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Slagg et al.

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[54] MODULAR POTENTIOMETER

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[52] **U.S. Cl.**..............................**338/132,** 338/128, 338/134, 338/166, 338/174

[51] **Int. Cl.**..............................**H01c 9/02**

[58] **Field of Search**..............................338/134, 174, 166, 132, 128, 338/129, 130, 131, 133

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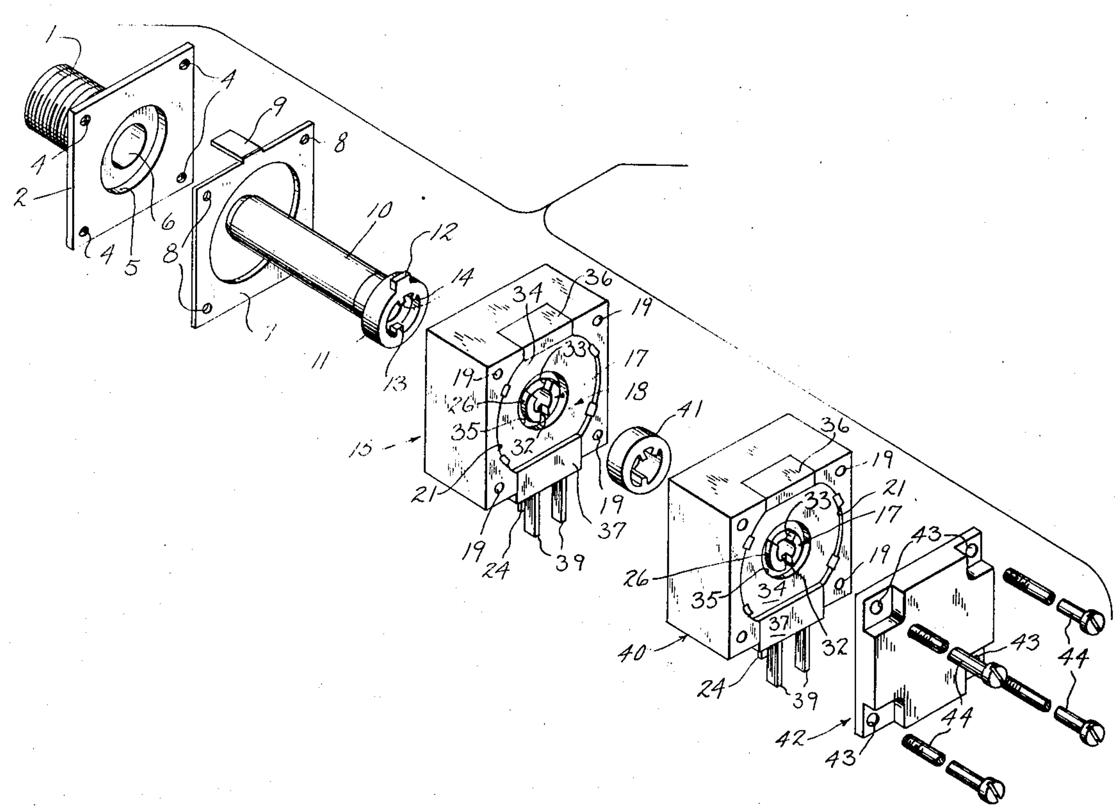
[57] **ABSTRACT**

A potentiometer module, containing circular resistance and collector paths with a sliding control bridging between the paths, is combined with other similar modules in side by side, stacked relation to form one of a possible assortment of multiple potentiometer controls. The modules are fastened together by four stack bolts extending through them and screwed at one end into a face plate formed on the back of a threaded bushing. The face plate and bushing are at one end of the stacked modules, and a shaft inserted through the bushing controls all modules simultaneously. Several alternative arrangements of the modules are shown, and in one, for example, two concentric shafts each control selected modules. Each potentiometer module has a rectangular case containing a rotor with a movable contact. A collector ring is disposed axially to one side of the movable contact and a resistance track deposited on a base is disposed to the other side of the movable contact. The rotor passes completely through the module and has an opening through it to allow passage of shafts connected to other modules.

24 Claims, 9 Drawing Figures



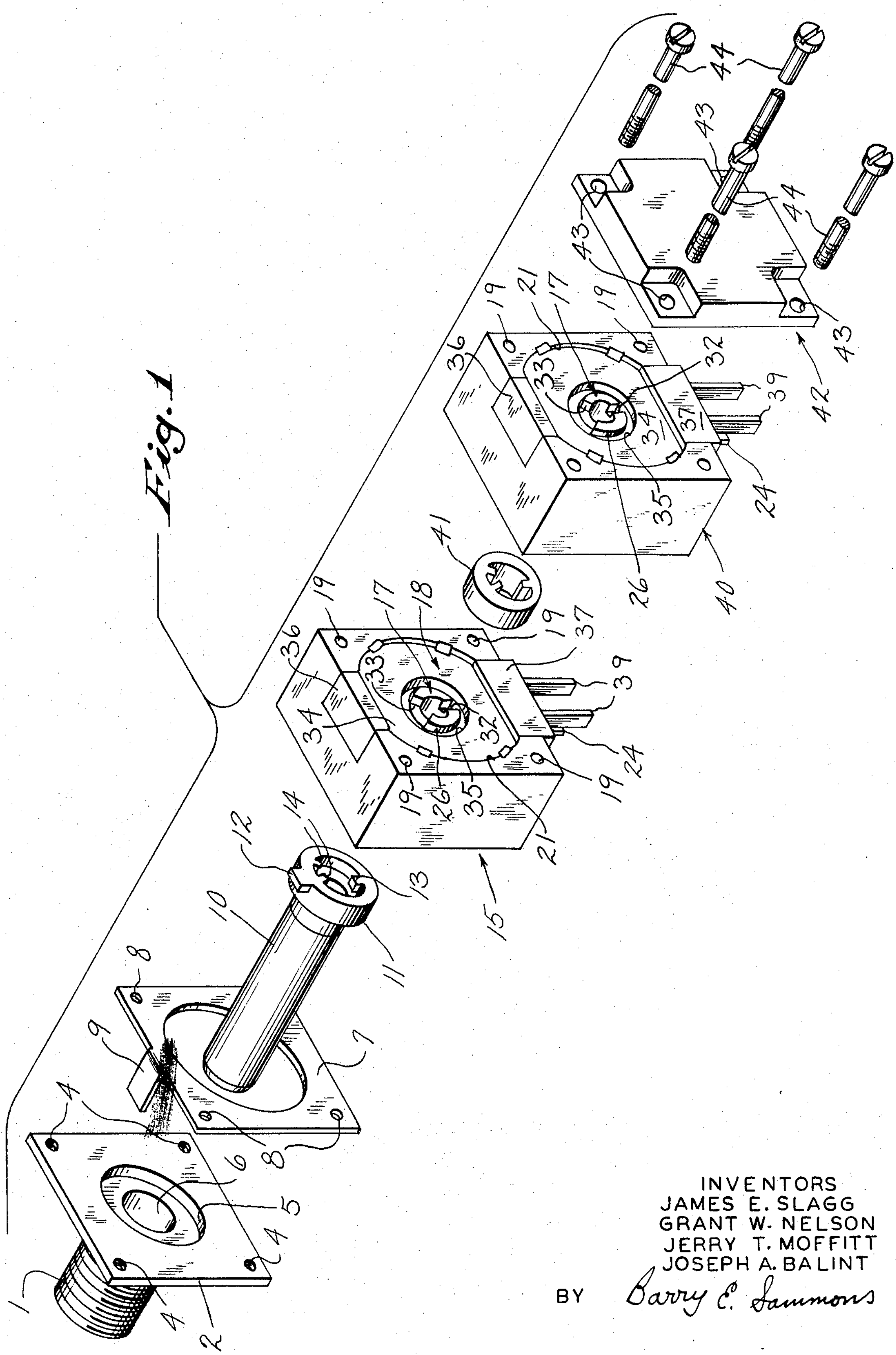


Fig. 1

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Fig. 2

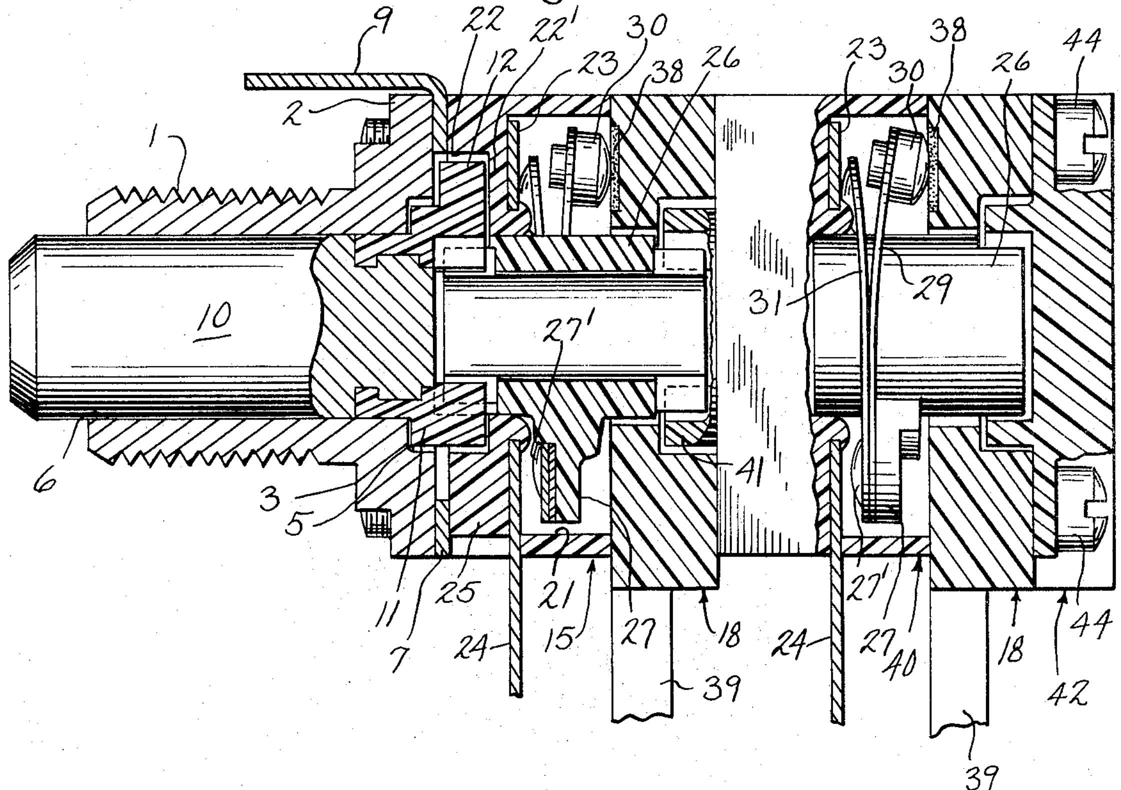

Fig. 8

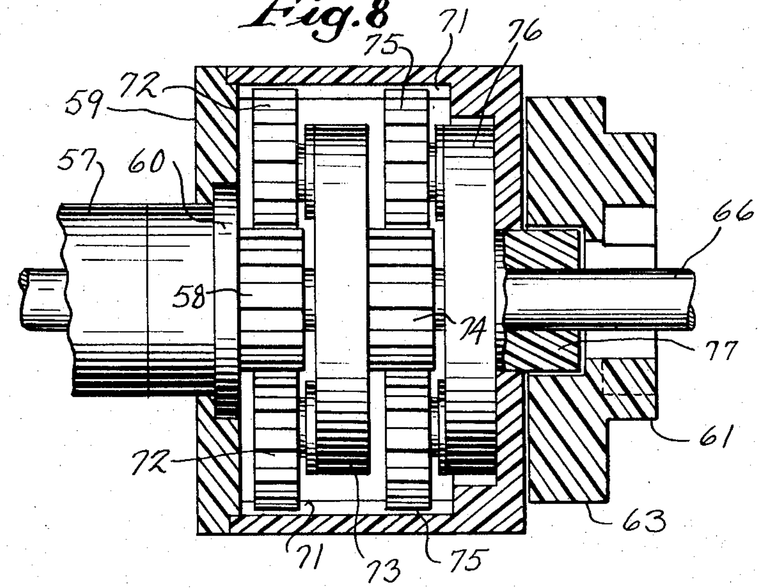

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Fig. 3

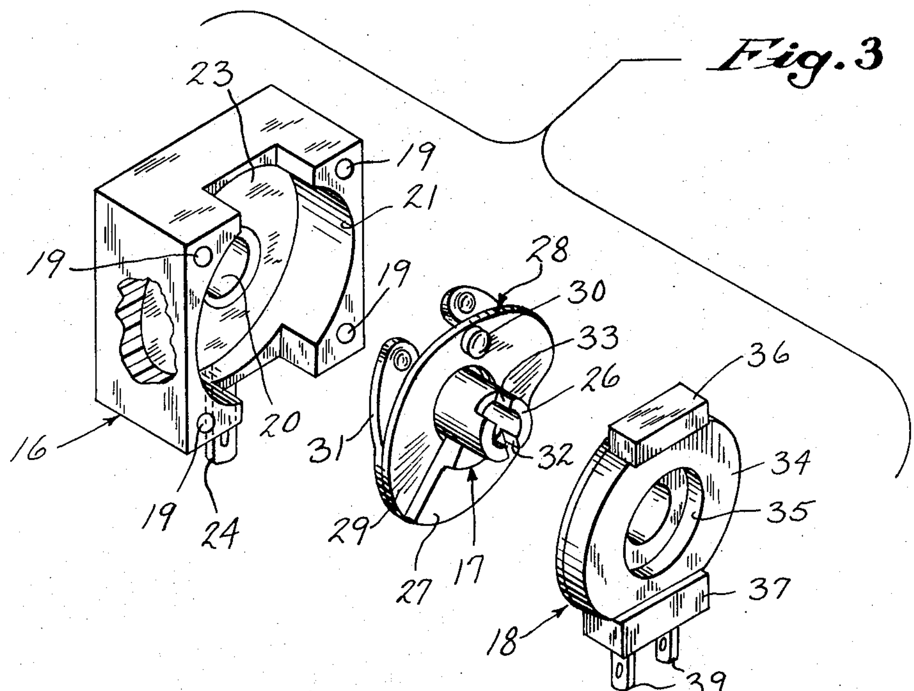


Fig. 4

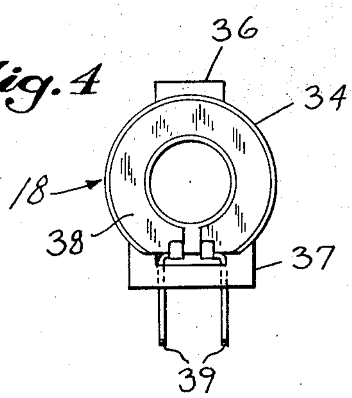


Fig. 5

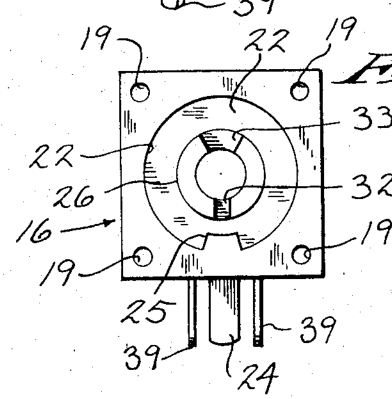
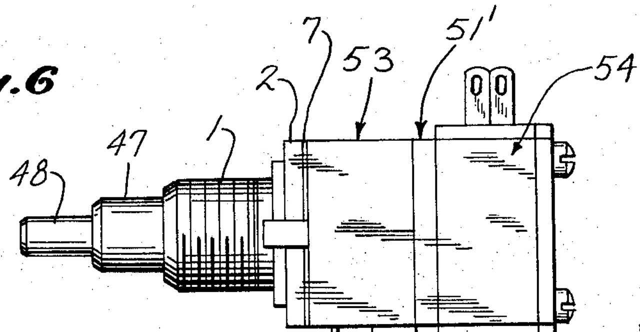


Fig. 6



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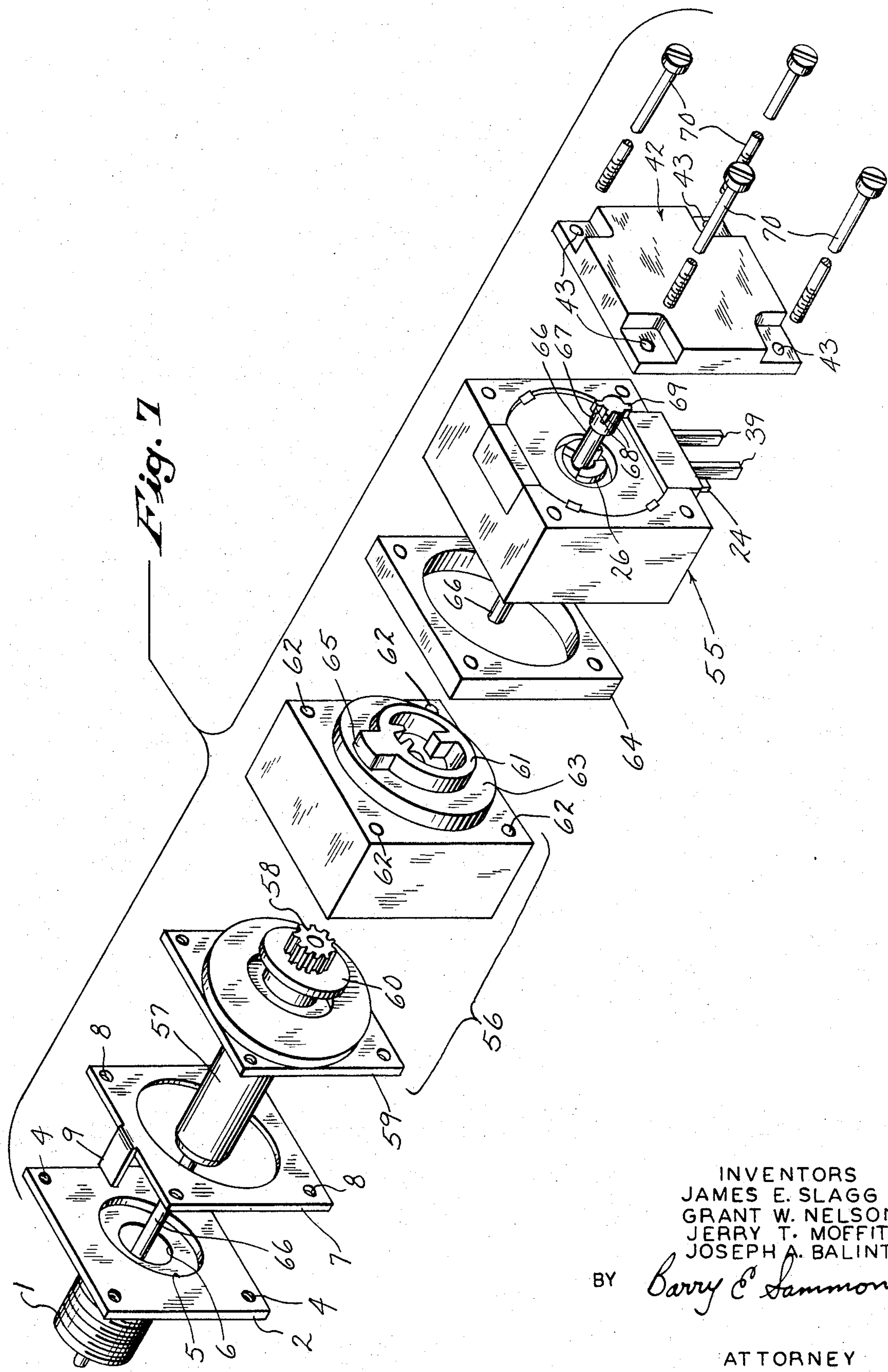

Fig. 7

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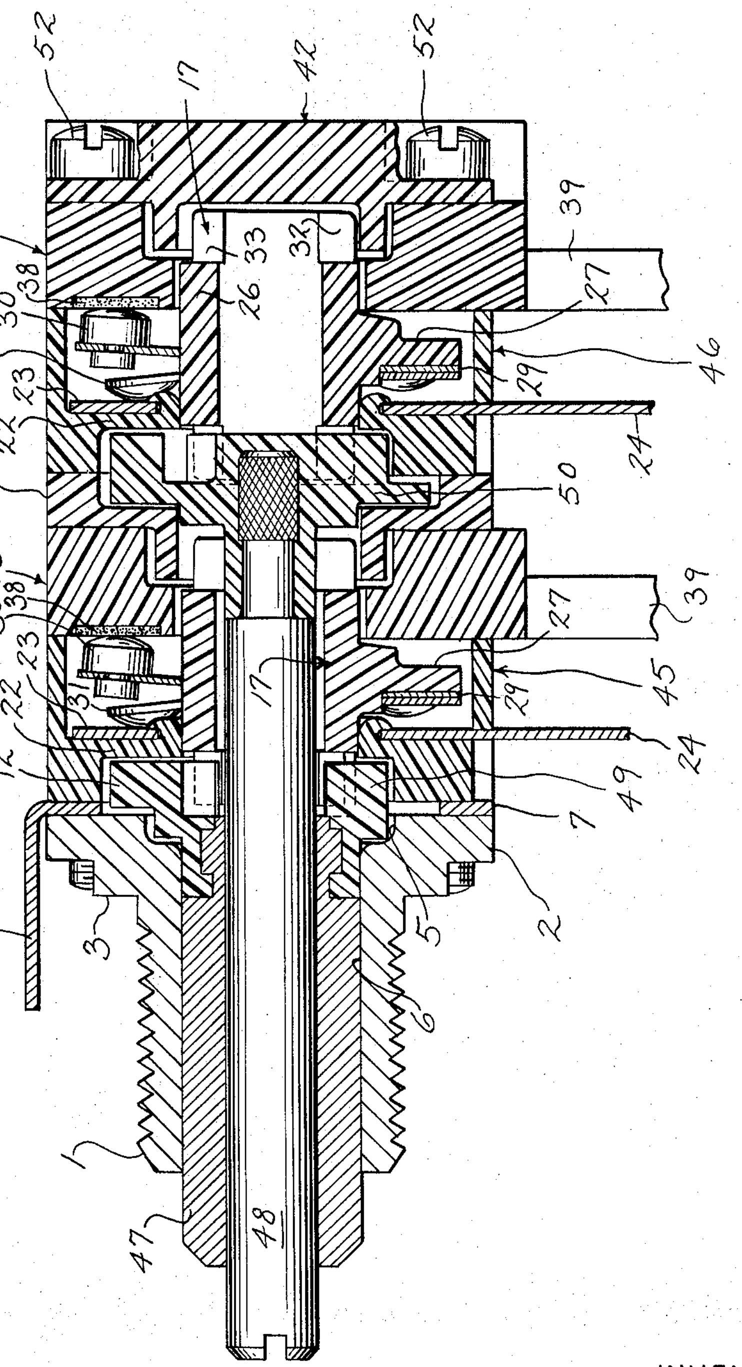

Fig. 9

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MODULAR POTENTIOMETER

BACKGROUND OF THE INVENTION

The present invention relates to variable resistors, or potentiometers, having a circular resistance track and a shaft which rotates a conductive brush around the resistance track to vary the resistance between the brush and the ends of the track.

Typically, the shaft is inserted through a bushing which is adapted for attachment to a control panel or other mounting surface. A case attached to the back of the bushing contains a circular resistance track disposed around and concentric with the axis of the shaft. A conductive collector is also disposed around the axis of the shaft and in the same plane as the resistance track. A conductive brush connected to the end of the shaft bridges the gap between the resistance track and collector and moves around the track when the shaft is rotated. As in the patent to Dehn et al., U.S. Pat. No. 2,868,931 titled "Variable Resistance Control," the collector may be annular shaped, having a hole through its center through which the shaft may pass.

By extending the shaft through the collector and back surface of the case, other specially adapted cases also containing resistance and collector elements can be coupled to the back of the first potentiometer section. The shaft extends through the first potentiometer section to control the second potentiometer section.

Prior potentiometers are very inflexible. The first potentiometer section is an integral part of the shaft and bushing and subsequent potentiometer sections must be specially adapted to attach to its back. Multiple section potentiometers are generally assembled in the factory and require the customer to order and stock each type of control he needs. The variety of control types needed by a customer can be quite large, including not only a variety of special physical configurations such as vernier controls and concentric shaft arrangements with differing numbers of potentiometer sections and shaft shapes, but also a wide range of electrical values for each potentiometer section.

Another limitation on present controls is their depth, or axial length. With multiple section potentiometers the maintenance of proper alignment between the rotors of each section becomes more difficult as the number of sections is increased. Misalignment causes excess wear on the coupling mechanism between sections and makes fine adjustment of the resistance setting of the control difficult. As more potentiometer sections are combined one on back of the other, the increased leverage and the inadequate means presently used to attach them together add to the likelihood of misalignment. Typically, the potentiometer section to be attached has a series of tabs protruding from its front surface which tabs snap around the case of the potentiometer section to which it is attached. Particularly when more than two sections are combined, the control becomes very susceptible to damage from bumping and consequent misalignment during assembly of the equipment.

Another problem encountered when combining potentiometer sections, is the necessary increase in their diameter required to accommodate the shaft passing completely through potentiometer sections. The diameter of the annular shaped collector in prior devices is increased to allow for the shaft opening through it, and consequently the diameter of the surrounding resistance track must be relatively large to provide sufficient insulation between the concentric resistance track and collector. As a result, combining potentiometer sections into single controls has resulted in either an increase in their size or cost of manufacture.

SUMMARY OF THE INVENTION

The present invention comprises a potentiometer module connectable to a bushing and shaft and connectable to other similar potentiometer modules to form a multiple section control. The modules are securely fastened together by a plurality of stack bolts inserted through them and into the bushing. The potentiometer module includes a case having a rotor carrying a movable contact, a resistance track axially disposed to one side of the movable contact and in electrical contact with the movable contact, and a collector axially disposed to the other side of the movable contact and in electrical contact therewith. The rotor communicates with both the front and back surface of the potentiometer module for coupling to a shaft or other potentiometer module.

A general object of the invention is to provide a universal potentiometer module which can be combined with other modules to form a multiple section control. The module can be connected directly to the bushing or mounted on the back surface of another module.

Another object of the invention is to provide a potentiometer module which can be securely fastened to other modules. The modules are structurally similar and have stack bolt openings passing completely through them from front to back. When combined to form a control, therefore, the openings are aligned to receive stack bolts which pass completely through the modules and securely fasten them to the bushing. Assembly is easy and rotor alignment is maintained regardless of the number of potentiometer modules used.

Another object of the invention is to provide a potentiometer module which is a universal building block for customer-built controls. Modules of differing resistance value and taper can be stocked by customers along with bushings, shafts, stack bolts, switches and other functional modules. Any number and order of modules can be combined to provide the desired control. The hardware used is essentially identical for each control with the exception of the stack bolt length. Thus maximum flexibility is obtained with a minimum available stock.

Still another object of the invention is to provide a potentiometer module having a rotor which extends completely through the module, but does not necessitate an increase in case size. By removing the collector from the plane of the resistance track to a plane on the opposite side of the movable contact, a relatively large opening can be provided for the rotor without increasing the outside diameter of the resistance track. The movable contact is thus disposed axially between the resistance track and the collector. The contact pressure necessary to maintain electrical connection is obtained by biasing the movable contact against both the resistance track and the collector. The forces thus generated are substantially equal and opposite so that no moments are applied to the rotor.

The foregoing and other objects and advantages of the invention will appear from the following description. In the description reference is made to the accompanying drawings which form a part hereof, and in which there is shown by way of illustration and not of limitation a preferred embodiment of the invention. Such embodiment does not represent the full scope of the invention. But rather the invention may be employed in many different embodiments, and reference is made to the claims herein for interpreting the breadth of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded isometric view of a dual section control incorporating the potentiometer module of the present invention,

FIG. 2 is a view in elevation of the control in FIG. 1 with the first potentiometer module in cross section taken along the shaft axis and with parts of the second potentiometer module cut away,

FIG. 3 is an exploded isometric view of a potentiometer module,

FIG. 4 is a plan view of the base which forms a part of the potentiometer module,

FIG. 5 is a front plan view of the potentiometer module,

FIG. 6 is a view in elevation of a single section concentric shaft control with switch,

FIG. 7 is an exploded isometric view of a single section concentric shaft vernier control,

FIG. 8 is a view in cross section of a reduction gear module which forms part of the control shown in FIG. 7, and

FIG. 9 is a view in cross section with parts in the round taken along the shaft axis of a dual section concentric shaft control incorporating the potentiometer module of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1 and 2, a cylindrical bushing **1** threaded along its outside surface includes a square face plate **2** formed at its back end perpendicular to the central axis of the bushing **1**. The bushing **1** also includes a circular mounting surface **3** which extends forward from the front surface of the face plate **2**, completely around the bushing **1**. The bushing **1** is typically inserted through a hole in a control panel (not shown in the drawings) and the mounting surface **3** is drawn tightly against the back surface of the control panel by tightening a nut around the bushing **1** (not shown) against the front surface of the control panel. Four threaded stack bolt holes **4** are formed through the face plate **2**, each located near one of its corners. A circular recess **5** is formed in the back surface of the face plate **2** concentric with a shaft opening **6** which extends completely through the bushing **1**, along and concentric with its central axis.

A square locating plate **7** having a large central opening is mounted against the back surface of the face plate **2**. The locating plate **7** also has four stack bolt holes **8**, one located near each corner and in alignment with the stack bolt holes **4** in the face plate **2**. A locating lug **9** is formed midway along one edge of the locating plate **7**. The locating lug **9** extends axially forward, past the face plate **2** and midway along the length of the bushing **1**. When mounted on a control panel, the locating lug **9** is inserted through a hole or slot in the panel to properly orient the control and prevent it from rotating.

A shaft **10** with a molded plastic female coupler **11** connected to its back end, extends forward through the shaft opening **6**. The outer rim of the female coupler **11** has a diameter larger than that of the shaft opening **6**, and its forward edge seats in the recess **5** formed in the back of the face plate **2**. The female coupler **11** is annular shaped having a central opening into which a base key **13** and two wing keys **14** extend radially. The wing keys **14** are spaced slightly apart and located directly opposite the base key **13** on the inside surface of the coupler **11**. A portion of the female coupler **11** clears the rear surface of the face plate **2** and a limit tab **12** is formed on the outer rim of this portion. The limit tab **12** extends radially outward and is free to revolve with the shaft **10**.

Fastened to the back side of the locating plate **7** is a first potentiometer module **15**. Referring to FIG. 3, the module **15** includes three basic components, a rectangular shaped case **16**, a rotor **17** and a base **18**. A front plan view of the base **18** is shown in FIG. 4 and a front plan view of the module **15** is shown in FIG. 5. The case **16** is formed from molded plastic or metal and has a square cross section with sides aligned with the sides of the face plate **2** and locating plate **7**. Four stack bolt holes **19** pass completely through the case **16** from front to back, and align with the stack bolt holes **8** in the locating plate **7**. A shaft opening **20** is formed through the center of the case **16** from front to back, and a deep circular recess is formed in the back surface of the case **16** to form a compartment **21**. The diameter of the compartment **21** is less than the width of the case **16** and rectangular slots are cut in the top and bottom sides of the case **16** through to the compartment **21**. A shallow circular recess **22** is formed on the front surface of the case **16**, concentric with the shaft opening **20**. As shown best in FIGS. 2 and 5, an annular-shaped wall **22'** is thus formed and separates the front recess **22** from the compartment **21**. When assembled, the coupler **11** including the limit tab **12**, fits into the front recess **22** against the wall **22'**. A stop **25** is formed and extends upward from the bottom of the front recess **22** and forward from the wall **22'** to prevent complete rotation of the shaft **10** by engagement with the limit tab **12**.

As shown in FIGS. 2 and 3, a metallic collector ring **23** is located in the compartment **21** attached to the back side of the wall **22'**. The collector ring is annular shaped, having an outside diameter less than that of the compartment **21** and an inside diameter larger than the shaft opening **20**. A collector terminal **24** extends from the collector ring **23** downward through the bottom side of the case **16**.

As shown in FIGS. 2 and 3, the rotor **17** includes a hollow sleeve **26** of molded plastic which fits snugly in the case shaft opening **20**. Both ends of the sleeve **26** are identical. The front end of the sleeve **26** fits snugly into the female coupler **11**. As shown in FIG. 5, it has a narrow notch which forms a base keyway **32** and a wider notch directly opposite which forms a wing keyway **33**. The keyways **32** and **33** receive the keys **13** and **14** of the female coupler **11**. A plastic flange **27** is formed midway between the sleeve ends and partway around its circumference. A movable contact assembly **28** is firmly attached to the front face of the flange **27** by sonic welding a pair of plastic rivets **27'**. The movable contact assembly **28** includes a metallic wiper ring **29** which completely encircles the sleeve **26** and is deformed to bend axially backward. A conductive button **30** is attached to the wiper ring **29** at a point directly opposite its attachment to the flange **27**. Also included is a contact ring **31** attached to the front face of the wiper ring **29** at the flange **27**. It wraps substantially around the sleeve **26** and has two contact ends which are deformed to bend axially forward. This deformation creates a spring force acting to press the contact ends of the wiper ring **29** against the collector ring **23** when the sleeve **26** is inserted into the shaft opening **20**.

As shown in FIGS. 2–4, the module base **18** is formed of molded plastic and has an annular-shaped body **34** which fits within the compartment **21** of the case **16**. A recess **35** is formed in the back surface of the body **34** concentric to its central opening. A rectangular cap **36** is formed on the top edge of the body **34**, and a rectangular pedestal **37** is formed on its lower edge directly opposite the cap **36**. The cap **36** and pedestal **37** tightly engage the case **16** and provide means of anchoring electrical terminals connected to a resistance track **38** deposited in the front surface of the body **34**. The track **38** comprises a layer of conducting material in the form of metals and metal oxides dispersed within a glass matrix. The track **38** extends around the front surface and terminates above the pedestal **37**. Each of the two ends of the resistance track **38** are electrically and mechanically connected to one of the two terminals **39**. The terminals **39** extend through the pedestal **37** out the bottom side of the module **15**.

When assembled, the rotor **17** is inserted first into the case compartment **21** followed by the base **18** which is retained by hot staking portions of the plastic case **16** against the back surface of the base **18**. A housing containing the collector **23**, rotor **17** and resistance track **38** is thus formed. The front end of the sleeve **26** protrudes through the shaft opening **20** and is substantially flush with the front surface of the module **15**. The back end of the rotor sleeve **26** protrudes through the opening in the base **18** and is substantially flush with the back surface of the module **15**. The length of the rotor sleeve **26** is not crucial to the invention—it is necessary only that the rotor **17** communicate with both the front and back surface of the module **15** in order that it may be coupled to adjacent modules, stacked either in front or back of the module **15**. The movable contact **28** is located axially between the resistance track **38** and the collector ring **23**. The permanent deformation of the wiper ring **29** spring biases the button **30** against the resistance track **38** insuring good electrical contact. Likewise, the permanent deformation of the contact spring **31** spring biases its contact ends against the collector ring **23**. The button **30** of the wiper ring **29** is circumferentially aligned between the contact ends of the contact spring **31**. The moments generated by the contact bias forces are equal and opposite and therefore generate no net moment, or transverse torque on the rotor **17**.

All of the potentiometer modules referred to subsequently herein are structurally similar to the module **15** described above. To more clearly describe the various controls which can be built with the potentiometer module of the present invention, however, the modules are given different reference numbers. For example, in the dual section control shown in FIGS. **1** and **2**, a second potentiometer module **40** is fastened to the back surface of the first module **15**. A link **41** having identical female coupling connections at each end is disposed between the modules **15** and **40** to connect their rotors **17**. The link **41** fits snugly in the recess **35** on the back surface of the first module **15** and in the recess **22** formed on the front surface of the second module **40**.

A square back plate **42** covers the back surface of the second module **40**, and four stack bolt holes **43**, each located near one corner, are formed in the back plate **42**. Four stack bolts **44** having threaded ends are inserted through the back plate **42**, the second module **40**, the first module **15**, the locating plate **7**, and into the face plate **2**. The surface of the back plate **42** is recessed adjacent each of its corners to countersink the stack bolt heads. By using stack bolts **44** of appropriate length, the second potentiometer module **40** can be removed to form a single section control, or other modules can be added. Regardless of the number of potentiometer modules, the stack bolts **44** can be tightened to form a rigid structure virtually impervious to forces tending to misalign the modules. Threaded stack bolts **44** are shown herein and provide for easy disassembly of the control, however, metal or plastic rivets can also be used when cost reduction is a more important factor and as used herein, the term "stack bolt" is intended to include rivets and other similar fastening devices which are inserted through openings in parts to clamp them together.

The potentiometer module is a building block which can be used to form numerous types of controls. For example, as shown in FIG. **9**, a double section, concentric shaft control is formed with a first potentiometer module **45** and a second potentiometer module **46**. The bushing **1**, face plate **2**, and back plate **42** are identical to those in the double section control described above. The shaft, however, is divided into an outer shaft **47** and a concentric inner shaft **48**. Attached to the back end of the outer shaft **47** is a female coupler **49**, identical to the coupler **11** described above. The outer shaft **47** engages and drives the rotor **17** of the first potentiometer module **45**. The inner shaft **48**, on the other hand, extends through the outer shaft **47**, its coupler **49**, and the first potentiometer module **45**. A female coupler **50** is formed on the back end of the inner shaft **48** to engage and drive the rotor **17** of the second potentiometer **46**. Because the sections of the control are driven separately, a square spacer **51** having four aligned stack bolt holes (not shown in the drawing) is inserted between the first and second modules **45** and **46** to separate their rotors and provide space for the female coupler **50**. Four stack bolts **52** are inserted through the back plate **42**, the second module **46**, the spacer **51**, the first module **45**, the locating plate **7** and into the face plate **2**. Because of the added spacer **51**, the stack bolts **52** are slightly longer than those used with the conventional double section control described above. Of course, additional modules can be added to the control and driven by either the outer shaft **47** or inner shaft **48**. For example, additional potentiometer modules can be stacked directly behind the first module **45** with links **41** used to couple their rotors **17**. Alternatively or additionally, potentiometer modules can be stacked behind and coupled to the rotor **17** of the second module **46**.

As shown in FIG. **6**, the concentric shaft arrangement is also useful to separately drive a first potentiometer module **53** and a switch **54**. The switch section **54** can be either rotary or push-pull, the only constraint on its design being the placement of four stack bolt holes in alignment with the holes in the potentiometer module **53**. A spacer **51'** is inserted between the module **53** and the switch module **54** although it may also be formed as an integral part of the switch module **54**. The outer shaft **47** drives the rotor **17** of the potentiometer module **53** as in the concentric shaft arrangement described above, and the inner shaft **48** is attached to the switch section **54** by a suitable coupling means (not shown in the drawing). Additional modules can be added and driven by either shaft **47** or shaft **48**.

As shown in FIGS. **7** and **8**, the potentiometer modules can also be used to form a vernier control. A potentiometer module **55** and a reduction gear module **56** are combined with a bushing **1**, face plate **2**, locating plate **7**, and back plate **42** identical to those described above. The reduction gear module **56** has a square cross section and contains four stack bolt holes **62** aligned with the stack bolt holes in the face plate **2** and locating plate **7**. The reduction gear module **56** is attached to the back surface of the locating plate **7** and is driven by an outer shaft **57** which extends through the bushing **1**, face plate **2**, locating plate **7** and a central opening in a front cover **59** of the module **56**. A first sun gear **58** is attached to the back end of the outer shaft **57** and a circular retainer flange **60** is formed around the outer shaft **57** immediately forward of the sun gear **58** to retain the shaft **57** to the front cover **59**.

As shown in FIG. **8**, located within the reduction gear module **56** is a gear train connecting the sun gear **58** to a female coupler **61**, rotatably attached to the back surface of the module **56**. The interior of the module **56** is circular in cross section and has a gear rack **71** around its entire circumference. The first sun gear **58** engages and drives a pair of first planet gears **72** which engage and revolve around the gear rack **71** when the outer shaft **57** is rotated. The first planet gears **72** are each rotatably attached to the front surface of a circular flange **73** on a second sun gear **74**. The second sun gear **74** engages and drives a pair of second planet gears **75** which engage and revolve around the gear rack **71**. The second planet gears **75** are each rotatably attached to the front surface of a flange **76** which is formed as an integral part of a drive shaft **77**. The drive shaft **77** extends out through an opening in the back surface of the reduction gear module **56** and attaches to a circular pedestal **63**, upon the back surface of which the female coupler **61** is integrally formed. Thus the gear train links the outer shaft **57** to the female coupler **61** to drive the latter at a substantially reduced rate of rotation.

The sun gears **58** and **74** and the drive shaft **77** each have central openings through them to accommodate an inner, concentric shaft **66** which extends completely through the outer shaft **57**, the reduction gear module **56**, and the potentiometer module **55**.

In the preferred embodiment the female coupler **61** and the circular pedestal **63** extend out the back surface of the reduction gear module **56**, and as a consequence, a square spacer **64** having a large central opening to accommodate the pedestal **63** is inserted between the reduction gear module **56** and the potentiometer module **55**. The female coupler **61** directly engages and drives the front end of the rotor **17** in the potentiometer module **55**. The spacer **64** need not be a separate item, but instead may be formed as an integral part of the gear reduction module **56**.

Formed on the back end of the inner shaft **66** is a plastic coupler **67** having two wing keys **68** and a base key **69**. The coupler **67** mates with and drives the back end of the rotor **17** in the potentiometer module **55**. A back plate **42** covers the back surface of the module **55** and four stack bolts **70** tightly fasten the components of the vernier control to the face plate **2**.

By rotating the inner shaft **66**, the rotor **17** of the potentiometer module **55** is controlled directly, whereas rotation of the outer shaft **57** controls the rotor **17** at a substantially reduced rate through the gear reduction module **56**. Other potentiometer modules can be added and controlled in like fashion by inserting them between the spacer **64** and the potentiometer module **55** and coupling their rotors **17** together with links **41**. Also, more concentric shafts can be added and coupled to selected potentiometer modules.

It is apparent that by using identical potentiometer modules with a minimal amount of hardware, a large number of different controls can be built. Because parts are kept to a minimum and no special equipment is needed, assembly is made easy, thus allowing less skilled personnel or customers to assemble controls. Additionally, fastening the modules together with stack bolts assures alignment of the rotors and shaft even when large numbers of modules are combined and subjected to external bending forces. Finally, displacing the collector ring axially to the side of the movable contact opposite the resistance track allows passage of two or more concentric rotatable members through the center opening in a resistance track of minimal outside diameter and substantially reduces the moment forces on the rotors, which forces make fine control settings difficult and cause excessive wear of the couplers between modules.

We claim:

1. A potentiometer module the combination comprising:
- a case having a front and back surface;
- a rotor connected to said case to rotate about an axis, said rotor having a movable contact;
- a collector connected to said case and disposed axially to one side of said movable contact and in electrical contact therewith; and
- a resistance track connected to said case and disposed axially to the other side of said movable contact and in electrical contact therewith;
- wherein said rotor includes a sleeve having ends which communicate with the front and back surfaces of said case and said collector and resistance track are disposed around said sleeve.

2. A potentiometer module as recited in claim **1**, wherein said sleeve has identical coupling means at its ends.

3. The potentiometer module as recited in claim **1**, wherein said movable contact comprises:
- a wiper which is spring biased against said resistance track by a force acting axially in one direction; and
- a contact ring which is spring biased against said collector by a force acting axially in the opposite direction.

4. The potentiometer module as recited in claim **1**, wherein said resistance track is formed on an annular-shaped base disposed around said rotor sleeve and connected to said case.

5. A control the combination comprising:
- a bushing adapted to attach to a control panel;
- a shaft extending through said bushing;
- a coupler connected to the back end of said shaft;
- a first potentiometer module having front and back surfaces, said first module including a rotor which communicates with the front surface of said first module to connect with said coupler and which extends through said first module to communicate with its back surface;
- a second potentiometer module having front and back surfaces, said second module including a rotor which communicates with the front surface of said second module to connect with the rotor of said first module and which extends through said second module to communicate with its back surface; and
- a plurality of stack bolts each passing completely through said first and second modules to fasten them to the bushing.

6. A control as recited in claim **5**, wherein said first and second potentiometer modules are structurally identical, each rotor having a sleeve which communicates with the front and back surfaces of the module and a movable contact, each module also having a collector disposed around said rotor sleeve and axially to one side of said movable contact to make electrical contact therewith and a resistance track disposed around said rotor sleeve and axially to the other side of said movable contact to make electrical contact therewith.

7. A control the combination comprising:
- a bushing adapted to attach to a control panel and having a shaft opening extending through it from front to back;
- a face plate disposed around the opening at the back end of the bushing and perpendicular to the central axis of the shaft opening;
- a first potentiometer module fastened to the face plate, said first module having a rotor in alignment with the shaft opening axis, which rotor extends completely through the first module and has a central concentric opening completely through it;
- an outer shaft rotatably retained within said shaft opening and connected to the rotor of said first module, said shaft having a central concentric opening;
- a second potentiometer module structurally identical to the first potentiometer module and connected to the first potentiometer module, said second module having a rotor aligned with the rotor of said first potentiometer module; and
- an inner shaft rotatably retained within and passing through the openings in the outer shaft and the rotor of the first module to connect with the rotor of the second module.

8. The control as recited in claim **7** wherein a plurality of stack bolts extend through aligned openings in the first and second potentiometer modules to connect said modules to the face plate, wherein said aligned openings are substantially parallel to the axis of rotation of said rotors.

9. The control as recited in claim **8** wherein the module rotors each include a movable contact connected to a sleeve and each module includes a collector disposed around said sleeve and axially to one side of said movable contact and a resistance track disposed around said sleeve and axially to the other side of said movable contact.

10. A control the combination comprising:
- a bushing adapted to attach to a control panel or the like and having a shaft opening extending through it from front to back;
- a face plate disposed around the opening at the back end of the bushing and perpendicular to the central axis of the shaft opening;
- a gear reduction module fastened to the face plate, said gear reduction module including a gear train with an output which rotates at a reduced rate of rotation with respect to a rotatable input;
- an outer shaft rotatably retained within said shaft opening and connected to rotate said gear train input, said outer shaft having a central concentric opening;
- a first potentiometer module fastened to said gear reduction module, said first module having a rotor in alignment with the shaft opening axis and coupled to said gear train output, which rotor extends completely through the first potentiometer module and has a central concentric opening completely through it; and
- an inner shaft rotatably retained within and passing through the outer shaft and reduction gear module to connect with the rotor of the first potentiometer module.

11. The control as recited in claim **10**, wherein a plurality of stack bolts extend through aligned openings in the gear reduction module and first potentiometer module to connect said modules to the face plate, and wherein said aligned openings are substantially parallel to the axis of rotation of said rotor.

12. The control as recited in claim **10**, wherein the potentiometer module rotor includes a movable contact connected to a sleeve and the potentiometer module includes a collector disposed around said sleeve and axially to one side of said movable contact and in electrical contact therewith, and a resistance track disposed around said sleeve and axially to the other side of said movable contact and in electrical contact therewith.

13. The control as recited in claim **10**, wherein said gear train includes a first sun gear connected to said outer shaft, a first planet gear set connected to revolve around said first sun gear when the outer shaft is rotated to rotate said gear train output.

14. The control as recited in claim **13**, wherein a second sun gear is connected for rotation by said first planet gears, and a second set of planet gears connect to revolve around said second sun gear when it is rotated to rotate said gear train output.

15. The control as recited in claim **14**, wherein there is a central opening through said first and second sun gears through which said inner shaft passes.

16. In a variable resistance module the combination comprising:

a housing having front and back walls with a compartment therebetween and also having central openings in the walls communicating with the compartment;

an electrical resistance track on the inside of one of said walls facing into the compartment;

an electrical collector on the inside of the other of said walls and also facing into the compartment, whereby said resistance track and collector are spaced from one another in facing relation;

a rotor within said compartment journaled in said central openings for turning motion; and

contact means in said compartment mounted by said rotor for rotation therewith that has a first sliding contact in engagement with said resistance track and a second sliding contact in engagement with said electrical collector.

17. A variable resistance module as in claim **16** in which said resistance track and electrical collector are circular and located concentric with the axis of rotation of said rotor; and

wherein said sliding contacts are spring biased in opposite axial directions.

18. A variable resistance module as in claim **17** wherein said sliding contacts are circumferentially aligned to minimize transverse torque on the rotor.

19. A variable resistance module as in claim **16** having in combination therewith a bushing at the front of the module;

a rotatable control shaft in said bushing; and

a detachable coupling connection between the rear end of said shaft and said rotor.

20. The structure of claim **19** in combination with a second module like the first module, said second module being attached to the rear of the first module, and there being a detachable coupling connection between the rotors of the modules.

21. The structure of claim **19** in combination with a second module like the first module, said second module being attached to the rear of the first module, the rotors and control shaft are hollow, a second inner shaft extends through said hollow rotors and control shaft, and there being a coupling connection between the rotor of said second module and said second inner shaft.

22. A control formed by connecting together a plurality of physically identical potentiometer modules, each module including:

a case having a front and a back wall spaced to define a compartment between the walls;

a collector connected to said case and located within said compartment;

a resistance track connected to said case and located within said compartment; and

a rotor rotatably attached to said case and communicating through openings in the front and back walls thereof to couple with the rotors of adjacent potentiometer modules.

23. The control as recited in claim **22**, wherein an opening is formed through each rotor, and the rotors of adjacent modules are coupled by means of a link which has an opening that aligns with the openings in the coupled rotors.

24. The control as recited in claim **22** in which a face plate is attached to the front wall of one potentiometer module and a shaft journaled in a bushing formed on said face plate couples with the rotor of said one potentiometer module.

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