United States Patent

Richardson

[15] **3,683,132**

[45] **Aug. 8, 1972**

[54] **FLEXIBLE PRINTED CIRCUIT FORMING CONTACT SURFACE AROUND STATOR OF ROTARY SWITCH**

[72] Inventor: **Lonnie J. Richardson,** Elgin, Ill.

[73] Assignee: **Oak Electro/Netics Corp.**

[22] Filed: **Sept. 8, 1970**

[21] Appl. No.: **70,203**

[52] U.S. Cl. .....**200/11 R,** 200/153 LB, 200/166 PC, 200/168 K

[51] **Int. Cl.** **H01h 19/62**

[58] **Field of Search**.....200/166 PC, 153 LB, 153 L, 200/168 K, 11 D, 11 G, 11 H, 6 BA, 6 C

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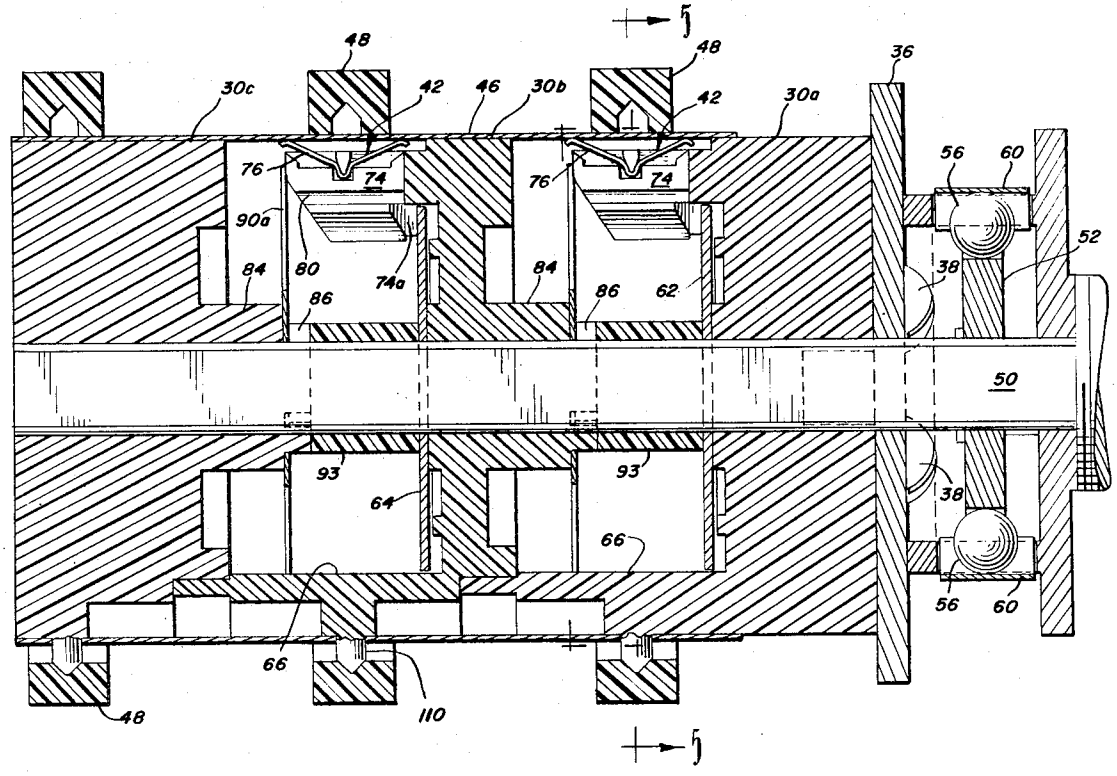
Primary Examiner—J. V. Truhe
Assistant Examiner—George A. Montanye
Attorney—Hofgren, Wegner, Allen, Stellman and McCord and Daniel C. McEachran

[57] **ABSTRACT**

A switch having movable contacts which make and break connections with conductive areas of a printed circuit. The printed circuit is on a flexible film base, wrapped around a cylindrical stator having a plurality of longitudinally movable contacts. The contacts are positioned by a rotary cam. The switch may have one or a plurality of axially aligned sections. Circuit elements, as resistors, capacitors, inductors, transistors or the like may be mounted directly on the film base.

17 Claims, 16 Drawing Figures



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SHEET 1 OF 5

Fig. 4

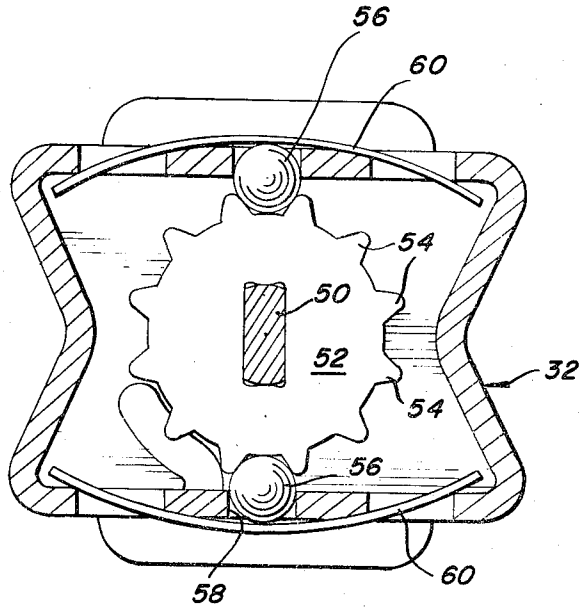
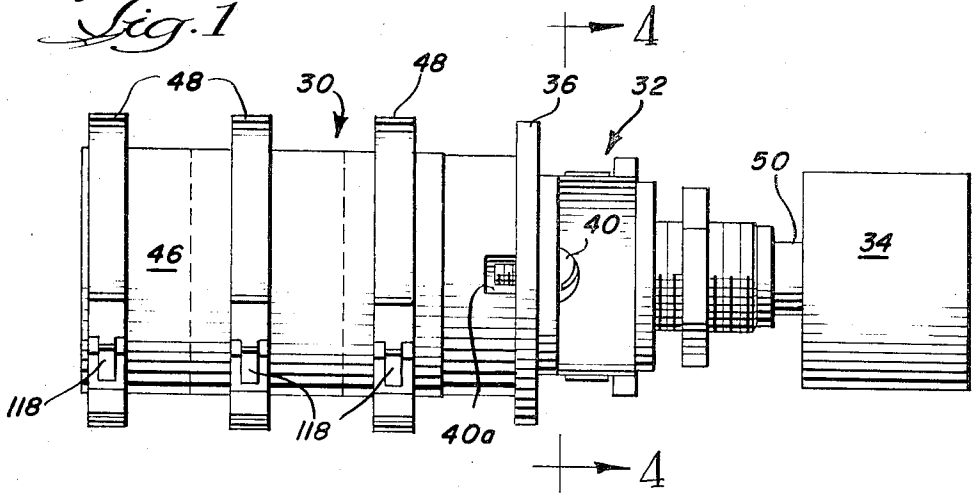


Fig. 1



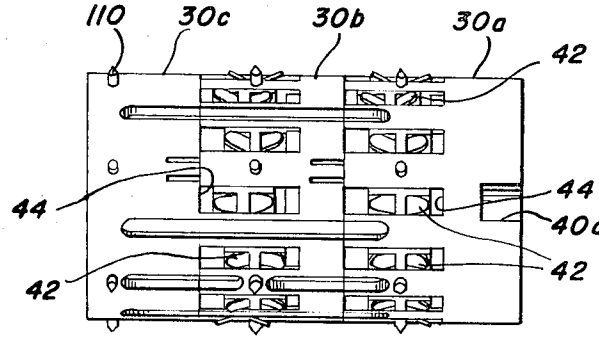


Fig. 2

INVENTOR

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BY Hoffman, Wagner, Cullen, Stellman & McCord

ATTORNEYS

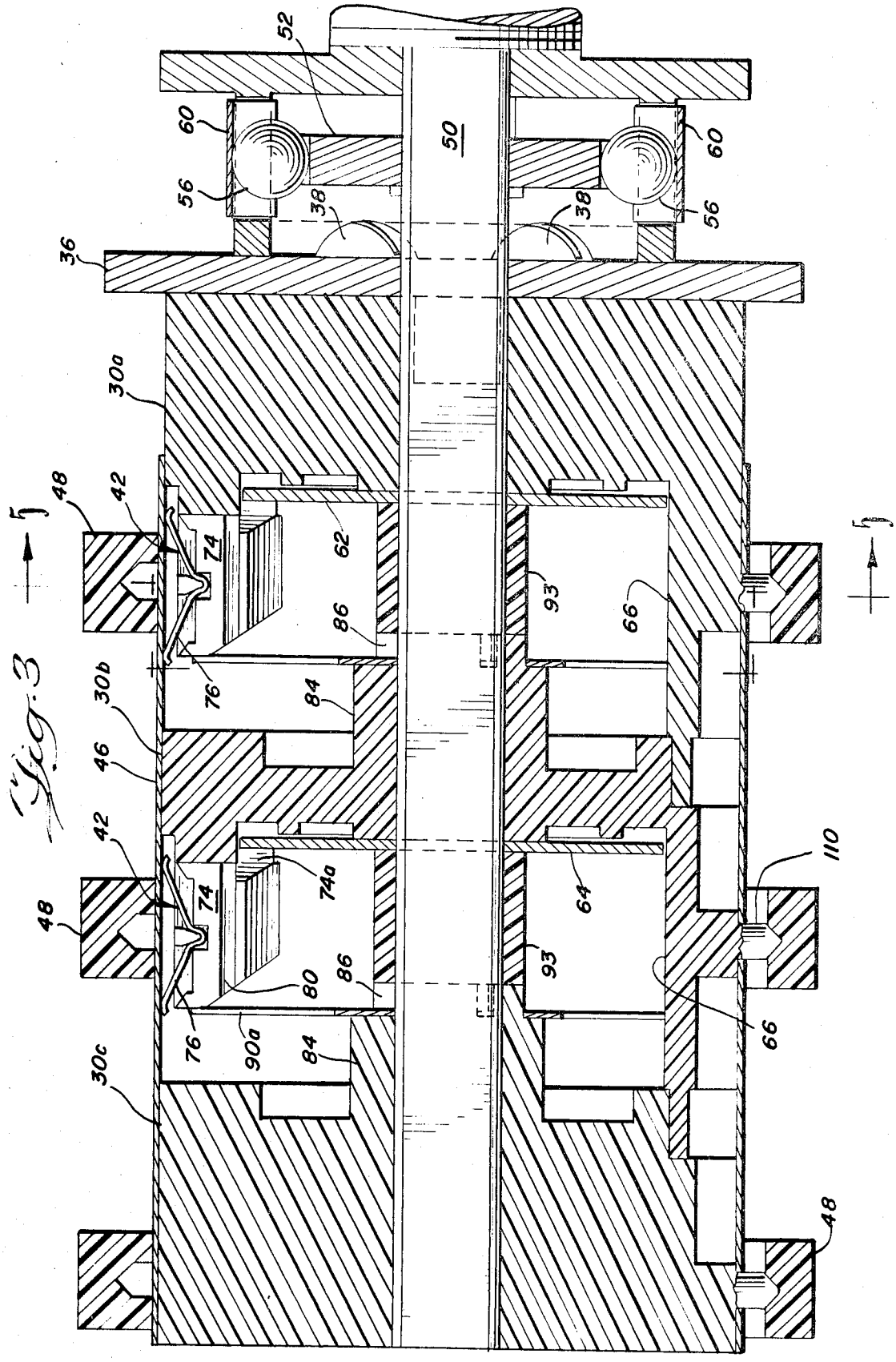

52
60
56
38
50
36
30a
48
42
74
62
86
93
66
76
84
30b
46
74a
80
90a
64
110
30c

Fig. 3

Fig. 5

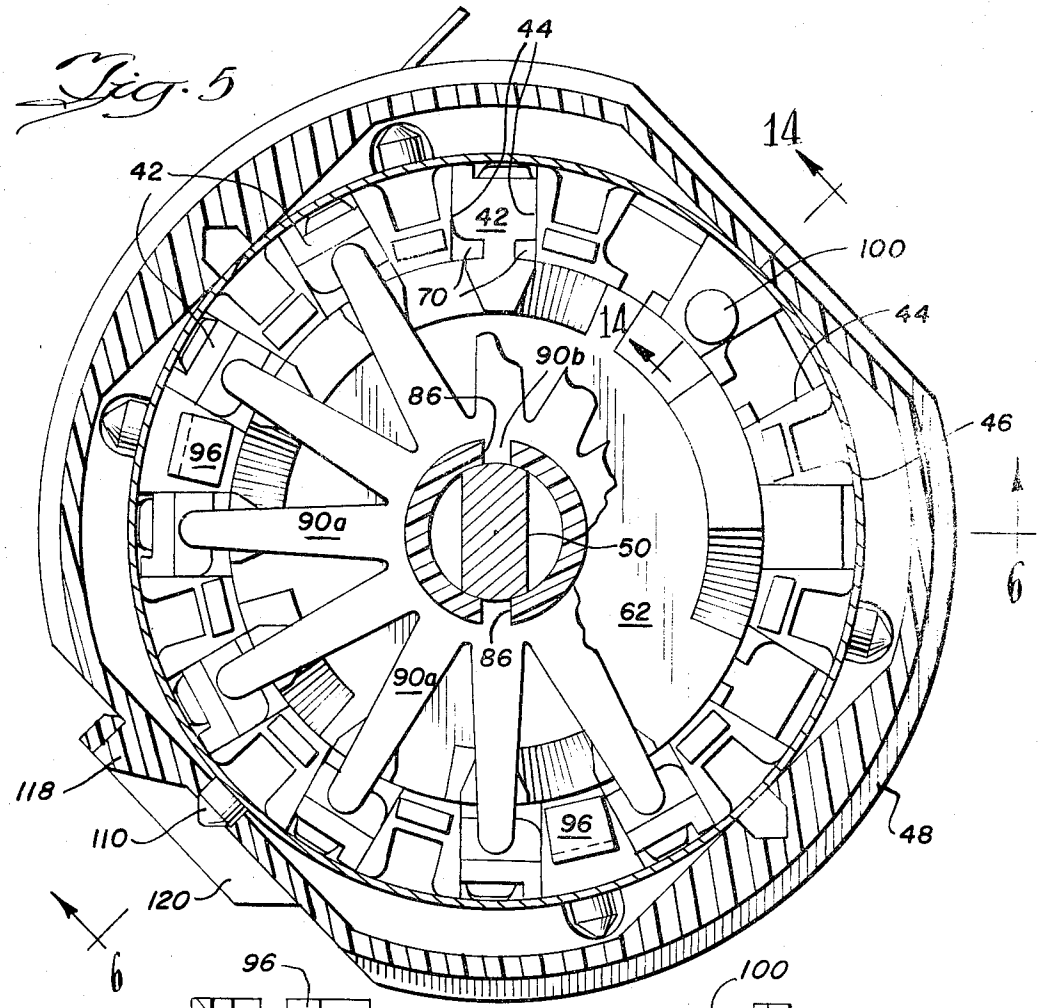

44
14
42
42
100
70
14
44
90b
86
46
96
90a
50
6
62
86
90a
118
96
48
110
120
6

Fig. 6

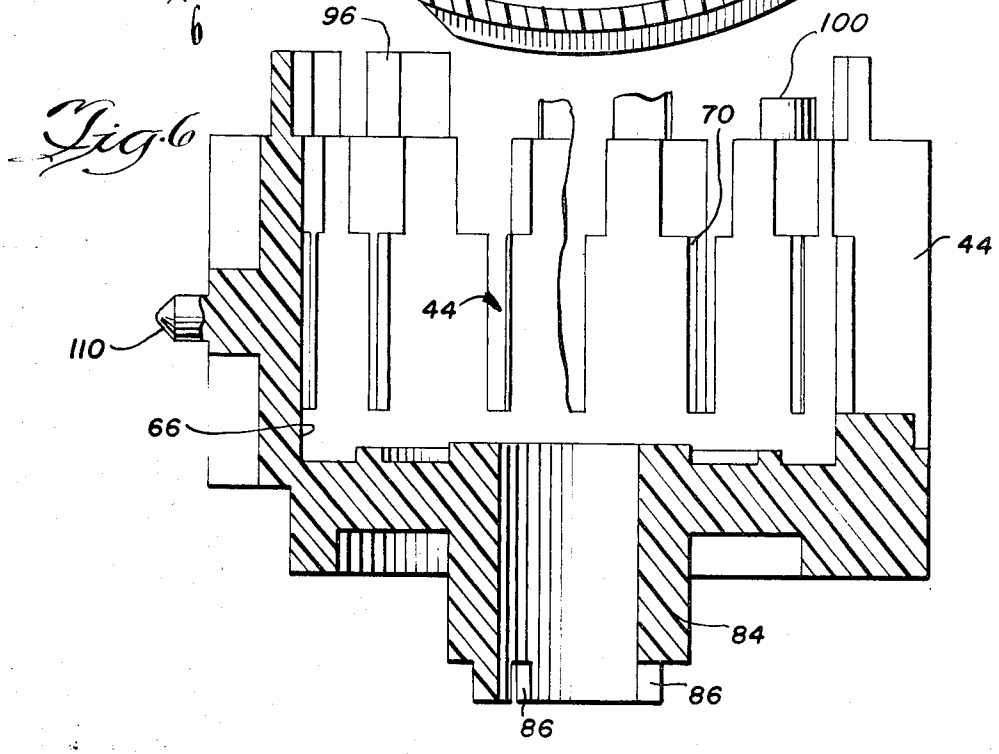

96
100
70
44
44
110
66
84
86
86

Fig. 8

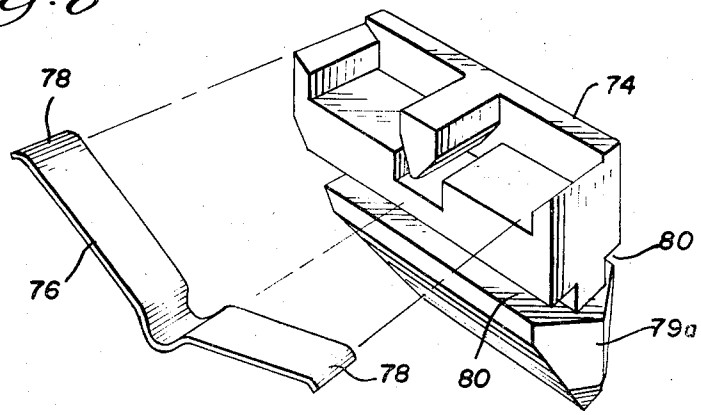


Fig. 7

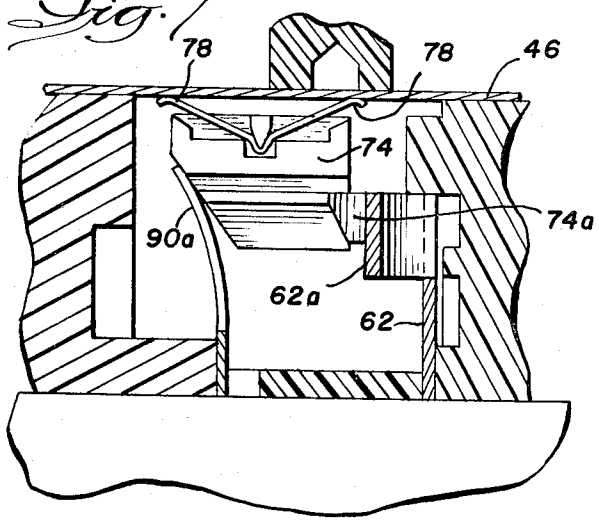


Fig. 11

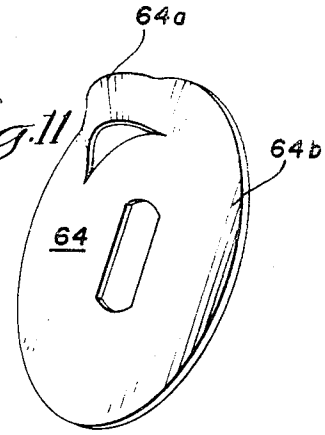


Fig. 9

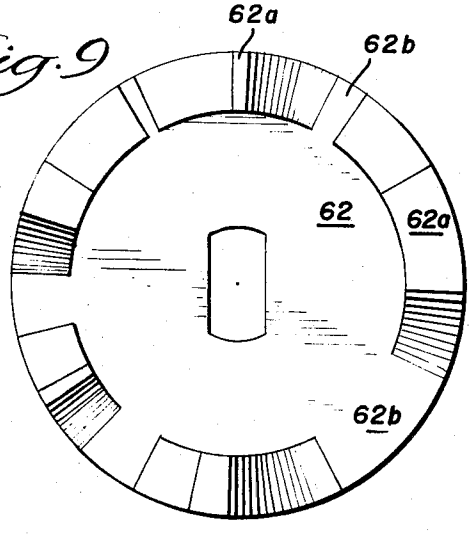


Fig. 10

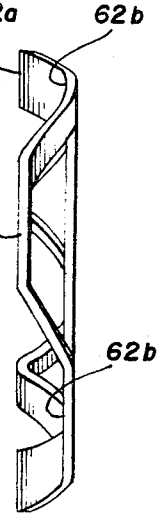


Fig. 15

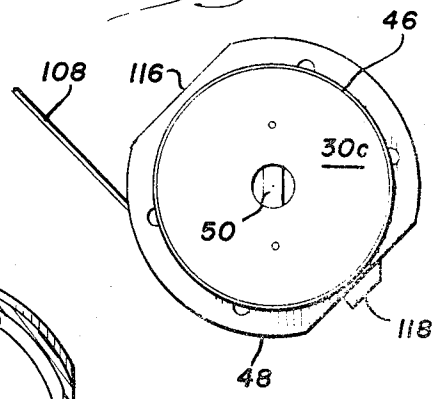


Fig. 16

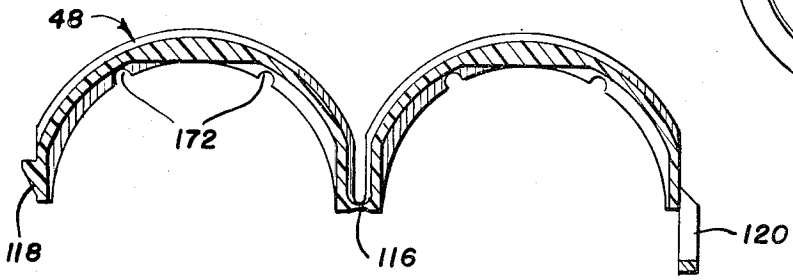


Fig. 13

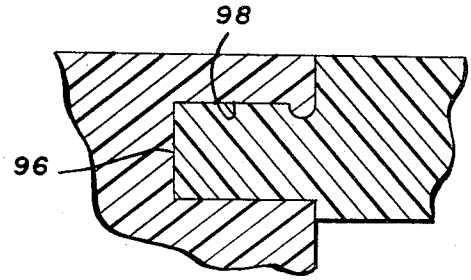


Fig. 14

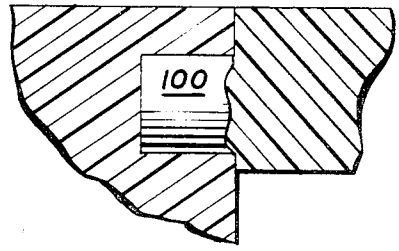
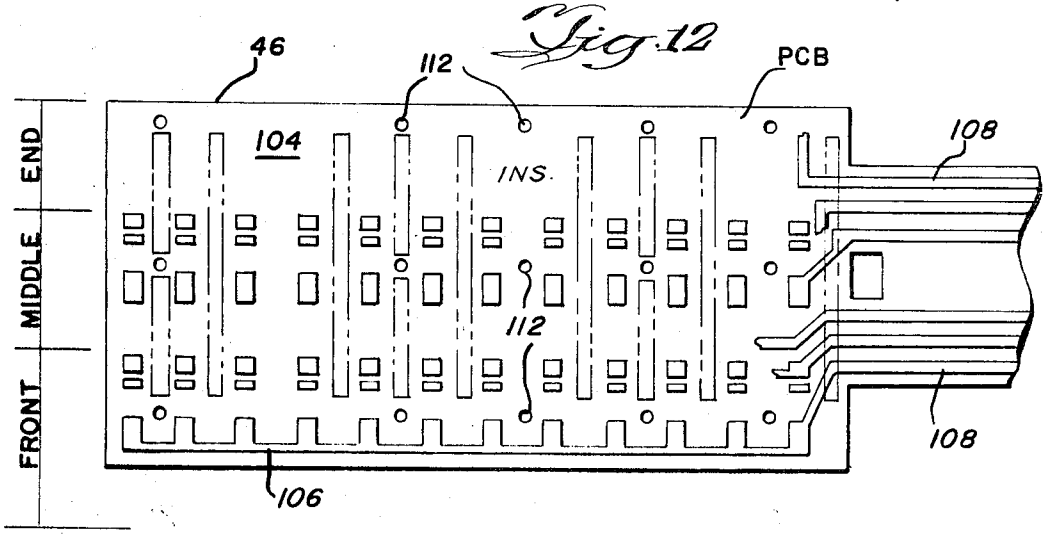


Fig. 12



FLEXIBLE PRINTED CIRCUIT FORMING CONTACT SURFACE AROUND STATOR OF ROTARY SWITCH

DESCRIPTION OF THE PRIOR ART

Various proposals have been made for combining multi-position rotary switches with printed circuitry. See, for example, U.S. Pats. Nos. Luhn 2,794,081, Hartz 2,869,033 and Volkenburg 3,242,270. In general, the approach has been to use printed circuit panels as the stator sections for multi-section rotary switches. This has some economies in material and labor, when compared with wiring a conventional rotary switch into a circuit, but does not represent a compact combination of switch and conduit.

SUMMARY OF THE INVENTION

The present invention is concerned with a novel switch construction utilizing printed circuitry on a flexible film, mounted on an elongated cylindrical switch stator with movable switch contacts which make and break circuits with the conductive areas printed on the film. More particularly, the switch may have one or more sections, each section having a plurality of longitudinally movable contacts actuated by a rotary cam.

One important feature of the present invention is that it provides a switch mechanism which is inexpensive, compact and can be adapted for use in any of a wide variety of different printed circuits. The rotor-stator structure of the switch can receive and operate movable contacts in any or all of many separate positions for making and breaking connections with a particular printed circuit.

Another feature of the present switch is its ability to readily accommodate additional gangs of movable contacts.

Still another feature resides in the flexible printed circuit which is wrapped around the cylindrical stator and has an exposed outer surface on which circuit elements, such as resistors, capacitors, inductors, transistors or the like, may be directly mounted.

Other features and objects will be apparent from the drawings and the description of the preferred embodiment.

While an illustrative embodiment of the invention is shown in the drawings, and will be described in detail herein, the invention is susceptible of embodiment in many different forms and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a switch embodying the invention;

FIG. 2 is a side view, as in FIG. 1, showing only the stator portion of the switch including switching contact assemblies;

FIG. 3 is an enlarged longitudinal section through the switch of FIG. 1;

FIG. 4 is an enlarged section along line 4—4 of FIG. 1;

FIG. 5 is an enlarged fragmentary section and view generally along line 5—5 of FIG. 3;

FIG. 6 is a section through an integral plastic insulating member forming a portion of the stator and generally taken along line 6—6 of FIG. 5;

FIG. 7 is a fragmentary section showing a switch contact assembly as in FIG. 3, but in a different position;

FIG. 8 is an exploded view of the contact assembly;

FIG. 9 is a plan view of the cam for moving switch contact assemblies;

FIG. 10 is a side view of the cam in FIG. 9;

FIG. 11 is a perspective view of another cam;

FIG. 12 is a plan view of a representative printed circuit sheet used in the switch;

FIG. 13 is an enlarged fragmentary longitudinal section through a snaplock;

FIG. 14 is an enlarged fragmentary longitudinal section through a locating pin and receiver;

FIG. 15 is an end view from the left of FIG. 1; and

FIG. 16 is a section through a film clamping ring in open position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1, a preferred form of the printed circuit switch of this invention includes a cylindrical stator 30 having an indexing mechanism 32 mounted at one end thereof via an adaptor plate 36 and a rotor having a control or circuit selector knob 34. Adaptor plate 36 is secured to the end of stator 30 by screws 38 (FIG. 3) and the indexing mechanism 32 is in turn attached to the adaptor plate 36 by two screws 40 which extend into receivers 40a in the front end of stator 30.

As best seen in FIGS. 2 and 3, stator 30 includes three nonconductive molded plastic sections, i.e., a front section 30*a*, a middle section 30*b*, and a rear section 30*c*. The cap or end stator sections 30*a* and 30*c* are closed by flat end walls to prevent entry of dust into the switch assembly. The three sections 30*a*, 30*b* and 30*c* are held together by suitable releasable or "snap" lock means which will be described below.

Each of sections 30*a* and 30*b* includes a circular array of contact assemblies 42 with each contact assembly 42 mounted in a slot-like receiver 44 (FIGS. 2, 5 and 6) for longitudinal or axial sliding movement between two spaced positions. Contact assemblies 42 can be omitted from some of the receivers 44 within an array whenever an incomplete array is needed to accommodate a desired switching function. The electrically conductive contacts of assemblies 42 are accessible at the surface of stator 30 with the assemblies in either position. Thus, the illustrated embodiment is a ganged unit having two circular arrays of movable contact assemblies.

As shown in FIGS. 1, 3 and 5, a flexible printed circuit sheet 46 is provided as a wrap-around on the outer surface of stator 30 for engagement with contact assemblies 42. The inner surface of the sheet 46 includes a conductive printed circuit on a non-conductive substrate and is held against the outer surface of stator 30 by a series of three circular clamp members 48. Preferably, one of the clamp members 48 is positioned over or adjacent each circular array of sliding contact assemblies 42 to assure more positive contact of the printed circuit with the contact assemblies.

In general, the device is used to switch between a variety of different contacts on the printed circuit by rotating knob **34** through a plurality of different stations. A detent mechanism holds the rotor in each stator and a different disposition of the various contact assemblies **42** with respect to the printed circuit can be provided for each station of selector knob **34**.

Turning now to more specific details of construction of the device shown in FIG. **1**, and with special reference to FIGS. **3** through **5**, the selector knob **34** is secured by a suitable set screw to a shaft **50** which has a double-D configuration and extends through a continuous central axial bore in the indexing mechanism **32**, the adaptor plate **36** and the stator **30**.

The indexing mechanism **32** (FIGS. **3** and **4**) is similar to that shown by Lewandowski et al. in U.S. Pat. No. 3,293,382, issued Dec. 20, 1966, employing a toothed detent wheel **52** on the shaft **50** with 12 radially extending spaced teeth **54** engaged by detent balls **46** mounted in ball receivers **58** and urged inwardly between pairs of adjacent teeth **54** by leaf springs **60** to hold the rotor in each of twelve stations.

In stator **30**, two axially spaced metal discs or cam plates **62** and **64** are mounted on shaft **50** for rotation therewith. The cam plates **62** and **64** are received in deep recesses **66** in the distal ends of the bodies of stator sections **30*a*** and **30*b*** and are axially slidable on shaft **50** for ease of assembly.

The slot-like receivers **44** (FIGS. **2**, **5** and **6**) are formed in the walls of recesses **66** of stator sections **30*a*** and **30b** and the side walls of receivers **44** have inwardly projecting guide flanges **70** for slidably receiving and retaining the contact assemblies **42**. As seen in FIGS. **3**, **7** and **8**, each contact assembly **42** includes an electrically insulating contact retainer **74** and an open V-shaped electrically conductive leaf spring contact **76** having contact points **78** at each end protruding slightly above the outer surface of stator **30** in engagement with the printed circuit sheet **46**. Each contact retainer **74** is provided with a groove **80** on each side thereof which slidably receives an inwardly projecting flange **70** of the receiver **44**. The slot-like receivers **44** extend to and are open at the lip of the side wall of the recess **66** in sections **30*a*** and **30*b*** so that the holders **74** can be readily mounted into selected receivers **44** from their open ends prior to joining the stator section.

As best seen in FIGS. **7** and **9** through **11**, the cam plates **62** and **64** have rises or lift surfaces **62*a*** *and* **64*a***, and falls **62*b*** and **64*b*** therebetween, coincident with various detented indexed positions. The lift surfaces **62*a*** and **64*a*** are for the purpose of slidably driving the contact assemblies **42** in receivers **44** from right to left as viewed in FIGS. **1–3** and **7** as a cam rise **62*a*** or **64*a*** is presented to each contact assembly **42** on rotation of shaft **50**. The falls similarly permit return of assemblies **42** from left to right.

Referring to FIGS. **3** and **6**, each of stator sections **30*b*** and **30*c*** has a hub **84** at the proximal end thereof through which the central cylindrical bore for shaft **50** extends. A hold down leaf spring **90** (see also FIG. **5**) having a plurality of 12 radially extending leaf spring arms **90*a*** is received and held against rotation by lug portions **90*b*** in radial grooves **86** of each hub **84**. A tubular spacer member **93** extends between each hub **84** and the facing cam plate **62** or **64** to keep the cam plates properly seated in recesses **66**.

As seen in FIGS. **3**, **7** and **8**, each contact retainer **74** has a raised surface portion **74a** for riding on and against a cam plate **62** or **64**. The other end of each contact retainer **74** abuts a leaf spring arm **90*a*** and each arm **90*a*** has sufficient bias to retain end **74*a*** against the lows or falls of cam plate **62** or **64**. As the cam plate is rotated with shaft **50** from a position in FIG. **3** in which a low is presented to end **74*a*** of a contact retainer **74** to a position in FIG. **7** in which a high is presented, the contact retainer **74** is driven to the left against the urging of leaf spring **90** relative to printed circuit sheet **46** carrying the contact points **78** to a new position on the printed circuit sheet. It will be apparent that different cam arrangements on the cam plates can be to produce a variety of different results with regard to moving respective ones of the contact assemblies **44** to new positions relative to printed circuit sheet **46**, to produce a variety of different making and breaking effects on a given printed circuit.

Although the device described in the drawings uses only two gangs of circularly arranged contacts, many more gangs can be used by adding more sections **30*b*** between the sections **30*a*** and **30*c*** with each section **30*b*** provided with a cam plate of similar or different cam arrangement. The printed circuit of sheet **46** would be commensurately extended in length to accommodate the added contact assemblies **42**. As additional sections **30*b*** are added, the length of shaft **50** will, of course, need to be extended to accommodate the extra length of the stator **30**.

For snaplocking the stator sections together, referring to FIGS. **5**, **13** and **14**, at the proximal end of each of the bodies of sections **30*b*** and **30*c*** are provided two snaplock receivers **98** which receive snaplock lugs **96** on the distal ends of each of the bodies of sections **30*a*** and **30*b***. The two snaplock receivers **98** on each of sections **30*b*** and **30*c*** are spaced approximately 120° from each other about the axis of shaft **50**, as are the lugs **96** on sections **30*a*** and **30*b***. And a locating pin **100** on the distal end of each of sections **30*a*** and **30*b*** is received in a bore in the proximal end of the adjacent sections **30*b*** and **30*c***, pin **100** being spaced 120° from each of the lock lugs **96** on the respective stator section. The locating pin **100** locates the adjacent sections in proper angular dispositions with respect to each other and the snap lugs **96** are received in the receivers **98** and resiliently held therein to releasably secure the adjacent sections together. It will also be seen that a long array of sections **30*b***, including contact assemblies **42**, cam plates and springs **90**, can be joined in this manner to each other between sections **30*a*** and **30*c***.

After the three sections **30*a***, **30*b*** and **30*c*** have been joined to form the stator **30** containing the operating elements described above, and the indexing mechanism **30** and knob **34** are assembled, the printed circuit sheet **46** can be wrapped around the stator and the clamps **48** applied to produce the device as it appears in FIG. **1**.

The printed circuit sheet **46**, best seen in FIG. **12**, includes a non-conductive, flexible plastic substrate portion **104** and a circuit printed of conductive material such as copper at **106**. In the form shown, the conductive circuit **106** includes two stations for each electrical contact **76** used, e.g., one for the make position of each contact **76** and one for the break position or different make position of each contact **76**. Lead portions backed by non-conductive substrate **104** extend from

each of the two separate circuits from the two gangs of the switch shown in FIG. 1 as seen at 108 in FIGS. 12 and 15 so that the switch can be properly electrically connected with other electrical circuitry.

Spaced around the exterior of the assembled rotor sections, as best seen in FIG. 2, are three circular arrays of circumferentially unevenly spaced, radially projecting locating pins 110 which receive the flexible printed circuit by impaling approximately spaced holes 112 in the sheet 46 much in the same manner as a film is threaded on sprockets of a movie projector.

One clamp 48 is applied over each circular array of projections or pins 110. As shown in FIGS. 15 and 16 each clamp 48 is generally circular in configuration and has a weakened or hinge portion 116 for opening and closing the clamp. To lock the clamp in closed position, a snap projection 118 is provided at one end which can be received and held by a snap receiver 120 when the clamp is closed around the stator section and printed circuit sheet 46. The inner surface of each clamp 48 has a circular array of receivers 172, properly spaced for receiving a circular array of locating pins 110.

In the preferred form, as best seen in the plan view of the printed circuit board as shown in FIG. 12, the spacing holes 112 are provided at different distances from each other from left to right, to correspond with the uneven circumferential spacing of projections or pins 110 on the outer surface of stator 30 so that the printed circuit sheet 46 can be wrapped around the assembly of stator sections from only one starting place and in only one direction, thereby assuring proper alignment of the printed circuit with the contact points 78 to achieve the desired switching effect.

In operation, the knob 34, shaft 50 and cam plates 62 and 64 are rotated one or more stations and held or detented in the selected station by the index mechanism. Rotation of each cam plate causes one of its rises or falls to act against each contact assembly 42 of the respective gang, moving it longitudinally and causing the contact to move to or through a new electrical contact position on the printed circuit, e.g., to make or break or make-and-break a circuit, depending on the design of the printed circuit. Since there can be several lift surfaces or rises, as well as falls, on a single cam plate, several contact assemblies in each gang can be moved simultaneously. The design of the cam plate can be varied to give a dwell period for a contact or a faster or slower rise time to allow one contact to make or break before another. Variations in the height or thickness of contact pads on the printed circuit, different rise levels of the cam plate, and varied lift surfaces of the cam plate can allow an almost infinite variety of switching functions depending on the diameter of the switch and the number of detent positions. Thus the switch can be adapted to receive any of a wide variety of printed circuit sheets, providing any of an unlimited number of switching function possibilities.

The printed circuit may be a single layer with copper on one or both sides, or may be a multilayer circuit sheet. The choice depends on the complexity of the circuit and the switching functions to be performed. Interconnections of a multilayer circuit sheet may be by conventional means, e.g. eyelets, plating thru holes, etc. Circuit elements such as resistors, capacitors, inductors, transistors and the like can be secured directly on the outer exposed surface of the circuit sheet and electrically connected to the switch circuitry at such eyelets. The lead portion of the switch circuit may be brought out from the end of the switch or from the side for connection into an overall circuit. For improved life and minimal contact resistance, the printed circuit is preferably plated.

I claim:

1. A printed circuit switch comprising an insulating cylindrical stator and a rotor mounted in the stator for rotary movement, a flexible printed circuit sheet wrapped around and secured to the outer surface of said stator and having electrically conductive paths thereon, and electrical contact means mounted for movement responsive to rotation of said rotor, with said contact means being movable relative to the printed circuit sheet for contacting said conductive paths.

2. The switch of claim 1 wherein said contact means includes a plurality of electrical contacts and said printed circuit comprises a separate conductive portion at each of two stations for each contact of said plurality of contacts.

3. The switch of claim 1 wherein said electric contact means is mounted for movement between two stations.

4. The switch of claim 1 including mounting means for the electrical contact means in said stator mounting the contact means for sliding movement in a path generally parallel to the axis of the rotor.

5. The switch of claim 4 wherein said contact means comprises a plurality of separate contacts and said rotor includes cam means mounted on a rotary shaft for moving each electric contact on rotation of the shaft.

6. The switch of claim 5 wherein said contact means comprises a circular array of a plurality of contacts each mounted in a separate contact retainer member with each retainer member separately longitudinally slidable in said mounting means.

7. The switch of claim 6 wherein said slidable retainer members are equally spaced in the circular array around the axis of the stator.

8. The switch of claim 1 further characterized in that said electrical contact means includes contact holder means supporting electrical contact elements, said electrical contact elements being in engagement with the inner surface of said flexible sheet and said rotor comprises a shaft coaxial with said cylindrical stator and cam means mounted for movement with the shaft for moving said contact holder means.

9. The switch of claim 8 including spring means biasing said contact holder means toward said cam means.

10. The switch of claim 1 wherein the stator comprises a plurality of longitudinally stacked stator sections each having contact means, said contact means having a circular array of longitudinally slidable contacts in electrical contact with the printed circuit and each array of contacts has separate cam means for driving the contacts in one direction and separate spring means for returning the contacts in the other direction.

11. The switch of claim 1 including locator holes in said sheet received on radially projecting pins on the outer surface of the stator for properly locating the conductive paths relative to the contact means.

12. The switch of claim 11 including a clamp means receiving and cooperating with said radially projecting

pins to secure said sheet to the stator outer surface and in contact with the electrical contact means.

13. The switch of claim 1 wherein said stator comprises a plurality of longitudinally stacked and ganged stator sections, each having contact means attached thereto.

14. The switch of claim 13 wherein said rotor includes a plurality of cams, one for cooperating with each of said contact means.

15. The switch of claim 13 including snaplock means for locking said ganged sections together.

16. The switch of claim 15 including locator pin means properly locating said snaplock means and stator sections relative to each other in preselected disposition.

17. The switch of claim 1 including means for properly locating the printed circuit sheet on the stator outer surface.

* * * * *