

July 2, 1963

A. M. DAILY ET AL
VARIABLE RESISTOR

3,096,500

Filed June 30, 1961

3 Sheets-Sheet 1

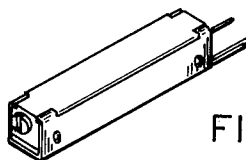


FIG. 1.

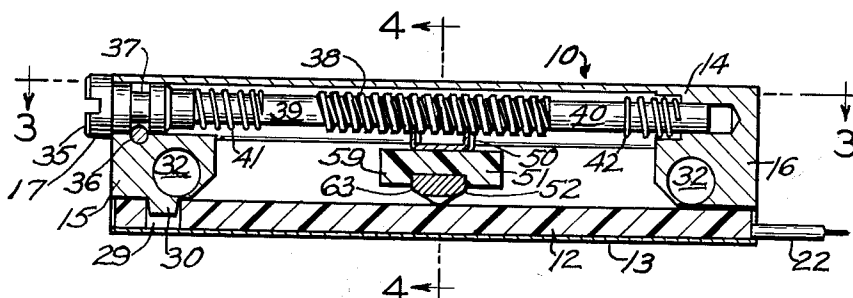


FIG. 2.

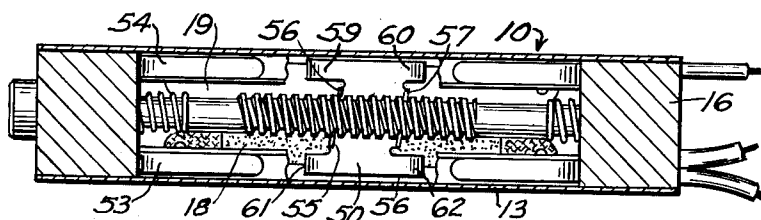


FIG. 3.

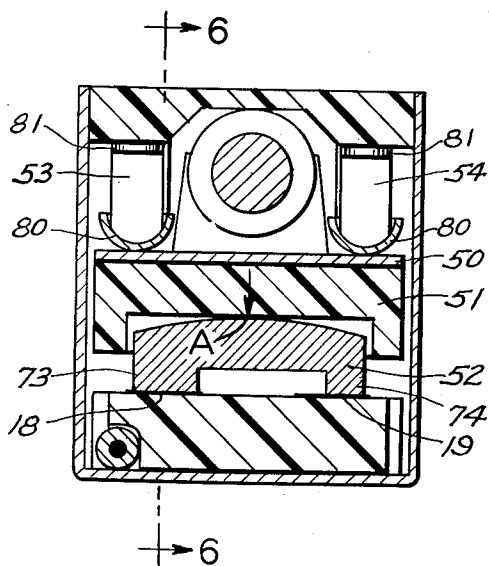


FIG. 4.

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FIG. 5.

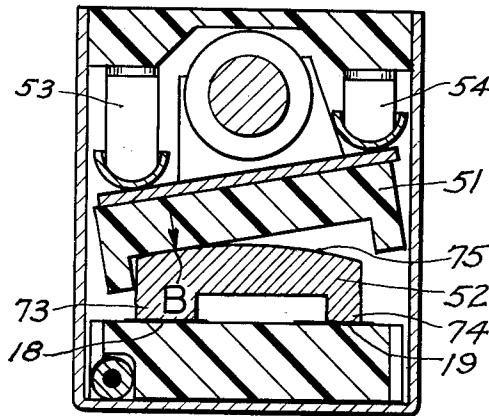


FIG. 6.

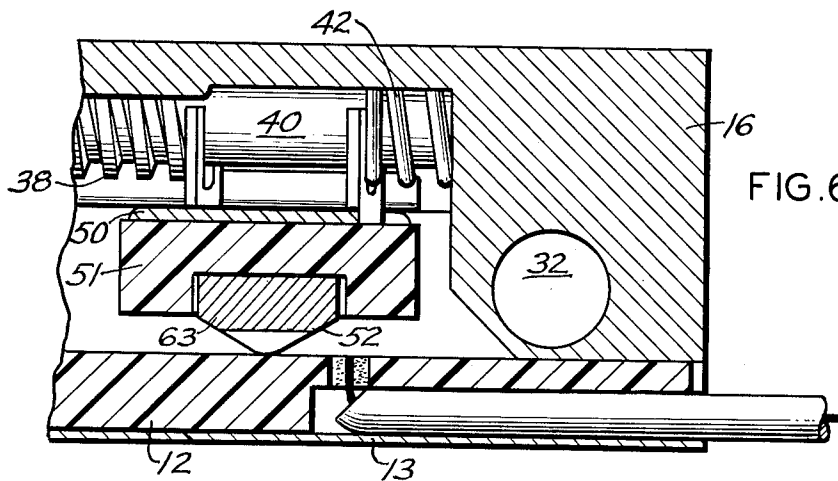
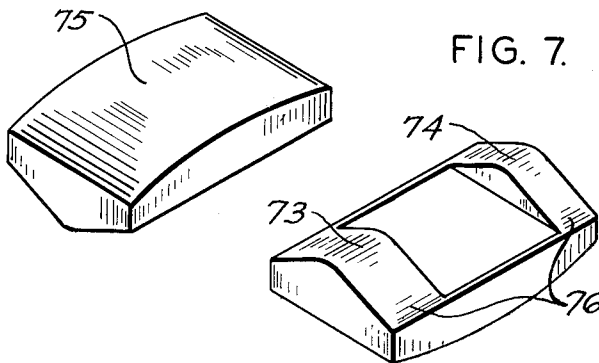


FIG. 7.



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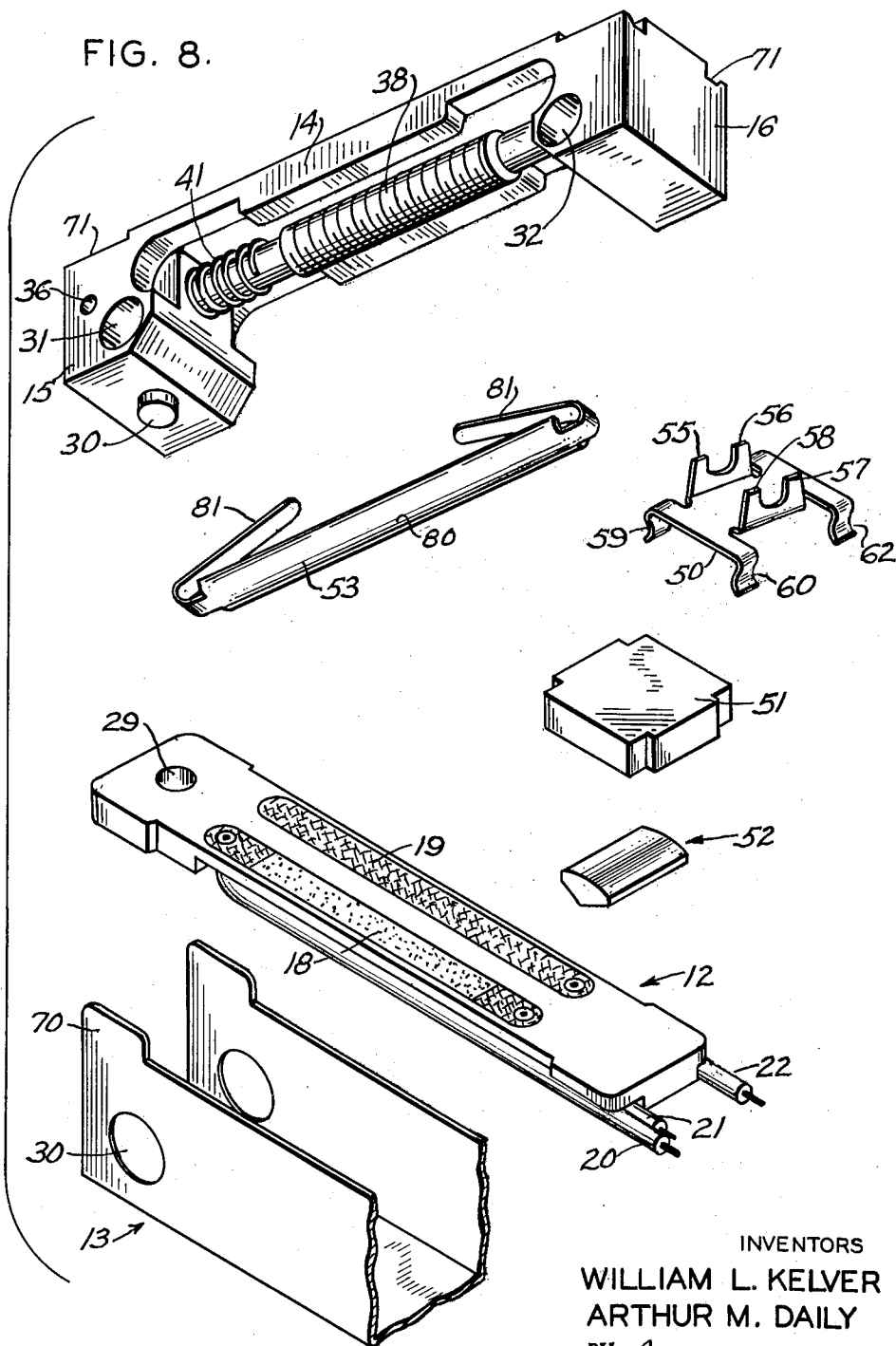
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FIG. 8.



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VARIABLE RESISTOR

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Filed June 30, 1961, Ser. No. 121,173

5 Claims. (Cl. 338—183)

This invention relates to variable resistors generally and in particular to variable resistors which are adjusted by the rectilinear movement of contact means along parallel resistive and conductive paths. Specifically, this invention relates to variable resistors of this type which employ a leadscrew to move the contact means along the parallel conductive and resistive paths.

Variable resistors are equipped with a variety of resistive elements and each type has characteristics which influence the selection of the contact to be used with the element. The type of element also effects the amount of contact pressure which is required for best results. For example, a soft carbonaceous element requires a correspondingly soft contact with a minimum of contact pressure, whereas a hard resistive element such as a ceramic-metallic film requires a correspondingly hard contact with a substantial amount of contact pressure. Another consideration is the abrasiveness of the element.

The variable resistors toward which this invention is specifically directed, the type which employs a leadscrew to move the contacts along parallel conductive and resistive paths, are usually equipped with a nut or driver which travels along the leadscrew as the leadscrew is rotated. Attached to the nut or driver is the contact means which comprises two spring arms, which either have a contact button attached to their ends which in turn engage the resistive and conductive paths or the spring arms act as the contacts themselves. In either case, the spring arms must do at least two things: furnish contact pressure and form a part of the electrical circuit of the control. If the separate contact button is not provided, they must act as the contact also.

Generally, it is impossible for all practical purposes to find a material which has good spring qualities and which is also a good conductor of electricity. It is, of course, much more difficult to find a material with these two characteristics and which is also a good contact.

This problem is accentuated when the resistive element is either highly abrasive or hard or both as in the case of the ceramic-metallic elements. Then a good spring is required to furnish the necessary contact pressure, and a highly conductive abrasion resistant material is required for the contact. The contact problem can be overcome by using a separate contact button attached to the spring arm but this still leaves the problem of the conducting spring. Inherently a metal having good spring qualities has a hard, easily oxidized surface which makes the metal a poor conductor.

Another problem which is unique to this type of control and which is solved by this invention is the tendency of the contact pressure to vary depending upon the direction that the leadscrew is being rotated. This variation in pressure results when the driver tends to rotate in the same direction as the leadscrew due to the friction existing between the two. This rotation of the driver with the leadscrew, albeit slight, changes the contact pressure being exerted by the two spring fingers normally used to carry the contacts. The contact pressure is increased on one contact and decreased on the other which causes changes in contact resistance which are unpredictable, of uncertain amount, and very undesirable.

It is the principal object of this invention to provide a variable resistor in which a bridging type contact formed

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of extremely abrasive resistant and highly conductive material is the only current conducting member connecting the resistive and conductive paths in the control.

It is a further object of this invention to provide a variable resistor in which the contact pressure is provided by noncurrent carrying members. It is an additional object of this invention to provide contact means which are so arranged and constructed that the rotation of the driver under the influence of the rotation of the leadscrew will cause no appreciable variation in contact pressure. Other objects will be apparent to those skilled in the art from the detailed description of the invention set out below.

The invention consists of an improved and simplified design which greatly improves the operation of the control as well as meeting the objects set out above. Briefly, it involves the use of a uniquely shaped bridging contact which is arranged with a convex surface, the curvature of which extends laterally of the control. This convex surface makes line contact with a nonconductive contact carrier or drive block which is rigidly connected to a driver which in turn engages the threads on the leadscrew. Two independent springs extend longitudinally along the control parallel to the leadscrew and engage the driver on either side of the leadscrew. These two springs provide the contact pressure and also prevent excessive rotation of the driver and drive block. The contact makes line contact through its convex surface with the drive block so that rotation of the driver in the direction of rotation of the leadscrew will not tend to cause the contact to lose contact with either the resistive or conductive elements and will cause only a slight change in contact pressure.

The invention will now be described in detail in connection with the accompanying drawings which are identified as follows:

FIGURE 1 is an isometric view of the control embodying this invention drawn to scale to give an indication of its actual size.

FIGURE 2 is a vertical section taken through the control along its central longitudinal axis showing the contact assembly approximately midway between the end walls of the control.

FIGURE 3 is a sectional view taken along line 3—3 of FIGURE 2.

FIGURE 4 is a cross-sectional view taken through the contact assembly along line 4—4 of FIGURE 2 showing the position of the components at rest.

FIGURE 5 is a cross-sectional view taken along the same line as FIGURE 4, showing the relative position of the components when the leadscrew is being rotated in a counter-clockwise direction.

FIGURE 6 is a sectional view of the contact assembly taken along line 6—6 of FIGURE 4.

FIGURE 7 is a pair of isometric views of the contact of this invention clearly illustrating its important features.

FIGURE 8 is an exploded isometric view of each part of the control.

The reference numeral 10 indicates the control generally. Making up the housing of the control is the base 12, a U-shaped bottom cover 13 and a top cover 14 equipped with end walls 15 and 16. The U-shaped bottom cover 13 maintains the base 12 in position against the end walls 15 and 16 through a plurality of tangs 70 which are bent over into slots 71 provided in the top cover. These housing members combine to provide a completely enclosed elongated space within which operate the leadscrew and the contact assembly, the two moving members of the control.

The end walls 15 and 16, which are integral parts of the top cover 14, rotatably support the leadscrew 17. Also

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located in the end walls are the openings 31 and 32 which extend not only transversely through these end walls, but through both sides of the U-shaped bottom cover 13 to provide means for mounting the control. This is usually done by arranging two parallel rods which pass through the holes 31 and 32 and allow a number of these controls to be stacked on the rods in side by side relationship.

The base 12 is made from a nonconductive material, preferably a ceramic, and is generally rectangular in cross-section. Mounted on the base in parallel relationship are the resistive path 18 and the conductive path 19. Appropriate recesses are provided on the bottom side of the base to accommodate the leads 20 and 21 which are connected to the extreme ends of the resistive path 18 and the lead 22 which is connected to the conductive path 19. At one end of the base, a hole 29 is provided to receive the pin 30 formed on the end wall 15. The engagement of the pin 30 in the hole 29 serves to prevent relative movement between the base 12 and the top cover 14.

The leadscrew 17 has a slotted head 35 so that it can be rotated by a screw driver or a similar tool. It is rotatably mounted in the two end walls 15 and 16 and spans the opening above the resistive and conductive paths on the base. A transverse pin 36 passes through the end wall 15 and engages the groove 37 in the leadscrew and prevents relative longitudinal movement between the leadscrew and the end walls. It is equipped with modified square threads 38, and as can be seen in the drawings, only its middle portion is threaded, leaving two unthreaded areas 39 and 40 on each side of the threaded portion. Installed in these unthreaded portions and encircling the leadscrew are the coil springs 41 and 42. This arrangement of unthreaded areas and coil springs provides a clutch to prevent damage to the control should the leadscrew be rotated too far in either direction. This feature of the control is explained in detail in the copending application, Serial No. 109,953, filed May 15, 1961, and assigned to the same assignee.

The contact assembly comprises the driver 50, the drive block 51, the contact 52, and the two springs 53 and 54. The driver is designed to engage the threads of the leadscrew so that it is forced to move longitudinally as the leadscrew is rotated. It is made from spring steel and is equipped with four arms 55-58 which engage the threads of the leadscrew and four arms 59-62 which engage the drive block 51. As best seen in FIGURE 3, the pair of arms 55-56 and the pair of arms 57-58 each engage a thread on the leadscrew.

In other words, the arms 55 and 56, and the arms 57 and 58 are offset from each other on the same angle as the helix angle of the threads 38 and are, in fact, portions of the internal thread form designed to mate with the threads on the leadscrew. This is clearly illustrated in FIGURE 3. These four arms perform in exactly the same manner as a half nut. A full nut which would encompass the entire circumference of the leadscrew would perform equally as well; however, for ease of assembly, the half nut or its equivalent, the driver 50 with its four upwardly extending arms or thread engaging members, is preferred.

The arms 59-62 secure the driver 50 to the drive block 51. The drive block is preferably made of non-conductive material so that the driver, the leadscrew, and the two leaf springs will be electrically insulated from the current carrying members of the control. In fact, neither the metal housing nor any of the other conductive members of this control will be "hot" when the control is in use. This allows the control to be handled, adjusted, etc. as desired without fear of electrical shock to the operator.

A cavity 63 is formed in the bottom side of the drive block to accommodate the contact 52. The contact 52 may be made from any good contact material having the characteristics best suited to the type of resistive element used. It should be of a material capable of being readily formed into the shape illustrated in FIGURE 7.

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A sintered carbon contact, for example, has been found particularly suitable for use with hard abrasive resistive elements like the ceramic-metallic films.

The side 76 of the contact which engages the resistive path and the conductive path is convex with a crest of comparatively short radius so that when initially installed, the contact will make line contact with the resistive path and the conductive path. In use, the crest of this convex surface will wear rapidly, particularly if one of the ceramic-metallic resistive films is used in the control, until it has become truncated to the point where there will be sufficient surface area over which to distribute the contact pressure. At this time, the wear of the contact will stop for all practical purposes. In other words, the contact will be "lapped in" during the initial operation of the control.

The convex surface 76 in contact with the resistive and conductive paths may extend the length of the contact or, as illustrated, it may have its center portion removed, leaving the two contact points 73 and 74. In most cases, it will be better to remove this center portion and thereby provide each contact point with a length somewhat shorter than the width of the element along which it is to travel. Otherwise, the surface of the base 12 between the conductive path and the resistive path would have to be maintained perfectly smooth or recessed to insure that no high spots or ridges existed which could force the contact to break its connection with either the conductive path or the resistive path. This is particularly true when fired-on metal or "cermet" films are used. These films have very little thickness and, for all practical purposes, are flush with the surface of the base.

The top surface 75 of the contact 52 is also convex. Preferably, this surface 75 should have the following characteristics. It must be arcuate and it must have a radius long enough to insure that any line of force perpendicular to a tangent thereto will pass below the center of gravity of the contact. Only in this way can it be certain that the contact will never tilt due to the rotation of the drive block.

This principle is demonstrated in FIGURES 4 and 5. In FIGURE 4, all of the components are in equilibrium. The two springs 53 and 54 are compressed between the top cover 14 and the driver 50 and provide the force for the necessary contact pressure. This force is evenly distributed between the contact points 73 and 74 and is transmitted to the contact through the point A which is equidistant from its two ends. As a matter of fact, the contact unit pressure is not the same since the area of the contact point 73 is greater than that of the contact point 74. However, the total contact pressure is equal.

As illustrated in the drawings, the two springs 53 and 54 not only serve to furnish the force for the contact pressure but also provide the means for preventing the driver from rotating with the leadscrew. The driver will rotate to some extent when the leadscrew is rotated since the forces exerted by each spring must be unbalanced to resist the frictional force between the driver and the leadscrew, tending to rotate the driver. The springs then do not prevent all rotation but they do provide a better method of preventing excessive rotation than the alternate method of having the driver engage the housing. The springs provide resilient holding means which do not increase the frictional force resisting the longitudinal travel of the driver. In other words, the frictional force existing between the springs and the driver will be present at all times and by having the driver engage the housing, an unnecessary additional frictional force would be created.

The springs are formed from any good spring material and no thought need be given to the conductivity of the material since they are not current conducting members of the control. This allows the use of a material such as Inconel which has good spring qualities and which retains

these qualities at elevated temperatures, but which is a poor conductor of electricity.

The springs comprise the body portion 80 and the two end portions or blades 81 and 82 which are integrally attached to the body 80. The blades are bent back over the body and form an angle with the body so that when installed, they will be forced toward the body, thus creating the resilient force necessary to furnish the contact pressure desired.

As illustrated, one blade on the spring is made slightly shorter than the other to make sure that each end has a different resonant frequency.

The body portion 80 is arcuate in cross section so that it will make line contact with the driver 50 at all times even though the driver rotates to some extent in the direction of rotation of the leadscrew. This is illustrated in FIGURES 4 and 5.

When the leadscrew is rotated in a counter-clockwise direction, the frictional force between the driver 50 and the threads of the leadscrew causes the driver to rotate to the position illustrated in FIGURE 5. Obviously, when the control is new and the threads on the leadscrew are well coated with lubricant, the frictional force tending to rotate the driver will be very small. As the control is used, however, this frictional force will increase so that it is quite possible that the driver will rotate to the extent shown at some time during the life of the control. This is particularly true where the control is used in an environment of high ambient temperatures.

As shown in FIGURE 5, when the leadscrew is rotated, the point of contact between the drive block and the contact move to the point B. The line of force from the springs 53 and 54 is now being exerted on the contact along a line perpendicular to a tangent to the surface 75 at the point B.

The total force being exerted by the two springs remains approximately constant. As the driver rotates, one spring is extended and therefore exerts less force, whereas the other spring is further compressed and therefore exerts a greater force on the driver. The total force of the two springs thus tends to remain constant. However the total contact pressure created by the springs will be reduced when the driver rotates with the leadscrew since the force will no longer be applied vertically to the contact. The reduction will be slight since the rotation will always be less than 10° which would reduce the vertical component of the total force by only 1.5%. The distribution of this force will change, of course, and the contact pressure at 73 will increase whereas the contact pressure at 74 will decrease, since the point of application B has moved closer to end 73. Upon the counter-clockwise rotation of the shaft, the opposite will be true.

The curvature of the surface 75 is such that in no case will the direction of the force exerted by the drive block on the contact pass above the center of gravity of the contact or above the outside edges of the contact. This insures that the contact will have no tendency to tilt or rotate around one of the contact points and that a positive downward force is exerted at both contact points. The position shown in FIGURE 5 is the worst possible and even there the contact point 74 is positively held in engagement with the conductive strip 19.

The horizontal component of the force exerted through the point B is resisted by the frictional forces existing between the contact points and the resistive and conductive paths.

Obviously, by providing a contact means with the above described features, the objectives of this invention are fulfilled. The drive block may now rotate under the influence of the rotation of the leadscrew without any danger of causing the contact to break its electrical connection with either the resistive path or the conductive path, or even cause any substantial change in the contact pressure of the control. Further, this invention illus-

trates how contact pressure can be provided by non-current carrying members of the control, thus allowing much greater freedom in the selection of material for both the springs and the contact itself.

The invention claimed is:

1. In a variable resistor of the type wherein contact means bridging parallel conductive and resistive paths are caused to traverse said paths by rotation of a leadscrew, improved contact means comprising: a contact of conductive material electrically connecting the conductive and resistive paths, a drive block of nonconductive material, the contact and the drive block having interengaging surfaces one of which is convex so that the drive block engages the contact along a line parallel to the conductive and resistive paths, a driver attached to the drive block which engages the leadscrew of the variable resistor so that it is moved longitudinally by the rotation of the leadscrew, said contact means being further characterized by the fact that the driver and the drive block may rotate slightly in the direction of rotation of the leadscrew while maintaining line engagement with the contact.

2. An improved variable resistor comprising: a base of nonconductive material upon which conductive and resistive paths are supported, housing means for the base, a leadscrew rotatably supported by the housing means in spaced parallel relationship to the conductive and resistive paths, and contact means arranged to be moved longitudinally along the conductive and resistive paths by rotation of the leadscrew, said contact means comprising: a contact which electrically connects the conductive and resistive paths, a driver which engages the leadscrew and is moved longitudinally by its rotation, and a drive block of nonconductive material which transmits the longitudinal motion of the driver to the contact, said contact means being further characterized by the fact that the contact has a first convex surface making contact with the resistive and conductive paths and a second convex surface opposite the first convex surface making longitudinal line contact with the drive block.

3. The variable resistor of claim 2 further characterized by the fact that a sufficient amount of the mid portion of the first convex surface of the contact is removed to insure that the two remaining end portions are shorter in length than the width of the conductive and resistive paths which they engage.

4. An improved variable resistor comprising: a base of nonconductive material, a conductive and resistive path mounted on the base in parallel side by side relationship, housing means comprising: a U-shaped cover the web of which supports the base and the side arms of which extend upward alongside of the base, a top cover arranged to close the open end of the housing, depending end portions on the cover which engage the base and maintain the base and cover in spaced relationship and provide end walls; a threaded shaft rotatably supported by the end portions and extending above and parallel to the conductive and resistive strips; a driver engaging the threaded shaft so that as the shaft is rotated, the driver is moved longitudinally along the shaft; a drive block of nonconductive material driven by the driver and having a rectangularly shaped flat-bottom recess in its lower surface adjacent the base; a contact of highly conductive material disposed in said recess having a first convex surface extending transverse of the base and electrically connecting the conductive and resistive strip and having a second convex surface opposite from the first and engaging the cover along a line extending longitudinally of the control; said control being further characterized by having spring means on each side of the threaded shaft engaging the top cover and the driver to resiliently urge the driver, the drive block and the contact toward the conductive and resistive paths and to resist rotation of the driven when the threaded shaft is rotated; said springs being characterized by the fact that the portion engaging

the driver is arcuate so that line contact is maintained between the driver and the spring means.

5. In a variable resistor having a housing, a base of nonconductive material in the housing and supporting an elongated resistive path and a parallel conductive path, a leadscrew rotatably supported by the housing above and parallel to the resistive and conductive paths, an electrically conductive contact engaging both the resistive path and the conductive path, contact housing means which engages the contact along a line parallel to the resistive and conductive paths and which also engages the

leadscrew so that rotation of the leadscrew will cause the said housing means and the contact to move longitudinally along the resistive and conductive paths, and spring means arranged on either side of the leadscrew in compression between the contact housing means and the housing of the variable resistor to resiliently rest rotation of the contact housing means.

References Cited in the file of this patent

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2,997,679 Barden et al. ----- Aug. 22, 1961