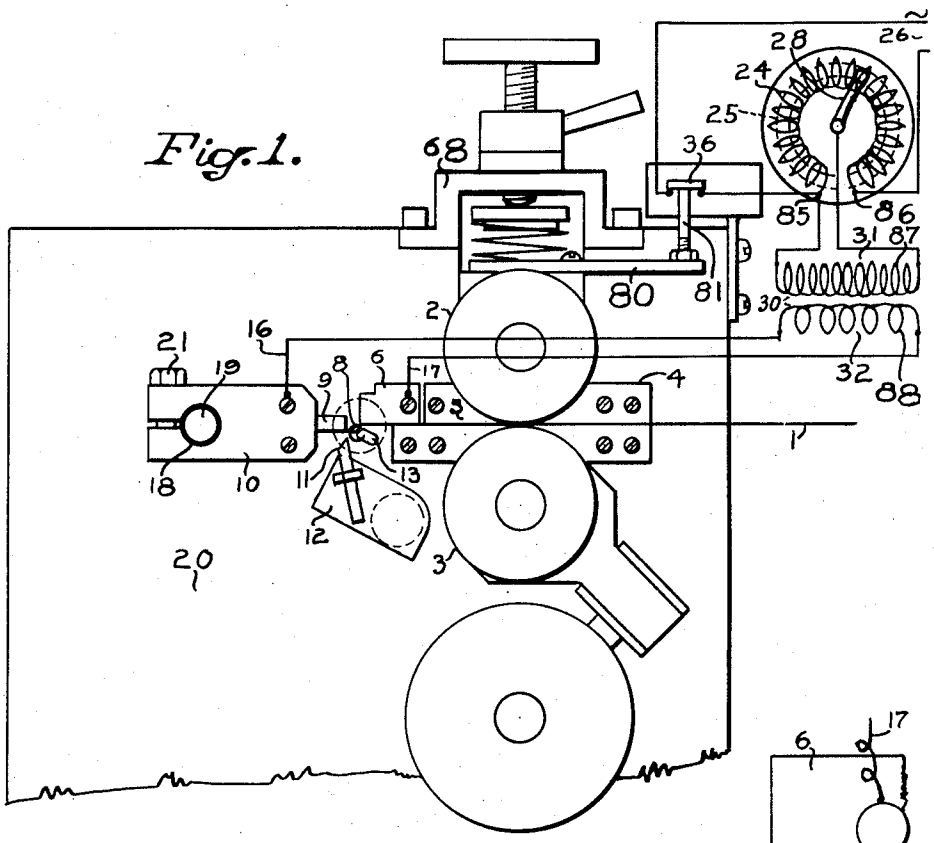
April 15, 1958 W. CONRAD 2,831,102

APPARATUS FOR COILING AND ELECTRICALLY TREATING WIRE

Filed Nov. 10, 1955 2 Sheets-Sheet 1

Fig. 1.



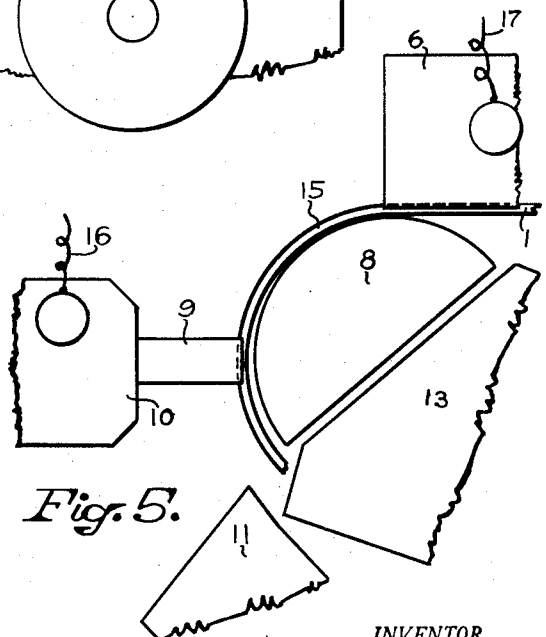


Fig. 5.

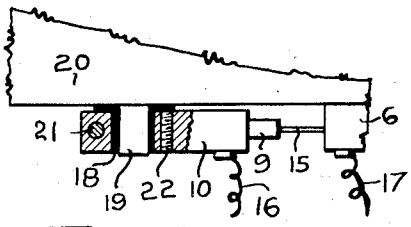


Fig. 6.

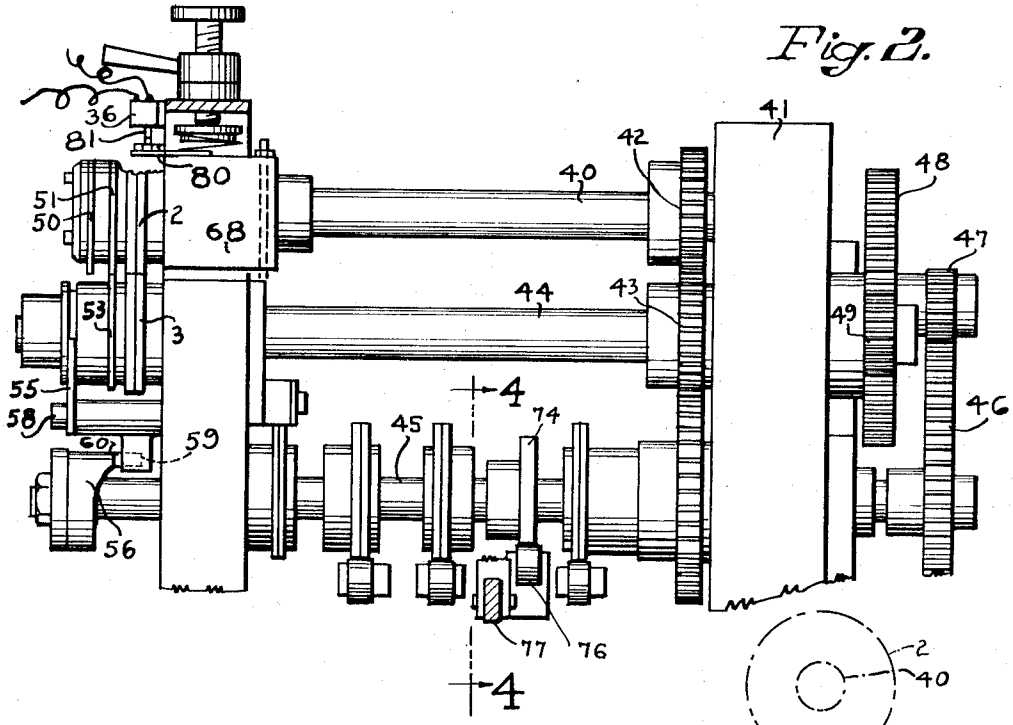
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APPARATUS FOR COILING AND ELECTRICALLY TREATING WIRE

Filed Nov. 10, 1955 2 Sheets-Sheet 2

Fig. 2.



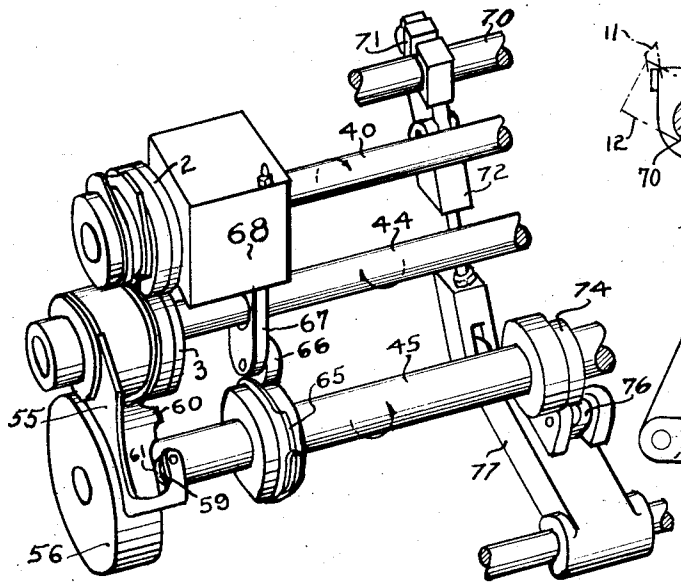


Fig. 3.

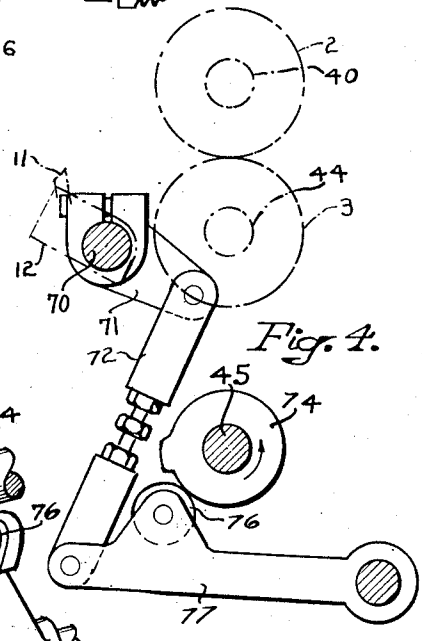


Fig. 4.

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APPARATUS FOR COILING AND ELECTRICALLY TREATING WIRE

Wilbur Conrad, Unionville, Conn.

Application November 10, 1955, Serial No. 546,142

4 Claims. (Cl. 219—153)

This invention relates to a wire coiling machine, and more particularly to apparatus for coiling a wire and electrically treating it to reduce the coiling stress.

When a wire is drawn, coiled or otherwise shaped, there may be a residual stressed condition in the grain structure. Coiling or bending a pretempered wire to form a spring or desired shape causes the metal grain fibres to be placed under tension at the outside of a curve and under compression at the inside, so that the stresses within the wire are uneven. This residual stress in a helical spring wire often uses up as much as 50% of the total stress the particular wire can stand before it takes a permanent set when the elastic limit of the metal is exceeded, and which should be available to resist subsequent deformation. The fatigue life of the spring is directly related to the condition of internal stress, and such stress may cause the spring to fracture or fail more quickly than if it were free from the coiling stress.

Various procedures have been adopted for relieving the stress in a coiled wire spring. A standard procedure comprises coiling a wire and severing the coil therefrom and subsequently giving the coil a low temperature normalizing treatment. This usually comprises heating a basketful of coiled springs in an oven for a considerable but varying length of time, usually between one half and six hours, and within a desired temperature range, usually around 500° F. The temperature and time duration are determined by trial and error for the average springs in the basket, but those near the outside may be overheated if the interior springs are heated sufficiently. This cumbersome procedure constitutes a bottleneck in the plant, and frequently the springs are heated too high for too short a period, in order to cut down the time consumption. The results are consequently uneven, and the springs display a lack of uniformity in their stress relief and a reduced fatigue life. Moreover, the required long period of heating causes a growth of the grain at the surface of the metal and so changes the grain structure to a detrimental extent. This may result in a weakening of the molecular cohesions and a reduction of the resistance of the spring metal against bending and fracture. It has also been proposed to heat treat a specially shaped spring by passing an electric current through a spring after it has been coiled and severed to raise its temperature to a desired normalizing condition, but a direct current gives only a heating effect and is not satisfactory because of the exterior grain growth. That step is, moreover, performed after the spring has been fully made and has recoiled to a larger size and a somewhat uncontrolled shape.

It has been observed that there is a material lack of uniformity in the wire drawing and coiling stresses in a coiled wire, so that the pitch, diameter and shape of springs made by the same procedure are not uniform. That is, in the coiling zone of a universal spring coiling machine, the wire is forced by a guide and a coiling point

to coil around a stationary arbor, and the pitch of the coil is determined by a tool which deflects the wire laterally. The wire is unconfined after it has passed the coiling point and so usually recoils or assumes a larger radius. When the spring is heated subsequently in a normalizing treatment, it will be reduced somewhat in diameter, and the spring which has taken the least amount of recoil will have the minimum diameter change. Hence, if the standard heat treatment is not uinform, there will be a considerable variation in diameter from spring to spring. Moreover, such treatment may not provide a uniform product if the springs have been permitted to recoil haphazardly and it is attempted to heat treat them subsequently without control as to shape and size. It is desirable to relieve the stress within the coil while the wire is confined in a predetermined shape by the coiling tools.

It is the primary object of my invention to overcome these various problems and to provide apparatus for electrically treating a wire, whatever may be its dimensions, shape and intended use, while it is still under the initial coiling or bending stress and thereby to minimize or reduce the internal stresses and to restore the potential resiliency of the wire, as well as to reduce materially any lack of uniformity in articles made in duplicate operations from a single type of wire. Other objects will be apparent in the following disclosure.

In accordance with this invention, I pass an alternating electric current through the wire while it is still held under the coiling stress and cause a controlled molecular orientation or other electrical and heating effect which reduces the wire drawing and coiling stresses and provides a greater uniformity of grain structures and thus restores to the wire much of its original potential resiliency and resistance to a permanent deformation or set. The electrical treatment is accomplished while the wire product is still in the coiling or bending machine and before it has been severed from the feed wire, and preferably during the coiling or bending stage, so that the stresses are relieved while the shape is maintained. The alternating electric current is preferably derived from a stepless, variable voltage transformer connected to a suitable power line, and the voltage is controlled to provide a current flow, depending on the size and resistance of the wire, which will relieve the stresses without overheating the wire so as to cause grain growth or other detrimental effect incidental to the usual normalizing treatment. In this way, close limits and tolerances may be maintained and springs and other coiled or bent wire objects may be made with a desired uniformity of structure.

Wire of various types and dimensions may be bent into many shapes, such as the standard compression and tension springs which are made in both helical, spiral and other shapes; and the term "coil" is intended herein to cover the various related articles and procedures involving bending and shaping a wire that is drawn continuously or intermittently from a supply source and severed after the form has been made. Various types of objects, herein termed coiled wire, may have the internal stress reduced and the wire normalized, while it is being held under the coiling stress with its bent shape maintained, by subjecting the wire to a controlled alternating electric current of a definite voltage determined by the wire resistance and which does not cause detrimental heating of the wire. I preferably introduce a low voltage alternating current continuously during the wire bending stage and while the wire is in the forming machine and under its initial bending stress. By using an alternating current, the normalizing procedure is effected without causing an appreciable grain growth as may result from the use of an externally applied heat or an over-heating effect of a direct current. This treatment, therefore, relieves or re-

duces both the stress that is put into the wire while it is drawn as well as the additional stress caused by bending the wire violently to shape it. Although the theories underlying this invention are not fully understood, I believe that the pulsating effect of an alternating current, as compared with a direct current, permits the normalizing of the metal to be effected at a lower temperature and with a lower voltage and minimizes the possibility of excessive or detrimental grain growth. The grain structure of the metal shows very little change over the original structure when the wire is subjected to an alternating low voltage current.

Although this invention is applicable to various types of wire coiling machines, it has been illustrated as applied to the machine described in my prior application Serial #447,278 filed August 2, 1954, and to which reference may be had for further description of the mechanism thereof.

Referring to the drawings illustrating a preferred embodiment of this invention:

Fig. 1 is a diagrammatic view of essential portions of the wire coiling machine and an electrical diagram of the circuits arranged for applying an alternating current to the wire during the coiling stage;

Fig. 2 is a fragmentary elevation of essential portions of the machine which serve for feeding, coiling and cutting the wire and for controlling the electric current applied thereto;

Fig. 3 is a fragmentary perspective view of those portions of the machine relating to the wire feeding and cutting actions;

Fig. 4 is a side elevation taken on the line **4—4** of Fig. 2 of the cam mechanism which operates the wire cutter;

Fig. 5 is an enlarged diagrammatic view of the wire coiling parts and particularly showing the extent of the coiled wire to which the electric current is applied; and

Fig. 6 is a detail showing the insulated mounting of the wire coiling point and the electric current connections to the point and a wire guide.

As illustrated particularly in Figs. 1 and 5, the wire **1** is fed forward at a uniform rate by means of grooved feed rolls **2** and **3** and between pairs of guide blocks **4** and **5** to a position beneath or above a grooved guide block **6** where the wire is forced around an arbor **8** by means of the grooved end of a coiling point **9**, which in turn is adjustably and movably supported by means of a clamping block **10**. A cutting tool **11** suitably mounted on a pivoted support **12** serves to sever the completed wire coil from the infeeding wire **1**. A pitch controlling tool **13** is suitably mounted to deflect the wire and determine the spacing of the coils of a helix formed on the machine. These features may be made and used in accordance with prior constructions and practices, such as is set forth in my prior application.

In accordance with my invention, I apply an alternating current to the coil prior to its severance from the infeeding portion of the wire and preferably while the wire is under the coiling stress and its size and shape are accurately controlled by the coiling point, arbor and pitch controlling tool. The electricity may be applied to a suitable portion or all of the coil, and I prefer, in accordance with the embodiment herein illustrated, to apply the electricity to that arcuate portion **15** which is between the conductive metal guide block **6** and the metal coiling point **9** and while the coil shape and size are accurately controlled, so that the stresses in the wire and particularly those set up by the coiling operation are relieved while the shape of the coil is maintained.

As diagrammatically illustrated in Fig. 5, the alternating electric current is preferably applied to the portion **15** of the wire where it is initially bent at the start of forming the convolutions of a helical coil around the arbor **8**. A suitable voltage, usually from 2 to 40 volts and 60 cycles, is selected according to the wire resistance to give the required electrical and heating effect in the portion **15** of the coil. One electric terminal **16** may be connected electrically to the block **10** and thus to the coiling point **9**, and the other terminal **17** is suitably grounded to a portion of the machine, such as the guide block **6**, which is in circuit with the infeeding wire. The support **10** is suitably insulated as by means of a rubber or fiber bushing **18** surrounding a post **19** (Fig. 6) extending from the machine frame **20** and to which the block **10** is adjustably clamped. The block **10** comprises a forked portion held in clamping engagement on the post **19** by means of an adjustable bolt and nut **21**. The block **10** may be adjusted toward and from the machine frame **20** and held in a laterally adjusted position by means of a set screw **22** (Fig. 6) which also engages a flanged portion of the insulating bushing **18**.

The source of low voltage alternating current, as shown in Fig. 1, may be a step-down variable voltage transformer **24**, such as a step-less "Variac" auto-transformer. This comprises a transformer winding **24** on a laminated ring core **25** of magnetic metal. The power line **26** of a suitable voltage, such as 110 volts, is connected to the ends or suitably spaced terminals of the coil. One side of the power line and a transformer terminal is connected to the load, and the other line from the load is connected to a movable arm **28** which makes a sliding contact with the transformer coil. In the illustrated showing, a supplemental step-down transformer **30** is interposed between the ultimate load and the "Variac" transformer. The primary coil **31** of this second transformer constitutes the load for the "Variac" and the secondary coil **32** is directly connected to the terminals **16** and **17** which transmit the alternating current to the wire. This auto-transformer involves the induction of a counter E. M. F. which materially limits the no load current flow, and the voltage that is derived therefrom is determined by the ratio of the number of transformer turns picked off by the movable arm **28** to the total number of turns in the transformer. Thus the current flow is limited primarily by the load resistance of the wire portion **15**.

It will also be appreciated that the low resistance of the wire portion **15** for the ordinary sizes of wire coils requires a very low voltage input to give the desired heating and electrical effect. Since the current is applied uniformly within the wire structure, the heating effect is uniform and does not produce the grain growth or other skin effects involved in heating the wire from an external heat source. Moreover, the current is applied for only a very short period of time, because of the comparatively rapid rate at which the coiling wire moves past the heating zone **15**. Hence, a high temperature condition applied momentarily to the wire need not cause an overheating of the wire and the temeprature may be accurately controlled to avoid any detrimental effect. It is found in practice that the portion **15** of the wire touches the coiling arbor only at the beginning of its travel, so that the current cannot be short-circuited through the arbor. However, suitable precautions may be taken to insure a satisfactory insulation of the wire. In this embodiment of the invention, the electricity is applied continuously to the coil during its formation, and since the length of the arc **15** and the cross section of the wire remain constant, the amperage of the current remains constant during this electric treatment.

A normally closed switch **36** is introduced in either the primary or the secondary circuit but is here shown as controlling the main power line circuit. This switch is normally closed during the wire coiling operation, so that the current is applied continuously to the arcuate section **15** of the coil as the wire is being initially bent. This switch **36** is operated to break the circuit just prior to the movement of the cutting tool **11** which severs the coil from the infed wire **1**.

In order that the wire feeding and severing stages of

the coil production may be understood, reference may be had to my prior application and the construction illustrated somewhat diagrammatically in the drawings. The wire is fed forward by the grooved rolls 2 and 3 to the coiling zone, and these rolls in the machine of my prior application are rotated at a uniform rate and in the wire feeding direction. To stop the wire feed caused by the steadily rotating rolls, the upper feed roll 2 may have its drive shaft 40 pivotally mounted at its right hand end in the framework 41 of the machine (not shown) so that the roll may be raised from the wire at a required time and thus stop the wire feed. The gears 42 and 43 respectively fixed to the shafts 40 and 44 of the rolls 2 and 3 serve to drive the rolls in the required directions. Power is suitably applied to the shaft 44 which is connected to drive the roll 3 so that the two shafts rotate in unison for the wire feeding. Beneath the shaft 44 and gear connected thereto is a camshaft 45 which is driven at a slow rate through a suitable reduction mechanism. A large gear 46 on the right hand end of the camshaft is driven by a small gear 47 on a jackshaft driven by speed reducing gears 48 and 49, the latter being mounted on the camshaft.

The upper feed roll 2 is raised and lowered by means of two lifting cams 50 and 51 which are mounted on shaft 40 and rotate with its associated feed roll 2. A disk shaped cam follower 53 is mounted to rotate concentrically with the lower shaft 44, and this cam follower is moved laterally by means of a yoke arm 55 to positions of engaging either of the lifting cams 50 and 51 or to be located therebetween in an inoperative position. The yoke 55 is moved to a required position in accordance with the shape of a barrel cam 56 mounted on the end of camshaft 45 and rotating therewith. A spring urged plunger 58 connected to the yoke 55 is moved by means of a cam following roller 59 on the plunger which has its position determined by the shape of the barrel cam 56 as shown in Figs. 2 and 3 and my prior application. The barrel cam 56 has a high point 60 and a low point 61 (Fig. 3). The spring pressed plunger 58 (omitted from Fig. 3) serves to urge the cam follower 53 toward the left, so that the roller 59 will follow the contour of the barrel cam 56. This construction is such that when the cam follower 59 rides between the high and low points on cam 56, the cam follower 53 will normally lie between the two lifting cams 50 and 51 during the wire feeding stage.

When the wire feed is to be stopped and the coil cut off, the follower 53 is moved towards the right into contact with the lifting cam 51, as is caused by the follower 59 riding up to the high point 60 of the barrel cam. When the wire feeding is to be resumed, the follower 53 is shifted toward the left by the roller 59 riding down onto the low surface 61 of the barrel cam. This causes the left hand cam 50 to lower the feed rolls gradually into contact with the wire, in accordance with the shape of that cam and to start the wire feeding at a precisely measured time.

A further feature of the machine of my prior application involves a holding cam 65 mounted on the camshaft 45 and which operates through a follower roller 66 on a member 67 depending from the bearing housing 68 which carries the upper feed roll. This cam construction is such that after the lifting cam 51 has stopped the wire feeding, the slow motion cam 65 moves to a position where it holds the upper feed roll lifted for a long enough period to permit severing the wire coil.

Associated with the wire coiling apparatus is the severing tool 11 mounted on a rocking member 12 carried by a short shaft 70. This shaft has fixed thereto a lever arm 71 which is operated by means of a pitman rod 72 of adjustable length. A cam 74 on the shaft 45 has a high point thereon arranged to strike a cam roller 76 carried by a rocking lever 77 connected to the pitman rod and suitably mounted in the base of the machine. The parts are so arranged that at the required time, the cutter 11 is rocked forward to cut off the wire coil against the nose of the coiling arbor 8.

The various cams are so positioned and timed relatively that the feed rolls 2 and 3 will feed an exact length of wire to the coiling zone while the electric current is being applied to the arcuate portion 15 of the coil. When the right length of coil has been made, the cam follower 53 shifts towards the right to cause the upper cam 51 to lift the feed roll, and then the other cam 65 serves to hold that feed roll lifted for a long enough period to permit the wire cutter 11 to be operated by its cam 74 which is timed to cause the cutting immediately after the feeding has been stopped.

It is desirable in this construction that the electric current be stopped just at the time when the feeding of the wire is stopped and that the circuit be broken just prior to the cutting action so that all of the wire coil will be electrically treated. This breaking of the circuit may be caused simply by having the switch 36 so constructed that it is normally closed, but is opened when the bearing housing 68 is lifted. The switch arm may be operated through an arm 80 attached to the housing which moves the plunger 81 (Fig. 1) upwardly and lifts the cross bar 36 from an electrical connection with the two contact terminals of the 110 volt wire circuit, as indicated diagrammatically in Fig. 1. Thus, the current is broken at the exact moment when the wire feed is stopped, so that all of the coil has been electrically treated at the time when it is severed. Likewise, when the upper roll 2 is lowered onto the wire, then the contact post 81 is lowered to make the circuit in the switch 36.

The alternating current may be controlled in accordance with the requirements which are determined by the metallurgical composition, the gauge and the electrical resistance of the wire, the desired temperature, the rate of wire movement, and the intended use of the coil, and particularly to avoid an excessive heating of the wire and a consequent spoiling of the temper, reduction of the hardness or other detrimental conditions. For example, a high carbon spring wire usually runs into the blue embrittlement range at a temperature above about 525° F. To avoid this condition, a high carbon steel wire should not be heated above 500° F. An oil tempered or a hard drawn wire is usually kept below 500° F. A stainless steel wire may be heated to a higher point, such as 600° F. to 800° F.

Hence, the composition of each wire should be determined, and the applied current should be controlled according to the wire requirements and the rate at which the wire moves through the treatment zone. The current is to be controlled for heating the wire momentarily to that temperature at which the metal is normalized and the molecular orientation accomplished to relieve the stressed condition. The repeated reversal of the alternating current is thought to apply a reversing polarity to the molecules just as a reversal of magnetism will neutralize a magnetized body. Where a coil is being made progressively at a rate of about 100 feet per minute and the current is applied continuously to a section of the coil as herein described, I may use a voltage of from 5 to 6 volts for a No. 21 spring wire (0.032 inch diameter) to relieve the torsion stresses. By this treatment, a low cost hard drawn wire may be made equal to the more expensive music wire in its ability to withstand stress.

It may also be observed that the wire is held in a limiting shape and position by the arbor, the coiling point, the wire guide and the pitch tool, but that the wire does not touch the arbor for about 90° after the first contact, and use is made of this particular arcuate portion for the heat treatment where the coil form is fixed. After the wire passes the coiling point, it is unconfined and free to recoil so that it usually assumes a larger radius than caused

by the wire guiding and confining tools. In making the coil it is necessary to exceed the elastic limit of the spring wire, otherwise it would spring back to a perfectly straight condition. Hence, the more the wire is deformed or its elastic limit exceeded, the less recoil it will have. For example, if a 0.125 inch diameter spring wire should be coiled on a mandrel of the same diameter, then the recoil would be only a few thousandths of an inch. Whereas, if the same wire were coiled on a 2 inch diameter mandrel, it might recoil when free to about 4 inches in diameter. When springs are heated for stress relief purposes, they usually reduce somewhat in diameter, and springs that have taken the least amount of recoil will have the diameter reduced only slightly, while the springs which have shown a considerable recoil may have a considerable reduction in diameter. Hence, if the heat treatment is not uniform, there will be considerable variation in diameter from spring to spring. One feature of this invention involves giving the wire a uniform electrical and heat treatment so that the ultimate diameter and condition of the coil will be uniform or with close tolerance. Hence, the springs have their stresses uniformly relieved from end to end, and the springs thus made successively are uniformly alike and do not require any further treatment for relieving stresses.

In a machine as above described, which has the wire fed at a uniform rate by uniformly rotating feed rolls, a constant voltage setting on the transformer serves for a progressive treatment of the entire spring. In the case of a "segment" type of coiling machine, such as is shown in the Blount and Fisher Patent No. 2,175,426, the feed rolls start slowly and gradually accelerate to a maximum speed at the mid point of the wire feed and then decelerate to a stop. For this type of machine the voltage may be increased and then decreased in accordance with the variation in the wire feed so as to insure a uniform treatment at all times. In that case, I may use the cam control construction described and claimed in my copending application, Serial #562,273, filed January 30, 1956.

It will now be appreciated that various modifications may be made in the apparatus and that the above disclosure is to be interpreted as a description of the underlying principles of the invention and one embodiment of the same and not as imposing limitations on the appended claims.

I claim:

1. Apparatus for coiling wire comprising mechanism for feeding wire progressively to a coiling arbor and stopping the wire feed, means including the arbor to coil the wire progressively, mechanism operating in a timed relation with the coil formation to sever the finished coil from the stopped wire, means including a transformer for furnishing an alternating current of controlled low voltage and means acting in timed relation with and prior to the coil severance for introducing the alternating current progressively into a portion of the wire being coiled.

2. Apparatus for coiling wire comprising power driven rolls for moving a wire forward progressively, mechanism for starting and stopping the wire feed, coiling tools including an arbor for coiling the wire on the arbor, a source of alternating current having a voltage related to the wire resistance for reducing a coiling stress therein, means including electrical connections for applying said current continuously to a portion of the moving wire where it is under the coiling stress, means including a switch for breaking the electric circuit when the coil is completed, and time controlled cutter mechanism for severing the coil from the wire after the electric circuit has been broken.

3. Apparatusf or coiling wire comprising a coiling arbor, means for feeding wire progressively to the arbor, means associated with the arbor for making a coil from the wire, means providing an electric current of a uniform voltage predetermined relative to the wire resistance to provide a controlled treatment of the wire, means forming an electrical circuit with a portion of the moving wire and continuously introducing the electrical current into that portion of the wire which is being coiled and thus progressively relieving a stressed condition therein, mechanism to stop the coiling operation, means including a switch to break the electric circuit at the end of the coiling operation and wire severing mechanism acting after the circuit has been broken to sever the soil from the infeeding wire.

4. Apparatus for coiling wire comprising a power driven mechanism for feeding wire progressively to a coiling zone, tools in said zone for coiling the wire including a wire guide, an arbor, a coiling point and a pitch controlling tool, automatic cutter mechanism to sever from the wire a predetermined size of coil, means providing an electric current of low voltage related to the wire resistance for reducing a coiling stress in the coil, an insulated electrical connection to the coiling point, an electrical connection to introduce electric current into the moving wire coil remote from said coiling point, and switch mechanism acting in timed relation with the cutter mechanism for connecting said transformer to said terminals and electrically treating the wire continuously while it is being coiled and prior to the coil severance.

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