Feb. 24, 1953 D. F. HASTINGS 2,629,799

ADJUSTABLE RESISTANCE DEVICE

Filed March 30, 1951 2 SHEETS—SHEET 1

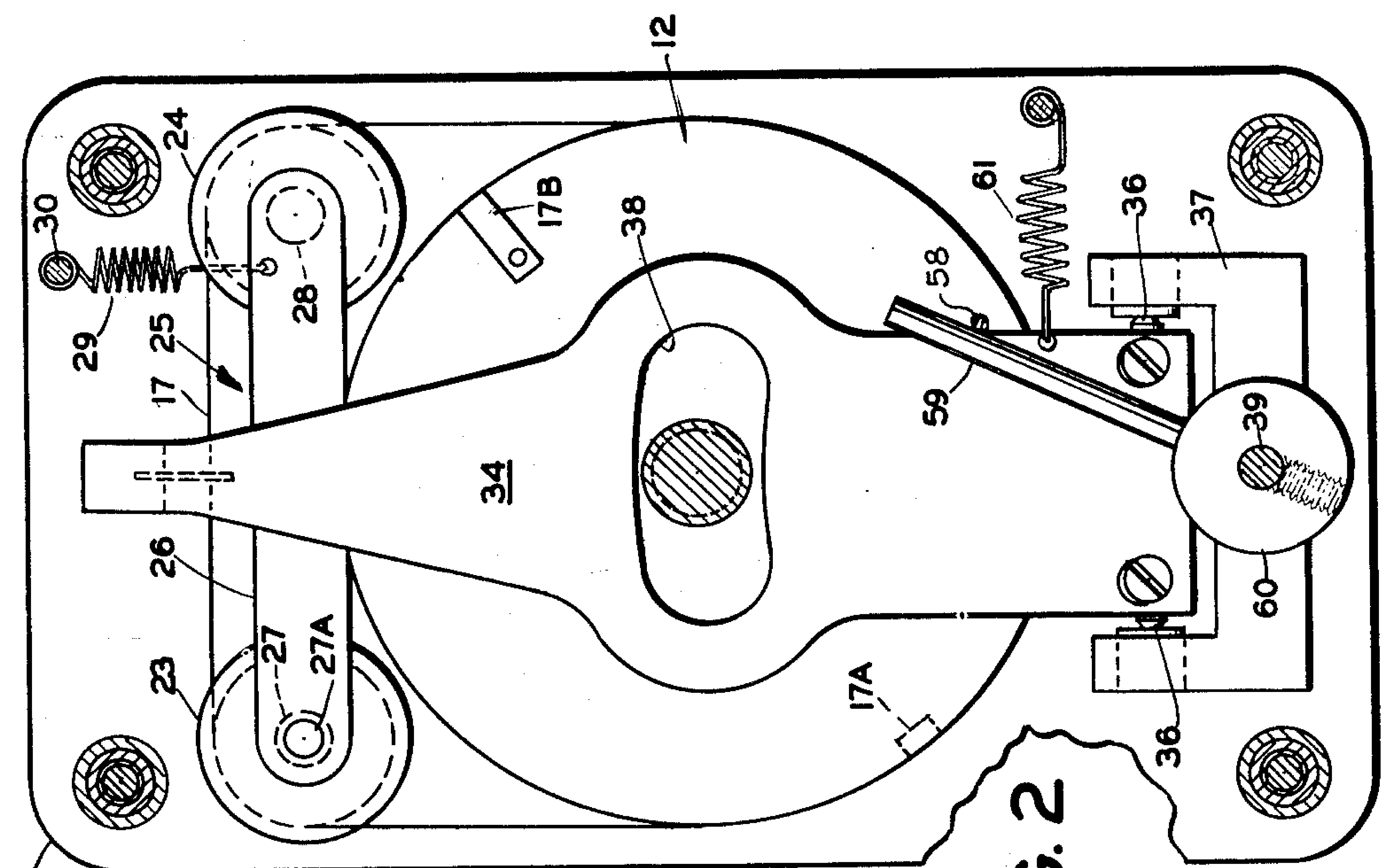

FIG. 2

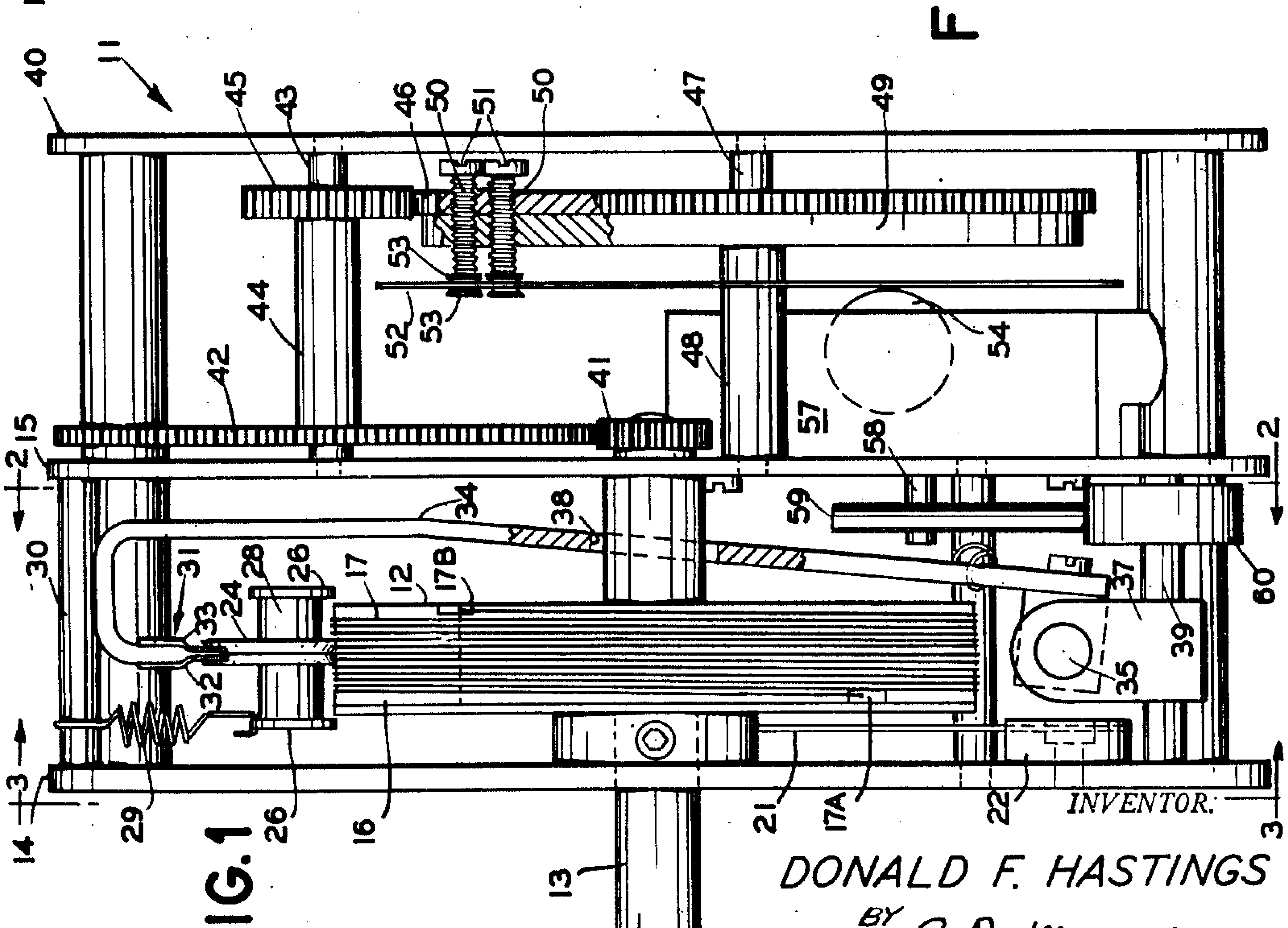

FIG. 1

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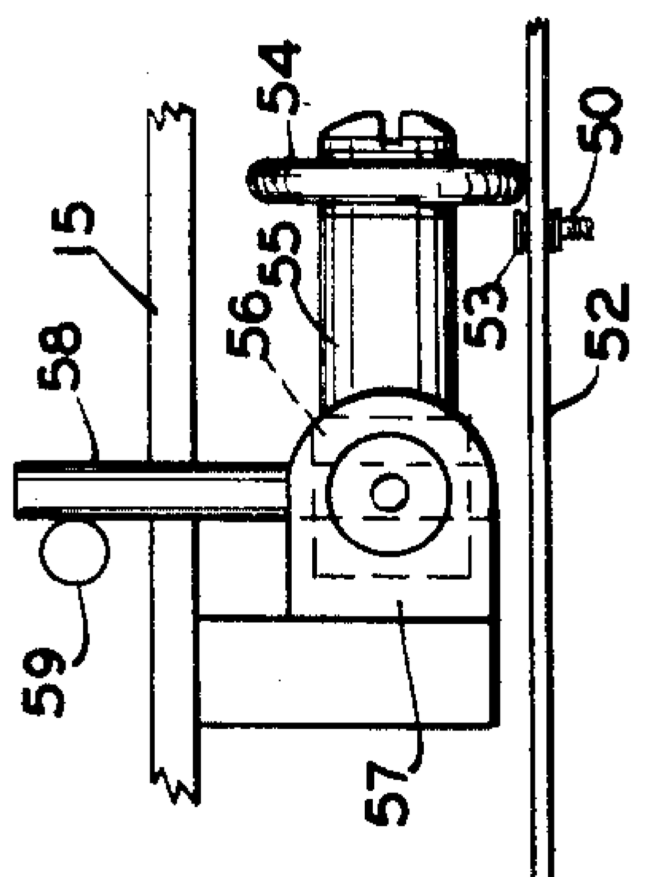

FIG. 4

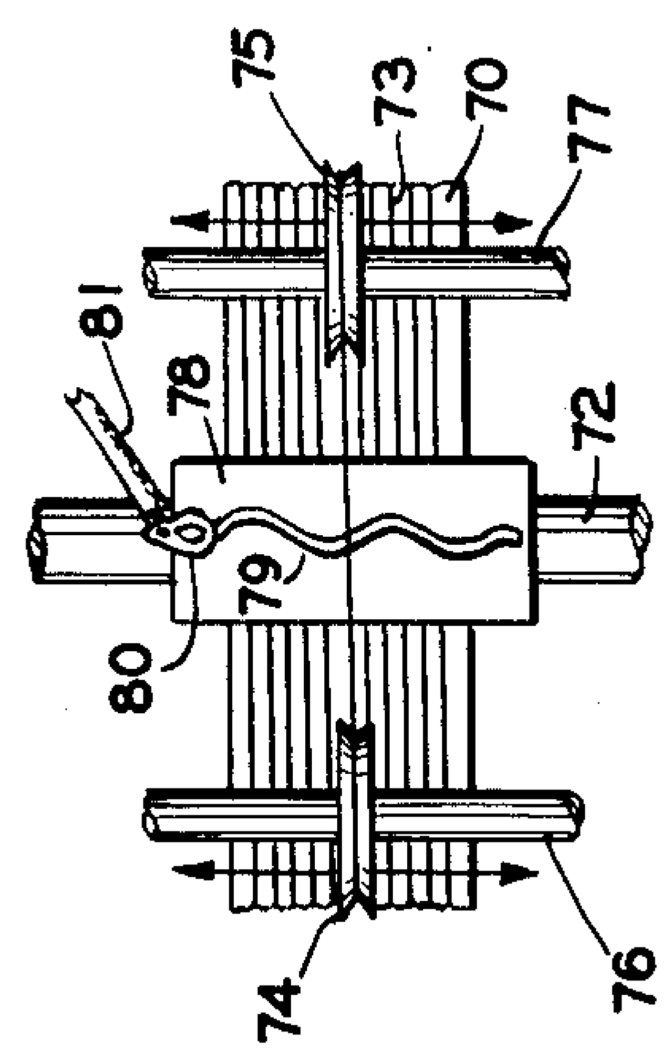

FIG. 5

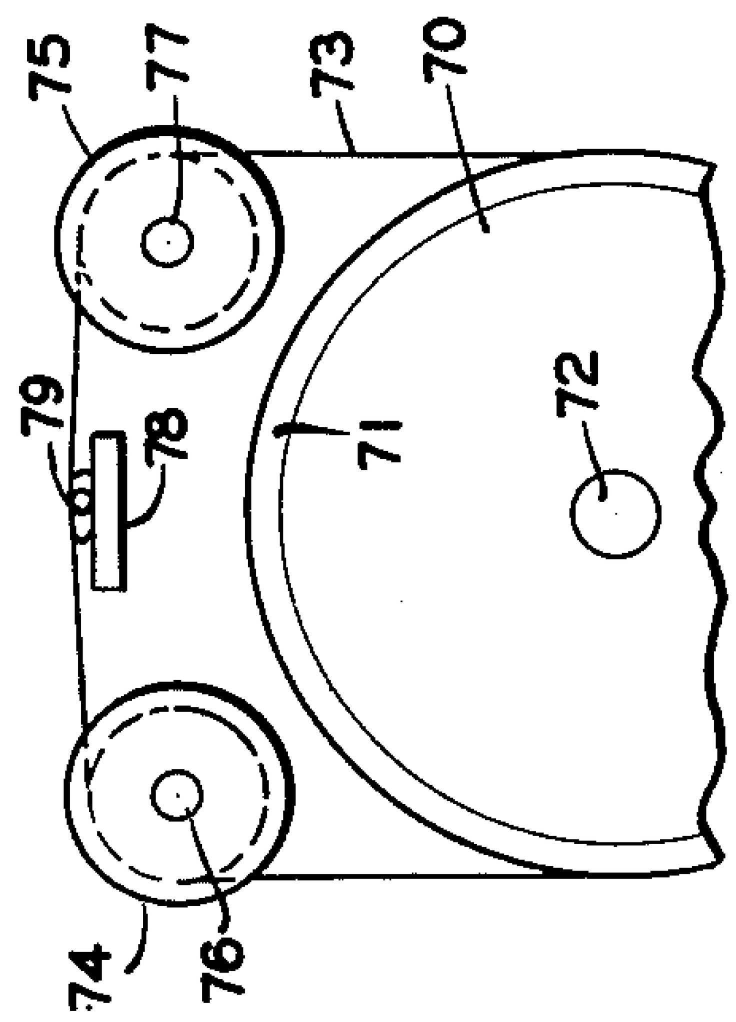

FIG. 6

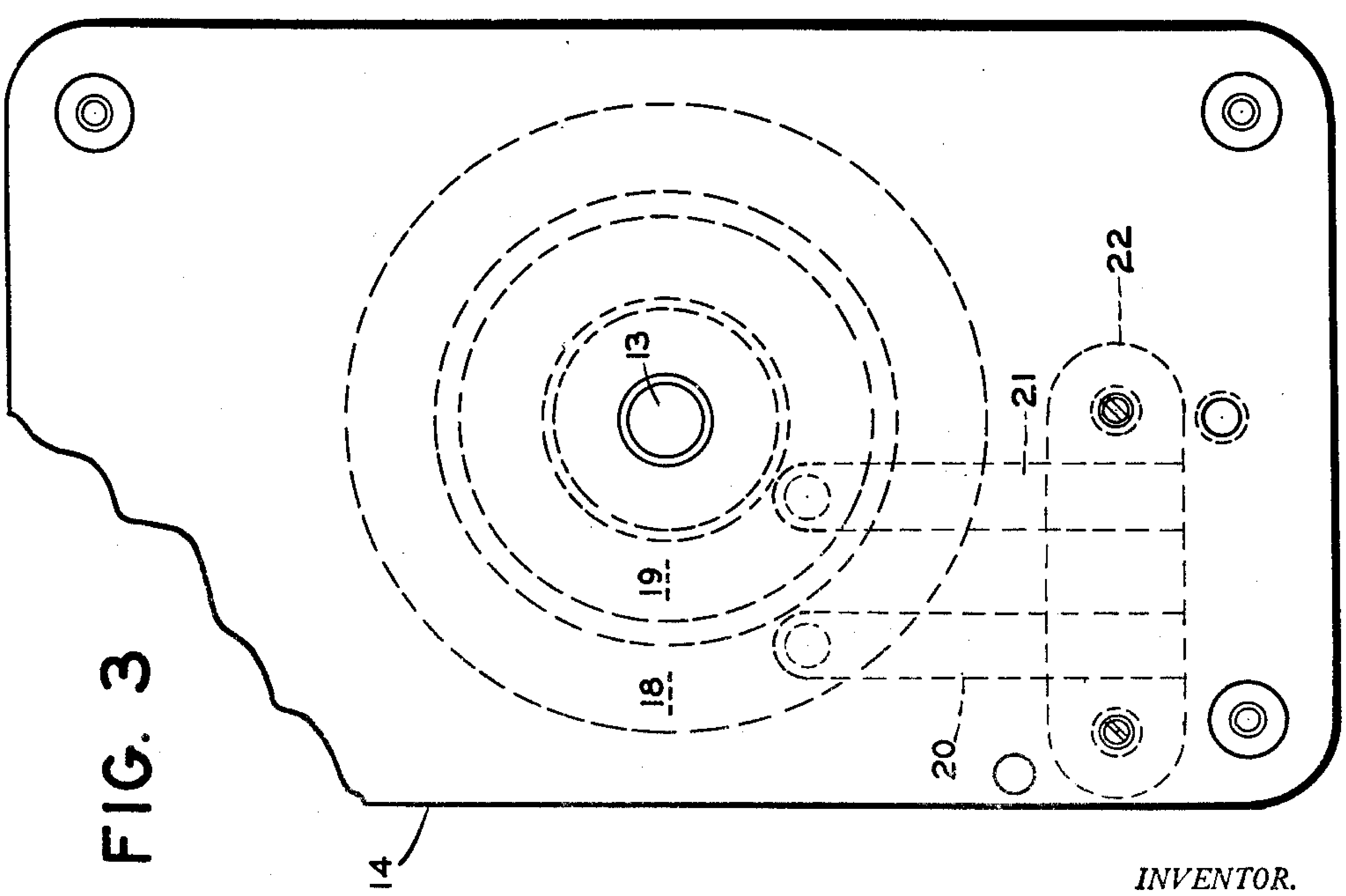

FIG. 3

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2,629,799

ADJUSTABLE RESISTANCE DEVICE

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Application March 30, 1951, Serial No. 218,431

16 Claims. (Cl. 201—59)

This invention relates to control devices for electrical circuits and more particularly to an adjustable resistance device having means for compensating for non-linear changes in the resistance thereof.

Adjustable resistance devices, such as potentiometers and rheostats, are commonly employed in an electrical circuit or in a network for inserting a predetermined amount of resistance into the circuit. These devices in some cases take the form of a pair of drums about which a resistance element or wire may be wound. In this type of a device, one end of the resistance element is fastened to one drum while the other end is fastened to the other drum so that upon rotation of the drums the wire will be unwound from one drum and wound on the other drum. A stationary contact is positioned at a point midway between the drums to engage successive portions of the resistance element as it is passed from one drum to the other. The contact is connected in the circuit for inserting a predetermined value of resistance therein determined by the length of wire on one drum as compared to the length on the other drum. Since the cross section and length of the wire are known, the resistance desired to be inserted in the circuit may be obtained by rotating the drums a predetermined amount. In some devices, the contact is moved about a stationary drum to engage a resistance wound about the outer periphery of the drum. In both cases, a definite error may arise because the change in resistance along the wire is non-linear due to the non-uniform physical structure of the wire. A non-linear change in resistance may occur for other reasons, such as, change in resistivity of the wire due to non-uniform grain structure as a result of improper heat treatment, or because the composition of the wire itself varies from a predetermined standard. Again, the error may arise from the fact that the drum may not be perfectly concentric with the driving shaft, or, the diameter of the threads on the drum may be different to provide in effect a greater length of wire in one thread as compared with the length of wire in another thread. It has been found in practice, that most of the commercial adjustable resistance devices, such as potentiometers, cannot furnish predetermined values of resistance having less than 0.10 percentage error. These potentiometers are not suitable for circuitry wherein linearity must be held to closer tolerances.

The present invention therefore, contemplates a precision adjustable resistance device which

includes means for compensating for the non-linear changes in resistance of the resistance element. In one embodiment of the invention, a rotatable drum has a resistance element in the form of a wire wound about the periphery thereof, the ends of the element being fastened to the drum. A pair of spaced insulated pulleys carry successive portions of the wire as the drum is rotated. A contact connected in the circuit is positioned midway between the pulleys for engaging the wire so as to insert a predetermined value of resistance in the circuit depending upon the amount of rotation of the drum. Means are provided to displace the contact from its normal midway position along the wire, the amount and direction of displacement depending upon the non-linear changes in resistance of the wire, to adjust the resistance of the circuit linearly. In a second embodiment of the present invention, the contact comprises a stationary deformed wire curved in accordance with the non-linear change in resistance of a resistance element wound about a single rotatable drum to adjust the resistance of a circuit linearly.

Accordingly, an object of the present invention is to provide a precision adjustable resistance device for compensating for the non-linear change in resistance of the resistance element.

Another object is to provide a novel adjustable resistance device wherein a resistance element is wound on a rotatable drum, and a contact engages the element and is displaced relative thereto from a reference position in accordance with the non-linear changes in resistance of the element.

A further object is to provide a novel precision adjustable resistance device wherein a resistance element is wound on a rotatable drum and engages a movable contact which is moved along the resistance element by cam means to compensate for non-linear changes in resistance of the element.

A still further object is to provide a novel adjustable resistance device wherein a resistance element wound on a rotatable drum engages a stationary contact preformed in accordance with the non-linear change in resistance of the element to adjust the resistance of a circuit linearly.

The foregoing and other objects and advantages of the present invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein two embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purposes of illustration only, and are not to be construed as defining the limits of the invention.

In the drawings wherein like reference numerals refer to like parts,

Fig. 1 is a side elevational view of one embodiment of the novel adjustable resistor of the present invention;

Fig. 2 is a rear elevation view of part of the adjustable resistance device of Fig. 1, taken along line 2—2;

Fig. 3 is a front elevation view of the adjustable resistance device of Fig. 1 showing the collector ring and brush arrangement for connecting the resistance element in a circuit;

Fig. 4 is a top plan view of a roller-cam arrangement utilized in the adjustable resistor of Fig. 1;

Fig. 5 is a top plan view of another form of the present invention; and

Fig. 6 is a front elevation view of the embodiment of Fig. 5.

Referring now to the drawings for a more detailed description of the present invention and more particularly to Fig. 1 thereof, the novel adjustable resistor hereof is shown as a potentiometer and is generally designated by the numeral **11**. Potentiometer **11** comprises a rotatable drum **12** fixed to a driving shaft **13** which is journalled in a pair of spaced plates **14** and **15**. Shaft **13** may be manually actuated, or may be driven by automatic means to suit the particular requirements of the system with which the potentiometer is to be employed. Drum **12** has fixed thereon an externally threaded sleeve **16** of insulating material which accommodates a predetermined length of a resistance element or wire **17** positioned in the threads of the sleeve. The ends of wire **17** are fixed to the drum **12** by metallic inserts **17A** and **17B** and are electrically connected by the inserts to a pair of concentric collector rings **18** and **19** respectively (shown by broken lines in Fig. 3), disposed on one face of the drum. Brushes **20** and **21** (shown in broken lines in Fig. 3) engage the collector rings **18** and **19** respectively, and are mounted in an insulated terminal block **22** fixed to plate **14**. Connection of the resistance element **17** to a circuit or electrical network may be made by conductors (not shown) connected to the brushes **20** and **21**.

Part of one turn of the wire **17** is carried free of the threads of sleeve **16** by a pair of insulated pulleys **23** and **24** spaced from the drum. The pulleys are mounted on a carriage **25** which comprises a pair of spaced frame members **26** only one of which is shown in Fig. 2. The pulleys **23** and **24** are supported for movement axially of the drum by a pair of shafts **27** and **28** respectively, journalled in the spaced members **26**. Shaft **27** is hollow and accommodates therethrough a shaft **27A** the ends of which are seated in plates **14** and **15**. Spaced members **26** are spring-held at the end adjacent pulley **24** by a coil spring **29** which is fixed at its other end to a spacer bar **30** supported by plates **14** and **15**. In the instant arrangement, members **26** and pulley **24** pivot about shaft **27A**. For purposes of clarity, shaft **27A** and pulley **23** are not shown in Fig. 1. By reason of the foregoing arrangement, the wire **17** is tensioned by the pulleys **23** and **24**, and as the shaft **13** is actuated successive parts of the wire pass between the pulleys. The pulleys are free to axially slide along shafts **27** and **28** as well as rotate, and therefore, as the shaft **13** is rotated the pulleys take up a position directly over the points at which the wire meets the threads of sleeve **16**.

A contact **31** comprising a pair of contact members **32** and **33** normally engages the wire **17** at a point which is midway between the pulleys (Figs. 1 and 2). The contact members **32** and **33** are carried by a contact arm **34** which is supported for oscillation about a point **35** directly below drum **12**. A pair of pins **36** (Fig. 2) fixed to the lower side portions of the arm are seated in bearings fixed to a substantially U-shaped bracket **37** to permit oscillation of arm **34** about point **35**. An opening **38** formed in arm **34** permits the arm to be disposed between plates **14** and **15** and about shaft **13**. A shaft **39** journalled in plates **14** and **15** carries bracket **37** and is adapted, by means hereinafter to be described, to angularly displace the bracket about the axis of the shaft. A conductor (not shown) may be connected to the U-shaped bracket **37** to connect the contact **31** in a circuit.

Fixed to one end of shaft **13** and disposed between plate **15** and a third plate **40** is a pinion **41** which meshes with a relatively large gear **42** supported on a shaft **43** journalled in plates **15** and **40**. Gear **42** is fixed to a coupling sleeve **44** supported on shaft **43**, the sleeve having fixed at the other end thereof a pinion **45** which moves with gear **42**. A second relatively large gear **46** meshes with pinion **45** and is supported on a sleeve **48** disposed on a shaft **47** journalled in plates **15** and **40**. Gear **46** has fixed thereto an annular face plate **49** which has a plurality of threaded openings formed at equal radial distances from the center of the plate. The openings are spaced at predetermined and equal intervals from each other and are each adapted to received a cam adjusting screw **50**, only two of which are shown in Fig. 1. The adjusting screws **50** have a kerf **51** cut in the head thereof for permitting the insertion of a suitable tool to axially displace the screws relative to face plate **49**. A thin deformable cam ring **52** of spring material is spaced from the face plate **49** and fixed for rotation therewith by the screws. The end portions of screws **50** have smooth shank portions which fit into openings formed in cam ring **52** which are aligned with the threaded openings in the plate **49**. Disposed on each end of the smooth shank portions of screws **50** and on both sides of ring **52** are buttons **53** which permit the screws to be rotated with respect to the ring but prevent axial movement thereof with respect to the ring. The contour of the cam ring **52** may by reason of the foregoing, be adjusted to form any desired shape simply by rotating screws **50** a predetermined amount in either direction.

A cam roller **54** is disposed between plates **15** and **40** for engagement with the surface of cam ring **52** (Fig. 4). Roller **54** is loosely mounted for rotation on a shaft **55** (Fig. 4) which is fixed perpendicularly to a rectangular shaped shaft **56** supported for angular displacement in a block **57** fixed to plate **15**. A pin **58** is also secured to shaft **56** and at right angles to shaft **55** to engage a second pin **59** fastened to a collar **60** which is fastened to shaft **39**. A coil spring **61** biases the contact arm **34** to the right, as seen in Fig. 2, to hold pins **58** and **59** in contact with each other to take up backlash in the arrangement described. It is apparent from the foregoing structure that cam roller **54** and shaft **55** are moved by the contoured surface of cam ring

52 to displace shaft 56 and rock pins 58 and 59, thereby oscillating contact arm 34 about shaft 39. In this manner, the contact 31 is displaced from a point midway between the pulleys an amount depending upon the contour of cam ring 52, the contact 31 engaging the wire 17 as it is displaced.

Gears 41, 42, 45 and 46 provide a gear reduction arrangement between drum 12 and cam ring 52, and is such that the cam makes less than one full revolution for the required number of revolutions of the drum to pass the entire active length of the wire 17 over the space between pulleys 23 and 24. In the instant arrangement, one revolution of drum 12 passes one turn of wire past the contact 31, and cam ring 52 is rotated an angular distance equal to one half the distance between two successive screws 50. Thus, the contoured surface of the cam ring between two successive screws is directly related to two turns of the resistance element on the drum. In other words, the displacement of contact 31 with respect to two turns of wire is controlled by a single screw of the adjustable cam 52.

The value of resistance to be inserted in the circuit in which the resistance element 17 is included depends upon the point of engagement of contact 31 along the length of the resistance wire. Thus, when the contact 31 is positioned directly over the first thread of sleeve 16, looking from left to right in Fig. 1, the length of wire 17 between the insert 17A connected to collector ring 18, and the contact is a minimum and, therefore, the resistance inserted in the circuit is a minimum. As drum 12 is rotated in a direction to increase the effective length of wire between contact 31 and insert 17A the resistance inserted in the circuit likewise increases, and if the drum is rotated until a minimum length of wire remains between contact 31 and insert 17B connected to collector ring 19, then the resistance in the circuit is the greatest. Since the length and cross-sectional area of the wire are known, the linear change in resistance of the wire as the drum is rotated may be computed. Therefore, if it is desired to insert a certain value of resistance in the circuit, the shaft 13 is rotated until the contact 31 engages a point on the wire which will give the desired resistance. Normally, contact 31 is at a point midway between the pulleys 23 and 24 when the change in resistance is linear. However, since the cross-sectional area of wire 17 cannot be made perfectly uniform in practice, and the wire may vary in resistivity, and/or there is a variation of the thread diameter of the drum, a non-linear change in resistance results as the wire is moved past the contact 31.

To overcome this non-linear change in resistance, contact 31 is displaced from the midway point, and along the wire, so as to insert more or less resistance in the circuit depending upon whether the resistance of the wire between the insert 17A connected to collector ring 18 and the midway position of the contact is greater or less than its calculated value. If the resistance is greater than its calculated value, then the contact 31 will be displaced from its midpoint position to decrease the length of wire between collector ring 18 and the contact, and, conversely, if the resistance is less than its predetermined value then the contact is displaced so as to increase the effective length of wire in the circuit. In this manner, the non-linear change of resistance in wire 17 as it is driven by drum 12 past the contact 31 is corrected automatically to effect a linear change in resistance.

Considering the operation of the arrangement described, if it is desired to insert a resistance into a circuit which requires the drum to make two complete revolutions, shaft 13 is rotated two revolutions. The threads of sleeve 16 are arranged to advance in one direction so that the wire, as it leaves the sleeve, moves the pulleys 23 and 24 axially of the drum to the right, as seen in Fig. 1, to position the pulleys directly over the points at which the wire meets the drum. The contact 31 also moves to the right about its pivot 35 due to the movement of the pulleys and the wire thereon. Motion of shaft 13 is taken up through reduction gears 41, 42, 45 and 46 to displace cam ring 52 an angular amount equal to the distance between two successive threaded members on the cam. If it is assumed that the linear change in resistance of the two turns of wire on drum 12 is not uniform, then the portion of the cam ring between the two threaded members 50 under consideration is contoured by the screws in accordance with a previous determination of non-linearity of change in resistance of the particular two turns of wire, to move cam roller 54 outwardly or inwardly with respect to the cam ring. This movement is transmitted to pin 58 which rocks pin 59 to angularly displace shaft 39 and U-shaped bracket 37 to thereby displace contact 31 from the midway position. The contact 31 will be moved either to the left or right of the midway position depending upon whether the amount of resistance is to be decreased or increased in conformance with the previous determination of non-linearity of wire 17.

An improved embodiment of the present invention is illustrated in Fig. 5 of the drawings, wherein a rotatable drum 70 having a sleeve 71 of suitable insulating material formed thereon is rotated by a shaft 72 fixed to the drum. Sleeve 71 is threaded externally thereof and accommodates a predetermined length of a resistance element or wire 73 wrapped about the sleeve. Each end of the wire is fastened to the drum and connected to its respective collector ring and brush, in a manner similar to the adjustable resistor of Fig. 1, so as to connect the wire in an electrical circuit or network. The collector ring and brush structure is identical with the corresponding structure disclosed in Fig. 1. A pair of insulated pulleys 74 and 75 are supported for rotation, and movement axially of the drum, by shafts 76 and 77, respectively, the latter being journalled in a pair of spaced plates not shown. Successive portions of resistance element 73 are carried and tensioned by the pulleys, and as the drum 70 is rotated the pulleys are free axially to slide along the shafts 76 and 77 and thus take up a position directly over the points at which the wire meets the threads of the drum.

Coming now to the novel feature of the improved embodiment, a stationary block 78 of insulating material is positioned between the pulleys 74 and 75, by means not shown, and has cemented or otherwise attached thereto, a contact member 79 consisting of a curved wire. Physically connected to one end of contact member 79 is a terminal element 80 which connects the contact member in the electrical circuit by way of a conductor 81. The contact member 79 is so positioned with respect to the wire 73 carried by the pulleys, that the contact member is engaged by the resistance element as the pulleys move axially of the drum in the direction of the arrows. The pulleys **74** and **75** tension the resistance element **73** to provide a positive contact pressure between the contact member and resistance element. Contact member **79** is deformed or curved in accordance with the change in resistance of each turn of resistance wire **73** on the drum to compensate for non-linear change in resistance. The deformation of contact member **79** may be easily computed before it is attached to the stationary block **78** by positioning a straight contact wire on the block midway between the pulleys **74** and **75**. Since the length and cross-sectional area of the resistance element are known as well as variations in resistivity, the change in resistance as the element is moved past the contact wire may be found by connecting the resistance element and contact wire to a suitable indicating instrument. By moving the resistance element past the contact wire, the indicating instrument will effect indications of the non-linear change in resistance of the resistance element. When the resistance is less than the predetermined value for the length of resistance element between the contact wire and the end connected to the collector ring the contact point is advanced by deforming the contact wire so as to include the additional resistance required, and conversely, if the resistance is less than the predetermined value the contact point is moved back to decrease the amount of resistance. In this manner, the non-linear change in resistance of the resistance element is compensated and the curvature of the contact wire **79** may be determined. It is readily apparent that deformed contact member **79** accomplishes the same results as effected by the gear reduction, cam and contact arrangement of the first embodiment previously described and, as such, is an improvement thereover.

It may be readily understood from the foregoing that the present invention provides an adjustable resistance device which is capable of compensating for non-linear changes in resistance of its resistance element so as to insert in a circuit a linear change in resistance. The adjustable resistance device may be used interchangeably as a potentiometer, rheostat and voltage divider by connecting the resistance element and contact member in a circuit in a manner apparent to those skilled in the art.

Although two embodiments of the invention have been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes may be made in the design and arrangement of parts without departing from the spirit and scope of the invention as will now be understood by those skilled in the art.

I claim:

1. A device for preselecting the resistance to be inserted into an electrical circuit, comprising a resistor element having non-linear resistance characteristics, resistance selecting means for displacing said element along a predetermined path so as to select the value of resistance to be inserted into said circuit, and contact means adapted for connection with said electrical circuit for engaging said resistor element as it is displaced in said predetermined path, said contact means being calibrated in accordance with the non-linear characteristics of said resistor element for compensating for non-linear changes in the resistance so that a linear change in resistance will be effected in said electrical circuit.

2. A device for preselecting the resistance to be inserted into an electrical circuit, comprising a resistor element having non-linear resistance characteristics, a rotary member having said resistor element wound thereon, the ends of said element being adapted for connection in said circuit, selecting means adapted to drive said rotary member to select the value of resistance to be inserted in said circuit, and contact means adapted for connection in said circuit and engaging said resistor element, said contact means being calibrated in accordance with the non-linear resistance characteristics of said resistor element for compensating for non-linear changes in the resistance of said element so that a linear change in resistance is effected in said circuit by said selecting means.

3. A device for preselecting the amount of resistance to be inserted into an electrical circuit, comprising a resistor element having non-linear resistance characteristics, means for displacing said element along a predetermined path so as to select the value of resistance to be inserted in said circuit, a movable contact adapted for connection in said circuit engaging the resistor element as the latter is displaced along said path, and means calibrated in accordance with the non-linear resistance characteristics of said resistor element for displacing said contact from a reference position and along said element to compensate for the non-linear resistance characteristics of said resistor element.

4. A device for preselecting the amount of resistance to be inserted into an electrical circuit, comprising a resistor element having non-linear resistance characteristics, a drum having said resistor element wound thereon, the ends of said resistor element being fastened to said drum, means for driving said drum to select the value of resistance to be inserted in said circuit, a movable contact adapted for connection in said circuit and engaging said resistor element, and means calibrated in accordance with the non-linear resistance characteristics of said element and connected for displacing said movable contact from a reference position and along said element to compensate for the non-linear resistance characteristics of said resistor element.

5. A device for preselecting the amount of resistance to be inserted into an electrical circuit, comprising a resistor element having non-linear resistance characteristics, a shaft, a drum mounted for rotation by said shaft, said drum having said resistor element wound thereon, means connected for actuation by said shaft and calibrated in accordance with the non-linear resistance characteristics of said resistor element, a movable contact adapted for connection in said circuit and engaging said resistor element to adjust the value of the resistance to be inserted into said circuit, said contact being displaced from a reference position and along said resistor element by said calibrated means to compensate for the non-linear resistance characteristics of said resistor element.

6. A device for preselecting the amount of resistance to be inserted into an electrical circuit, comprising a resistance wire having a non-linear resistance characteristic, a drum having threads formed thereon, said drum having said resistance wire wound thereon and lying in said threads, a contact adapted for connection in said circuit and positioned to engage said resistance

wire, a shaft for rotating said drum, and means calibrated in accordance with the non-linear resistance characteristic of said wire, said last-mentioned means connected for actuation by said shaft and adapted to displace said contact along said wire to compensate for the non-linear resistance characteristic of said wire.

7. A device for selecting the value of a resistance to be inserted into an electrical circuit, comprising a resistance wire having a non-linear resistance characteristic, a movable contact adapted for connection in said circuit, a drum having said resistance wire wound along the periphery thereof, a shaft for rotating said drum, means for lifting a portion of said resistance wire from said drum so as to bring successive portions of said wire into engagement with said contact, and means calibrated in accordance with the non-linear changes in resistance of each turn of wire on said drum, said last-mentioned means being connected for actuation by said shaft for displacing said contact along said wire to compensate for the non-linear resistance characteristic of said wire.

8. A device for selecting the value of a resistance to be inserted into an electrical circuit, comprising a resistance wire having non-linear resistance characteristics, a drum having threads formed thereon, said drum having wound thereon and in said threads said resistance wire, a shaft connected for rotating said drum, a cam follower arrangement calibrated in accordance with the non-linear resistance characteristics of each turn of said wire on said drum and connected for actuation by said shaft, a movable contact adapted for connection in said circuit and engaging said resistance wire to select the value of resistance to be inserted into said circuit upon rotation of said drum, said movable contact being displaced from a reference position and along said wire by said cam follower arrangement to compensate for the non-linear resistance characteristics of said wire in order to insert the correct resistance in said circuit.

9. A device for compensating for non-linear changes in the resistance of a resistor element adapted for connection into an electrical circuit, comprising a drum mounting said resistor element along the outer surface thereof to constitute a plurality of turns of the resistance element, a shaft connected for rotating said drum, a deformable cam ring connected for angular displacement by said shaft from a reference position, said cam ring being deformed in accordance with the non-linear changes in resistance of said element and having marked off thereon positions corresponding to each turn of said element on the drum, a cam follower adapted to engage said cam ring, a movable contact adapted for connection in said circuit and positioned to engage successive turns of said element to select the value of resistance to be inserted into said circuit, said movable contact being connected for displacement along said element by said cam follower to adjust the value of the resistance to be inserted into said circuit linearly.

10. A device for selecting the value of resistance to be inserted into an electrical circuit, comprising a resistor element having non-linear resistance characteristics, a drum mounting said resistor element, means for rotating said drum, a contact adapted for connection in said circuit and positioned to engage said resistor element so as to select the value of resistance to be inserted into said circuit, said contact being curved in accordance with the non-linear resistance characteristic of said resistor element for compensating for the non-linear resistance characteristics of said element.

11. A device for selecting the value of resistance to be inserted into an electrical circuit, comprising a resistor element having a non-linear resistance characteristic, a drum having said element wound thereon, means for driving said drum, and a stationary preformed contact adapted for connection in said circuit and formed in accordance with the non-linear resistance characteristic of said element, said contact engaging successive portions of said resistor element and positioned with respect to the latter so as to vary the point of engagement therebetween to compensate for the non-linear resistance characteristic of said resistor element.

12. A device for selecting the value of resistance to be inserted into a circuit, comprising a resistor element having a non-linear resistance characteristic, a drum having threads formed thereon for accommodating said resistor element, means for rotating said drum, tensioning means spaced from said drum and adapted to move in a direction axially of the drum upon rotation of the latter, said tensioning means being adapted to carry successive portions of said resistor element as the drum is rotated, and a contact member preformed in accordance with the non-linear resistance characteristic of said resistor element and adapted for connection in said circuit, said contact member being positioned so as to engage successive portions of said element to provide a linear change in the value of the resistance inserted into the circuit.

13. A device for selecting the value of resistance to be inserted into an electrical circuit, comprising a resistor element having a non-linear resistance characteristic, a drum having a plurality of threads formed thereon, said drum having said resistor element wound in said threads, means for rotating said drum, tensioning means spaced from said drum and adapted to move in a direction axially of the drum, said tensioning means being adapted to carry successive portions of said resistor element, and contact means adapted for connection in said circuit and engaging said resistor element, said contact means including a contact wire spaced from said drum and arranged longitudinally thereof so that successive portions of said resistor element move along the length of said contact wire upon rotation of said drum, said contact wire being deformed in accordance with the non-linear resistance characteristic of said resistor element.

14. An electrical device comprising a predetermined amount of a resistor element adapted for insertion into an electrical circuit, the element being of a nature such that as a varying amount thereof is inserted into the circuit the change in the resistance produced thereby is other than linear, contact means engaging said element, and means for displacing said element relative to said contact means whereby for a given displacement thereof a given amount of the element is inserted into the circuit, said contact means being constructed to vary the amount of the element inserted into the circuit by the displacing means to thereby compensate for the non-linear resistance characteristic of said element.

15. An electrical device comprising a predetermined amount of a resistor element adapted

for insertion into an electrical circuit, the element being of a nature such that as a varying amount thereof is inserted into the circuit the change in the resistance produced thereby is other than linear, contact means engaging said element, means for displacing said element relative to said contact means whereby for a given displacement thereof a given amount of the element is inserted into the circuit, and means for varying the point of engagement of said contact means with said element whereby the amount of the element inserted into the circuit by the displacing means is varied to thereby compensate for the non-linear resistance characteristic of said element.

16. A variable resistance device comprising a resistor element having a non-linear resistance characteristic, a contact engaging the element, means providing relative displacement between

the element and contact to vary the effective resistance of the device, and means providing a variable point of engagement for the contact with the element to compensate for the non-linear resistance characteristic of the element.

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