Aug. 13, 1974 L. P. CAWLEY 3,829,375

ELECTROLYTIC CELL MEANS

Filed Nov. 2, 1973 2 Sheets-Sheet 1

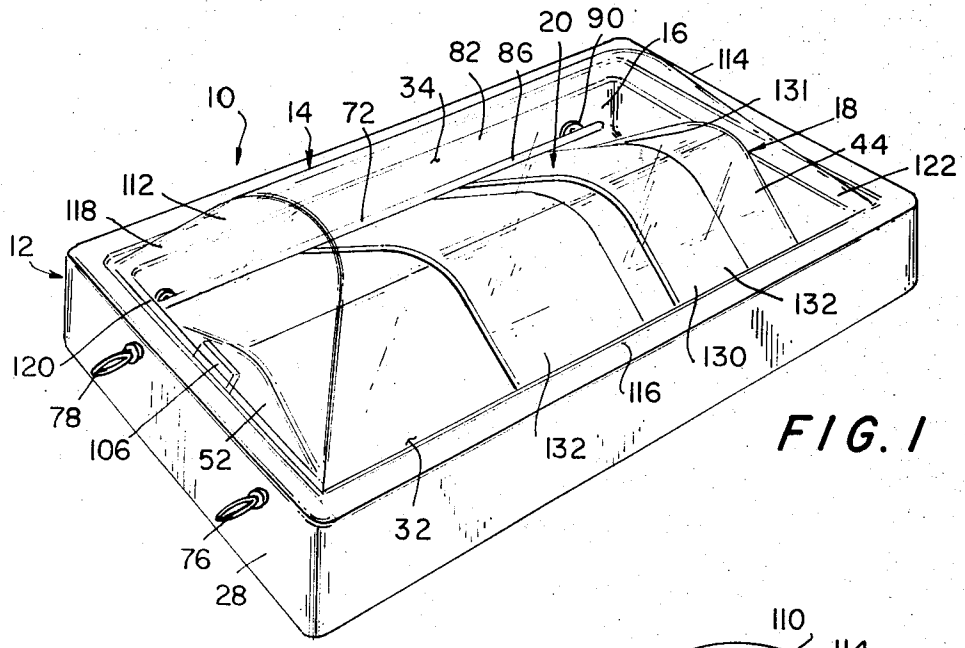


FIG. 1

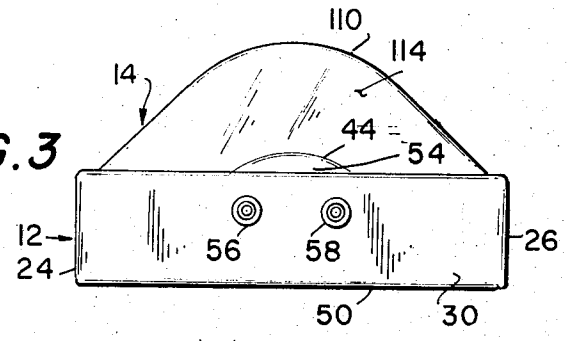


FIG. 3

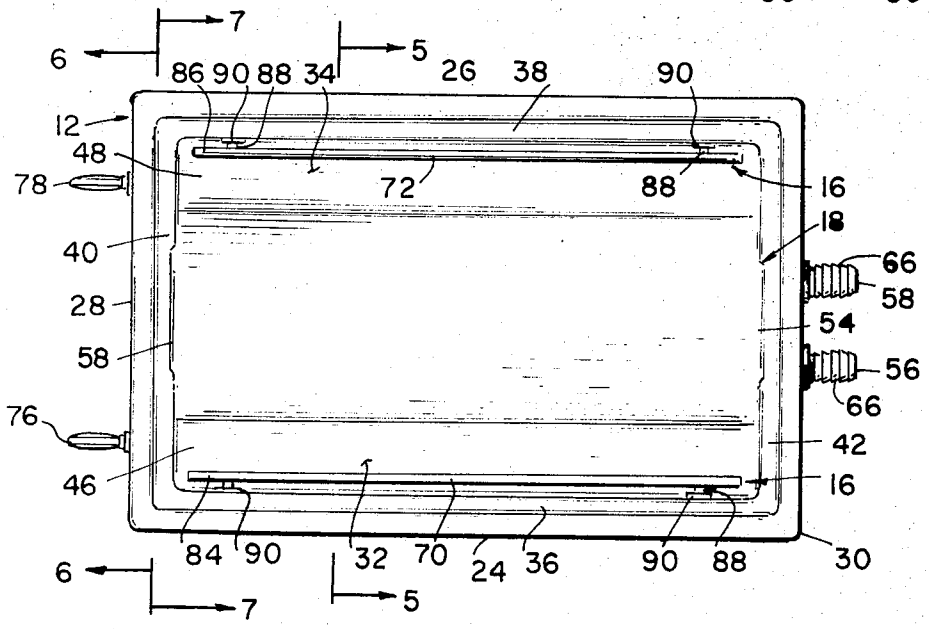


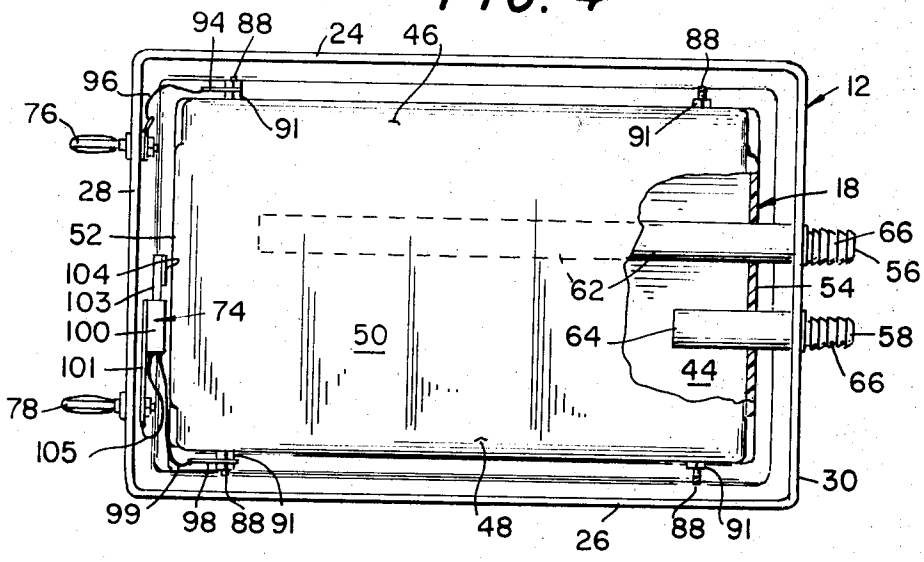
FIG. 2

ELECTROLYTIC CELL MEANS

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FIG. 4



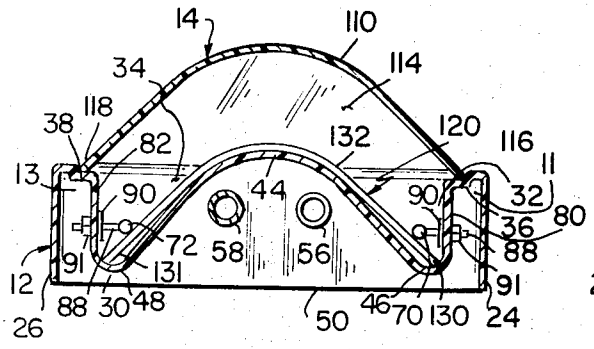


FIG. 5

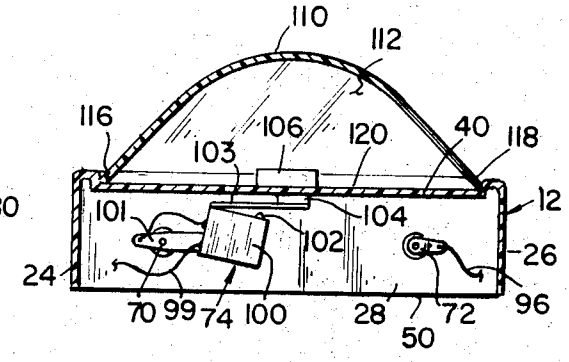


FIG. 6

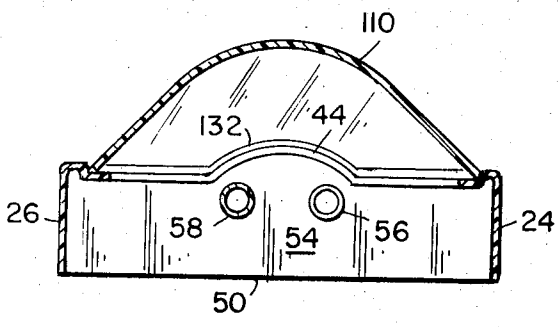


FIG. 7

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ELECTROLYTIC CELL MEANS

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Continuation-in-part of application Ser. No. 297,638, Oct. 16, 1972, now Patent No. 3,798,152. This application Nov. 2, 1973, Ser. No. 412,631

Int. Cl. B01k 5/00

U.S. Cl. 204—299 7 Claims

ABSTRACT OF THE DISCLOSURE

An electrolytic cell means for immunodiffusion comprising a tray with a bottom, a first side having a first annulus therein, a second side including a second annulus therein, and a pair of ends. An enclosed heat transfer fluid reservoir is integrally bound to the sides and has an inlet and an outlet for circulating a heat transfer fluid therethrough. The enclosed reservoir additionally has an essentially parabolic shaped roof connected to the sides, and a pair of ends attached to the bottom, sides, and to the roof. The annuli are in communication with the roof and the inlet and the outlet. The parabolic shaped roof has a first sloping portion and a second sloping portion. The first side and the first sloping portion define a trough which has an electrode secured therein, and the second side and the second sloping portion define another trough which has another electrode secured therein which is oppositely charged from the other electrode. An electrical source is connected to the two electrodes.

BACKGROUND OF THE INVENTION

This is a continuation-in-part application of my copending application Ser. No. 297,638, filed Oct. 16, 1972, now U.S. Pat. No. 3,798,152.

1. Field of the Invention

This invention is related to an electrolytic cell. More specifically, this invention provides an electrolytic cell which is to be used in the field of electrophoresis and immunoelectrophoresis, and the like.

2. Description of the Prior Art

Numerous types of electrolytic cells are known in the prior art as operable in immunoelectrophoresis work for the passing of an electric current through a flexible gel coated slide. Some of the prior art devices utilize a closable container with the flexible slide having the opposite ends thereof supported in separate ionizing solutions wherein an electric current is passed into the ionizing solutions and in turn through the slide's coating. Other electrophoresis devices utilize ionizing solutions into two separate portions of a container with the ionizing solutions held in absorbent material blocks on which the slide specimen rests wherein the electric current is passed through the solution held in the blocks and through specimen or slide and its coating. Generally, the electrophoresis devices in the prior art have no means for cooling or heating the apparatus and/or the specimen slide to maintain a constant temperature. Electrophoresis devices which do have cooling or heating capacity are constructed specifically to heat or cool a block like portion of gel material rather than a slide like specimen with a gel coating thereon.

In my previously mentioned co-pending application, I invented an electrolytic cell which comprised a tray with a bottom, a pair of sides and ends, and an enclosed heat transfer fluid reservoir having an inlet and an outlet integrally bound to the sides. The enclosed reservoir included a base and an essentially parabolic shaped roof connected to the base. The sides of the tray each had an enclosed elongated annulus therein which had no communication with the roof and the inlet and the outlet of the enclosed reservoir. The purpose of this invention was to provide an electrolytic cell structure including an enclosed heat transfer fluid reservoir that was capable of being maintained at a substantially constant temperature by passing a fluid therethrough while simultaneously being superimposed by a conductive gel which had a structure defined by a pliable elongated strip with an electrolytic environment situated on the exterior thereof. Since this invention I have discovered that the aforementioned purpose was better attained by expanding the enclosed heat transfer fluid reservoir such that the annulus of each of the tray sides is in communication with the parabolic shaped roof and the inlet and the outlet of the reservoir. Therefore, what is needed and what has been invented by me is an electrolytic cell structure for immunodiffusion which does not include the previously mentioned disadvantages of the prior art, and is an improvement over my invention disclosed in my aforementioned co-pending application.

SUMMARY OF THE INVENTION

The present invention accomplishes its desired objects by broadly providing an electrolytic cell means for immunodiffusion comprising a tray with a bottom, a first side connected to the bottom and having a first annulus therein, a second side attached to the bottom and including a second annulus therein, and a pair of ends attached to the sides and to the bottom. An enclosed heat transfer fluid reservoir is integrally bound to the first and to the second sides and includes an inlet and an outlet for circulating a heat transfer fluid therethrough. The enclosed reservoir additionally includes an essentially parabolic shaped roof connected to the sides and a second pair of ends attached to the sides, to the bottom, and to the roof. The first and second annuli are in communication with the roof and with the inlet and the outlet. The parabolic shaped roof has a first sloping portion and a second sloping portion. The first side and the first sloping portion and the second side and the second sloping portion define a first trough and a second trough, respectively. A first electrode and a second electrode are respectively secured within the first and second troughs. An electrical source is connected to the first electrode and to the second electrode which is oppositely charged from the first electrode.

It is therefore an object of the invention to provide an electrolytic cell structure for immunodiffusion overcoming the aforementioned disadvantages of the prior devices.

It is another object of the invention to provide an electrolytic cell structure having a means to regulate the temperature of the cell structure and particularly of a conductive gel specimen held in the cell structure during the operation thereof by passing a fluid through a cavity in the cell structure.

It is still another object of the invention to provide an electrolytic cell structure which is adapted to receive and hold in a fixed position conductive gel specimen slides while the slides are positioned in contact with electrodes and in contact with a portion of the cell adjacent to a cavity of the cell which is used as a heat source or heat sink.

It is still yet another object of the invention to provide an electrolytic cell structure which in operation is maintained at a substantially constant temperature by passing a fluid through a cavity portion of the structure while simultaneously having a conductive gel and placed therein for purposes of electrophoresis, immunoelectrophoresis, immunodiffusion, electroimmunodiffusion, and other like purposes.

These, together with various ancillary objects and features which will become apparent as the following descrip-

tion proceeds are obtained by this novel electrolytic cell, a preferred embodiment being shown in the accompanying drawings, by way of example only, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the electrolytic cell taken from above the end with the electrical connections, and having the cover in place and two slide specimens of conductive gel mounted in the cell;

FIG. 2 is a top plan view of the cell structure alone with the cover removed;

FIG. 3 is an end elevation view of the electrolytic cell structure taken from the end having the fluid conduits and with the cover in place;

FIG. 4 is a bottom plan view of the electrolytic cell structure having portions of the cavity cut away for clarity;

FIG. 5 is a vertical sectional view of the electrolytic cell structure taken along the line 5—5 in FIG. 2;

FIG. 6 is a vertical sectional view of the electrolytic cell structure taken along the line 6—6 in FIG. 2 showing the magnetically operable switch means; and

FIG. 7 is a vertical sectional view of the electrolytic cell structure taken along the line 7—7 in FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

Referring in detail now to the drawings, wherein similar parts of the invention are identified by like reference numerals, an electrolytic cell structure, generally indicated as **10**, includes a tray portion **12** with a cover **14** positioned over an open portion of the tray **12** that has an oppositely chargeable electrode means **16** in its side portions and an internal cavity portion **18** in the center portion of the tray. As shown in FIG. 1 the electrolytic cell **10** is adapted to mount a plurality of conductive gel slide specimens **20**. Such slide specimens are used in immunoelectrophoresis work and are flexible plastic members with a conductive gel coating. The conductive gel slide specimens **20** are positioned to be in contact with the electrode means **16** on their end portions or in contact with an electrolyte which is in contact with the electrode means **16** and also in contact with the cavity portion **18**. As it is shown the electrolytic cell **10** with a cover **14** in place on the tray **12** is ready for operation once an electrical source has been conected with the electrode means **18** to oppositely charge them and a fluid source connected with the cavity means **18** as will be described hereinafter.

The tray portion **12** of the electrolytic cell **10** is preferably an integrally formed structure and has a cavity portion **18** integrally constructed generally in the center portion thereof. As shown in the drawings the tray **12** is in its preferred form, namely an elongated rectangular structure. The tray portion **12** has a bottom **50** and elongated sidewalls **24** and **26** integrally joined with end walls **28** and **30** and has the interior thereof formed into two trough portions indicated generally at **32** and **34** extending in the elongated direction thereof which are used to contain the electrolyte. Sidewalls **24** and **26** have annuli **11** and **13** therein, respectively. The interior of the tray portion **12** in its cross-sectional shape is shown in FIG. 5 and shown from the top or open portion thereof in FIG. 2. The upper portion of the tray portion **12** is preferably open for access to its interior and is closable by the cover **14**. On the upper interior portion of the tray portion **12** is a recess area to receive and hold the lower peripheral portion of the cover **14**. The recess portion is on the upper interior portion of the sidewalls and is indicated at **36**, **38**, **40**, and **42**, on the respective sidewalls **24**, **26**, **28**, and **30**. As can be seen in the combination of FIGS. 2, 5, and 6, the recess portion is an integrally formed portion of the tray and receives the edge portion of the cover **14**.

The cavity portion **18** is integrally formed between the troughs **32** and **34** and is in communication with annuli **11** and **13**. The cavity portion **18** has a dome portion **44** extending upward from the trough bottoms **46** and **48** as shown clearly in FIG. 5. The bottom portion of the cavity **18** is the bottom of the tray, **50**. The cavity portion **18** has end walls **52** and **54**, joining the bottom **50**, the dome portion **44** and extending above the recess portions **40** and **42** on its uppermost portion as can be seen in FIG. 1 and FIG. 3. A pair of conduits **56** and **58** extend through the end wall **30** of the tray portion **12** and into the cavity interior **60** through the cavity end wall **54**. The conduits **56** and **58** are open and are used for the passing of a fluid through the cavity's interior **60** for the purpose of regulating the temperature of the electrolytic cell **10**. The conduits **56** and **58** are shown clearly in FIG. 4 in their relative positions in the cavity portion **18**. The conduit **56** is elongated and has its inner end **62** terminating at the end of the cell structure opposite to that which it enters the structure, and terminating near the cavity end wall **52**. The other conduit **58** is a shorter conduit and has its inner end **64** terminating near the cavity end wall **54**. The exterior of both of the conduits **56** and **58** is preferably formed with a rippled exterior indicated at **66** so as to provide for the easy attaching and sealing of flexible conduits used to connect electrolytic cell **10** in fluid communication with a fluid source. When in operation fluid will pass through the length of the cavity **18** as it flows in one of the conduits and out the other.

The electrode means **16** includes a pair of elongated electrodes **70** and **72** mounted in the troughs **32** and **34**, a magnetically actuated switch means **74** and a pair of electrical connectors **76** and **78**. The electrode means **16** is oppositely chargeable and provides the means of passing an electron flow into and in through the conductive gel, and is actuated by placing the cover **14** on the tray **12**. The electrodes **70** and **72** are supported from the interior upright sidewalls of the troughs **32** and **34**, the sidewalls are indicated at **80** and **82**, respectively. Each of the electrodes **70** and **72** are constructed similarly from an electric conductive material and have an elongated rod portion **80** and **82** respectively with a plurality of support members **88** extending therefrom for mounting same with the trough sidewalls. In use, one of the electrodes is positively charged and the other is negatively charged. The support members **88** are integrally attached to the elongated rods **84** and **86** and have a flange portion **90** spaced a distance from the rod to contact the interior side of the trough walls and have a nut or the like **91** attached to the support element on the exterior side of the trough sidewall. The flanges and nuts **90** and **91** securely attach the rods **84** and **86** to the tray structure **12** on the interior of the trough's sidewalls in a position opposite to the dome portion **44** of the cavity portion **18** as shown clearly in FIG. 5.

One of the electrodes, in this instance the electrode adjaccent the tray sidewall having numeral **24**, is connected via a lug **94** and a wire **96** to the electrical connector **76**. The other electrode having the numeral **70** and adjacent to the tray structure sidewall **24** is connected via a lug **98** and wire **99** to a micro switch **100** which is a part of the magnetically operated switch means **74**.

The micro switch **100** is supported by mount **101** from the electrical connector **78** and is a normally open switch closed by allowing the actuator button **102** to extend from the body of the switch. The micro switch **100** has a pivotably mounted swinging arm **103** secured to one side thereof extending past the opposite side of the switch and having a magnetic element **104** on the extended end thereof. In the normal non-use position the swinging arm **103** rests on the body of the switch **100** pressing the actuator button **102** into the switch structure and maintaining an open circuit. The cover **14** has a magnetic element **106** on one end thereof positioned generally as shown in FIG. 1. This magnetic element **106** attracts the other magnetic element **104** on the switch means **74**. In the operating position the cover **14** is in place on the tray and the swinging arm **103** is raised from the switch body and the actuator button **102** is allowed to extend

from the switch body thereby closing the circuit. It is to be noted that switch means other than the specific micro switch and swinging arm arrangement shown and described herein can be used to affect a similar result, that being to connect the electrodes with a source of electrical power when the cover is in place on the tray **12**. In use of the magnetically operable switch means it has been found that such functions well and is effectively insulated from damage due to corrosion since it is substantially sealed within the electrolytic cell structure **10**. The electrical connectors **76** and **78**, as shown, are conventional quick disconnect style connectors usable to attach a low voltage direct circuit source to the electrolytic cell **10** for opposite charging of the electrodes **70** and **72**.

It is to be noted that the fluid source and electrical source can be attached to the electrolytic cell **10** in the removably attachable manner, as shown. However, in the alternative the electrical source and the fluid can be permanently attached to the electrolytic cell structure **10** without substantially departing from the scope of the invention. In the use and operation of the electrolytic cell **10** of this invention in primarily a laboratory atmosphere it has been found convenient to have the electrical and fluid sources removably attachable to the cell structure for convenience and ease in cleaning the structure and storage of same when it is not in use.

The cover portion **14** of the electrolytic cell structure **10** is preferably formed of a transparent material as illustrated in the drawings. A dome shaped cover **14** is provided having a rounded center portion **110** and inwardly sloping end portions **112** and **114** terminated at its elongated peripheral edges **116** and **118**, and shorter end portion edges **120** and **122**. The peripheral edges of the cover portion **14** rest in the recessed portion of the open portion of the tray structure **12** with the cover of the edge portions **116**, **118**, **120** and **122** resting in the recessed portions **36**, **38**, **40**, and **42**, respectively. The magnetic member **106** is attached to the cover end portion **112** as shown in FIG. 1 and FIG. 6. When the cover **14** is in place on the tray portion **12** the magnetic member **106** must be at the end of the tray having the switch means **74**, so the magnetic members **104** and **106** will attract each other thereby causing the micro switch **100** to be closed. The cover **14** is preferably constructed of a transparent material so that the user can watch and monitor the electrolytic process taking place in the electrolytic cell **10**. In electrolytic work of the type described, the cover **14** has been found useful to prevent the gel specimens from drying during the diffusion process.

When the electrolytic cell **10** of this invention is in use the conductive gel slide speciments **20** are placed within the tray portion **12** as shown in FIG. 1 and FIG 5. The articles or slide specimens **20** usually used in immunoelectrophoresis and immunodiffusion work are elongated strips of a transparent plastic material which have been coated on one side with an agar gel material and are placed in the tray portion with the gel coated slide thereof upward. FIG. 5 shows in detail the specific position of the slide segments **20** when properly in place in the cell structure **10**. In this position the slide segments have the ends thereof **130** and **131** in the lower portion of the troughs with the coated side thereof being in contact with the electrode rods **70** and **72**, respectviely, or the electrolyte in the troughs **32** and **34**, and having the center portion of the slide **132** in contact with the dome surface **44** of the cavity portion **18**. In this position substantially all the surface of the slide specimen **20** is in contact with the exterior cavity surface so a maximum heat transfer between the slide strip and the cavity portion **18** is achieved. It is not necessary for the slide specimens to touch the electrodes, they must only be in contact with the electrolyte or buffer solution in the troughs. The fluid passed through the cavity portion **18**, can be either used to heat or to cool the electrolytic cell structure **10** depending upon the desire of the user and more specifically the particular requirements of the test or type of tests to be performed with the electrolytic cell structure **10**. In practice it has been found that in immunoelectrophoresis work the cell structure **10** must be cooled during its operation and this can be achieved by connecting the conduits **56** and **58** to a water source and passing the water through the cavity interior **60** thereby cooling the cavity portion **18** and in turn cooling the articles or slide specimens **20**. Temperature of water passing through the cavity interior **60** can be used to specifically regulate the temperature of the electrolytic cell **10** and the conductive gel slide specimens **20** by regulating its temperature and rate of flow through the cavity portion **18**. In the event the electrolytic cell must be heated then warm water or hot water can be circulated through the cavity portion **18** and in the same manner used to regulate the temperature of the electrolytic cell structure **10** and the conductive gel slide specimens **20**. In practice it has been found that water is a convenient fluid to use for regulating the temperature of the electrolytic cell structure. However, other fluids both liquid and gaseous may be used if so desired.

In the manufacture of the electrolytic cell structure of this invention, it is obvious the cell structure can be easily produced from a plastic material to achieve the end product. The tray portion of the electrolytic cell structure **10** can be molded or formed in substantially one piece with the conduits **56** and **58** and the bottom **50** added and joined after formation of the other portions. The cover portion **14** can be easily molded or formed from transparent plastic material and have the magnetic element **106** attached thereto. The electrode means **16** consist of standard elements and easily fabricatable elements which can be mounted with and attached to the tray structure **12**.

In the use and operation of the electrolytic cell structure of this invention, it is seen that same provides an electrolytic cell with means to regulate the temperature thereof by using a fluid passing through an enclosed cavity of same, and which has an electrode means with a switch means to connect the electrodes thereof to a source of electrical power when the cover of the cell structure is in place. When the electrolytic cell **10** is in use a fluid, such as water, can be circulated through the enclosed cavity portion **18** of the cell structure thereby raising or lowering the temperature of the cell structure and the gel slide specimens therein as desired by the user. Enclosed cavity portion **18** is delineated by ends **52** and **54**, bottom **50**, sides **24** and **26** with annuli **11** and **13**, respectively, therein, and parabolic or dome shaped roof **44**. The magnetically operable switch is a convenience to the user in that the electrodes of the cell are not connected to the power source until the cover is in place on the tray. The electrolytic cell structure of this inveniton is particularly adapted for use in the areas of electrophoresis, immunoelectrophoresis, electroimmunodiffusion and immunodiffusion although it may be used for other electrolytic operations and areas of endeavor.

As will become apparent from the foregoing description of the applicant's electrolytic cell structure, relatively simple, and inexpensive means have been provided to regulate the temperature of an electrolytic cell that is adapted for holding articles such as conductive gel slide specimens. The electrolytic cell structure **10** is provided with a magnetically operable switch means to connect the electrodes thereof to a power source when the cover is placed on the tray, as it is when in normal operation. The cooling apparatus of the electrolytic cell structure has a cavity portion enclosed in the tray portion of the structure which is easily connectable with a fluid source such as water, so the electrolytic cell can be heated or cooled as desired by passing water or other fluid through the cavity portion of the structure.

While the invention has been described in conjunction with preferred specific embodiments thereof, it will be understood that this description is intended to illustrate

and not limit the scope of the invention, which is defined by the following claims.

I claim:

1. An electrolytic cell means for immunodiffusion comprising a tray with a bottom, a first side connected to said bottom and having a first annulus therein, a second side attached to said bottom and including a second annulus therein, and a pair of ends attached to said sides and to said bottom, an enclosed heat transfer fluid reservoir integrally bound to said first and to said second sides and including an inlet and an outlet for circulating a heat transfer fluid therethrough, said enclosed reservoir additionally including an essentially parabolic shaped roof connected to said sides and a second pair of ends attached to said sides, to said bottom, and to said roof, said first and second annuli being in communication with said roof and with said inlet and said outlet, said parabolic shaped roof having a first sloping portion and a second sloping portion, said first side and said first sloping portion defining a first trough and said second side and said second sloping portion defining a second trough, a first electrode secured in said first trough, a second electrode oppositely charged from said first electrode attached in said second trough, and an electrical source connected to said first electrode and said second electrode.

2. The electrolytic cell means of Claim 1 additionally including a cover removably engaging with said tray.

3. The electrolytic cell means of Claim 2 additionally including means attached within said tray for actuating the flow of electrical current from said electrical source.

4. The electrolytic cell means of Claim 3 wherein said means for actuating said flow of said electrical current from said electrical source comprises a first magnetic member attached to said cover, a switch connected within said tray, and said first magnetic member magnetically closes said switch when said cover engages with said tray.

5. The electrolytic cell means of Claim 1 wherein said first and said second troughs include an electrolytic fluid which immerses said first and said second electrodes.

6. The electrolytic cell means of Claim 5 additionally including at least one conductive gel having a structure defined by a pliable elongated strip having an electrolytic environment mounted thereon and superimposed on said parabolic roof such that the structure thereof contours said roof and has one end immersed in said electrolytic fluid of said first trough and the opposite end immersed in said electrolytic fluid of said second trough.

7. The electrolytic cell means of Claim 6 wherein said inlet and said outlet of said enclosed reservoir are removably connectable to a heat transfer fluid source, and said first electrode and said second electrode are removably connected to said electrical source.

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