# United States Patent [19]

**Allison et al.**

[11] **3,862,633**

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[54] **ELECTRODE**


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[52] **U.S. Cl.** ..... **128/2.06 E,** 128/417, 128/DIG. 4

[51] **Int. Cl.** ..... **A61b 5/04**

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



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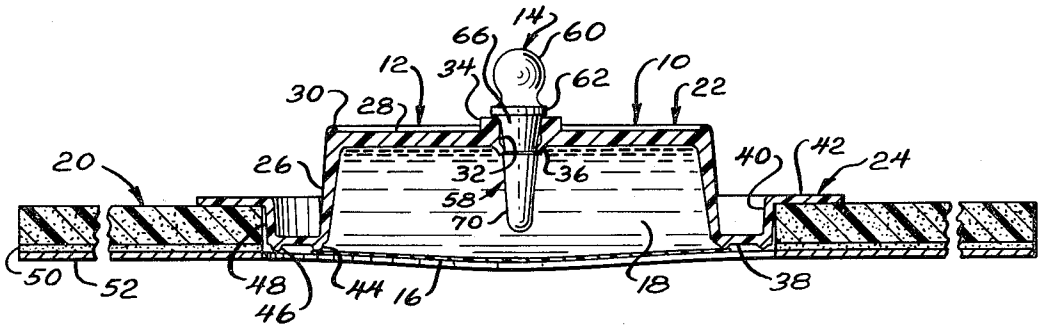
[57] **ABSTRACT**

A biomedical electrode for use in cooperation with a signal-receiving apparatus is the subject matter of this invention. The instant electrode is one which is particularly adapted for use in observing certain phenomena of the subject by observing electrical signals on the surface of the subject. The electrode includes an open-sided, resilient container, with a microporous diaphragm closing the open side. An electrolyte is contained in the container and permeates the diaphragm to unite with skin fluids of the subject. The container contains a filling aperture on the side opposite the open side. An annular sealing flange is formed integral with the container and extends into the filling aperture. A terminal plug is positioned in the filling aperture in sealing engagement with the annular sealing flange to seal closed the filling aperture.


**14 Claims, 9 Drawing Figures**



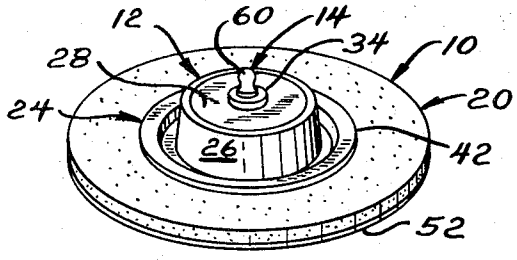



Fig. 1

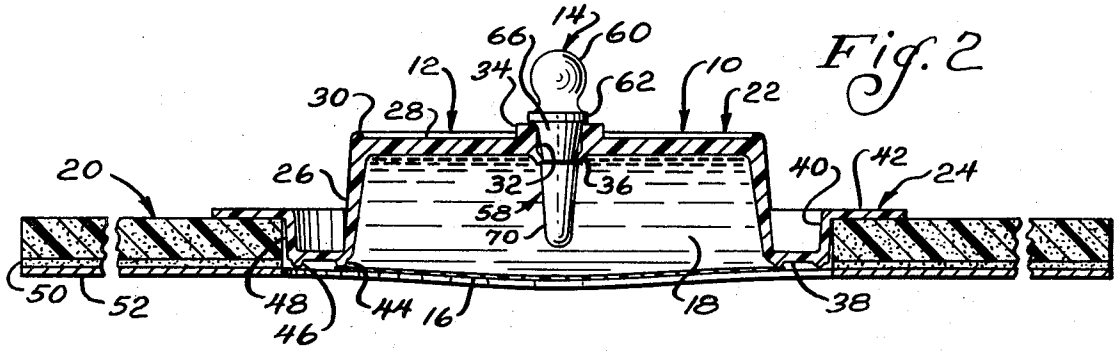



Fig. 2

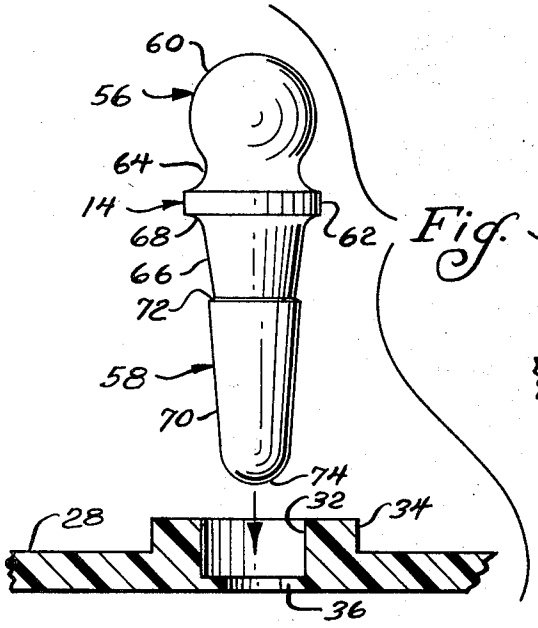



Fig. 3

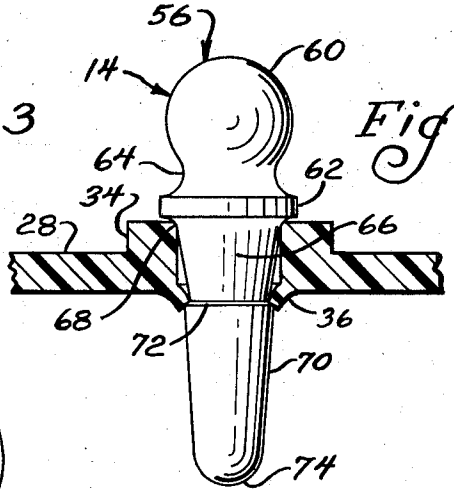
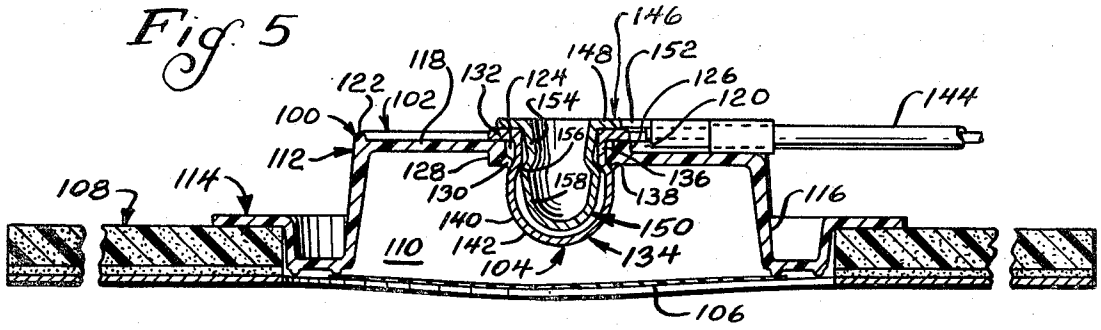



Fig. 4

Fig. 5



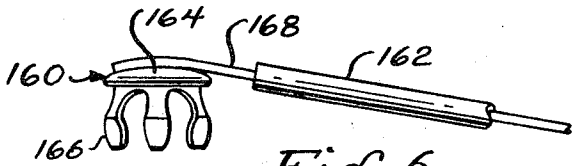
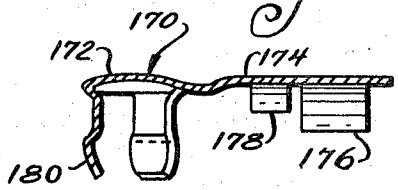




Fig. 6

Fig. 7



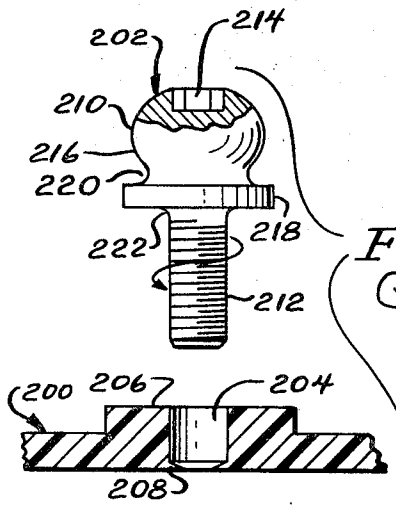
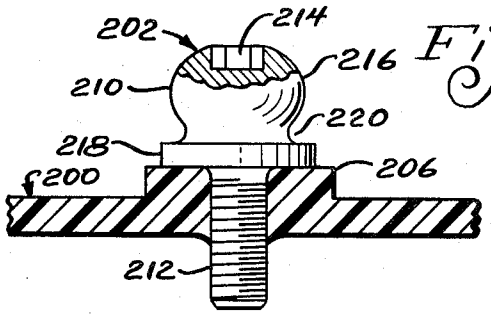




Fig. 8

Fig. 9



# ELECTRODE

## BACKGROUND OF THE INVENTION

The general construction of a biomedical electrode such as that which is the subject matter of this invention is well-known in the art and is disclosed in U.S. patent application Ser. No. 303,335, filed on Nov. 3, 1972. The specific construction of such an electrode is adequate for short-run production. However, when large quantities of electrodes are required, the construction of the electrode is such that it is difficult to fill the electrode container with an electrolyte and then quickly and inexpensively seal closed the container to retain the electrolyte in the container.

## SUMMARY OF THE INVENTION

The present electrode is a specific improvement of an electrode which has a container having a permeable diaphragm on one side of the container. The container is filled with an electrolyte through a filling aperture. The container has an annular sealing flange formed integral therewith and extending into the filling aperture. Once the container is filled with electrolyte, a terminal plug is inserted into the filling aperture and into sealing engagement with the container and with the annular sealing flange to seal closed the filling aperture. The terminal plug performs three functions in the electrode. One function is to provide a terminal for connection of the electrode to a lead; the second function is to seal closed the filling aperture; and the third function is to provide the necessary metal in contact with the electrolyte to form an electrical half cell for operation of the electrode. It is therefore a principal object of this invention to provide an improved biomedical electrode construction, which electrode may be quickly and easily assembled.

It is another object of the present invention to provide an improved construction of a biomedical electrode in which the various parts of the electrode may be quickly and easily manufactured.

It is a still further object of the herein-disclosed invention to provide a biomedical electrode which has a minimum of parts.

Other objects and uses of the instant invention will become readily apparent to those skilled in the art upon a perusal of the following specification in light of the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a biomedical electrode embodying the present invention;

FIG. 2 is an enlarged cross-sectional view of the biomedical electrode shown in FIG. 1, with portions broken away;

FIG. 3 is an enlarged side elevational view of a filling aperture in a container of the electrode of FIG. 2, showing a terminal plug in position for insertion into the filling aperture;

FIG. 4 is an enlarged cross-sectional view of the parts of FIG. 3, but showing the terminal plug in its sealing position in the filling aperture;

FIG. 5 is a cross-sectional view of a biomedical electrode similar to that shown in FIGS. 1 and 2, but showing a modified container and terminal plug construction;



FIG. 6 is a side elevational view of a connector which is particularly adapted for use with the biomedical electrode shown in FIG. 5;

FIG. 7 is a side elevational view of another form of connector which may be quickly attached to a lead, which connector may be used in connection with the biomedical electrode shown in FIG. 5;

FIG. 8 is a fragmentary cross-sectional view of a portion of a container of a biomedical electrode having a slightly modified form and a terminal plug particularly adapted for mounting in a filling aperture of the container; and

FIG. 9 is a cross-sectional view of the parts shown in FIG. 8, but showing the terminal plug positioned in a sealing attitude in the filling aperture.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and especially to FIG. 2, an electrode which is a specific embodiment of the instant invention is shown therein and is generally indicated by numeral **10.** The electrode generally includes a container **12** and a terminal plug **14** mounted in the container. A microporous diaphragm **16,** made of a thin sheet of plastic material, such as, polypropylene, is mounted on the open side of container **12.** The container is filled with an electrolyte **18,** which is an 0.25 percent sodium chloride solution having a wetting agent, a bacteria inhibitor, and glycerine to control evaporation. A mounting pad **20** is secured to the container for attaching the electrode to a subject.

Container **12** is a resilient injection-molded part, which in this instance is a polypropylene part, though any other suitable material may be used. The container generally consists of two integral parts, a cup **22** and a mounting flange **24.** Cup **22** includes an annular sloping wall **26,** with a top **28** formed integral with the smaller portion of sloping wall **26.** A bead **30** is formed integral with the outer periphery of the top **28.** In the center of the top **28,** there is a filling aperture **32,** with a terminal boss **34** formed integral with the top around the aperture **32.** Formed interiorly of filling aperture **32,** there is a resilient annular sealing flange **36,** having its outer periphery formed integral with the container. Flange **36** extends inward of the sealing aperture for engagement with the terminal plug **14,** as will be described in detail hereinafter.

Mounting flange **24** includes an annular cup flange **38,** having its interior formed integral with the lower portion of sloping wall **26.** A cylindrical wall **40** is formed integral with the outer periphery of the flange **38.** An annular pad flange **42** has its inner edge formed integral with the cylindrical wall **40.** An annular diaphragm bead **44** is formed integral with an inner edge of the flange **38** for receipt of the diaphragm. A sealing bead **46** is formed integral with the outer edge of flange **38.**

Mounting pad **20** is a thin piece of reticulated polyurethane foam, in which there are 50 to 150 pores per linear inch. The pad had a container aperture **48** receiving a portion of the container **12.** A network of adhesive **50** is placed on one side of the pad **20,** with a conventional release paper **52** positioned over the adhesive. The pad **20** is secured to the flange **42** by heat sealing. A conventional sealing sheet (which is not shown herein) is mounted on the annular bead **46** to prevent the electrode from drying out in storage. How-

ever, when the electrode is in use, the sealing sheet is removed from the bead so that the diaphragm may contact the surface of a subject.

Terminal plug **14**, in this instance, is a solid piece of tin-plated brass. The plug generally consists of a connector head **56** and a sealing body **58** formed integral with the head. The head includes a spherical portion **60**, with an annular shoulder **62** formed therein and an annular fillet **64** between the portion **60** and the shoulder **62**. The body includes a tapered shank **66** formed integral with the shoulder and having a fillet **68** between the shank and the shoulder. The body also includes a tapered nose **70** formed integral with the shank **66**. The nose **70** terminates in a rounded end portion **74**. A beveled seal face **72** is integrally formed between nose **70** and shank **66**.

There is a very specific interrelationship of the sizes of the terminal plug **14** and filling aperture **32** and sealing flange **36**. The diameter of the sealing shoulder **62** is greater than the diameter of the filling aperture **32**. The maximum diameter of the nose **70** is less than the diameter of the filling aperture. The minimum diameter of the tapered shank **66** is less than the diameter of the filling aperture **32**, but greater than the interior diameter of the sealing flange **36**. The distance from the shoulder **62** to the beveled seal face **72** is slightly greater than the distance from the top of the boss **34** to the bottom of the top **38**, as viewed in FIGS. **2**, **3** and **4**, but less than the length of the filling aperture plus the width of one side of the annular sealing flange **36**. The length of the nose **70** is slightly less than the height of the sloped wall **36**, for reasons which will become apparent hereinafter.

Electrode **10** is assembled by securing the diaphragm **16** to the diaphragm bead **44** and securing the pad **20** to the flange **42**. A sealing sheet (which is not shown) is placed over the diaphragm, into sealing engagement with bead **46**. Cup **22** is filled with electrolyte **18** through the filling aperture **32**. Once the cup is sufficiently filled, the terminal plug **14** is inserted into the filling aperture to seal closed the filling aperture.

The terminal plug **14** is inserted into the filling aperture with the longitudinal axes of the plug and the filling aperture being aligned. The tapered nose **70** is inserted into the upper portion of the aperture; and an axial force is applied to the plug so that the rounded end portion **74** first engages the sealing flange **36**. The sealing flange **36**, being resilient, is deformed by the rounded end portion; and the outside walls of the tapered nose **70** then are moved into engagement with the sealing flange **36**. The sealing flange is disposed downward as the tapered nose slides through the sealing flange. The plug is moved downward until the sealing shoulder **62** is placed adjacent to the upper surface of boss **34**; and the tapered nose, in its entirety, passes through the sealing flange until the sealing flange engages the beveled seal face **72**. The diameter of the tapered shank **66** is greater than the diameter of the aperture through the sealing flange, so that the sealing flange is held downward in engagement with the seal face **72**, thus locking the plug in position, with the fillet **68** in sealing engagement with the interior of the boss **34**. It may be appreciated that the fillet deforms the boss slightly so that there is a double seal on the terminal plug.

There is one seal between the sealing flange **36** and the seal face **72**, as may be best seen in FIG. **4**. There is a secondary seal between the fillet **68** and the upper portion of the boss **34**. The sealing action also serves to lock the plug into position, so that the plug is held securely in place.

The nose **74** extends downward into the cup, toward the diaphragm **16**, but does not touch the diaphragm **16**. However, the plug is immersed in electrolyte **18**. The terminal plug, having its nose tin-coated, forms an electrical half cell with the electrolyte.

The electrode is applied to the skin of a subject by first removing the sealing sheet from bead **46**. The release paper **52** is also removed from the pad. The electrode is adhesively secured to the patient by positioning the electrode at a desired location and applying a load to the mounting pad **20**. Thus, diaphragm **16** is placed into contact with the skin of a patient. The diaphragm **16**, being microporous, has electrolyte **18** permeating the diaphragm to wet slightly the exterior surface of the diaphragm so that, as soon as the diaphragm is placed into contact with a subject's skin, good contact is made between the diaphragm and the subject's skin fluids without the use of any other material or scraping the subject's skin. As is conventional, a lead is attached to the terminal plug.

Measurements are taken in a conventional fashion, using conventional equipment. The electrical condition is observed on electrical measuring equipment. There is a faithful reproduction of a signal since there is ionic conduction through diaphragm **16** since the electrolyte permeates the microporous diaphragm uniting with the skin fluids providing a conductive path directly between the electrode and the inner layer of the subject's skin. The amount of noise and other electrical disturbances is held to a minimum, thereby giving a high-fidelity signal.

The electrolyte is a physiological saline solution, thus allowing the electrode to remain on a patient's skin for a prolonged period of time. As the subject perspires, the perspiration does not affect the operation of the electrode.

It is a simple matter to move the electrode by pulling the pad off the skin of the subject. The electrode, being inexpensive to manufacture, may then be discarded.

Another form of an electrode embodying the present invention is shown in FIG. **5**. The modified form of electrode is generally indicated by numeral **100**. The electrode **100** generally consists of a resilient polypropylene container **102**, a terminal plug **104** mounted in the container, a microporous thin sheet polypropylene diaphragm **106** mounted on an open side of container **102**, and a polyurethane foam mounting pad **108** secured to the container. The container is filled with an electrolyte **110**, which is identical to electrolyte **18**.

Electrode **100** is identical to electrode **10**, except for the construction of the container **102** and the terminal plug **104**. Container **102** generally consists of two parts, a cup **112** and a mounting flange **114**, which mounting flange is identical to mounting flange **24**. The cup **112** includes an annular sloping wall **116**, with a top **118** formed integral with the smaller portion of the sloping wall **116**. A terminal groove **120** is formed in the top **118**. A discontinuous bead **122** is formed integral with the top. The bead **122** is discontinuous only at the portion where the groove **120** extends through the bead. A filling aperture **124** is formed in the center of the top, with a wall **126** forming a part of a terminal portion adjacent to the groove **120**. An interior boss **128** is

formed on the interior surface of the top, surrounding aperture **124**. A sealing flange **130** is formed integral with the boss **128** and extends inwardly into the filling aperture.

The terminal plug **104** is a stamped brass hollow tin-plated plug, which includes an annular head **132**, with a hollow body **134** formed integral therewith. The hollow body includes a shank **136**, having one end formed integral with the annular head **132**. A seal face **138** is formed integral with one end of the shank. A hollow nose **140** is formed integral with the face **138**, and has a rounded end portion **142**.

A lead wire **144** is connected to the terminal plug by a connector **146**. The connector **146** includes a connector head **148** and a connector body **150**. The connector head has formed integral therewith a conventional gripping portion **152**. The connector body **150** has a conical connector shank **154**, with a locking face **156** formed integral therewith and a connector snout **158** formed integral with the face **156**.

The electrode **100** is assembled in much the same manner that electrode **10** is assembled. After the container **102** is filled with the electrolyte **110**, the terminal plug **104** is forced into the filling aperture **124**. The construction of the terminal plug is such that the exterior diameter of the nose **104** is less than the diameter of the filling aperture **124**, but greater than the interior diameter of the sealing flange **130**. As the terminal plug is forced into the container, the sealing flange is forced into the container and outward. Then, when the nose passes entirely through the sealing flange, the sealing flange engages the seal face **138** and tends to push the plug into the container. However, the annular head **132** engages the top **118** so that the terminal plug is held securely in place. It follows that there are two seals between the housing and the terminal plug. One seal exists between the sealing flange **130** and the seal face **138**. The second seal exists between the annular head **132** and the top **118**. The tin-plated nose **140** is immersed in the electrolyte to form a half cell.

The electrode **100** gives a low profile in that the electrode does not have its terminal plug extending upward and outward of the electrode. The connector **146**, which is electrically connected to the terminal plug, also provides a low profile. It may be appreciated that the connector **146** is connected to the terminal plug by inserting its connector body **150** into the terminal plug and snapping the connector body in so that the face **156** engages the interior of the seal face **136**, while the connector head **148** is in engagement with the annular head **132**. The gripping portion **152** and the lead **144** lie in the groove **120**, so that the overall height of the connector positioned in the electrode is not substantially higher than the electrode.

Other forms of connectors may be used with the electrode **100**, such as those shown in FIGS. **6** and **7**. A button connector **160** is shown connected to a lead **162**. The button connector has a conventional head **164**, with a plurality of spring legs **166** formed integral with the head. The lead **162** has a wire **168** soldered to the head **164**. The connector **160** is snapped into the terminal plug **104** by positioning the spring legs **166** into the opening of the terminal plug and pushing the button downward so that the spring legs engage the interior surface of the nose **140** to make contact. A solderless connector **170** is shown in FIG. **7**. The solderless connector has a head **172**, with an elongated ribbon portion **174** formed integral with the head. The ribbon portion has a pair of clamping arms **176** and **178** for engagement with the lead. The head **172** has a plurality of spring legs **180** formed integral therewith, which spring legs also fit into the aperture of the terminal connector. Whether connector **160** or **170** is mounted in electrode **100**, each provides a low profile.

Irrespective of which connector is used with the electrode **100**, the electrode operates in the same manner as the electrode **10**, which is described in detail above.

Another improved electrode construction is shown in FIGS. **8** and **9**. Only a portion of a top **200** of a container, with a terminal plug **202**, is shown therein inasmuch as the remainder of the electrode is identical to electrode **10**. The top **200** has a filling aperture **204**; and a boss **206** is formed integral with the top. Adjacent to the interior surface of the top, there is an annular tapered sealing flange **208** extending inwardly of the filling aperture. The terminal plug **202** includes a head **210** and a threaded body **212**. The head **210** includes a generally spherically shaped portion **216**, having a conventional tool recess **214**, for receipt of a tool (in this instance, an Allen wrench). Head **210** also includes a shoulder **218** formed integral with portion **216**, with a fillet **220** therebetween. A fillet **222** is formed at the junction of the shoulder and the threaded body. The terminal plug is, in this instance, made of tin-plated brass.

Terminal plug **202** is inserted into filling aperture **204** after the container has been filled with electrolyte. Terminal plug **202** is positioned in the filling aperture and then turned with an appropriate instrument positioned in recess **214** until the threads pass through sealing flange **208**. The plug is rotated until the bottom of shoulder **218** engages boss **206** and fillet **222** deforms the boss slightly so that there is a seal between the upper surface of the boss **206** and fillet **222**. The filling aperture is completely sealed by the sealing flange **208** engaging body **212** and by the engagement of fillet **222** with boss **206**. The operation of the electrode is the same as that described in connection with electrode **10**.

Although a specific embodiment of the present invention has been shown and described in detail above, it is readily apparent that those skilled in the art may make various modifications and changes in the specific disclosure without departing from the spirit and scope thereof. It is to be expressly understood that the instant invention is limited only by the appended claims.

What is claimed is:

**1**. A biomedical electrode for use on a subject for receiving electrical signals from said subject, comprising: a resilient container having an open side, a thin microporous diaphragm sealingly secured to the container closing said open side, an electrolyte in the container in contact with the diaphragm permeating the diaphragm to wet the outside surface of the diaphragm to have direct contact with the surface of a subject through the diaphragm between the surface and the electrolyte in the container, said container having a filling aperture, a resilient annular sealing flange formed integral with the container and extending inwardly to the filling aperture, and a terminal plug mounted in said filling aperture in sealing engagement with the annular sealing flange and having a portion in contact with the electrolyte to form a half cell therewith, said terminal plug locked in said filling aperture by said sealing flange, said terminal plug including a head extending

exteriorly of the container, and a body positioned in the filling aperture and in sealing engagement with the resilient annular sealing flange to seal closed the filling aperture.

2. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the terminal plug is elongated, said head defines a portion of a sphere and is adapted for connection to a lead for electrical connection to an instrument, and a shoulder is formed integral with said portion of a sphere; and said body includes a tapered shank having its wider portion formed integral with the shoulder, a seal face formed integral with the tapered shank adjacent to the narrower end of said tapered shank, said seal face being adapted for sealing engagement with the resilient annular sealing flange, and a nose formed integral with the seal face and being adapted for contact with the electrolyte, said nose having its free end rounded to facilitate insertion of the terminal plug through the annular sealing flange.

3. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 2 wherein the distance from the shoulder to the seal face is greater than the length of the filling aperture but less than the length of the filling aperture plus the width of the sealing flange, and said diameter of the tapered shank adjacent to the seal face is greater than the internal diameter of the annular sealing flange.

4. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the terminal plug is an elongated terminal plug, said head of the terminal plug is adapted for connection to a lead for electrical connection to an instrument, and said body includes a tapered shank having its wider portion adjacent to the head.

5. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 4 wherein the body has a seal face formed integral with the tapered shank adjacent to the narrower end of the tapered shank, said seal face is adapted for sealing engagement with the resilient annular sealing flange.

6. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the terminal plug has a connector receptacle for receipt of a connector to make electrical contact therewith.

7. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 6 wherein the container includes a radial terminal groove in the side spaced away from said open side for receipt of a lead.

8. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the head of the terminal plug is held in sealing engagement with the container to form a seal therebetween, thereby forming a secondary seal for the filling aperture.

9. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the terminal plug is an elongated terminal plug; said head of the terminal plug is adapted for connection to a lead for electrical connection to an instrument; and said body includes a tapered shank having its wider portion adjacent to the head, a seal face formed integral with the tapered shank adjacent to the narrower end of the tapered shank, said seal face being adapted for sealing engagement with the resilient annular sealing flange, and an elongated nose formed integral with the seal face and being adapted for contacting the electrolyte.

10. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the head is solid and has a rounded exterior, said body is threaded over a portion of its length for threaded sealing engagement with the resilient annular sealing flange to seal closed the filling aperture, and the head sealingly engages the container to form a secondary seal therewith for the filling aperture.

11. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the annular sealing flange is tapered and has its thinner portion adjacent to the interior thereof, and said body is threaded for threaded sealing engagement with the annular sealing flange.

12. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the annular sealing flange is tapered and having its thinnest portion adjacent to the interior thereof, said head is solid and has a rounded exterior surface, said head includes a tool recess in its surface spaced away from the body for receipt of a tool for rotating said plug, and said body is threaded over a portion of its length for threaded sealing engagement with the resilient annular sealing flange to seal closed the filling aperture.

13. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the container includes a radial terminal groove in the side spaced away from the open side for receipt of a lead, said terminal plug has a connector receptacle for receipt of a connector to make electrical contact therewith, a flat head connector mounted in the connector receptacle, and a lead electrically connected to the connector and having a portion lying in the radial terminal groove to provide a low profile for the biomedical electrode.

14. A biomedical electrode for use on a subject for receiving electrical signals from said subject as defined in claim 1 wherein the container includes a radial terminal groove in the side spaced away from the open side for receipt of a lead; said terminal plug has a connector receptacle for receipt of a connector to make electrical contact therewith; said head of the terminal plug is flat and adapted for engagement with the container; said terminal plug body includes a tapered shank having its wider portion adjacent to the head, a seal face formed integral with the tapered shank adjacent to the narrower end of the tapered shank, said seal face being adapted for sealing engagement with the resilient annular sealing flange, and an elongated nose formed integral with the sealing face and adapted for contacting the electrolyte; a flat head connector mounted in the connector receptacle; and a lead electrically connected to the connector and having a portion lying in the radial terminal groove to provide a low profile for the biomedical electrode.

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