April 16, 1963 R. M. BERMAN ETAL 3,085,577

BODY ELECTRODE

Filed June 12, 1961

FIG. 1.

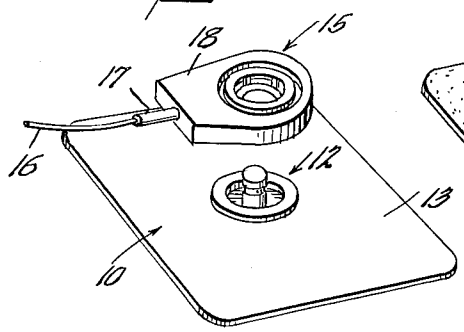


FIG. 2.

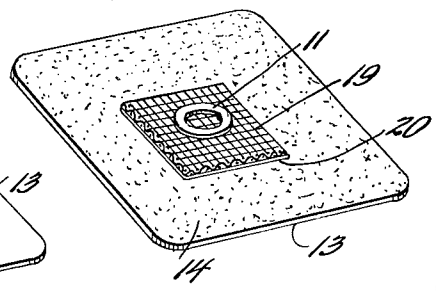


FIG. 3.

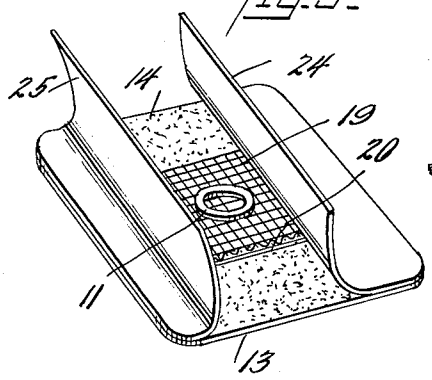


FIG. 4.

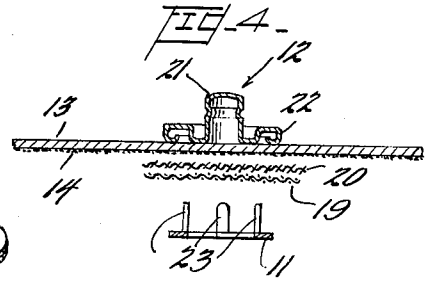
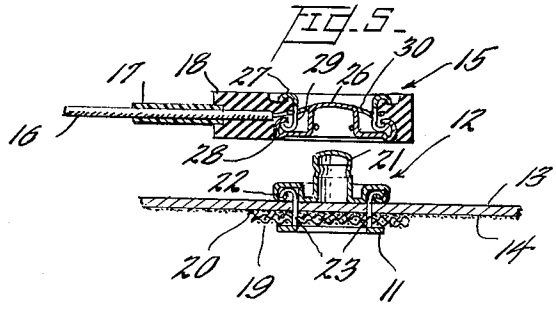


FIG. 5.



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BODY ELECTRODE

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This invention is a continuation-in-part of copending application S.N. 102,495, filed April 12, 1961, and generally relates to improvements in medical electrodes designed for application to the body. It is particularly concerned with such electrodes that are self-adhering and adapted for substantially continuous application to the body for relatively long periods of time, permitting the transfer of electrical signals to and from the body, for measurement and other functions, while the patient is performing his normal and regular activities and bodily functions.

Generally speaking, in the past most medical electronic equipment for diagnostic or therapeutic purposes has been of the desk or console variety that is confined to the hospital or doctor's office because of its relatively large size and weight, and the application and removal of electrical signals to and from the patent from this equipment has been through the use of body electrodes electrically connected to the apparatus by means of electrical wires. The electrodes are generally applied for a relatively short period of time while the patient is maintained relatively immobile, and may be satisfactorily held in place on the patient by hand, by a strap or harness, suction cups, or the like. However, with the development of miniature electronic equipment, many varieties of electromedical apparatus are presently being made portable and adapted to be worn by the patient resulting in a vast new array of medical tools that provide more dynamic measurement and treatment of the patient taken over a longer period of time, at locations away from the doctor's office, and while the patient is performing his normal routine work habits and other body exercises. For example, portable electrocardiograph apparatus is now available permitting dynamic electrocardiograms to be taken of the patient while at his home, place of business, or elsewhere while he is occupied at work or in other physical activities.

The successful use of these new body worn medical tools imposes many additional requirements on the body connected electrodes. Initially, to provide the patient with a minimum of distress, inconvenience or embarrassment, the electrodes must necessarily be made small, lightweight, and inconspicuous and must more readily conform to changing body curvatures and body movements without impeding the patient's activities. From the standpoint of providing consistently accurate electrical measurement or therapy, the electrodes must also continuously make good, low resistance electrical contact with the same location on the body while the patient is performing a variety of body movements. The electrode must also provide constant electrical connection to the portable cardiograph or other medical apparatus being carried by the patient, despite extensive movements of the patient. In addition to these more demanding requirements, it is also desired that the electrodes be inexpensive and disposable, be easily attached to and removed from the body, and be easily electrically connected to and disconnected from the portable medical apparatus.

To comply with these extensive new requirements, the present invention provides a novel electrode construction of very small size and light weight that is adapted to be adhesively secured to the body by means of a flexible tape having a pressure sensitive adhesive over one surface

thereof. This tape is provided on the adhesive backed side with an extended electrically conducting body contacting member of moderately flexible material, such as a wire screen or the like, that is adapted to make continuous low resistance body contact despite extensive movement of the body and to actually promote moderate swelling and erythema of the skin into and against the body contacting member responsively to such body movements. To additionally insure that the necessary low electrical resistance contact is made, the electrode is provided with an absorbent material for retaining a conductive paste in proximity to the body contacting part, with the adhesive tape securing means being constructed to provide a substantially water tight seal over the body contacting member and absorbent material. This water tight seal prevents the escape or drying of the paste for a long period of time, measured in some instances in hours, despite extensive movements of the body and varying changes in curvature of the skin beneath the electrode. For maintaining these parts connected to the tape, there is provided a retaining ring structure having projections that pierce the tape and engage a novel snap fastener device on the opposite side of the tape. This snap fastener device provides the dual function of cooperating with the ring structure to retain the electrode parts assembled to the flexible tape, and in addition enables a flexible external wire to be easily and detachably joined to the electrode, thereby permitting the electrodes to be detachably electrically connected to the electrocardiograph as other electromedical apparatus. The flexibility of the external wire permits extensive movement of the patient without disturbing the electrode attachment to the body or the electrical connection between the electrode and medical apparatus.

It is accordingly a principal object of the invention to provide a portable body electrode for efficiently conveying electrical signals to and from the body during normal body activities and exercises.

A further object is to provide such an electrode that may be attached in a secure manner to the same body location for long periods of time and that provides continuous low electrical resistance to the body despite various body movements and exercises.

Another object is to provide such an electrode that is small and inconspicuous that presents a minimum of inconvenience or distress to the user.

A further object is to provide a wet body electrode that is substantially sealed to the body when in use to prevent drying out for a relatively long period of time.

Still another object is to provide an inexpensive disposable electrode having the features discussed above.

A still further object is to provide such an electrode having a snap fastener connection for easily and rapidly connecting or disconnecting external electrical lead wires thereto.

Other objects and many additional advantages will be more readily understood by those skilled in the art after a detailed consideration of the following specification taken with the accompanying drawings, wherein:

FIG. 1 is a perspective view of a preferred electrode construction according to the invention and illustrating the upper surface portions thereof and the snap fastener connecting means.

FIG. 2 is a perspective view similar to FIG. 1 and illustrating details of the underside of the electrode for adhesive contact to the skin of the patient.

FIG. 3 is a perspective view similar to FIG. 2, and illustrating a preferred peel off covering for the pressure sensitive adhesive tape.

FIG. 4 is a cross-sectional view illustrating the various parts of the electrode in disassembled relationship, and

FIG. 5 is a cross-sectional view similar to FIG. 4, and

illustrating details of the connection means for detachably fastening the external electrical wire to the electrode contact.

Referring now to the drawings for a detailed consideration of one preferred electrode structure according to the invention, there is best shown in FIGS. 1 and 2, the upper and lower parts of the preferred electrode structure comprising a flexible supporting tape 10 of suitable nonporous fabric or the like, together with the electrical body contacting parts 11 and 19 on its underside and a male snap fastener part 12 on its upper side, all of these parts being fastened together on the tape 10.

The underside of the tape 10 is provided with a pressure sensitive adhesive 14 enabling the electrode to be attached to the skin and be tightly retained in position despite varying changes in body curvature that serve to flex the tape 10 into conformity with the skin surface. Suitable adhesives for this purpose are now available and commonly employed in self retaining bandages that are essentially water tight and water impervious and will retain their tight engagement with the skin for long periods of time despite perspiration, humid atmosphere, changes in temperature and the like.

The electrical body contacting parts of the electrode are compressed of a moderately flexible flat conducting member 19 made of wire mesh, screening or the like, that is centrally disposed on the underside of the tape 10, and although of somewhat extended area, is smaller in surface dimensions than the tape 10, thereby being adapted to be enclosed and sealed by the tape 10 when the electrode is attached to the body. The tape 10 is constructed to be considerably more flexible than screening 19 whereby the screening produces slight erythema of the skin with movement of the body.

Immediately underneath the screening part 19 and substantially coextensive with the underside of the screen 19, there is provided a thin porous absorbent pad of material 20, as best shown in FIG. 4, that may be made of cotton, gauze or like material. This pad 20 is adapted to absorb and retain an electrically conductive paste that is applied over the screening 19 before the electrode is attached to the body thereby to additionally insure that a constant low electrical resistance is maintained between the electrode and the body.

For retaining these parts to the tape 10 and for providing electrical contact through the tape 10, there is provided a small rigid annular metal part or member 11 disposed centrally of the tape 10 and screening 19 and preferably formed in the shape of a thin ring or annulus having a plurality of integrally attached upstanding prongs 23 extending upwardly and spaced about its inner periphery. During assembly of the electrode, these prongs 23 are adapted to pierce the tape 10 and be crimped or deformed into engagement with a male connector part 12 disposed on the upper side 13 of the tape 10, as best shown in FIG. 1. The interconnection of the ring 11 on the underside of the tape 10 with the male connector part 12 on the upper side of the tape 10 serves to tightly sandwich the screening 19, absorbent pad 20 and tape 10 therebetween, as well as providing a low resistance electrical contact through the tape from the body contacting parts on its underside to the male connector part 12 on its upper surface. Since the tape 10 is formed of resilient material, it effectively seals about the openings made by the piercing prongs 23 to provide a substantially imperforate lower surface on the electrode to prevent escape or drying of the conductive paste. Additionally, as will be discussed more fully hereafter, the male connector part 12 is also constructed in such fashion as to tightly cover those areas of the tape that are pierced by the prongs 23 thereby to further insure that the conductive paste may not escape or dry.

For detachably connecting the electrode to an external lead or wire 16 leading to the electromedical apparatus (not shown), the upper connector part 12 is provided with

an upstanding enlarged head portion 21 that may be necked as shown in FIGS. 4 and 5, together with an annular depression and an outer annular channel 22 all of which form the male portion of a snap fastener connector 12. The external electrical wire 16 is, in turn, soldered or otherwise suitably fastened to a complementary female snap connector member, generally indicated at 15, that is adapted to detachably engage with the male member 12 to provide a low resistance electrical connection between the lead wire and the electrode. As best shown in FIG. 5, the female connector part 15 is provided with a central opening 26, having a pair of resilient wires therein functioning as springs to engage the necked portion of the male head 21 whereby the female connector is adapted to detachably fit over yet tightly engage the head portion 21 of the male connector 12 thereby providing a good electrical and mechanical connection between the members 15 and 12.

In its overall size, the complete electrode is small enough to easily attach to most locations on the body, with the flexible tape 10 conforming to the curvature of the body at that location and continuously urging the screening 19 and central ring 11 into engagement with the skin despite various body movements. The greater inflexibility of the screening 19 produces a slight irritation and erythema of the skin causing slight swelling and drawing of the skin more tightly against the screening 19. This results in continued low electrical resistance contact between the skin and the electrode over long periods of time, which, of course, is considerably enhanced by the conductive paste being retained in the contacting area by the absorbent pad 20.

It is to be particularly noted that in this preferred construction, the flexible nonporous tape 10 completely covers the contacting ring or annulus 11, the screen 19, and the pad 20, and accordingly provides a liquid tight seal over the mass of conductive paste. Thus when the electrode is adhesively attached to the skin of the patient, the ring 11 and screen 19 contact the skin, and the conductive paste therein is substantially sealed by the tape 10 in contact with the skin and is consequently maintained in its wet or semiliquid state for a long period of time without drying out. Thus the electrode maintains a very low resistance contact with the same location on the patient's skin for a long period of time and despite various body movements producing changes in body curvature.

The inexpensive nature and construction of the electrode renders it disposable after each use on the patient. It is intended that the electrodes will be individually packaged in small sterile wrappers of cellophane or the like. Due to their small size, a relatively large number of such wrappers may be provided in a single box or package and marketed in the same manner as preformed adhesive bandages of known varieties.

For maintaining the adhesive layer 14 in fresh clean condition before use, and for enabling the electrode to be easily applied to the skin without sticking to other items during its handling, the underside of the tape 10 containing the adhesive layer is preferably covered with a pair of peel off layers 24 and 25, made of suitable inexpensive paper, plastic or the like, as is shown in FIG. 3. Before application to the skin, these layers 24 and 25 are easily removed to expose the adhesive surface 14 underneath. If desired, the conducting paste may be added to the electrode prior to the sealing of each electrode within its individual wrapper. Alternatively, a dab of the paste may be added over the screen 19 from a squeeze tube or the like just prior to applying the electrode to the body.

Although the electrode itself is intended to be disposable after a sustained application to the body, the female connector part 15 is permanently soldered or attached to the lead wire 16 leading to the medical apparatus (not shown) and is intended to be used over and over again with different electrodes. Alternatively, if desired, since the female connector 15 and lead wire 16 are also relatively

inexpensive, these members also may be disposable after each use if desired.

It is believed evident that the snap connector male and female members **15** and **12**, respectively, are easily and quickly disengaged and engaged thereby to easily connect and disconnect the electrode to the external electrical apparatus. The connecting wire **16** may, in many applications, be made thin and highly flexible to permit diverse body movements without disturbing the electrical connections or impeding the patient's movement. To prevent the lead **16** from breaking due to continued flexure and stress near its connection to the female connector **15**, a short section of reinforcing tube **17** of nylon or other suitable plastic may be provided over the wire **16**, as shown in FIGS. 1 and 5, at the location where the wire enters the female connector member **15**. This tubular section relieves the strain on the wire **16** at this position preventing its breaking and separation from the connector part **15**.

Referring to FIGS. 4 and 5 for further details of the preferred construction and assembly of the parts, the male connector part **12** is preferably formed with an outer annular flange **22** disposed concentrically about the upstanding headed part **21** and being bent inwardly to provide a hollow channel facing the upstanding prongs **23** of the retaining ring **11**. During assembly of these parts, the prongs **23**, after penetrating the tape **10** enter into the annular channel and are crimped or deformed therein, as best shown in FIG. 5, to tightly lock these members together on opposite sides of the tape as shown. The outstanding flange part **22** tightly covers the pierced openings in the tape **10** made by the prongs **23** to seal the tape in a fluid tight manner to prevent escape or drying out of the conductive paste. As noted above, the tape **10**, being resilient, also closes about the prongs **23** passing therethrough whereby the tape **10** is very effectively sealed and will retain the conductive paste in a wet or moist condition for many hours.

As best shown in FIG. 5, the female connector member **15** is also preferably formed in two parts; the upper part **30** being in the general form of an annulus and having projections **27** adapted to interengage with a flange part **28** provided on the shaped female part **26** for receiving the projecting head **21** of the male connector **12**. For providing a readily grasped handle and covering on the female connector **15** as well as providing support for the wire lead **16**, these assembled members may be molded within a suitable plastic **18** of nylon or the like, as shown, with the plastic **18** extending peripherally around the metallic connector parts **26** and **30** and enclosing portions of the lead wire **15** and stress relieving tubing **17** while exposing the central depression **26** in the female connector to engage the male connector head **21**, as is desired.

Although but one preferred embodiment of the invention has been illustrated and described, many variations may be made by those skilled in the art without departing from the spirit and scope of this invention. Accordingly, this invention should be considered as being limited only by the following claims appended hereto.

What is claimed is:

1. A disposable exercise electrode for making low resistance electrical contact with the skin comprising: a small two-part rigid conducting member having a lower part and an upper part adapted to interengage with each other with low electrical resistance, a flexible supporting tape having an adhesive on its underside, a body contacting layer disposed on the underside of said tape, said upper part and lower part of the conducting member sandwiching said tape when interengaged with each other, said upper part having a portion formed as one of the male or female portions of a snap fastener, an external flexible external electrical lead for detachable interconnection to said portion of the upper part, said lead having a rigid snap fastener part at one end thereof for detachably mating with said portion of said upper part, one of said upper and lower parts of the conducting member having a portion piercing said tape and the other part being provided with receiving means for said piercing portion, said piercing means and receiving means being crimped together to connect said parts to sandwich said tape.

2. A disposable miniature body electrode comprising: a flexible tape for adhesive application to the skin, a small thin conducting member disposed on the underside of the tape, a conducting member having a snap fastener portion disposed on the upper side of the tape from said thin member and being interengaged with said thin member by a portion of one of said members piercing said tape and engaging the other member, said tape being of resilient, nonporous material, thereby to seal the opening occupied by said piercing portion and provide essentially an airtight covering over said thin conducting member when the tape is applied to the skin, and a layer of absorbent material on the underside of said tape for receiving a conductive paste, whereby the tape provides an essentially airtight seal over the conductive paste when the electrode is applied to the skin.

3. A body electrode comprising a flexible tape having an adhesive on one side thereof, a conductive screen, a snap fastener member having two parts, each disposed on an opposite side of the tape and interengaged with each other to sandwich said tape and screen, an external electrical lead having a complementary snap fastener part, for easy engagement and disengagement with the snap fastener member for providing external electrical connections to the electrode, and a detachable covering over the adhesive bearing side of the tape adapted to be removed before the electrode is applied to the skin.

4. A body electrode for self-adhering attachment to the skin and making low electrical contact therewith despite extensive movements of the body and varying curvatures of the skin, said electrode being comprised of a flexible supporting tape having an adhesive on one side thereof, and a pair of substantially rigid conducting members disposed on opposite sides of the tape and interengaged with each other to sandwich the tape, an electrical conducting screen having an extended surface area greater than said rigid conducting members, said conducting screen being sandwiched by said interengaged members together with said tape and adapted to engage the skin when the tape is attached to the skin by said adhesive, a fluid absorbent layer of material disposed adjacent to said screen and also being sandwiched together with said screen and tape between said interengaged conducting members, said fluid absorbent layer being receptive to an electrically conductive paste to retain the paste in contact with said screen.

5. A body electrode comprised of a flexible tape for receiving an adhesive on its underside, an upper and lower electrical conducting member disposed on opposite sides of the tape and being interengaged to the tape to sandwich the tape, said upper member having a portion formed as a snap fastener for detachable engagement with an externally applied snap fastener, and said lower member having a flat electrical skin contacting portion, a screen having a surface of electrically conductive material, and a fluid absorbent pad adjacent said screen, said screen, pad, and tape being sandwiched between said interengaging conducting members in laminar relationship.

6. A body electrode that is innocuous in appearance, inexpensive, readily disposable, and capable of transducing electrical signals to and from the body despite extensive body exercises and changes in surface configuration of the skin comprising a flexible tape having one side for receiving an adhesive, a two-part rigid snap fastener member, one of said parts having a projection portion and the other part having a receptor portion adapted to interengage with the projection portion, said parts being

disposed on opposite sides of the tape with the projection portion of said one part piercing the tape and interlocked with the receptor portion of the other part, an absorbent pad on the side of the tape adapted to receive the adhesive and in engagement with the rigid part on that side of the tape, said pad adapted to receive an electrically conductive paste, said rigid part on the side of the tape opposite from the pad having a portion formed as one of the male or female portions of a snap fastener and adapted to detachably interengage with an external mating snap fastener member, thereby to convey electrical signals to and from the electrode.

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