United States Patent

Low et al.

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[54] COMPRESSIBLE BIOMEDICAL ELECTRODE

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[52] **U.S. Cl.** ..... **128/2.1 E**, 128/417, 128/DIG. 4

[51] **Int. Cl.** **A61n 1/04**

[58] **Field of Search** ..... 128/2.06 E, 2.1 E, 404, 417, 128/DIG. 4

[56] **References Cited**

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[57] **ABSTRACT**

A preferred embodiment of an electrode which incorporates a silicone rubber sponge which is immediately adjacent to a chlorided silver disk carried in a silicone rubber base, the electrode being covered with a thin leak-proof vinyl coating for storing electrolyte solution from the point of manufacture. The sponge rubber holds the electrolyte until it is required at the time of usage. A force on the exterior causes the electrolyte to moisten the skin to provide good ohmic contact with the subject.

2 Claims, 4 Drawing Figures

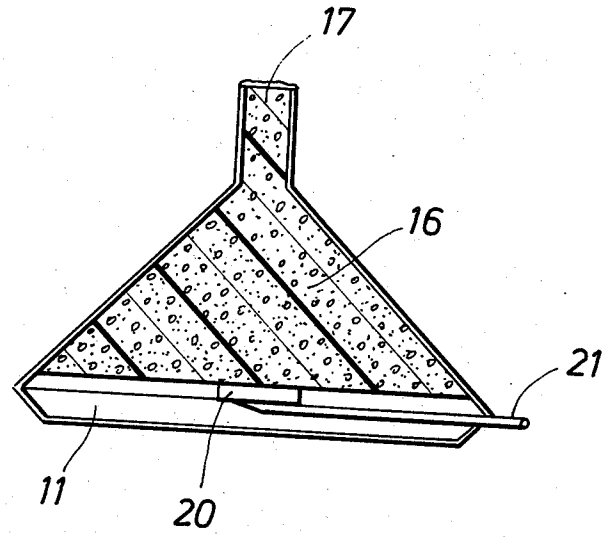
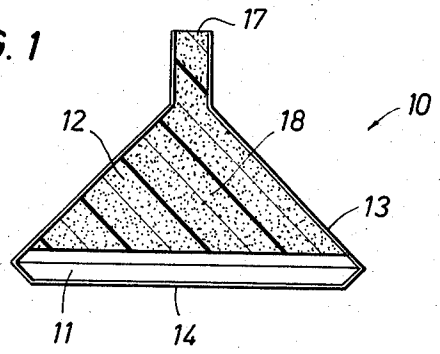


FIG. 1



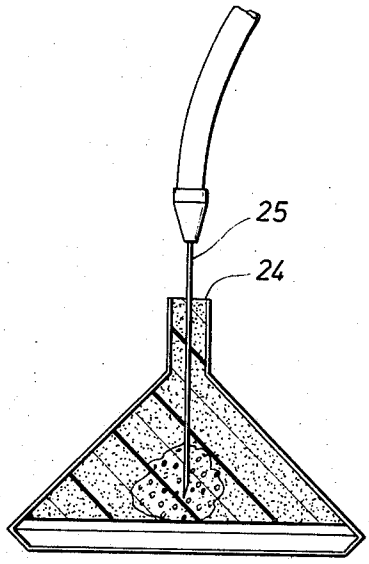
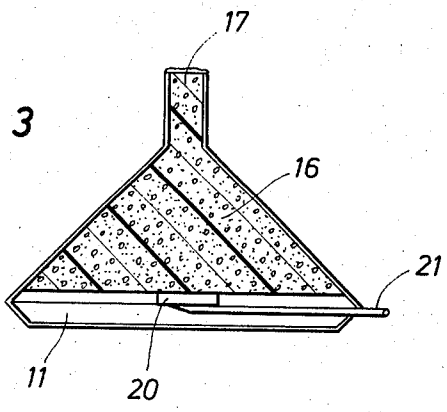


FIG. 2

FIG. 3



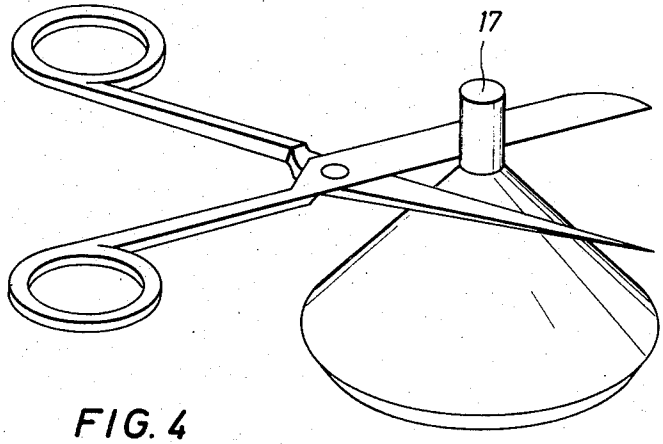


FIG. 4

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COMPRESSIBLE BIOMEDICAL ELECTRODE

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

SUMMARY OF PROBLEM AND SOLUTION

The acquisition of physiological signals in the laboratory permits the use of electrodes which are relatively complicated to prepare. However, test data outside the laboratory sometimes is not available because of the difficulty in preparation of electrodes. Quite often, the electrodes are difficult to prepare, difficult to install, and require continuous care so that usable data may be obtained. A metallic electrode, such as a silver disk, is attached to the selected area of the subject, normally including the preparatory steps of cleaning the skin and sometimes slightly abrading the skin. A conductive gel or paste is sometimes positioned between the skin and the electrode, and the electrode is normally taped in place or held by an elastic band to the skin of the subject. Clearly, this is a complicated procedure and the complexity thereof sometimes defeats the gathering of data in field conditions.

Efforts have been made in the past to devise metallic electrodes which have been attached to sponges for bearing electrolyte. Customarily, the metal electrode makes an indirect contact with the skin through a sponge which is made electrically conductive by saturation with some electrolyte. Installation and removal has been somewhat improved through the advent of such combination electrodes. However, such electrodes are very difficult to prepare for numerous reasons. For instance, they require a substantial amount of time to prepare the entire assembly for installation and usually, special precautions must be exercised to prevent the sponges from drying out. Normally, the electrodes are reused, and each reuse requires an additional soaking of the sponge in electrolyte. Inasmuch as a subject will have many electrodes attached to him in the normal course of events, the electrode preparation time can be quite excessive and, in reality, so excessive as to completely eliminate field use of combination sponge and metal disk electrodes. The special storage techniques for such electrodes, special handling techniques before and after use, and the tendency to dry out rapidly exemplify such problems as to forbid the use of the sponge and metal disk electrodes in the field.

The present invention is intended to provide a disposable electrolyte saturated sponge electrode which can be stored indefinitely without special arrangements. The electrode is readily stored without deterioration for an indefinite period of time, and yet is ready to use in a matter of seconds. The electrode is a throw-away device, thus eliminating problems associated with refilling after usage. The present invention is summarized as including a metallic electrode disk, typically chlorided silver, which is carried in a silicone rubber base. A sponge is formed above the silicone rubber base and on the other side of the metallic disk. The sponge is surrounded by a leak-proof flexible housing and is saturated with a suitable electrolyte. The device is installed on the subject and the electrolyte is simply squeezed from the sponge to soak the skin and communicate it with the disk.

Many objects and advantages of the present invention will become more readily apparent from a consideration of the following written specification and drawings, wherein;

FIG. 1 is a sectional view of the electrode of the present invention;

FIG. 2 is a view similar to FIG. 1 showing the step in which the liquid electrolyte is added to the sponge within the electrode;

FIG. 3 is a sectional view of the prefilled sponge electrode when it is completed and ready for use; and,

FIG. 4 shows one manner of preparing the electrode for use.

In the drawings, attention is first directed to FIG. 1 which shows an incomplete electrode 10. The electrode 10 of FIG. 1 will be first described, and thereafter, the method of preparation and the method of use will be set forth. The structure shown in FIG. 1 includes a silicone rubber base 11 and a silicone rubber sponge 12 thereabove. The silicone rubber sponge is surrounded by a thin vinyl coating 13 which extends over the face 14 of the silicone rubber base. The vinyl coating 13 is leakproof to hold the electrolyte liquid therein in a manner which will be described. The vinyl covering 13 covers all of the sponge rubber which has a body portion 16 and a thin neck 17 as will be described.

As shown in FIG. 3, an electrode 20 is incorporated. The electrode 20 can be formed of various materials, but the preferred material for this embodiment is a silver disk which is preferably cut from pure silver sheet stock to a diameter of about 6 to 8 millimeters and having a thickness of about one-half millimeter. A length of silicone rubber insulated stranded copper wire 21 is attached to the electrode 20. The attachment is preferably achieved by the use of silver solder. The junction is insulated with a vinyl coating. The gauge of the wire 21 is preferably sufficient to have adequate strength under all conditions of use and installation. Once the silver disk is joined to the wire, the uninsulated surface of the silver disk is chlorided by passing an anodizing current through it while it is submerged in a sodium chloride solution. The duration of the current and the salinity of the water are two factors which can be readily determined dependent on the amount of chloridation required for the silver disk. In any case, the pure silver matrix is altered to some extent to include the chloride atoms.

The wire and disk are preferably placed in a mold and a liquid silicone rubber poured in the mold to form the silicone rubber base 11 shown in the drawings. The silicone rubber base is a product commercially available from many sources. One source is the Dow Corning Co., which sells a mold making rubber under the trade name Silastic A, mix RTV. A typical catalyst is used with the Silastic. A suitable catalyst is RTV catalyst 4, by the Dow Corning Co. The silicone rubber base is formed about the disk and wire, and, among other things, provides structural support to the disk and wire and also provides an attachment surface for the porous silicone rubber sponge in a manner to be described hereinafter. In thickness, the silicone rubber base 11 is perhaps in the range of 2 to 3 millimeters thick, and it is perhaps twenty to 25 millimeters in diameter. Of course, the electrical lead 21 is carried out through the side at some appropriate point on the diameter.

After the silicone rubber base 11 has been joined to the wire 21 and the disk 20, the exposed face of the silver disk is carefully cleaned to remove all traces of silicone rubber and other contaminants. One cleaning agent which is suitable is zylene solution. The cleaning is accomplished quickly and the exposed surface is then able to provide the necessary ohmic conductivity with the skin of the subject as will be described hereinafter.

The conical sponge portion 16 is preferably formed of a silicone rubber foam to the shape illustrated. Representative dimensions can be something in the range of a diameter equal to the silicone rubber base 11 with a cylindrical upstanding member 17 which is perhaps five to six millimeters long. The total height of the electrode is perhaps sixteen to nineteen millimeters. A suitable material for the formation of the silicone rubber sponge 16 is Dow Corning Silastic silicone rubber foam, Product S5370 RTV.

The sponge rubber material 16 is joined to the base member 11 by a small amount of silicone rubber adhesive which is applied near the periphery. A typical adhesive is RTV 112 white silicone rubber adhesive manufactured by General Electric. Preferably, the adhesive is applied in a thin line about the outer periphery. Care must be exercised to not place the adhesive on the silver chlorided disk which is in the center. The silver chlorided disk must contact the sponge.

The entire completed assembly is next dipped in a liquid vinyl material. One suitable material is manufactured by Spectra-Strip, and bears the trade name Vyna-Kote. It is easily air-dried to form a thin, flexible insulating leakproof coating which is perhaps 0.002 – 0.003 inches thick.

The vinyl material covering the entire assembly is next cut away at the numeral **24** in FIG. **2**. A hollow injection needle **25** connected with a pressurized container of electrolyte solution is inserted through the exposed access opening **24** into the sponge material **16**. The needle is inserted part way into the sponge, care being exercised to not penetrate too deeply. Sufficient electrolyte material is injected into the sponge to completely saturate the sponge and the needle is withdrawn. The exposed tip is resealed with liquid vinyl to prevent loss of electrolyte in the completed structure, which can be stored indefinitely.

The device can be used with almost instant preparation. Whether its use is required immediately, or after many months of storage, the device is implemented in the manner shown in FIG. **4**. In FIG. **4**, the tab **17** is quickly and easily cut off and removed. At this juncture, the sponge material **16** is exposed and this exposed surface is placed against the skin of the subject. The electrode is then instantly ready to be used because the slight compression of the sponge material **16** on contacting the electrode **10** against the subject ejects a slight bit of liquid electrolyte onto the skin when the electrode is properly positioned. Slight pressure is normally required, and can be readily obtained through the use of elastic tape, and so on. The electrical pathway from the chlorided disk **20** to the skin is through the liquid electrolyte in the sponge **16** and the pathway is maintained with a minimum of irregularities in conductivity.

The device of the present invention is a throwaway device. It can be used and no particular steps are required at the completion of its use. The device is simply thrown away.

Attention is directed to the fact that preparation of the device for use is noticeably simple. As recounted above, only a few seconds are required for its preparation.

Note should be taken that the device described is such a device which does not require the addition of electrolytes to the device at the time of use. A suitable electrolyte may contain a number of metal salts, and by way of example and not limitation, one suitable electrolyte solution contains the following;

NaCl, 1.36g;
KCl, 0.08g;
$MgCl_2 \cdot 6H_2O$, 0.04g;
$NaH_2PO_4 \cdot H_2O$, 0.3g;
KH_2PO_4, 0.002 g;
Natrosol–250, 2.5g; polyvinylpyrrolidone–K90, 2.0g;
Zephiran chloride concentrate, 2ml;
H_2O to make 100cc total solution volume.

The method or manner of application is in the following fashion. After manufacture, the electrode is stored until it is ready for use. By and large, it is installed at any place on the user. It can, for example, be clamped against the head using a surrounding helmet which supports several electrodes at desired positions. Each may be secured in place with elastic and electrically connected. When needed, the helmet can be easily removed and the electrodes cut in the manner of FIG. **4**. When the helmet is placed on the head, the stretching of it, coupled with pressure on the exposed sponges, will wet the hair and skin sufficiently to couple the faint electrical signal to the silver disk. A long interval of use is possible because the sponge will, when jostled, re-moisten the skin to renew and continue the very good electrical path to the head. Perhaps no more than a minute is required to prepare perhaps six or eight electrodes in a helmet.

Broadly, the terminology adapted in the foregoing is extended to the claims which are appended hereto.

What is claimed is:

1. A compressible biomedial electrode assembly for obtaining electrical signals from a subject by contact with the skin, particularly hair bearing portions of the body, said assembly comprising;

a resilient base member having a generally planar surface;

an electrode positioned in the base member, said electrode having an exposed face in the planar surface of the base member;

an insulating output conductor connected to the electrode, and extending outwardly of the base member to transmit electrical signals from the electrode;

a mass of sponge-like resilient material in the form of a cone, the periphery of the base of the cone attached to the base member and the central portion of the base of the cone in contact with the exposed face of the electrode;

an electrolyte filling the sponge material;

leak-proof flexible material extending fully about the base member and the electrolyte filled sponge material to form a compressible housing for the assembly, the apex of the housing being adapted to be removed to expose a small area of the pre-filled electrolyte sponge material, the assembly being compressible under a slight pressure thereby extruding a small amount of electrolyte onto the skin so as to establish and maintain low resistance electrical contact with the skin.

2. The compressible biomedical electrode assembly set forth in claim **1** wherein a cylindrical tab extends from the apex of the conically shaped sponge material, said tab forming a filler for the electrolyte and a indicia for locating the portion of the housing to be removed to expose the sponge for wetted contact.

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