

[54] **BIOPOTENTIAL ELECTRODE**
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128/DIG. 4, 2.06 E, 418

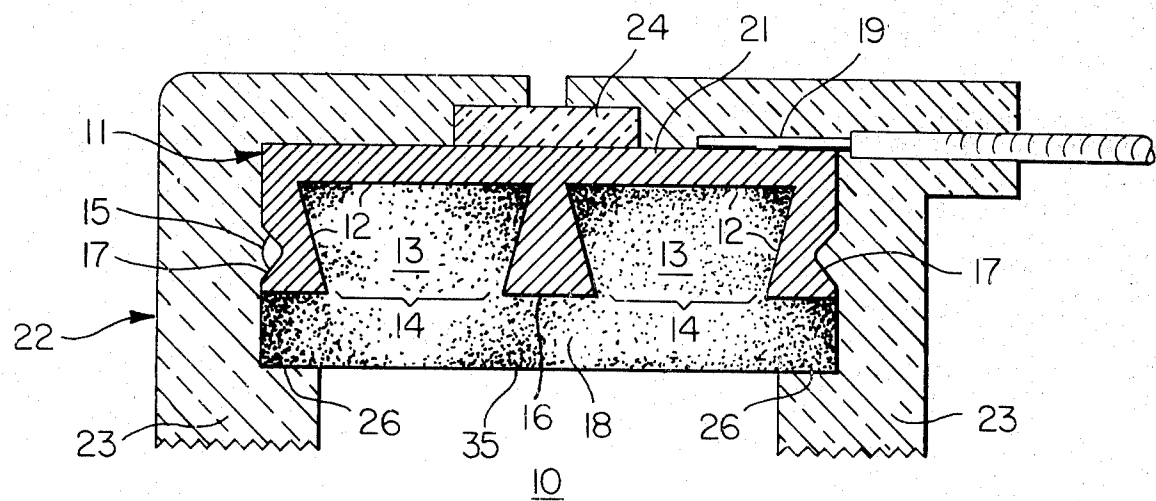
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[57] **ABSTRACT**
An electrode pellet formed of a compacted powder electrode material is held in a metal receptacle having a restricted opening. An electrically conductive lead is affixed to the exterior surface of the receptacle at a point removed from the opening. The receptacle and pellet with lead attached are encapsulated in a unitary plastic housing having a restricted opening which exposes a surface of the pellet. The housing is formed of a plastic crush pad and a molded plastic body which are fused together during encapsulation to provide a seamless one-piece case.

13 Claims, 2 Drawing Figures



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Fig. 1

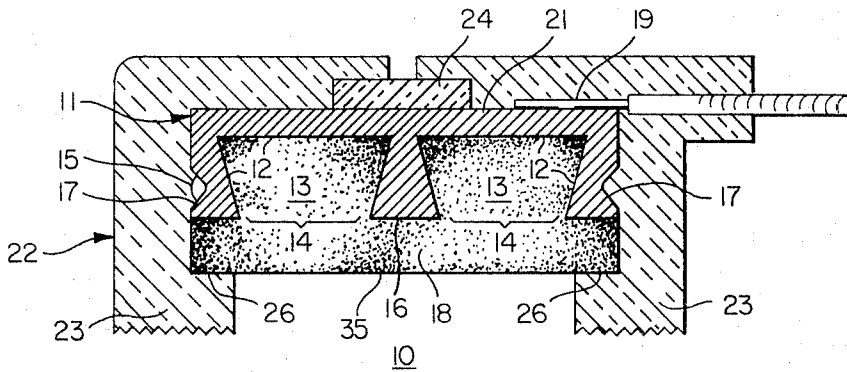
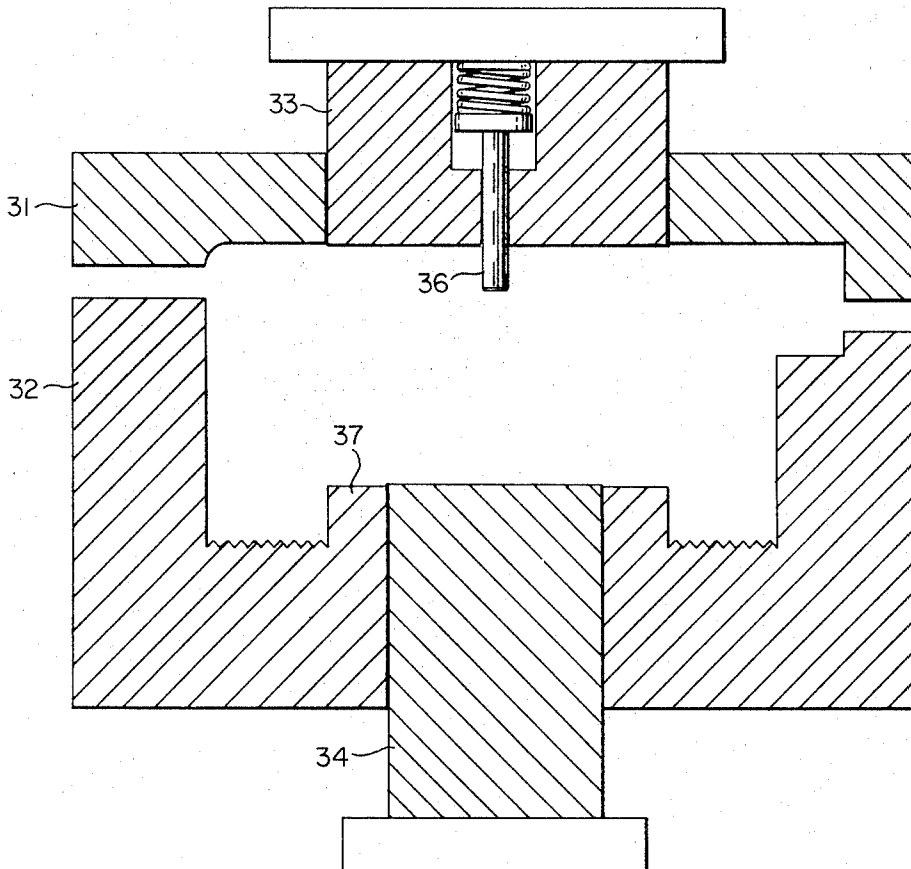


Fig. 2



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BIOPOTENTIAL ELECTRODE

BACKGROUND OF THE INVENTION

This invention relates to biopotential electrodes of the type used in the medical arts to detect, for various monitoring purposes, electrical potentials at the skin of a patient or subject. Effective electrical contact between the electrode and the skin is customarily established through an electrolyte gel. Skin potentials cause ions to flow through the gel to the surface of an active electrode material where they react, generating signals which are then detected and monitored by appropriate instruments.

A well-known biopotential electrode material is a porous compacted mixture of silver and silver-chloride powders. The porosity of this material provides a large electrode surface for contact with the electrolyte, while the material itself is characterized by chemical and electrical stability, low offset and polarization voltages, and a desirable low impedance.

Actual electrode structures, however, have not been able to realize the maximum benefits of the electrode material. In practice, it has been necessary to compact the powdered electrode material to a degree determined principally by the requirement that the pellet be strong enough to withstand the stress and strain imposed during assembly of the electrode structure and subsequently during actual use. In many cases this degree of compaction has been a compromise between the electrical and mechanical requirements, resulting in impedances higher than optimum and pellets overly subject to fracture and other forms of mechanical failure.

Prior electrode structures have employed a multi-part plastic housing which is assembled and cemented together to hold the electrode pellet and to protect the junction of the pellet and lead wire from the corrosive effects of the electrolyte as well as to avoid the adverse electrical effects of contact between the electrolyte and the dissimilar metal of the lead wire. Experience has shown that the joints and seams of the multi-part housing are subject to leakage, only a small amount of which may cause the undesirable effects described.

Occasionally the exposed surface of the electrode pellet becomes contaminated during use. In prior art electrodes it is generally not feasible to renew the surface of the pellet by abrasion as the compacted powder pellet will be fractured or dislodged from the housing.

The present invention substantially reduces the requirement that the electrode powder mass be compacted for strength, permitting the degree of compaction to be selected instead for optimum electrical characteristics. In addition, a unitary plastic housing is provided to eliminate the problem of electrode failure due to leakage at the seams. Finally, the design of the electrode provides sufficient strength to the compacted powder to permit renewal of the electrode surface by abrasion when required.

SUMMARY OF THE INVENTION

According to the invention, an electrode pellet is formed in a conductive receptacle having a restricted opening. The receptacle is of a strong and relatively rigid material, such as a metal, and is shaped to hold the pellet securely as well as to take the stresses and strains which would otherwise be imposed directly on the compacted powder mass during assembly of the elec-

trode structure and subsequently during actual use. A conductive lead wire is affixed to an exterior surface of the receptacle, preferably at a point remote from the opening so as to maximize the path length between the points where electrolyte may leak into the housing and the junction of the lead wire with the pellet receptacle. A unitary, electrically insulative housing is formed around the pellet and receptacle. The housing has a restricted opening which exposes the surface of the pellet. The housing comprises a crush pad of the same or a similar plastic material to that which forms its body. The crush pad serves during the manufacturing process to separate the receptacle from the means used to hold the pellet and receptacle as the body of the housing is molded around them. It fuses to the body during the molding process to produce a unitary, seamless housing impervious to the electrolyte with which the electrode assembly is used.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view of a biopotential electrode embodying the invention; and

FIG. 2 is a longitudinal cross-sectional view of an injection molding cavity which may be used in manufacturing the invention.

The biopotential electrode 10 in FIG. 1 comprises a receptacle 11 in the form of a shallow circular cup, the interior surface 12 of which flares to form a cavity 13 having a relatively narrow or restricted opening 14. The interior surface 12 has a protuberance, shown in the drawing as a conically flared post or pedestal 16, which serves further to restrict the opening 14 of cavity 13. The exterior surface of circular receptacle 11 includes a circumferential annular groove 17 which serves to improve the bond between receptacle 11 and the molded plastic housing described herein. Groove 17 may be made discontinuous, as by one or more tangs 15 which serve to anchor receptacle 11 against rotation in the housing.

Receptacle 11 is fabricated from a conductive and relatively rigid material, such as a metal. An electrode pellet 18 is formed in cavity 13 by compacting a powdered electrode material therein. A preferred electrode material is a mixture of powdered silver and powdered silver chloride. The choice of electrode material generally determines the choice of the metal used to form receptacle 11. Thus, with a pellet of silver and silver chloride, favorable electrical characteristics are obtained with a receptacle of silver metal or of brass plated with a sufficient thickness of silver to insure that the silver plate will not be penetrated by grains of the electrode powder as it is compacted.

The shape of cavity 13 is such that its interior surfaces provide a wedge effect against forces which may tend to push or pull pellet 18 out of receptacle 11. The surface of interior post 16 provides the same type of wedge effect to secure the portion of pellet 18 near the center of restricted opening 14. In addition to securely wedging pellet 18, interior surfaces 12 of cavity 13 support and protect the relatively fragile peripheral portions of pellet 18. The entire structure of receptacle 11 thus provides strength and support to the otherwise delicate pellet 18, shielding and protecting it from the stresses and strains imposed during manufacture and assembly as well as during actual use. By protecting pellet 18 from the most common causes of fracture, an

electrode assembly having a longer useful life than prior devices is realized.

Since the receptacle 11 provides strength and support to the compacted powder mass of pellet 18, the compaction pressure used to form the pellet may be selected to optimize the electrical characteristics of the electrode rather than being, as heretofore, a compromise between the requirements for electrical performance and those for mechanical strength. Since the pellet is formed in receptacle 11 prior to encapsulation of the electrode assembly, pellet 18 may be sintered to further improve its mechanical and electrical properties. Sintering is not generally feasible when the powder is compacted directly in a plastic housing as in some prior art devices, because the sintering temperatures are high enough to melt or deform most plastics.

In the embodiment illustrated in FIG. 1, the compacted powder mass overfills cavity 13 so that pellet 18 includes a portion filling the cavity and an integral portion outside of the cavity. The portion of pellet 18 outside of the cavity may be abraded as necessary to remove surface contamination and to renew the electrical properties of the electrode surface when necessary.

A conductive lead wire 19 is affixed, as by welding or soldering, to receptacle 11 at an exterior surface 21 remote from opening 14. The location of the junction between lead wire 19 and receptacle 11 is selected to maximize the length of the leakage path between the junction and the point where electrolyte may enter the electrode structure. Groove 17 provides a further increase to the path length, and additional measures may be employed to the same end.

The entire assembly of receptacle 11, pellet 18 and lead wire 19 is encapsulated in a unitary, seamless, molded thermoplastic housing 22 comprising a body 23 and a crush pad 24. Crush pad 24 is of a material the same as or similar to that of body 23. Housing 22 may be formed by injection molding around the receptacle-pellet assembly. Crush pad 24 serves during the molding process to separate the receptacle 11 from the portion of the molding apparatus used to hold the receptacle-pellet assembly in the mold. Body 23 and crush pad 24 are fused during the molding process so that housing 22 is an integral, seamless structure having no avenue through which the working electrolyte solution may penetrate. Housing 22 is molded with a shoulder portion 26 overlapping the edges of pellet 18 to provide protection and support to the more fragile peripheral portions of the pellet outside of the receptacle.

Housing 22 may be formed using injection molding apparatus of the type illustrated in FIG. 2 which comprises an upper die 31 and a lower die 32. Die 31 includes a core pin 33 slideable to facilitate ejection of the molded part. A similar core pin 34 is included in die 32. A spring loaded sliding pin 36, which may be associated with upper core pin 33, is included in upper die 31. In the process of manufacturing an electrode assembly according to the invention, a receptacle 11 containing an electrode pellet 18 is placed in lower die 32 with the surface 35 of the pellet 18 which is to remain exposed, resting on core 37. A crush pad 24 is placed on top of receptacle 11. As upper die 31 is lowered in place to seal the mold, pin 36 bears against pad 24 which distributes the force to receptacle 11 and holds the electrode assembly against core 37 of lower die 32.

Thus, the electrode assembly is firmly retained in proper position while the hot pressurized plastic is injected into the molding cavity formed by the dies 31 and 32. During the molding process the injected material fuses with pad 24 so that when upper die 31 and pin 36 are withdrawn, the housing 22 is a unitary seamless structure having the advantages described herein.

Although the invention has been described with reference to a specific illustrative embodiment many variations and modifications are possible and may be made by those skilled in this art without departing from its scope and spirit.

What is claimed is:

1. A biopotential electrode comprising:

a conductive receptacle defining a cavity having a restricted opening, the interior surface of the cavity being shaped to provide a wedge effect against the extraction of an electrode pellet in contact therewith;

an electrode pellet substantially filling the cavity defined by the conductive receptacle and in contact with the shaped interior walls thereof;

an insulative housing encapsulating the receptacle, said housing having an aperture exposing the surface of the electrode pellet; and

an electrically conductive lead in electrical contact with the receptacle and extending through the housing.

2. A biopotential electrode as in claim 1 and further including at least one protuberance from an interior surface extending into the cavity of the conductive receptacle.

3. A biopotential electrode as in claim 2 wherein the protuberance is larger at its free end than at its base.

4. A biopotential electrode as in claim 3 wherein the protuberance is conically flared.

5. A biopotential electrode as in claim 2 wherein the protuberance extends from the interior surface of the cavity opposite the restricted opening, toward the opening.

6. A biopotential electrode as in claim 1 wherein the cavity of the conductive receptacle is conically flared from the restricted opening to a flat interior base.

7. A biopotential electrode as in claim 1 wherein an exterior side surface of the conductive receptacle has a circumferential groove around the opening.

8. A biopotential electrode as in claim 7 wherein the groove is discontinuous.

9. A biopotential electrode as in claim 1 wherein the electrode pellet is formed of a compacted powder.

10. A biopotential electrode as in claim 1 wherein a portion of the pellet fills the cavity and another portion is outside of the opening.

11. A biopotential electrode as in claim 1 wherein the housing comprises a unitary seamless housing of a molded thermoplastic material.

12. A biopotential electrode as in claim 11 wherein the housing comprises a crush pad of a similar thermoplastic material, the crush pad being fused to the body of the housing.

13. A biopotential electrode as in claim 12 wherein the crush pad is positioned against the exterior surface of the conductive receptacle opposite the opening.

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