** as the speed of the strand increases.

A suitable servomechanism which is energized with an electrical input and has a mechanical output that rotates the pinion **45** to expose incremental lengths of the strand **10** to the heater **22** in direct proportion to the speed of

the strand, is shown in Fig. 2. Referring to Fig. 2, a direct current, tachometer generator 51 is located preferably near the strand-working machine 16 and is actuated by a sheave 52 through a shaft 53. The sheave 52 is engaged frictionally with and is rotated positively by the strand 10. As the speed of the strand 10 increases, the D.C. voltage output of the generator 51 increases proportionally. The output voltage of the generator 51 is connected in series additive with a source 55 of D.C. voltage, and the sum of these voltages is placed across a bank of resistors 56, 57 and 60.

The voltage across the resistor 60 is inserted in series opposition with the output voltage of a potentiometer circuit, shown generally at 61. The potentiometer circuit 61 is provided with suitably proportioned resistors 62 and 65, and a slide wire resistor 66, which is mounted fixedly on the periphery of a rotatable disc 67. One end of each of the resistors 62 and 65 is connected to an end of the slide wire resistor 66 by a flexible conductor 68 that permits the disc 67 to rotate with respect to the stationary resistors 62 and 65. The output of the potentiometer circuit 61 is connected between a stationary brush contact 70, positioned for sliding contact with the slide wire resistor 66, and a junction 71 intermediate of the resistor 62 and a variable resistor 72 which is associated with a source 75 of D.C. voltage the provide a standard, predetermined output voltage from the potentiometer circuit 61.

The series circuit that includes the voltage across the resistor 60 and the output voltage of the potentiometer circuit 61, which are of opposite polarity, as indicated in Fig. 2, will be referred to hereinafter as the "series operating circuit." The series operating circuit also includes a converter 76 for converting, into an A.C. voltage, any resultant D.C. voltage produced in the circuit due to the voltages included in this circuit not being of equal value. Such a resultant voltage will be the difference between the the two opposing voltages across the resistor 60 and at the output of the potentiometer circuit 61.

The converter 76 may be of the well-known vibrator type having a metal reed which is vibrated 60 times per second between a pair of contacts 77—77. Such vibration is caused by supplying a 60 cycle A.C. voltage to a coil 78 is the converter 76. The contacts 77—77 are connected electrically to the opposite ends of the primary 80 of a center tapped transformer 81. During one-half of the cycle, current flows in one direction in the upper half of the primary 80 and during the remaining half cycle it flows in the opposite direction in the lower half of the primary. Hence, a 60 cycle A.C. voltage proportional to the difference between the voltage across the resistor 60 and the output voltage of the potentiometer circuit 61, that is, proportional to the output of the series operating circuit, is introduced in a secondary 82 of the transformer 81.

The secondary 82 of the transformer 81 feeds the A.C. voltage impressed thereacross to an amplifier 85, wherein the A.C. voltage is amplified to a voltage sufficient to operate a balancing motor 86 in accordance therewith. The motor 86 is a two phase induction motor having two separate windings 87 and 90, and will not turn unless properly-phased A.C. voltages flow in both of its windings. The output of the amplifier 85 is supplied to the winding 87 and a standard A.C. supply voltage is supplied to the winding 90 from the same source that supplies the A.C. voltage to the coil 78 in the converter 76.

When the winding 87 is energized by a voltage from the amplifier 85, an output shaft 91 of the motor 86 will turn in a direction determined by the phase of the applied voltage. The phase of the voltage applied to the amplifier 85 and the winding 87 depends on the polarity of the resultant output voltage of the series operating circuit. Finally, the polarity of this circuit depends on which of the voltages, that across the resistor 60 (proportional to the output of the tachometer generator 51) or the output voltage of the potentiometer circuit 61 (across the contact 70 and the junction 71) is the larger.

It can be seen from Fig. 2, that when the voltage across the resistor 60 is the larger, current is supplied to the primary 80 of the transformer 81 through the center tap connected thereto. If the output voltage of the potentiometer circuit 61 is the larger, current is supplied to the transformer primary through the vibrating element in the converter 76. Hence, the voltages applied across the secondary winding 82 of the transformer 81 under these two conditions are 180° out of phase, and the shaft 91 will be driven in opposite directions thereby.

The output shaft 91 of the balancing motor 36 is connected to the pinion 45 through beveled gears 92 and 95, the latter of which is secured directly to the pinion 45 by a shaft 96. The disc 67 is also secured for rotation with the output shaft 91. When the motor 86 is energized, it rotates the shaft 91 to change the relative position of the slide wire resistor 66 with respect to the stationary contact 70 in such a manner as to reduce the voltage from the output terminals of the amplifier 85 to zero, and stop the motor at this point. This is accomplished because rotating the disc 67 will vary the output voltage of the potentiometer circuit 61. When this output voltage equals the voltage across the resistor 60, the resultant voltage, which is the output of the series operating circuit, is zero, Hence, there is no input voltage to the amplifier 85 and consequently no output voltage therefrom. The winding 87 of the motor 86 will not be energized and the motor will stop.

After the strand 10 passes through the annealing apparatus 12, the strand is guided below the surface of a quenching fluid, which may be continuously-recirculated water, within the quenching tank 17. The lower end of the tube 27 is always below the surface of the water to provide a liquid seal therefor. A suitable wiper 97, either of the mechanical type or one to which air under pressure is supplied, is secured to the tank 17 to remove any of the water from the strand 10 before the strand is wound upon the take-up reel 20.

To prevent oxidation of the strand during the annealing thereof, an inert gas may be supplied to the tubes 26 and 27. The gas may be injected into a supply pipe 99 and withdrawn through an exhaust pipe 100. A suitable seal 101 is provided at the upper end of the tube 26 to prevent the escape of the inert gas from the upper tube 26. A similar seal 102 is positioned at the lower end of the tube 27 to prevent the escape of the inert gas from the lower tube 27.

Operation

In explaining the operation of the present invention, it will be assumed that when the voltage across the resistor 60 is greater than the output voltage of the potentiometer circuit 61 (across the contact 70 and the junction 71), the phase of the voltage across the secondary 82 of the transformer 81 will be such that the motor 86 will rotate the output shaft 91 thereof in a counterclockwise direction as viewed in Fig. 2. This will cause the pinion 45 to be rotated in a clockwise direction, as viewed in Fig. 2, and the tubes 26 and 27 to be moved away from one another to expose a longer length of the strand 10. Conversely, it will be assumed that when the output voltage of the potentiometer circuit 61 is greater than the voltage across the resistor 60, the output shaft 91 of the motor 86 will be rotated in a clockwise direction, the pinion 45 will be rotated in a counterclockwise direction and the tubes 26 and 27 will move toward each other.

Whether moving toward or away from one another, movement of the tubes 26 and 27 will proceed until the disc 67 has rotated an amount sufficient to cause the output voltage of the potentiometer circuit 61 to be made equal to the voltage across the resistor 60. At this time

there is no resultant voltage in the series operating circuit from these two sources because these voltages are connected in series opposition and, hence, there will be no voltage across the secondary 82 of the transformer 81 to energize the winding 87 of the motor 86 and the motor will stop.

When the strand 10 is being advanced by the capstan 15 through the annealing apparatus 12 at its normal, maximum rate, the variable resistor 72 is varied so that the tubes 26 and 27 will open to expose predetermined, incremental lengths of the strand to the radiant burner 22 within the furnace 21. Should the speed of the strand be decreased from this normal value to a lower value, overheating of the strand may occur. Assuming that such a decrease of the speed of the strand 10 occurs, the output voltage of the tachometer generator 51 is decreased causing a decrease of the voltage across the resistor 60. The output voltage of the potentiometer circuit 61 is, therefore, greater than the voltage across the resistor 60, and there will be a resultant output voltage from the series operating circuit including the resistor 60 and the output of the potentiometer circuit 61.

This resultant D.C. voltage is converted into a proportional A.C. voltage in the converter 76, amplified in the amplifier 85 and applied across the winding 87 of the induction motor 86. It is of the proper phase that the shaft 91 of the motor 86 will be energized in a clockwise direction to rotate the pinion 45 in a counterclockwise direction and tend to move the tubes 26 and 27 toward each other. At this time, the disc 67 rotates in a clockwise direction, as viewed in Fig. 2, so that less resistance of the slide wire 66 is placed in the output of the potentiometer circuit 61 across the contact 70 and the junction 71. Rotation of the shaft 91 in a clockwise direction continues until a sufficient amount of the resistance of the slide wire 66 is removed and the output of the potentiometer circuit 61 equals the voltage across the resistor 60. At this time, there will be no resultant output voltage from the series operating circuit and no voltage will appear across the motor winding 87. The shaft 91 of the motor 86 will, therefore, stop in this position, and the tubes 26 and 27 will stop and be so positioned that the length of the space therebetween is proportional to the new lowered speed at which the strand 10 is advancing.

If the contact 70 were at such a point that no resistance of the slide wire 66 would be placed in the output of the potentiometer circuit 61, no short circuit occurs because of the resistor 65 in this circuit. Consequently, there is always some output voltage from the potentiometer circuit 61 even when the tubes 26 and 27 are completely closed and in abutting relationship. Such a relationship of the tubes should exist when the strand 10 is stationary. However, when the strand is stationary there will be no output voltage from the tachometer generator 51 to balance the output voltage then present from the potentiometer circuit 61. Since this would result in a constant energization of the winding 87 of the induction motor 86, the source 55 of D.C. voltage is placed in series with the tachometer generator 51 to oppose and cancel any output voltage from the potentiometer circuit 61 at this time. The source 55 is of such a value that the tubes 26 and 27 will be permitted to close completely and arrest further movement of the output shaft 91 of the motor 86.

While this invention has been illustrated as applied to the annealing of strands, it is obvious that the salient features of the invention may be employed in apparatus intended to perform other operations on strands. Also, while a particular servomechanism has been described and illustrated, it is to be understood that it is possible to employ any suitable servomechanism that will cause incremental lengths of a strand to be exposed to an annealing means in proportion to the speed of the strand passing therethrough.

What is claimed is:

1. A heat treating control system for strands of indefinite length, which comprises a furnace including heating means to heat such a strand to anneal it, means for normally advancing the strand continuously through the furnace, a sleeve through which the strand is passed mounted slidably within the furnace and designed to move longitudinally of the strand to expose incremental lengths of the strand to the heating means, rotary means engaging the strand and responsive to its speed, means for reciprocating the sleeve, and a servomechanism connected to said rotary means for actuating said reciprocating means in response to variations in the speed of said rotary means to vary the position of the sleeve and thereby to vary the incremental lengths of the strand exposed to the heating means in proportion to the speed of the strand.

2. A heat treating control system for strands of indefinite length, which comprises means for heating such a strand to anneal it, means for normally advancing the strand through the heating means, a pair of sleeves enveloping the strand, and means for moving the sleeves toward and away from each other to expose incremental lengths of the strand to the heating means in proportion to the speed at which the strand is advancing.

3. A heat treating control system for strands of indefinite length, which comprises means for heating such a strand to anneal it, means for advancing the strand through the heating means, two co-linear sleeves enveloping the strand and mounted slidably within the heating means, and means responsive to the speed at which the strand is advancing for moving the sleeves toward and away from each other to expose incremental lengths of the strand to the heating means in accordance with the speed at which the strand is advancing.

4. A heat treating control system for strands of indefinite length, which comprises a furnace for heating such a strand to anneal it, means for normally advancing the strand continuously through the furnace, a pair of co-linear sleeves enveloping the strand, the sleeves being mounted slidably within the furnace and designed to move between an abutting position whereby the strand is shielded completely from the heating means and a spaced position whereby predetermined, incremental lengths of the strand are exposed to the heating means, and means responsive to the speed of the strand for moving the sleeves between such positions.

5. A heat treating control system for strands of indefinite length, which comprises a furnace including means for heating and annealing such a strand, means for normally advancing the strand at a predetermined speed through the furnace, a pair of co-linear sleeves through which the strand is passed mounted slidably within the sides of the furnace, a rack and pinion arrangement engaging the sleeves and designed to move the sleeves between an abutting position within the furnace whereby the sleeves shield the strand completely from the heating means and a position without the furnace whereby predetermined, incremental lengths of the strand are exposed to the heating means, and a servomechanism energized by the strand and responsive to the speed thereof for actuating the rack and pinion arrangement and moving the sleeves to expose incremental lengths of the strand to the heating means in direct proportion to the speed of the strand.

6. A heat treating control system for strands of indefinite length, which comprises a furnace including heating means for heating and annealing such a strand, means for normally advancing the strand continuously past the heating means, a pair of co-linear sleeves mounted slidably within the furnace and so constructed and arranged that the sleeves are movable along their common axis from a position within the furnace where ends thereof abut and shield the strand completely from the heating means to positions where the ends are spaced apart by predetermined amounts to expose predetermined, incre-

mental lengths of the strand to the heating means, gearing means engaging each of the sleeves for moving the sleeves along their axis, and a servomechanism energized by the advancing strand and responsive to the speed thereof for actuating the gearing means and moving the sleeves to expose incremental lengths of the strand to the heating means in direct proportion to the speed thereof.

7. A heat treating control system for strands of indefinite length, which comprises a furnace, a heater within the furnace for heating such a strand to anneal it, means for normally advancing the strand continuously through the furnace and adjacent to the heater, a pair of tubular sleeves consisting of a heat-insulating material mounted slidably along a common axis through opposite sides of the furnace, a rack secured to each of the sleeves externally of the furnace, a pinion engaging the racks for moving the sleeves between a position where the ends of the sleeves within the furnace are abutting and a plurality of positions where such ends are spaced predetermined distances from each other, a servomechanism having an electrical input and a mechanical output, means for energizing the input of the servomechanism with an electrical signal proportional to the speed at which the strand is advancing, and means for connecting the output of the servomechanism to the pinion to move the sleeves apart such that incremental lengths of the strand are exposed to the heating means in direct proportion to the speed thereof.

8. A heat-treating control system for strands of indefinite length which comprises a furnace including heating means for heating and annealing such a strand, means for normally advancing the strand at a predetermined speed through the furnace, a sleeve mounted slidably within the furnace for receiving the strand therethrough, a rack and pinion device for moving the sleeve to and from a first position to shield the strand completely from the heating means and a second position to expose a predetermined length of the strand to said heating means, rotary means engaging the strand and responsive to the speed thereof, and a servo-mechanism connected to said rotary means for actuating said rack and pinion device in response to variations in the speed of said rotary means to vary the location of the sleeve to any position between said first and said second positions and thereby to vary the incremental lengths of the strand exposed to the heating means in accordance with the speed of the strand.

9. A heat-treating control system for strands of indefinite length which comprises a furnace including heating means for heating and annealing such a strand, means for normally advancing the strand at a predetermined speed through the furnace, a sleeve mounted slidably within the furnace for receiving the strand therethrough, a rack and pinion device for moving the sleeve to and from a first position to shield the strand completely from the heating means and a second position to expose a predetermined length of the strand to said heating means, means responsive to a condition of the strand, and a servo-mechanism connected to said responsive means for actuating said rack and pinion device in response to variations in said condition to vary the location of the sleeve to any position between said first and said second positions and thereby to vary the incremental lengths of the strand exposed to the heating means in accordance with said condition of the strand.

10. A heat-treating control system for materials of indefinite length which comprises a furnace including heating means for heating and annealing such a material, means for normally advancing the material at a predetermined speed through the furnace, a sleeve mounted slidably within the furnace for receiving the material therethrough, a device for moving the sleeve to and from a first position to shield the material completely from the heating means and a second position to expose a predetermined length of the material to said heating means, means responsive to a condition of the material, and a servo-mechanism connected to said responsive means for actuating said device in response to variations in said condition to vary the location of the sleeve to any position between said first and said second positions and thereby to vary the incremental lengths of the material exposed to the heating means in accordance with said condition of the material.

References Cited in the file of this patent

UNITED STATES PATENTS

2,629,162	Peck	Feb. 24, 1953
2,664,282	Mann	Dec. 29, 1953