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EROSION RESISTANT REFERENCE ELECTRODE ASSEMBLY

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This invention relates in general to a reference electrode assembly, and, in particular, to an erosion-resistant shield for a reference electrode of the class of electrodes that are easily eroded by immersion in a violently agitated liquid material, an example of such electrodes being the silver-silver chloride electrode.

The inhibiting of corrosion in liquid-containing vessels has become an important phase of electrochemistry. In many types of systems, corrosion can be effectively inhibited by the application of a positive control potential to the vessel wall and its corresponding negative voltage to an inert electrode maintained within the vessel. In order to continuously monitor the potential of the vessel, a reference electrode of substantially constant potential is immersed in, or placed in electrical communication with, the solution. The difference potential developed between the reference electrode and the vessel is monitored by an electronic controller and compared to a standard voltage. Any deviation between the difference potential and the standard voltage causes the controller to apply or alter current passing between the inert electrode within the solution and the vessel wall. The electrochemistry involved in anodic passivation, however, often requires that the potential of the vessel wall with respect to the reference electrode be maintained within very narrow limits. If the difference potential should wander from such limits, corrosion can result, thereby causing severe damage to, or destruction of, the vessel within a relatively short period of time. In order to maintain the necessary degree of vessel potential control, it is essential that the reference electrode employed be very reliable in the sense that it maintains its constant potential over extended periods of exposure to the corrosive solution.

In storage tanks, the reference electrode is seldom subject to violent agitation of the solution contained in the tank. The most severe agitation in this case results when the solution is either being placed within, or removed from, the tank. In process vessels, on the other hand, the vessels are often filled with a plurality of reactant solutions which must be violently agitated in order to achieve intimate contact therebetween. Such agitation can result from corrosive solution flowing into the tank in a violent manner, or it can result from mechanical stirring devices within the tank causing the solution to be violently moved. The agitation of the liquids contained in such process tanks frequently soon causes erosion of the reference electrode with a resultant decrease in its reliability.

The most common reference electrode and the one currently being most employed in the anodic passivation systems above described is formed by coating a silver rod with a heavy coating of silver chloride. The coating may, for example, be $\frac{3}{4}$ -inch thick. While silver chloride is inherently a relatively stable compound, it cannot withstand violent fluid agitation impinging upon its surface for any great length of time without beginning to erode. Several reference electrode systems have been tried and found somewhat effective in resisting erosion, but did not offer a complete solution to the problem. Such systems, for example, are electrochemical bridges wherein a weeping glass bridge is inserted within the solution and the reference electrode is mounted outside the vessel and communicates electrically with the vessel solution through

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the bridge. Such a system is described in our co-pending application Serial No. 797,986, filed March 9, 1959, now U.S. Patent No. 3,126,328, and divisional application Serial No. 126,204, filed July 24, 1961, now U.S. Patent No. 3,152,058, both entitled, "Electrolytic Bridge Assembly for the Anodic Passivation of Metals." In these cases a reference electrode is immersed in a reservoir containing a saturated solution of KCl with solid crystals of KCl in the reservoir. A conduit communicating with the KCl solution passes from the reservoir and into the solution within the vessel. At the end of the conduit is mounted a weeping glass bridge. This type of reference electrode assembly functions quite satisfactorily in systems where there is not a wide variation in pressure, or where the tank is not completely full. However, under adverse conditions, it becomes difficult to maintain the communicating orifice of the weeping glass bridge free of obstruction. Moreover, the assembly is very delicate in nature and is subject to breakage. Further, rapid variations in pressure may render the device inoperable by permitting corrosive solution to be forced up the conduit, disrupting the normal operation of the bridge. Further, the bridge may become difficult to seal, and as a whole, is rather expensive to maintain in operation.

For the above reasons, the solid reference electrode directly immersed in the corrosive solution is actually more satisfactory than the electrolytic bridge assembly, since it is not subject to contamination, is easy to seal and is very stable despite wide fluctuations in pressure, temperature and solution.

As indicated, however, solid reference electrodes are frequently eroded to a detrimental degree when immersed in a vigorously agitated corrosive solution, and attempts have been made to shield the electrodes from the erosive influence of such solutions by encasing them in a container of inert material. A portion of the container is made porous so that the solution may electrically contact the electrode. Despite some improvement in the problem of erosion afforded by this shielding technique, such shielded systems soon begin to function defectively due to the accumulation of gas in the pores formed in the container to permit electrical communication to be established between the electrode and the solution. This gas accumulation acts as an electrically insulating barrier.

Therefore, it is an object of this invention to provide a method for shielding a solid reference electrode which is immersed in a corrosive electrolyte so that it will not become eroded by the electrolyte when the electrolyte is agitated.

It is a further object of this invention to protectively shield a reference electrode without inhibiting the establishment of electrical communication between the electrode and an agitated corrosive electrolyte with which it is in contact.

It is a still further object of this invention to provide a method for removing air bubbles or gases that would otherwise tend to obstruct electrical communication between a shielded reference electrode and a corrosive solution in which such electrode is immersed.

In accordance with this invention, a reference electrode is surrounded by a hollow, inert shield. An aperture is provided in the top of the inert shield having a slightly smaller diameter than the conductor rod or lead which is connected to the reference electrode. Surrounding the aperture on the inside of the shield is a generally conical gasket. The gasket functions in a manner hereinafter described to provide a tight seal around the conductor rod. A shoulder is formed in the bottom of the shield substantially even with the bottom of the electrode. A porous disc or frit is placed against the shoulder across the bottom of the electrode and a collar is threaded into the lower end of the shield and bears against the bottom

of the porous disc. A plurality of vents are formed through the shield to intersect the periphery of the porous disc so that any gas or air trapped in the porous disc, or in the space between the porous disc and the bottom of the electrode will escape, thus permitting the solution in the vessel to flow through the porous disc and come in contact with the reference electrode.

Other objects, features and advantages of the invention will become apparent from the following description and claims when read in view of the accompanying drawings, in which:

FIGURE 1 is a cross-sectional schematic view of a process tank which has an anodic corrosion control system connected thereon;

FIGURE 2 is a cross-sectional view of a reference electrode provided with an erosion resistant shield in accordance with the teachings of this invention; and

FIGURE 3 is a cross-sectional view of another embodiment of this invention.

Similar numbers will be used throughout all figures where common structural elements are shown.

Referring to the figures in general, and particularly to FIGURE 1, reference character 10 refers to a process tank containing a corrosive electrolyte solution 12 and provided with an inlet pipe 14 and an outlet pipe 16. Mounted through the bottom 18 of tank 10 is an inert electrode 20 which has insulating material 22 electrically isolating it from tank 10. A conductor rod 24 extends from the inert electrode 20 and connects through a wire 26 to a switch 28. The other side of the switch 28 is connected to a power source 30 which may be, for example, a D.C. rectifier. Power source 30 is supplied through lines 32 which may be connected to a source of alternating current or to direct current.

Mounted through the top 34 of tank 10, and insulated therefrom by insulation 38, is a reference electrode 36. Reference electrode 36 is electrically connected through a wire 40 to a controller 42. A source of standard voltage 44 which may be a standard cell or mercury-type battery is likewise connected to controller 42 and provides a reference voltage with which the voltage developed between the reference cell 36 and the vessel 10 may be continuously compared. The remaining terminal of the power source 30 is connected through a wire 46 to the tank 10 and to controller 42. In order to insure that the solution 12 within process vessel 10 is continuously mixed, a motor 48 which is connected to any suitable source of power (not shown) through wires 41 is mounted on tank 10 and has its shaft 50 extending through the wall thereof. A plurality of paddles 52 are attached to shaft 50.

The anodic passivation system shown in FIGURE 1 is fully described in applications Serial Numbers 1,135 and 1,136, both of which were filed on January 7, 1960, now respectively U.S. Patents Nos. 3,127,337 and 3,208,925, assigned to the assignee of the present invention and entitled, "Anodic Passivation System." Briefly, the system operates as follows. Reference electrode 36 functions as a half-cell. Vessel 10 functions as another half-cell which is electrochemically connected to reference electrode 36 by the solution. Since the potential of reference electrode 30 is at all times constant, variations in the potential of vessel 10 will result in variations of the difference potential or voltage developed between the vessel and the reference electrode 36. Since the condition of the passive surface protecting the inner wall of vessel 10 can be related to the difference potential, the measurement of this potential provides an accurate measure of the state of passivation of the vessel.

The difference potential is applied to the controller 42 which compares the difference potential with the standard voltage 44 within the controller. Any deviation between the difference potential and standard voltage 44 will cause the controller 42 to generate an error signal.

The controller will then utilize the error signal to operate a mechanical linkage 54 which, in turn, will open or close switch 28. For example, if the voltage measured between wires 40 and 46 exceeds the voltage of standard voltage source 44, switch 28 will open, removing the supply of voltage from the inert electrode 20. Degeneration of the passive surface will cause the potential of the vessel to shift. As the potential reaches a predetermined low voltage, as measured between the wires 40 and 46, the controller 42 will again, through the mechanical linkage 54, close the switch 28. It should be understood, of course, that while a switch is illustrated in this application for simplicity, other types of control could be used which would function in a continuous or proportional-type operation.

As has been previously explained, in anodic passivation systems of the type illustrated in FIGURE 1, the reference electrode 36 is frequently eroded to a detrimental degree in systems in which the corrosive solution 12 is vigorously agitated. It is proposed by the present invention to provide a novel reference electrode assembly which may be utilized in the systems of the type shown in FIGURE 1 without the disadvantage which is posed by severe erosion of the electrode. One embodiment of such an erosion resistant electrode assembly is illustrated in FIGURE 2 of the drawings. In this figure, reference character 60 designates a generally cylindrical, solid electrode of sufficient potential stability and constancy to permit its use as a reference electrode of the type hereinbefore described. A typical solid electrode of this type is the silver-silver chloride electrode.

The solid electrode 60 may be formed integrally with, or otherwise suitably secured to an electrically conductive rod 62 of the same or different material as that of which the electrode 60 is fabricated. The rod 62 facilitates the incorporation of the reference electrode 60 in the corrosion control system illustrated in FIGURE 1 by permitting the electrode to be attached to a wire or lead, such as that represented by reference character 40 in FIGURE 1. Surrounding the solid reference electrode 60 is a generally tubular shield or housing 64. The material of construction of the shield or housing 64 is preferably chemically inert with respect to the corrosive solution and is resistant to erosion and corrosion by the solution in which the reference electrode assembly is to be immersed. Further, the material of construction of shield 64 must be electrically non-conductive or properly insulated from the reference electrode 60 and conductive rod 62. A material of construction which is preferably employed is a polyhalohydrocarbon plastic, such as those sold under the tradenames Teflon and Kel-F.

As will be perceived by reference to FIGURE 2, the upper end or top 66 of the generally tubular shield 64 is provided with an aperture or opening 68 therethrough for the accommodation of the rod 62, and in the illustrated embodiment of the invention, may be provided with an upwardly extending, externally threaded neck 70 to facilitate the securement of the reference electrode assembly to a mounting pipe 71, or to the top of a tank (not shown) containing the corrosive solution in which the electrode is to be immersed. A sealing member 72 of inverted, generally conical configuration is positioned around the conductive rod 62 and is positioned in a mating conically-shaped opening formed in the upper end 66 of the tubular shield 64. It will be noted that the lower portion 74 of the conically shaped sealing member 72 projects below the internal wall of the upper end 66 of the tubular shield 64 so that compression of the sealing member 72 into sealing engagement with the rod 62 may be effected. The lower end of rod 62 carries a plurality of threads 75. A washer 77 and a nut 79 are inserted over rod 62 and nut 79 tightened in the usual manner.

The generally tubular shield **64** is open at its lower end **76** and is provided at the lower end with a counterbore **78** of enlarged diameter which terminates at a downwardly-facing, circumferentially extending shoulder **80** formed in the internal wall of the shield **64**. The shoulder **80** is spaced from the upper end **66** of the shield **64** by a distance which is slightly greater than the length of the solid electrode **60** which is positioned inside the shield. A series of vent passageways **82** extend inwardly and downwardly from the outer surface of the shield **64** (when the electrode is in mounted position) to a point on the inner surface thereof which intersects the circumferential shoulder **80**.

A porous disc **84** which is preferably constructed of glass frit, or other inert porous material, is positioned in the enlarged counterbore **78** of the shield **64** and is diametrically dimensioned to bear against the shoulder **80** when a retaining nut **86** or other suitable securing means is utilized to bias the porous disc **84** upwardly in the shield **64**. In the embodiment of the invention illustrated in FIGURE 2, the counterbore **78** at the lower end **76** of the shield **64** carries threads which mate with the external threads of a generally cylindrical retaining nut **86**. The retaining nut **86** is preferably constructed of the same material as the shield **64**, although any erosion and corrosion resistant material may be employed.

In order to vent the tubular shield **64** and permit the corrosive electrolyte solution to rise therein in the manner hereinafter described, a small passageway **87** is formed through the upper end **66** of the shield and communicates with a larger counterbore **89** opening into the interior of the shield. Positioned in the counterbore **89** is a porous plug **91** which may suitably be constructed of the same material as the porous disc **84** located at the lower end of the shield **64**. The porous plug **91** is dimensioned to protrude from the counterbore **89** and bear against the reference electrode **60** so as to assure its retention in the counterbore.

In assembling and using the reference electrode assembly shown in FIGURE 2, the solid reference electrode **60** is first placed inside the generally tubular shield **64** with the conductor rod **62** passing through the conical washer **74** and through the aperture **68** in the top **66** of the shield. When the top of the electrode **60** has been brought into contact with the lower end **74** of the conical sealing member **72**, the washer **77** and nut **79** are placed over the conductor rod and the nut tightened until the conical washer makes a tight seal with the housing **64**. The porous disc **84** of glass frit is next positioned across the bottom of the electrode **60** and the retaining nut **86** threaded into place at the lower end **76** of the shield **64**.

After the reference electrode assembly has been assembled in the described manner, it is secured to the top of the vessel in which it is to be used by means of the threaded neck **70** or by pipe **71** (which is normally used to extend the reference electrode farther into the solution) or by other suitable means. The corrosive solution within the vessel is then free to communicate with the electrode **60** through the pores of the glass frit **84**. Upon prolonged usage of the reference electrode assembly, there would, but for the provision of the vent passageway **82**, develop an accumulation of gas within the pores of the porous disc **84** of sufficient magnitude and stability to constitute a barrier which would prevent the corrosive solution from contacting the electrode **60** through the pores of the disc. The vent passageways **82**, however, permit such accumulated gas to escape from the pores of the disc **84** and thus prevent the development of the described barrier. The location of the vent hole, however, is critical for the following reasons: (a) the pores **82** must be drilled so that gases can escape after the electrode is mounted and in use; and (b) they must contact both the top surface and the side of the porous disc **84** but must not create a passageway to the reference

electrode directly. If the end of the hole contacts the sides and not the top of the disc, all the gases will not escape, thereby rendering the electrode inoperative after a period of time.

Another modification of the electrode assembly of the present invention is illustrated in FIGURE 3 of the drawings. It will have become apparent from the description of the invention to this point that the basic assembly which has been described offers advantages with respect to the mounting of a liquid reference electrode in direct contact with the corrosive solution contained within a vessel to be protected, as well as in the case of solid electrodes of the silver-silver chloride type. The reference electrode depicted in FIGURE 3 therefore portrays the manner in which the reference electrode assembly of the present invention may be adapted to the inclusion of a liquid electrode therein. The electrode in this case constitutes a mercury-mercury sulfate electrode which may be effectively used in a vessel containing sulfuric acid or other corrosive electrolyte of analogous chemical character. The mercury sulfate paste is represented in FIGURE 3 by reference character **90**. The liquid mercury metal of the electrode is represented by reference character **92**, and, in general, will stand above the mercury sulfate paste **90** when both are positioned within the bore **94** of a generally tubular shield **96** of an inert material, such as Teflon.

In the embodiment of the invention illustrated in FIGURE 3, the porous disc **98** which is positioned at the lower end **99** of the tubular shield **96** is retained in abutting contact with the lower end of the shield by an internally threaded nut **100** which engages external threads on the lower end portion of the shield. A plurality of gas venting passageways **102** extend through the retaining nut **100** and terminate with their inner ends in juxtaposition to the porous disc **98**. It will be observed that, as in the case of the embodiment of the invention illustrated in FIGURE 2, the passageways **102** are angled to facilitate the escape of gas from the pores of the disc **98** and must contact the disc **98** in the same manner as the vents **28** contact disc **84** in FIGURE 2. At its upper end **104**, the tubular shield **96** is externally threaded for engagement with a metallic block **106**. The metallic block **106** in turn carries external threads **108** which permit it to be threadedly engaged with the top of the solution containing tank in which the electrode assembly is to be utilized.

In order to permit the mercury-mercury sulfate electrode to be connected in electrical circuitry of the general type illustrated in FIGURE 1 of the drawings, a suitable electrically conductive wire or lead **110**, such as a stainless steel wire, is passed through an opening **112** in the metallic block **106** and through a relatively small counterbore **114** formed in the upper end of the generally tubular shield **96**. The lower end of the wire **110** is immersed in the liquid mercury **92**.

For the purpose of providing a tight seal around the electrically conductive lead **110**, a sealing sleeve **116** of insulating material is provided around the lead **110** and inside the opening or aperture **112**. At the lower end of the opening **112** in the metallic block **106**, a generally frusto-conical opening **114** is provided in the block and forms a seat for the upper end of a resilient sealing member **118** of generally hexagonal cross-sectional configuration. The lower end of the sealing member **118** is positioned in a generally frusto-conical depression **120** which is formed in the upper end **104** of the tubular shield **96** so that, when the shield is threaded upwardly into the metallic block **106**, the sealing member **118** is compressed into the opening **114** and around the periphery of the lead **110** to form a tight seal preventing the ingress of corrosive solution or other deleterious substances to the interior of the reference electrode assembly.

With the mercury-mercury sulfate electrode assembly assembled in the operative position shown in FIGURE 3, the porous disc 98 functions in the same manner as the porous disc shown in the embodiment of the invention illustrated in FIGURE 2, and the gas vent passageways 102 function to prevent the disc from becoming clogged or obstructed by the accumulation of gas in the pores thereof.

From the foregoing description of the invention, it will be appreciated that an improved reference electrode assembly for use in anodic passivation control systems is provided by the present invention. Although the reference electrode assembly has been described, by way of example, as it is employed in combination with a system for controlling vessel corrosion by anodic passivation, those skilled in the art will appreciate that a number of other uses may be made of electrode assemblies of the described type, and that the assembly's manifest advantages and benefits are not limited to the exemplary uses hereinbefore described.

In view of the fact that minor modifications and innovations in the reference electrode assembly of the invention may obviously be made without departure from the novel concepts and principles underlying the invention, we wish it understood that such modifications and innovations are deemed to be circumscribed by the spirit and scope of the present invention except as the same may be necessarily limited by the language of the appended claims or reasonable equivalents thereof.

We claim:

1. A shield for protecting a reference electrode from the erosive influence of an agitated liquid in which said electrode is immersed comprising:

- (a) a reference electrode;
- (b) a tubular container dimensioned to closely surround said electrode and having an open lower end and a closed upper end, said closed upper end having an aperture therein facilitating passage therethrough of an electrical lead connected to said electrode;
- (c) a liquid permeable member sealingly positioned across the open lower end of said tubular container for supporting the reference electrode in said tubular container; and
- (d) passage means extending outwardly through the wall of said tubular container and only communicating with the periphery of said liquid permeable member to permit gas to escape from said permeable member when said electrode is in operational position.

2. A shield for protecting a reference electrode as claimed in claim 1 wherein said liquid permeable member is a porous glass disc.

3. An erosion resistant reference electrode assembly comprising:

- (a) a reference electrode characterized by a substantially constant potential with respect to a corrosive electrolyte in which said electrode is to be immersed;
- (b) an electrically nonconductive tubular shield encasing said electrode, said shield being open at one of its ends and closed at its other end, said closed end having an aperture therethrough;
- (c) an electrically conductive lead connected to said electrode and extending through the aperture in the closed end of said shield;
- (d) means for sealing said electrode conductive lead from said corrosive solution;
- (e) a liquid permeable member sealingly positioned across the open end of said tubular shield for electrical communication of said electrode with said corrosive electrolyte; and
- (f) gas passage means extending outwardly through the wall of said tubular container and communicating only with the periphery of said liquid permeable

member to permit gas to escape from said permeable member when said electrode assembly is in operational position.

4. A reference electrode assembly as claimed in claim 3 wherein said reference electrode is a silver-silver chloride electrode.

5. In an anodic passivation corrosion control system including a vessel to be protected from corrosion by a corrosive solution therein, an inert electrode, a source of direct current connected to said vessel and said inert electrode to make the vessel the anode and the inert electrode the cathode in an electrical circuit, and means for controlling the passage of current from said vessel to said inert electrode, the improvement in said controlling means which comprises protective tubular shield means immersed in said corrosive solution, said shield means having a porous portion which is permeable to said corrosive solution; a reference electrode in said tubular shield means and bearing against the porous portion thereof; and gas venting means extending outwardly through the wall of said shield and communicating only with the periphery of said porous portion for venting gas accumulating in the pores of said porous portion.

6. An erosion resistant shield for a reference electrode comprising:

- (a) a reference electrode;
- (b) a cylindrical container having an upper end and a lower end, the internal diameter of said cylindrical container being larger at its lower end and abruptly narrowing at a point intermediate the ends of said container to form a shoulder such that the distance between said upper end and said shoulder is equal to or greater than the length of said electrode;
- (c) a glass frit having a diameter greater than the smaller internal diameter of said shoulder;
- (d) means for retaining said glass frit against said shoulder; and
- (e) air passage means extending downwardly and inwardly through said container from the outer wall of said container and communicating only with the periphery of said glass frit to permit trapped gases to escape from said glass frit when said electrode is in operational position in said container.

7. An erosion resistant reference electrode assembly comprising:

- (a) an inert cylindrical container having a top and bottom, said top including means for mounting said assembly in a tank containing a corrosive solution, and said top having an axial opening therethrough;
- (b) a downwardly-facing, circumferential shoulder intermediate the bottom and top of the internal wall of said container;
- (c) an inert porous disc having a diameter larger than the internal edge of said shoulder;
- (d) means for retaining said inert porous disc against said shoulder;
- (e) a reference electrode having a conductor rod axially extending from one end thereof through the opening in the top of said container;
- (f) sealing means surrounding said opening on the inside of said container; and
- (g) gas passage means extending outwardly through the wall of said container and only communicating with the periphery of said inert porous disc, said gas passage means extending in a direction such that trapped gas in and around said porous disc will escape when said assembly is in operational position.

8. An erosion resistant reference electrode assembly comprising:

- (a) a generally cylindrical reference electrode having an axial conductor extending from one end thereof;
- (b) inert cylindrical shield means adapted to receive said electrode, said shield means having a top which includes an opening to receive said electrode conductor and sealing means surrounding said conductor

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- between the inside of said top and said electrode end;
- (c) a porous disc covering the remaining end of said cylindrical electrode;
- (d) means for sealingly retaining said porous disc over the remaining end of said electrode; and
- (e) gas passageways extending through the wall of said cylindrical shield and only communicating with the periphery of said porous disc, whereby gases trapped in said porous disc and between said porous disc and the remaining end of said electrode will escape, thereby permitting said electrode to communicate with its environment through said porous disc.
9. An erosion resistant electrode assembly adapted to be immersed in a conductive solution comprising:
- (a) a reference electrode having a conductor extending therefrom;
- (b) inert material surrounding said electrode and having a first opening adapted to pass said conductor therethrough and a second opening opposite said first opening;
- (c) means around said conductor sealing said first opening against said conductive solution;
- (d) inert porous means sealingly covering said second opening; and
- (e) gas passage means extending outwardly through the wall of said inert material surrounding said electrode and only communicating with the periph-

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ery of said inert porous means, whereby gases trapped between said inert porous means and said electrode and gases trapped in said porous disc may escape through said gas passage means thereby allowing said conductive solution to communicate with said electrode through said inert porous means.

10. A reference electrode assembly as claimed in claim 3 wherein said reference electrode is a mercury-mercurous sulfate electrode.

References Cited by the Examiner

UNITED STATES PATENTS

1,201,481	10/1916	McGall et al.	136—132
2,288,180	6/1942	Brengman et al.	204—195
2,672,441	3/1954	White	204—195
2,684,938	7/1954	Mantzell	204—195
2,934,484	4/1960	Anderson	204—195
2,978,400	4/1961	Sabins	204—195

FOREIGN PATENTS

888,767	2/1962	Great Britain.
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OTHER REFERENCES

Ives et al.: "Reference Electrode" (1971), pp. 403—406, 582 and 583.

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