Jan. 29, 1957 W. CONRAD 2,779,860

APPARATUS FOR MAKING, SIZING AND ELECTRICALLY TREATING A WIRE COIL

Filed Nov. 10, 1955 2 Sheets-Sheet 1

Fig. 1.

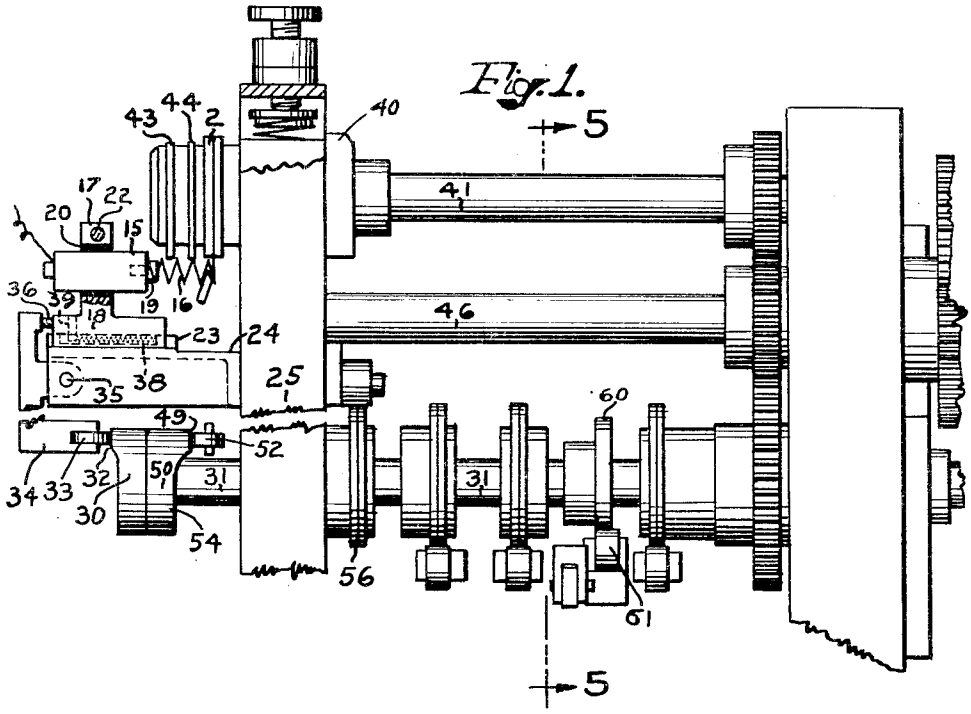
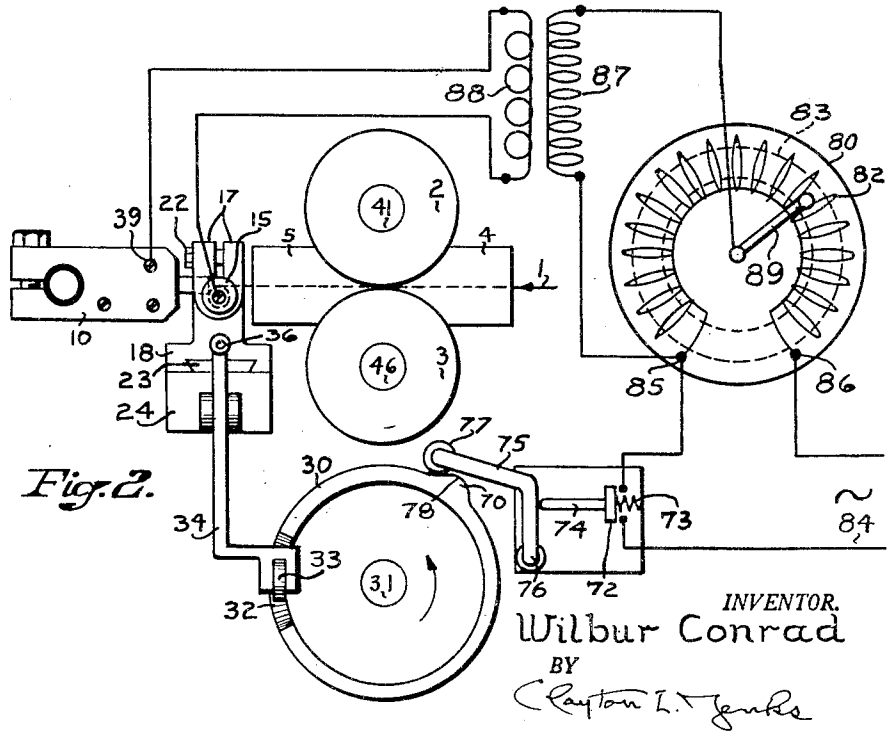


Fig. 2.



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Fig. 3.

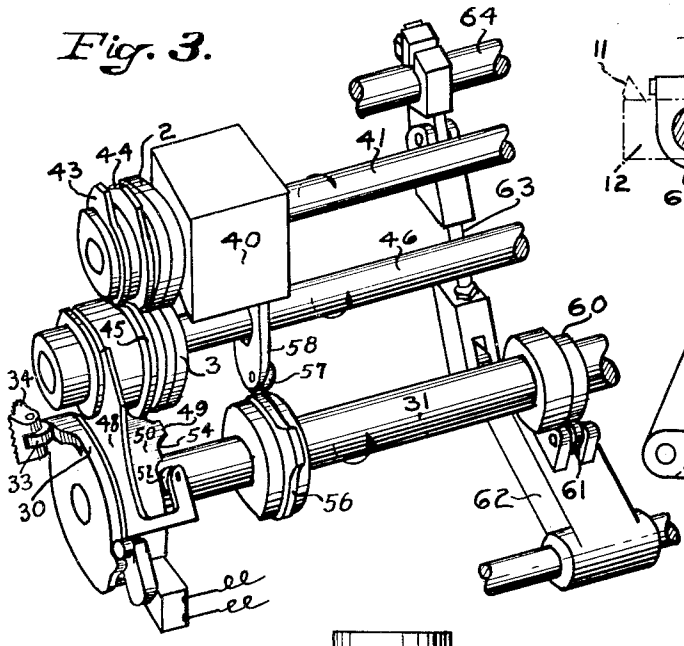
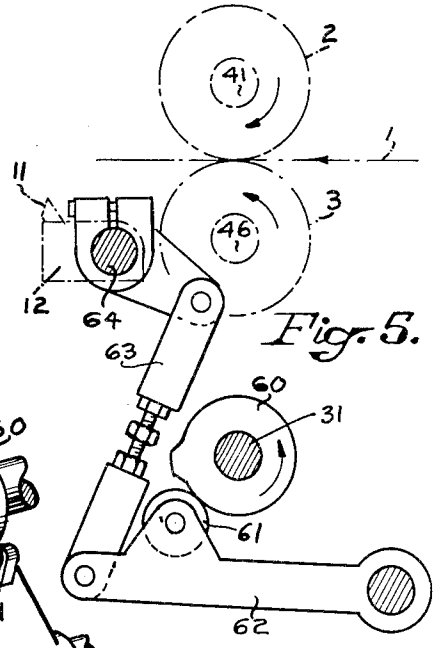


Fig. 5.



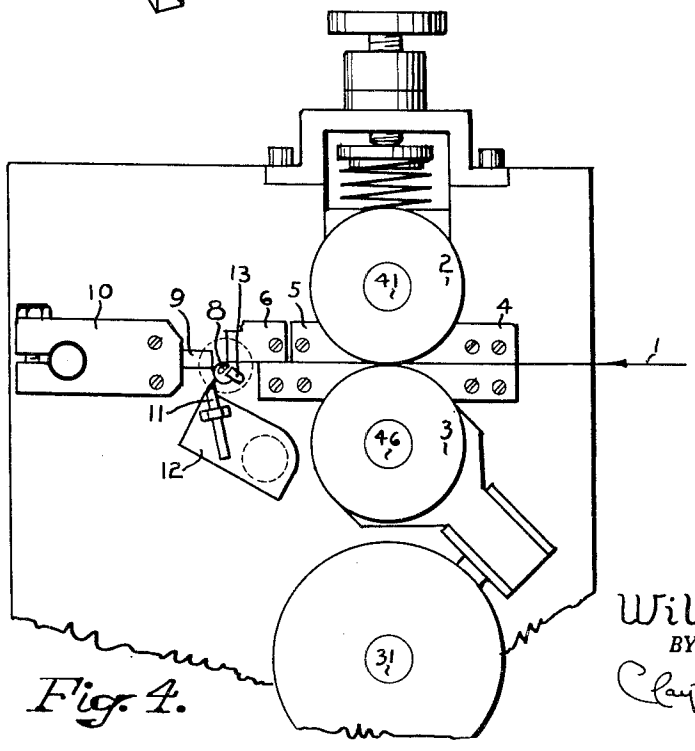


Fig. 4.

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2,779,860

Patented Jan. 29, 1957

2,779,860

APPARATUS FOR MAKING, SIZING, AND ELECTRICALLY TREATING A WIRE COIL

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Application November 10, 1955, Serial No. 546,189

7 Claims. (Cl. 219—153)

This invention relates to wire coiling machines, and more particularly to a structure for accurately sizing the free length of the spring and reducing the coiling stress therein.

A compression spring made of helically coiled wire is often required to be used at the top allowable stress which each particular type of spring metal is capable of withstanding, and the spring length should be accurate. Heretofore, springs have been made by coiling the wire on a conventional wire coiling machine and cutting off the spring in a length which is longer than the desired finished length. They are then heat treated in a furnace, after which they are cold set by compressing the springs until the coils are in close contact. Such a compressed cold set spring will not return to its original free length but will have a length somewhat nearer the desired measurement. Some springs are ground at their ends to provide bearing surfaces, and at that time the total length of the spring may be shortened to a uniform required length. It is desirable to avoid this need for an excessive grinding operation to control the length of the spring.

It is common practice to normalize the stressed wire by placing a group of the coiled springs in a basket and heating them in a large furnace or oven. The springs are heated for a considerable time, such as from one-half to five or six hours, according to the spring requirements. The length of heat treatment and the temperature are, however, determined largely by trial and error. The heat treatment is uneven, because of the large number of springs held in the basket, and the heating conditions are therefore set to give an average treatment in which the outer layer of springs may be overheated and the less exposed springs undertreated.

Another normalizing and sizing treatment involves clamping a set of springs between parallel plates and heat treating them in that condition while the spring lengths are held uniform. This expensive and laborious operation does not prevent a detrimental grain growth at the surface as is caused by the prolonged heating procedure. Also, the coiled spring has previously recoiled to a larger size and so is heat set in the recoiled condition and not in the coil dimensions and shape imposed by the tools of the coiling machine.

In accordance with my copending application Serial No. 546,142 filed on even date herewith, a wire may be electrically treated during the entire coiling operation by passing a current of uniform characteristics continuously through a segment of the wire. No provision is therein made, however, for setting a finished coil of normalized wire in a standard length.

The primary object of my invention is to provide apparatus whereby each spring may be treated at the end of the coiling operation and prior to its being severed from the in-feeding wire in order both to reduce the coiling stress therein and at the same time accurately size the spring.

A further object is to electrically treat a coiled spring

in the coiling machine to relieve the coiling and other stresses therein while the spring shape is held substantially fixed and its length is held according to a desired adjustment, as by stretching or compressing the coil. Other objects will be apparent in the following disclosure.

In accordance with this invention, I form a wire coil by means of suitable coiling tools, such as the wire guide block, the arbor, the coiling point and the pitch control member of a universal coiling machine shown in the U. S. Patent Blount and Fisher No. 2,175,426 of October 10, 1939. When a desired length of coil has been formed, the wire feeding is stopped and the coil is brought to a required length, and while its dimensions are thus fixed and before the coil has been severed from the wire, it is subjected momentarily to an alternating electric current of required voltage and amperage to reduce various stresses in the coil. A standard type of compression spring may be compressed to a desired length against the coiling tools, and while its shape and stressed condition are thus substantially fixed, it is treated by an alternating current having a low voltage related to the wire resistance which is applied for a short period and will not heat the wire detrimentally. Thus, the coil is normalized at a desired length.

Although the 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 No. 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 the preferred embodiment of this invention:

Fig. 1 is a fragmentary elevation of a wire coiling machine which embodies mechanism for electrically treating the wire coil after its formation and prior to its severance from the in-feeding wire, the lower feed roll being omitted for clarity of showing of the coil pressure mechanism;

Fig. 2 is a fragmentary diagrammatic view of the spring compressing and coiling mechanisms and showing the electric circuit for applying an alternating current to the coil;

Fig. 3 is a fragmentary perspective view of parts of the coiling mechanism and the cam control for the wire cutter;

Fig. 4 is a diagrammatic view of the coiling tools and wire feeding rolls; and

Fig. 5 is a sectional view illustrating the cam control for the cutter.

As more fully set forth in my prior application, a supply of wire 1 is fed forward by means of grooved feed rolls 2 and 3 and between pairs of guide blocks 4 and 5 on opposite sides of the rolls and thence to a position beneath or above a grooved guide block 6 located close to a coiling arbor 8. The wire passes around that arbor in the required coil shape as determined by the position of the grooved end of a coiling point 9 which 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 wire coil from the in-feeding wire 1. A pitch controlling tool 13 is also suitably mounted adjacent the arbor and arranged at the side of the convolution of the first coil to determine the spacing of the coils of the helix. These elements determine the shape and size of the coil in accordance with standard practice, and at the required time the cutting tool 11 is brought forward to sever the coil from the wire.

Prior to severing the coil, the longitudinally movable compression tool 15 is moved forward by a suitable controlling device, such as a cam, solenoid or fluid pressure operated mechanism, to engage the free end of the wire

coil and force it back towards the coiling tools to provide an exact coil length. When the length has been adjusted and while the coil is held fixed, an alternating current of required voltage is applied momentarily, such as for a small fraction of a second, to the fully made coil **16** so as to reduce a stress therein.

The pressure applying mechanism which serves to compress the completed coil against the forming tools comprises the cylindrical body **15** which is slidably mounted between the split arms **17** of an upstanding lug carried by the slide **18**. The body **15** carries a cylindrical reduced portion **19** sized to fit within the end of the coil. This part **19** may be adjustably and removably mounted in a socket in the body **15** for replacement according to the size required. The body **15** is adjustably mounted within an insulating bushing **20** made of fibre, rubber or other suitable material, which supports and electrically isolates it from the upstanding arm **17** on the slide. The body **15** may be clamped in place by means of a bolt **22** passing through the two spilt arms **17**. The slide **18** is suitably mounted on a dove-tailed slideway **23** supported by a bracket **24** on the machine frame **25**.

In order to move the pressure members **15**, **19** into engagement with the coil and to compress the latter to a required coil length, a suitable mechanism comprises a cam **30** mounted on the camshaft **31** which is shaped to provide a high spot **32** for engagement with the roller **33** on an arm **34** pivoted at **35** on the bracket **24**. The upper end of this arm **34** carries an adjustment screw **36** which is adapted to engage the left hand side of the slide support **18** and move the latter toward the right. A spring **38** suitably mounted beneath the slide body and engaging a depending member **39** thereof serves to hold the slide body toward the left and in engagement with the rocking arm **34**.

As more fully described in my prior application Serial #447,278, the upper feed roll **2** is supported by a bearing box **40** and its shaft **41** is pivotally mounted at its right hand end (not shown). Two lifting cams **43** and **44** (Fig. 3) mounted on the shaft **41** and rotating with the upper feed roll **2** are arranged to be engaged at controlled times by a cam follower ring **45** mounted to rotate with the shaft **46** which carries the lower feed roll **3**. The front cam **43** is shaped to lower the upper feed roll onto the wire to start the feeding operation and the rear lifting cam **44** serves to remove the upper feed roll from its driving engagement with the wire, so that depending upon the operation of these cams the wire is fed to make the coil or it is stopped to permit electrically treating and severing the coil.

The follower ring **45** is moved to its various positions by means of a yoke arm **48** suitably mounted and spring pressed toward the left, which is moved towards the right by means of the high point **49** on a barrel cam **50** carried by the camshaft **31**. That cam **50** is so shaped and coordinated with the lifting cams that when the follower **52** on the yoke arm **48** engages the low portion thereof, the follower ring **45** engages the feed roll lowering cam **43**. When the high point **49** of cam **50** comes into contact with the follower **52**, the follower ring **45** is moved to engage the lifting cam **44** which removes the feed rolls from driving engagement with the wire. An intermediate level **54** on the cam **50** provides for the follower ring **45** being located between the two cams **43** and **44** and thus inoperative. A further adjustably shaped holding cam **56** on the shafts **31** serves through a cam follower **57** carried by a bar **58** depending from the housing **40**, and acting in timed relation with the operation of the high part of cam **56**, to hold the upper feed roll from the wire until the electrical treatment and cutting operations have been effected.

Governed by the camshaft **31** is a further cam **60** (Fig. 3) which serves through a cam follower **61** on the rocking lever **62** to draw down on a pitman rod **63** of adjustable length and thus rock the cutting tool **11** about its supporting shaft **64** to sever the wire.

The various cams are so positioned and timed relatively that the feed rolls will feed an exact length of wire to form a coil, and when that predetermined length has been made, the cam follower **45** shifts toward the right to cause the upper cam **44** to lift the upper feed roll from the wire, and immediately thereafter the holding cam **56** causes the feed roll to be held in that lifted position. Then, the cam **30** (Fig. 1) causes the plunger **15**, **19** to move forward and compress the spring to an exact length.

The alternating electric current is applied momentarily to the coil, immediately after the coil length has been sized by the plunger **15**, by means of a further cam **70** on the periphery of the cam **30** or on a separate cam, if desired, which operates a control switch to make the electric circuit. This switch, in the embodiment illustrated in Fig. 2, has a contact bar **72** normally held open or away from the line terminals by means of a compression spring **73**, and an arm **74** of suitable construction is moved to close the switch by means of a lever **75** pivoted at **76** on the base of the machine. A cam follower roller **77** on the end of the lever normally rests against the cylindrical periphery of the cam **30**, but is elevated to close the switch momentarily by means of a short rise **78** on the cam periphery. This cam rise is so located that the cam roller **33** will have reached the height of its associated cam **32** and compressed the coiled spring **16** to its minimum length just prior to the closing of the switch **72**. The cam rise **32** which moves the coil compressing lever is long enough to hold the spring compressed while the roller **77** is passing over the cam rise **78**, so that the spring is held at a fixed length during the period of the introduction of the electric current to the spring.

The source of low voltage alternating current controlled by the switch **72**, as shown in Fig. 2, may be a step-down variable voltage transformer **80**, such as a stepless "Variac" auto-transformer. This comprises a transformer winding **82** coiled on a laminated ring core **83** of magnetic metal. The power line **84** of suitable voltage, such as 110 volts, is connected to the ends or suitably spaced terminals of the coil **82**. One side of the power line is connected through switch **72** with a transformer terminal **85** and the other side of the power line is connected to the opposite transformer terminal **86** so that the transformer winding comprises the load on the power line. The transformer may be connected directly to the load represented by the coiled wire **16**; but in the illustration an intermediate step-down transformer comprising the primary and secondary coils **87** and **88** are inserted between the variable transformer and the coiled wire load **16**. One terminal of the primary coil **87** is connected to the terminal **85** of the variable transformer and the other terminal of the primary winding **87** is connected to a movable arm **89** pivoted at the center of the variable transformer coil and which has a sliding contact with that coil. Thus the voltage applied to the primary coil **87** is a proportionate part of the 110 volts applied to the variable transformer as determined by the position of the movable arm **89**. The switch **72** is preferably located in the primary circuit, but may be arranged in the ultimate load circuit which comprises the wire coil **16**.

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 variable transformer turns picked off by the movable arm **89** relative to the total number of turns in the transformer. Thus, the current flow is limited primarily by the load resistance of the wire coil produced by the coiling tools. It will be appreciated that the low resistance of the formed wire coil **16** for the ordinary sizes of wire requires a very

low voltage in-put to give the desired heating and electrical effect. Since the current is applied momentarily within the entire wire coil **16**, the heating effect is uniform and does not produce a 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, such as $\frac{1}{25}$ second, and any high temperature condition applied momentarily to the wire need not cause an overheating of the wire. The voltage may be accurately controlled to avoid any dertimental effect.

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. After the coil has been made and compressed to the required length, the current may be applied momentarily to it, 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 stresses involved in cold working the metal. Wide variations may be made in the characteristics of the current. Nevertheless, it is desirable that an alternating current be used and that the wire be not heated excessively and to such an extent as to produce the undesired characteristics heretofore had when the wire is heated in a furnace. That is, overheating the wire such as spring metal may reduce the hardness or cause a growth of the grain structure at the surface and so change the wire structure to a detrimental extent. Any weakening of the molecular cohesions and a reduction of the resistance of the spring metal against bending and fracture is of course to be avoided.

It is also to be noted that the coil **16** is compressed to a fixed length between the slidable body **15** and the coiling tools comprising the grooved coiling point **9**, the pitch controlling tool **13** and the grooved guide **6** which retain their functions of positioning the wire for coiling until after the electricity has been applied. Immediately after the introduction of the low voltage alternating electric current and the breaking of its circuit, the cam **60** is operated in its controlled timing cycle to cut off the coil. Thereafter, the lifting cam **43** lowers the upper roll **2** onto the wire and a new coiling process starts.

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 a wire progressively, tools including a coiling arbor for making a coil on the wire, cutter mechanism for severing the coil from the wire, mechanism operating prior to the coil severance for subjecting the coil to a force which holds it at a predetermined length and means for introducing an electric current of controlled voltage into the non-severed coil while subjected to said force to reduce a stressed condition resulting from the coiling operation.

2. Apparatus for coiling wire comprising mechanism for feeding a wire progressively, tools including a coiling arbor for making a coil on the wire, cutter mechanism for severing the coil from the wire, mechanism operating prior to the coil severance for compressing the coil to a predetermined shorter length and means for introducing into the compressed non-severed coil an alternating current of a low voltage related to the wire resistance to reduce the coiling stress.

3. Apparatus for coiling wire comprising mechanism for feeding a wire progressively, tools including an arbor, a coiling point, a wire guide and a pitch controlling tool for coiling the wire helically on said arbor, mechanism for compressing the coil axially against said tools to a predetermined length, means acting while the coil is thus compressed for introducing an alternating current of a voltage related to the wire resistance which reduces a coiling stress therein, and switch mechanism acting in timed relation with the coil compression to introduce said current to the coil only while it is compressed.

4. Apparatus for coiling wire comprising mechanism for feeding a wire progressively, coiling tools which form a coil on said wire, a cutter mechanism for severing the coil from the wire, mechanism for compressing the coil against the tools and maintaining it at a predetermined length, means providing an alternating current of voltage related to the wire resistance for reducing a coiling stress in the wire, and cam control mechanism which causes the wire coil to be compressed and electric current to be introduced momentarily prior to the severance of the coil from the wire.

5. Apparatus for coiling wire comprising wire feeding rolls for moving a wire forward, coiling tools including an arbor for forming a coil on the end of said wire, cutter mechanism for severing the coil from the wire, power mechanism for compressing the coil to a predetermined length prior to its severance, means including a variable voltage transformer for introducing an alternating current into the compressed coil and timing mechanism which insures that the coil is compressed and the electric current applied momentarily prior to the severance of the coil from the wire.

6. Apparatus according to claim 5 comprising cam control mechanism which causes a predetermined length of wire to be fed to the coiling tools and a cam governing the timing mechanism.

7. Apparatus for coiling wire comprising power feed rolls, cam mechanism controlling the rolls which causes a predetermined length of wire to be fed forward and the wire to be stopped, coiling tools to coil the moving wire progressively, power mechanism to compress the completed coil to a predetermined length after the wire has stopped, electrical apparatus supplying a low voltage alternating current related to the wire resistance, cam controlled timing means to apply the current momentarily to the coil while it is held compressed and cam controlled cutter mechanism acting after the application of the current to sever the coil from the wire.

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