United States Patent [19]

Larson

[11] 3,879,593

[45] Apr. 22, 1975

[54] **MEMBRANE SWITCH**

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[73] Assignee: **Magic Dot, Inc.,** Minneapolis, Minn.

[22] Filed: **Mar. 29, 1973**

[21] Appl. No.: **346,055**

Related U.S. Application Data

[60] Division of Ser. No. 161,948, July 9, 1971, Pat. No. 3,737,670, which is a continuation of Ser. No. 865,760, Oct. 13, 1969, Pat. No. 3,737,670.

[52] **U.S. Cl.** .... **200/159 B;** 200/83 N

[51] **Int. Cl.** **H01h 13/54**

[58] **Field of Search** .... 200/159 B, 5 A, 83 N; 340/365 R, 365 A

[56] **References Cited**

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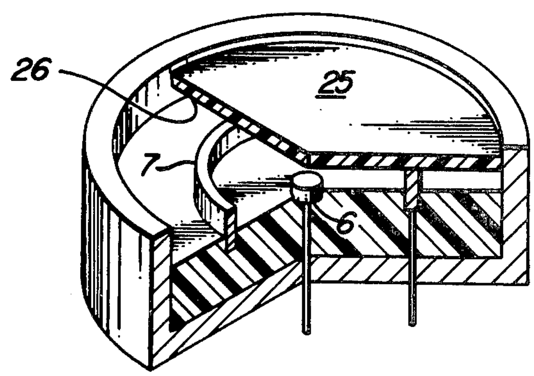
Assistant Examiner—William J. Smith
Attorney, Agent, or Firm—Wicks & Nemer

[57] **ABSTRACT**

In order to provide a sensitive, touch responsive electronic membrane switch, a pair of electrodes are disposed in a unique configuration and are coupled to a high gain amplifier. A membrane, having a conductive coating on a side facing the electrodes, is disposed over the pair of electrodes to perform a bridging function when the membrane is pressed against the electrodes to thus cause a positive switching condition at the output terminals of the high gain amplifier. In a first embodiment of the invention, the pair of electrodes comprises a first centrally disposed electrode encompassed by a second, circular electrode concentrically to, but longitudinally offset from the first electrode. The bridging of the electrodes is sensed and differentiated from the substantially infinite resistance normally existing between the two electrodes by the hight current gain amplification to provide a sharp change in current flow through a load connected to the output terminals of the high gain amplifier. The sharply differentiated state of the output terminals of the high gain amplifier may be utilized to control switching functions in any manner desired.

19 Claims, 7 Drawing Figures



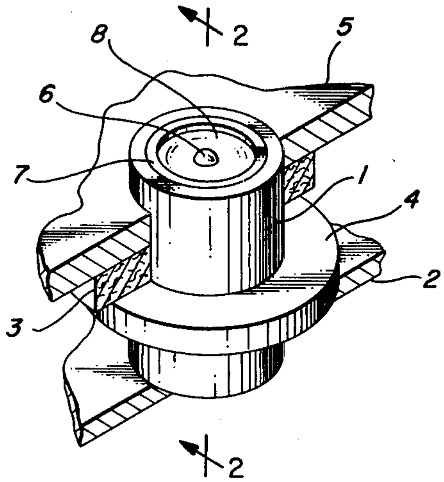


FIG. 1

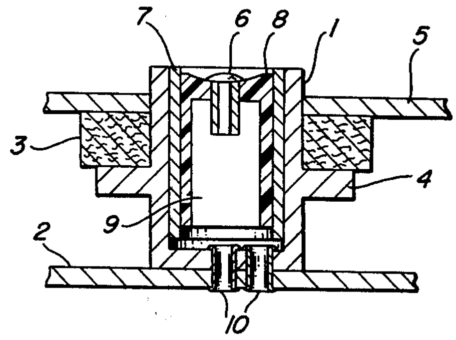


FIG. 2

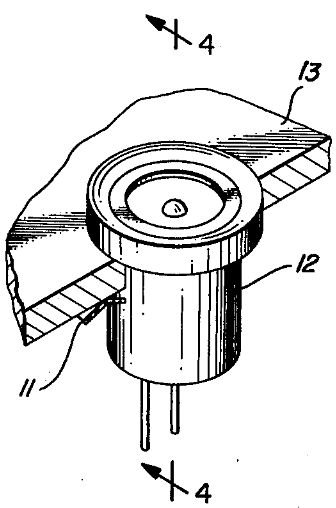
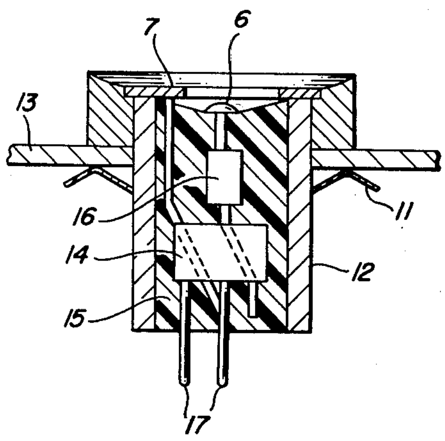


FIG. 3

FIG. 4



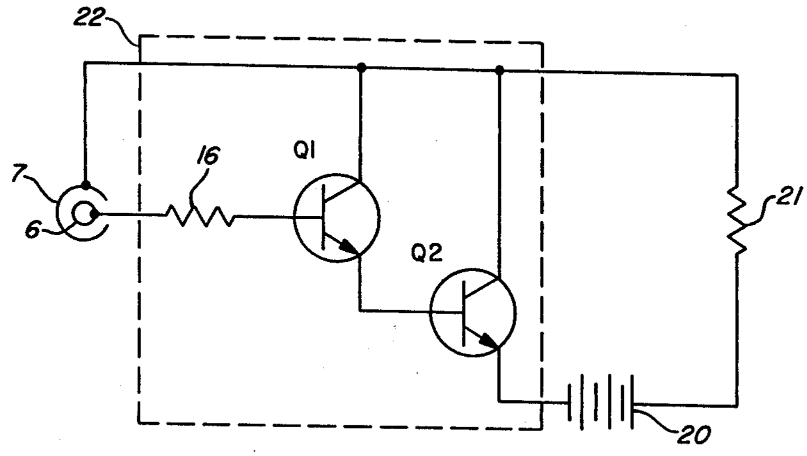


FIG. 5

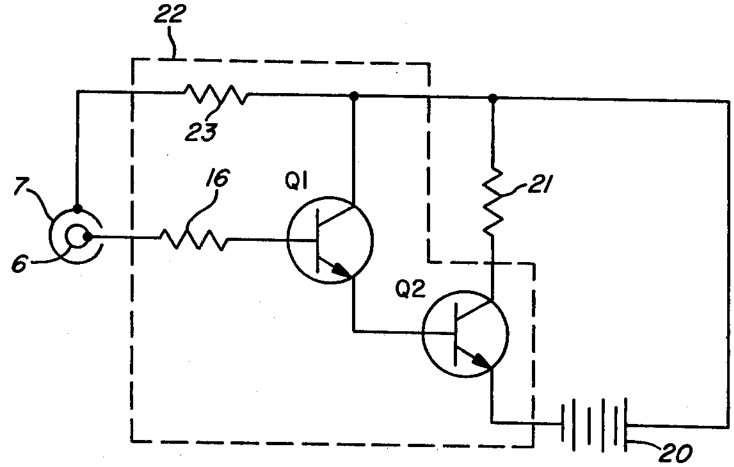


FIG. 6

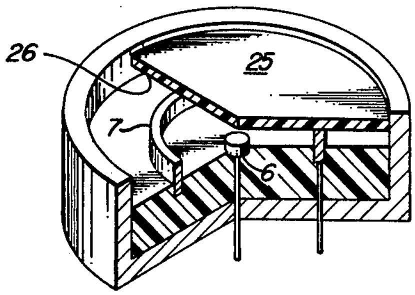


FIG. 7

MEMBRANE SWITCH

CROSS REFERENCES

This application is a division of application Ser. No. 161,948, filed July 9, 1971 now U.S. Pat. No. 3,737,670, June 5, 1973 which is a continuation of application Ser. No. 865,760 filed Oct. 13, 1969 in the name of Willis A. Larson, now U.S. Pat. 3,737,670 issued June 5, 1973.

This invention relates to electronic switching and, more particularly, to apparatus for utilizing a membrane, manually actuated, for providing discrete switching phenomena at the output terminals of an electronic circuit.

Prior art manually operated switches generally function on the mechanical principal of bringing two conductors into physical contact to complete a circuit through which current can flow. Because of the mechanical nature of the prior art switches, they are subject to wear and eventual failure as a result of the repeated operation of the moving parts, plating of material from one contact to the other because of unidirectional current flow, pitting, corrosion, and contamination in the form of accumulated dust, dirt, and chemical oxides formed by interaction between the contact material and the environmental atmosphere.

In an attempt to obviate the difficulties encountered by mechanical switches, touch responsive switches utilizing body capacitance or skin resistance have been proposed. however, these prior art touch responsive switches have been either very complex and costly to manufacture or somewhat dangerous because the voltages required to operate them are higher than desirable such that they have been deemed either impractical or useful only in applications in which high cost can be justified. Thus, it will be readily appreciated that a touch responsive switch which is highly reliable, safe, and lends itself to economical mass production would be highly desirable. Such a switch would find broad application for use with computer terminals, typewriter keyboards, calculator keyboards, control panels, and such other uses as require the entry of data through a primary switching interface unit.

It is therefore a broad object of this invention to provide an improved touch responsive switch.

It is a more specific object of this invention to provide a touch responsive switch utilizing a uniquely configured pair of electrodes coupled to a high gain amplifier.

It is another object of this invention to provide switching element electrodes which are unaffected by environmental contamination and which may be easily operated even if the operator is wearing gloves.

These and other objects of the invention are achieved, according to an embodiment of the invention disclosed and claimed in application Ser. No. 161,948, now U.S. Pat. No. 3,737,670, by utilizing, as the operated switching element, a pair of electrodes comprising a first centrally disposed electrode encompassed by a second, circular electrode longitudinally offset from the first electrode such that the pair of electrodes substantially conform to the contour of an operator's finger. When the operator touches the two electrodes, a finite resistance path is set up between the two electrodes, and this condition is detected through the use of a high current gain amplifier whose last stage will

reach saturation, or very near saturation, when even a relatively high resistance is placed across the electrodes to set up low level current flow into the input stage of the amplifier. However, when the resistance across the electrode is substantially infinite such that no current flows into the input stage, the last stage of the high gain amplifier is cut off. Thus, a load impedance may be driven by the final stage of the high gain amplifier in response to the differentiation between the resistance appearing between the two electrodes when they are bridged by galvanic skin resistance and when they are not bridged.

In the embodiment of the invention particularly adapted for use in contaminated environments which might create a sufficiently low resistance between the two electrodes to set up an artificial "touch" condition, a membrane provided with a conductive coating on its underside is placed over the electrode pair to provide a seal against such contamination. When the membrane is pressed downwardly against the electrodes, the conductive coating performs the bridging function which is sensed through the high gain amplifier.

The subject matter of the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, may best be understood by reference to the following description taken in connection with the accompanying drawings of which:

FIG. 1 is a perspective view of the switching system of the present invention showing the disposition of the inner and outer electrodes and housing especially adapted for printed circuit board use;

FIG. 2 is a cross section taken along the lines 2—2 of the housing illustrated in FIG. 1;

FIG. 3 illustrates a slightly altered physical configuration of the housing which renders it particularly suitable for panel mount operation;

FIG. 4 is a cross section taken along the lines 4—4 of the housing illustrated in FIG. 3 and also shows the manner in which the electronic circuitry associated with the electrodo pair may be contained within the housing;

FIG. 5 is a schematic diagram of a rather straightforward Darlington amplifier which provides adequate gain to perform the electronic switching initiated by bridging the electrodes with galvanic skin resistance;

FIG. 6 is a schematic diagram of a slightly altered Darlington circuit which places more voltage across the electrode pair to insure saturation of the final amplifier stage; and

FIG. 7 is a partially cutaway perspective view of a configuration for the electrode housing which is particularly useful in contaminated environments.

Referring now to FIGS. 1 and 2, a housing 1, which may be made of any suitable durable insulating material, is shown as it would be utilized with a printed wiring board. A dust seal 3 of foam rubber or the like is placed between the flange 4 of the housing 1 and a panel 5 through which the housing extends for manual access.

As best shown in FIG. 1, the electrode pair comprises a center electrode 6 and an annular electrode 7 concentrically disposed to the center electrode 6, but extending longitudinally upwardly beyond the uppermost limit of the center electrode. The center electrode 6 and the annular electrode 7 are separated and and held in their respective positions by an insulator ring **8.** It will be observed in FIG. **2** that the insulator ring **8** takes the form of a hollow cylinder to provide a chamber **9** into which the electronic components of the high gain amplifier may be placed as will be discussed in detail below. A pair of hollow conductors **10** are imbedded in the bottom portion of the housing **1** to provide communication to the chamber **9.** These hollow conductors permit a pair of leads to be brought from the chamber **9** to the lower surface of the printed wiring board **2** where they may be soldered into place in the usual manner. The solder will also adhere to the hollow conductors **10** to provide a certain degree of mechanical strength in attaching the switching system to the printed wiring board **2.**

FIGS. **3** and **4** illustrate a slightly differently configurated housing particularly adapted for panel mounting. The retainer clip **11** is utilized to hold the housing **12** tightly against the panel **13.** It will be understood by those skilled in the art that the retainer clip **11** could be replaced by a nut, provided the lower portion of the housing **12** were threaded to receive the nut, or by any other suitable method of panel mounting.

The cross-sectional view of FIG. **4** illustrates an encapsulated high d-c current gain amplifier **14** disposed within the chamber **15** of the housing **12.** The chamber **15** is filled with potting material to provide structural strength to the assembly and protection against contamination or other deterioration which could result from prolonged exposure to the atmosphere. A current limiting resistor **16** is connected between the center electrode **6** and one of the input terminals to the amplifier **14.** The annular electrode **7** is connected directly to a second input terminal to the amplifier **14.** A pair of leads **17** are utilized as output terminals to an external load and an external power supply as will be discussed in conjunction with the schematic diagrams of FIGS. **5** and **6.**

Referring now to FIG. **5,** a basic Darlington amplifier circuit is presented which is connected to the electrode pair **6** and **7,** to an external low voltage d-c power supply represented by the battery **20,** and to a current responsive load represented by the impedance **21.** The elements enclosed within the dashed line **22** are contained within the cavity **9** of FIG. **2** or the cavity **15** of FIG. **4.** It will be observed from an examination of FIG. **5** that only two leads need extend from the cavity; viz.: the negative lead from the power supply **20** to the emitter electrode of transistor Q2 and a lead which is common to one end of the current responsive load **21,** the collector electrodes of the transistors Q1 and Q2, and the annular electrode **7.**

In operation, when a substantially infinite resistance appears between the electrodes **6** and **7,** no current will flow between the electrodes, and both the transistors Q1 and Q2 will be cut off such that no appreciable current flows through the current responsive load **21.** Assuming the power supply **20** delivers nominally 5 volts and the current responsive load **21** to have a nominal value of 500 ohms, it has been found that a conductive path of as much as **10** megohms between the electrodes **6** and **7** will permit sufficient current to flow into the base electrode of the amplifier input transistor Q1 to bring output transistor Q2 into current saturation or very close thereto. Inasmuch as it has been shown that the galvanic skin resistance can vary from 20 kilohms to 10 megohms, it will be understood that the current passing through the current responsive load **21** can be switched from substantially zero to a full nominal value by placing the tip of ones finger such that the electrodes **6** and **7** are bridged. The basic operation of the high gain Darlington amplifier illustrated in FIG. **5** is well known and need not be discussed at length here. It may be pointed out, however, that a typical current gain for such a configuration would fall within the range of 20,000 to 100,000. As noted briefly above, the resistor **16** is placed within the circuit to limit the base current to the transistor Q1 to a safe level in case the electrodes **6** and **7** should be directly shorted with a metallic conductor or the like. With high gain transistors, such as 2N3904's used with a 5 volt power supply and 500 ohm load impedance, the resistor **16** may have a value of 1,000 ohms to afford adequate protection for the transistor Q1.

While the circuit of FIG. **5** is entirely adequate for most applications, the slightly rearranged circuit of FIG. **6** may be used for increased sensitivity. The result of placing the current responsive load **21** directly in series with the transistor Q2 in the FIG. **6** configuration is to apply a higher voltage gradiant across the electrodes **6** and **7.** Thus, the same resistance brought to bear across the electrodes **6** and **7** in the FIG. **6** circuit configuration will result in a somewhat higher base current to the transistor Q1 than in the FIG. **5** configuration. The resistor **23** may be added optionally to limit the voltage to which the operator is exposed in the event of a power supply failure which would otherwise place a high voltage between the electrodes **6** and **7.** Such a failure could take the form of a primary to secondary short in a power supply transformer (not shown) which conceivably could expose the operator to full line voltage if the resistor **23** were not provided.

The Darlington configurations of FIG. **5** and FIG. **6** are presented merely as exemplary of the high gain circuits which could be utilized. For example, it will be apparent to those skilled in the art that very sensitive applications might well require three stages of amplification rather than the two stages depicted. The current responsive load **21** can take any form necessary to achieve the switching function desired. For example, the load **21** may comprise a relay coil or subsequent high level electronic switching circuitry and may also include readout structure such as an incandescent lamp which may be optionally disposed within the housing supporting the electrodes **6** and **7** to be used with an electronic package permitting pushon-pushoff, latching, etc. response in addition to the normal momentary operation achieved with a simple current responsive load **21.** Further, those skilled in the digital arts will understand that it is a simple matter to generate a multibit alpha-numeric code in response to a change of state of the output stage of the high gain amplifier.

Referring back to FIGS. **1** and **4,** it is important to realize the significance of the configuration and disposition of the center electrode **6** and the annular electrode **7** with respect to one another. if it were possible to touch the center electrode **6** without first touching the annular electrode **7,** the usual alternating voltage induced into the operator's body would cause the switching system to turn off and on at the alternating frequency, typically 60 Hz. Thus, the center electrode **6** is depressed below the level of the annular electrode **7** to assure a good contact of the finger with the latter before contact is made with the center electrode **6.** By

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