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APPARATUS FOR MAKING ELECTRICAL RESISTORS

Filed April 1, 1959

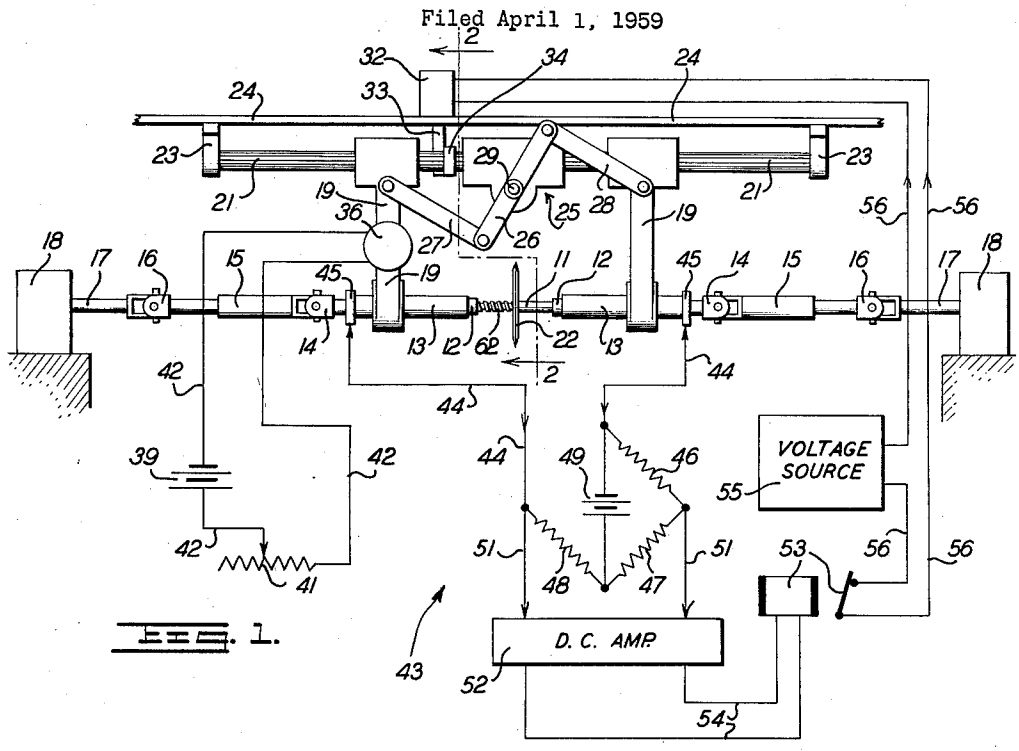

FIG. 1.

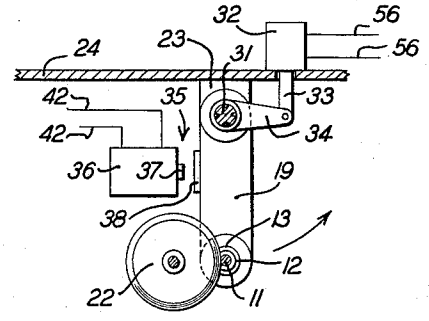

FIG. 2.

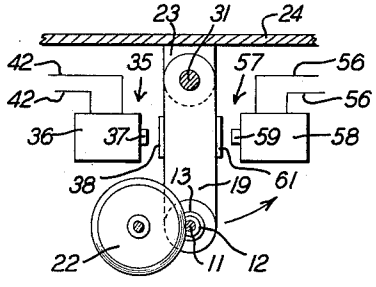

FIG. 3.

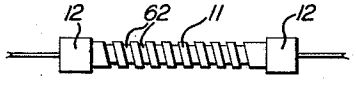

FIG. 4.

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APPARATUS FOR MAKING ELECTRICAL RESISTORS

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1 Claim. (Cl. 90—11.52)

This invention relates to an opparatus for making electrical resistors and more particularly to an apparatus for progressively spiralling electrical resistors formed of a thin conductive film deposited on a cylindrical insulating base.

In the manufacture of electrical resistors, such as deposited carbon resistors, it is customary to provide a resistor blank having a cylindrical insulating base and a thin conductive film deposited thereon. Frequently this film is carbon or a carbon compound. A helical groove is progressively cut through this film from one end of the resistor blank toward the other by means of a cutting or grinding wheel. In known techniques the resistor blank is held against the cutting wheel with a predetermined pressure by the gravitational force of the resistor blank and a related fixture used to support and rotate the resistor blank for spiralling. However, this technique has not proved entirely satisfactory because the degree of control of pressure of the resistor blank against the cutting wheel has been limited by the gravitational force of the resistor blank and the fixture.

An object of the present invention is the provision of a new and improved apparatus for making electrical resistors.

Another object of the invention is to provide an apparatus for cutting a spiral in electrical resistors to value wherein magnetic means control the pressure between the resistor blank and the spiral cutting wheel.

Apparatus illustrating certain features of the invention may include a pair of chucks for gripping the article for rotational and axial movement, a pair of drive shafts coupled to each chuck, and a frame. Fixed to the frame are supporting means having apertures in one end thereof for holding each shaft for rotational, axial, and pivotal movement about a predetermined common axis. Means for removing a predetermined portion of the film, deposited on the article, a magnet for holding the article in a predetermined position, and means for moving the article out of the predetermined position upon the removal of the predetermined portion of the film are also provided.

More specifically, an apparatus for cutting a spiral in a resistor formed of a thin film of carbon deposited on a cylindrical insulating base may include a pair of chucks for gripping the resistor for rotational and axial movement, a pair of drive shafts coupled to each chuck for turning them in unison, and a frame. A pair of spaced supporting arms are each fixed to the frame and have an aperture in one end thereof for holding each shaft for rotational, axial, and pivotal movement about a predetermined common axis. A cutting wheel is provided for removing a predetermined portion of the carbon film, an electromagnet being used to hold the resistor in cutting engagement with the wheel with a predetermined pressure. Means are also provided for pivotally swinging the resistor out of engagement with the cutting wheel upon the removal of said predetermined carbon film.

A complete understanding of the invention may be had from the following detailed description of a specific embodiment thereof when read in conjunction with the appended drawing, in which:

FIG. 1 is a front elevational view of a preferred embodiment of the invention showing an electrical control circuit;

FIG. 2 illustrates a sectional view of apparatus taken along line 2—2 of FIG. 1;

FIG. 3 shows a sectional view of another embodiment of the apparatus;

FIG. 4 illustrates a deposited carbon resistor of the type grooved to value by apparatus comprising this invention.

Referring to the drawing, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in FIGS. 1 and 3 a resistor blank **11** having a cylindrical base of insulating material, such as ceramic or the like, with a deposit thereon of resistance material possessing characteristics desired in the finished resistor. This resistance film may be carbon deposited on a cylindrical ceramic base by any one of several conventional depositing methods, such as by passing a controlled mixture of an inert gas and a hydrocarbon gas over the heated blank in a controlled atmosphere.

The apparatus which comprises a portion of the preferred embodiment of the invention being substantially symmetrical, only the left side of the apparatus as viewed in FIG. 1 need be described hereinbelow. The resistor blank **11** is gripped for rotation by a chuck **12** coupled fixedly to one end of a first independent drive shaft **13**, the other end of which is connected to a first universal joint **14**. As best seen in FIG. 1, chuck **12** includes two generally cylindrical members having aligned, opposing axial openings therein adapted to receive and grip the ends of resistor blank **11**. Such a chuck is well-known in the art to which the invention pertains, and one suitable form thereof may be seen in U.S. Patent 2,724,306 to V. A. Woodell (FIG. 4). The universal joint **14** is fixedly engaged to a telescopic shaft **15** adapted for transverse movement which shaft is coupled to a second universal joint **16**. A second independent drive shaft **17** is coupled to the joint **16**, and is driven by a motor means **18**. The motor means includes a gear arrangement, not shown, which transversely travels along splines, not shown, causing an arm **19** to move left or right along a splined guide rod **21** to obtain transverse motion of the resistor blank **11** with respect to the fixed position of a cutting wheel **22**. As shown in FIGS. 1 and 2, each first independent drive shaft **13** is held for rotational and axial movement by an arm **19** which is held pivotally by the splined guide rod **21**. The rod is rotatively supported by a pair of bearing members **23** fixed to a frame **24**.

Considering the apparatus as viewed in full in FIG. 1, the first independent drive shafts **13** are axially moved by the arms **19** in cooperation with the gear arrangement, not shown, of the independent motor means **18** so as to transmit axial movement to the resistor blank **11** and cause it to move transversely with respect to the cutting wheel **22** which is rotated in a stationary position. Also, horizontal inward and outward movement of the chucks **12** for engagement and disengagement of the resistor blank **11** is provided by the arms **19** through a link connector, generally designated by the numeral **25**, having an arm **26**, a link **27** pivotally connected to one end of the arm **26**, and another link **28** pivotally connected to the other end of the arm **26**. The link connector **25** is rotated about a pivot **29** by means not shown.

The pivotal movement of the arms **19** about a pivot **31** (FIG. 2) is controlled by a solenoid **32** fixed to the frame **24**, the solenoid having an armature **33** connected pivotally to a lever arm **34**. The lever arm **34** is coupled to the splined guide rod **21** to impart rotation to it upon vertical movement of the armature **33**. Such rotational movement of the splined guide rod **21** is transmitted to the arms **19** to cause them to rotate, for example, in the direction of the arrow shown in FIG. 2 which is away from the cutting wheel **22**.

An electromagnet, generally designated by the numeral 35, having a magnetizing coil 36 fixed to the frame 24 by appropriate means, not shown, a core 37, and an armature 38 fixed to one of the arms 19, controls the pressure between the resistor blank 11 and the cutting wheel 22. This pressure varies in accordance with the magnetic field strength of the electromagnet 35, which field strength is dependent upon the electrical current through the magnetizing coil 36. The current is controlled by a battery 39, FIG. 1, and a variable resistor 41, both of which are connected electrically in series with the magnetizing coil 36 by conductors 42. It is apparent that the current of the magnetizing coil 36 can be controlled by the variable resistor 41 to control the magnetic field strength of the magnetizing coil 36 so as to regulate the pressure between the resistor blank 11 and the cutting wheel 22.

A control circuit, designated generally by the numeral 43, is connected electrically to the resistor blank 11 by conductors 44, slip rings 45, shafts 13, and chucks 12. The arms 19 are appropriately insulated from the shafts 13 so as not to short-circuit the resistor blank 11.

The control circuit 43 includes a conventional Wheatstone bridge having fixed resistors 46, 47, and 48 in three branches thereof. The resistor blank 11 makes up the fourth branch of the bridge.

Battery 49 is connected electrically to the bridge in a conventional manner. Connected across the bridge by conductors 51 is a D.C. amplifier 52 which is coupled to a normally closed relay 53 by conductors 54. A voltage source 55 is connected in series with the contacts of the relay 53 and the solenoid 32 by conductors 56.

Referring to the embodiment shown in FIG. 3, an electromagnet 57 includes a magnetizing coil 58 fixed to the frame 24 by appropriate means, not shown, a core 59, and an armature 61 fixed to one of the arms 19. The electromagnet 57 is substituted for the solenoid 32 of FIGS. 1 and 2, and is connected electrically to the control circuit 43 by conductors 54 to pivot the arms 19 about the pivot 31.

It should be understood that in either of the embodiments of FIGS. 1 and 3, a permanent magnet could be substituted for the electromagnet 35 if a great degree of control of pressure between the resistor blank 11 and the cutting wheel 22 is considered unnecessary.

OPERATION

The resistor blank 11 to be helically grooved or spiralled to value is positioned within the chucks 12 by actuating a rotating means, not shown, to pivot the arm 26 of the link connector 25 in a clockwise direction about the pivot 29 thus moving axially the arms 19 and chucks 12 away from each other. While the chucks 12 are in this position the resistor blank 11 is axially aligned with the common horizontal axis of chucks 12 by holding means, not shown. The rotating means is again actuated to rotate the arm 26 of the link connector 25 in a counterclockwise direction to move the chucks 12 along their common axis to grip the resistor blank 11 for rotation.

After the resistor blank 11 is gripped by the chucks 12, one end of the resistor blank 11 is attracted and held against the cutting wheel 22 by the electromagnet 35 as shown in section in FIG. 2. The variable resistor 41 is adjusted to control the field strength of the magnetizing coil 36 to obtain the desired pressure between the resistor blank 11 and the cutting wheel 22.

Before the helical grooving is begun, control means, not shown, guide the second independent drive shafts 17 such that the left end of the resistor blank 11 engages the cutting wheel 22. At this time the left telescopic shaft 15 is axially extended and the right telescopic shaft 15 is foreshortened.

With the resistor blank 11 positioned within the chucks 12, it becomes one branch of the Wheatstone bridge and as such causes a bridge unbalance. Bridge resistors 46, 47, and 48 are of such a predetermined fixed value that the bridge will balance when the helical groove of the resistor blank 11 has advanced an extent necessary to achieve the desired resistance value. The bridge unbalance caused by the ungrooved resistor blank 11 causes a voltage across the center branch of the bridge which is amplified by the D.C. amplifier 52 thereby impressing a voltage across the normally closed relay 53. The impressed voltage opens the contacts of the relay 53 to prevent any voltage from the source 55 from being impressed across the solenoid 32, thus maintaining it inoperative when the relay 53 is operative.

With the second independent driving shafts 17 and the electromagnet 35 maintaining one end of the resistor blank 11 in engagement with the cutting wheel 22, the helical grooving operation is begun by simultaneously actuating the respective independent motor means 18 to rotate the resistor blank 11, and by actuating driving means, not shown, to rotate the cutting wheel 22. Thus a helical groove 62 is progressively cut through the film of the resistor blank 11. As the groove 62 is progressively cut from the end of the resistor blank 11 to the other, the electrical resistance of the resistor blank 11 increases until the Wheatstone bridge is in balance, at which time the bridge output falls to zero. With zero output from the bridge, the normally closed relay 53 becomes inoperative thereby closing its contacts. When these contacts are closed, a voltage from the source 55 is impressed across the solenoid 32 to move the armature 33 upwardly. Hence the lever arm 34, the arms 19, the first independent driving shafts 13, the chucks 12, and the resistor blank 11 are pivoted counterclockwise, as shown by the arrow of FIG. 2, away from the cutting wheel 22. The force pivoting the resistor blank 11 out of cutting engagement with the wheel 22 is large enough to overcome the magnetizing force of the electromagnet 35. Thus the resistor blank 11 has been helically grooved to a predetermined resistance value.

The embodiment of FIG. 3 operates similarly to that of FIGS. 1 and 2 except that upon Wheatstone bridge balancing, voltage from source 55 is supplied to the electromagnet 57. This voltage is of a magnitude to produce a magnetizing force much greater than that of the electromagnet 35, thereby causing the arms 19, the shafts 13, the chucks 12, and the resistor blank 11 to pivot out of cutting engagement with the wheel 22.

It should be understood that the above-described embodiment of the invention is merely illustrative and that numerous modifications may be made within the spirit and scope of the invention. Further, the particular apparatus illustrated is only one example of several types of apparatus which may be included in practicing the invention and the invention is not limited solely to the use of this apparatus.

What is claimed is:

In an apparatus for progressively cutting a helix in a resistor formed of a thin film of carbon deposited on a cylindrical insulating base, a pair of chucks for gripping the resistor for rotational and axial movement, a pair of shafts for simultaneously rotating and axially moving each chuck, a frame, a first and second supporting arm, each having an aperture in one end thereof for holding each shaft for simultaneous rotational and axial movement about a predetermined common axis, means for pivotally mounting the supporting arms to the frame, a cutting wheel for removing a portion of the film, the combination with said first and second supporting arms of an electromagnet having an operating coil fixed to the frame and a coacting armature fixed to the first supporting arm for attracting and holding the resistor in engagement with the cutting wheel, electrical supply means for energizing the electromagnet, a variable resistor in series with the supply means for controlling the magnetic field strength of the electromagnet, thereby controlling the pressure between the resistor and the cutting wheel, a Wheatstone

bridge having the resistor to be helixed connected in one branch thereof and normally having a voltage output, a normally open circuit, a relay responsive to the absence of a bridge output for closing said circuit, a solenoid having an operating coil fixed to the frame and a coacting armature fixed to the first arm and having said circuit in series with said operating coil, and a voltage source rendered effective by the operation of the relay and closing of the

circuit for energizing the operating coil of the solenoid to disengage the resistor and cutting wheel.

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