

[54] **DETECTION SYSTEM FOR PROTECTING
ANODES IN FLOWING MERCURY
CATHODE ELECTROLYTIC CELLS**

[75] Inventors: **Yoichi Adachi; Yoshiharu Harada,**
both of Tokyo, Japan

[73] Assignee: **Mitsui & Co. Ltd.,** Tokyo, Japan

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204/228

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[58] Field of Search..... 340/253, 248 E, 419;
204/225, 219, 220, 99, 228

[56] **References Cited**

UNITED STATES PATENTS

1,873,667 8/1932 Sabbah et al..... 340/253 E UX

2,459,186	1/1949	Sherman	340/253. R X
3,644,190	2/1972	Weist et al.....	204/228
3,689,398	9/1972	Caleffi	204/228 X
3,723,285	3/1973	Daga et al.....	204/228

FOREIGN PATENTS OR APPLICATIONS

1,239,835	7/1971	United Kingdom.....	204/228
1,167,001	10/1969	United Kingdom.....	204/99
1,212,488	11/1970	United Kingdom.....	204/225

Primary Examiner—G. L. Kaplan

Attorney, Agent, or Firm—Hammond & Littell

[57]

ABSTRACT

Describes an apparatus for protecting adjustable anodes in a horizontal mercury cell by measuring the flow of current in the bus line to the anodes, measuring variations of voltage between an anode and a flowing mercury cathode and adjusting the space between the anodes and the cathodes in accordance with the output signal of the measurement of current to the anodes and voltage between the anodes and the cathodes.

7 Claims, 5 Drawing Figures

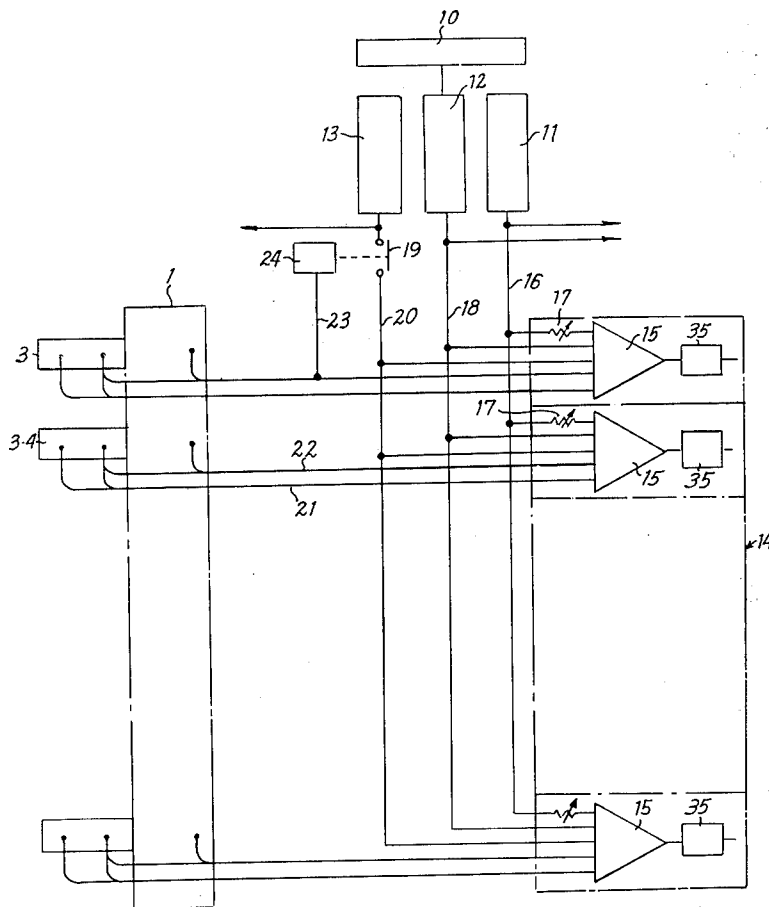


FIG. 1

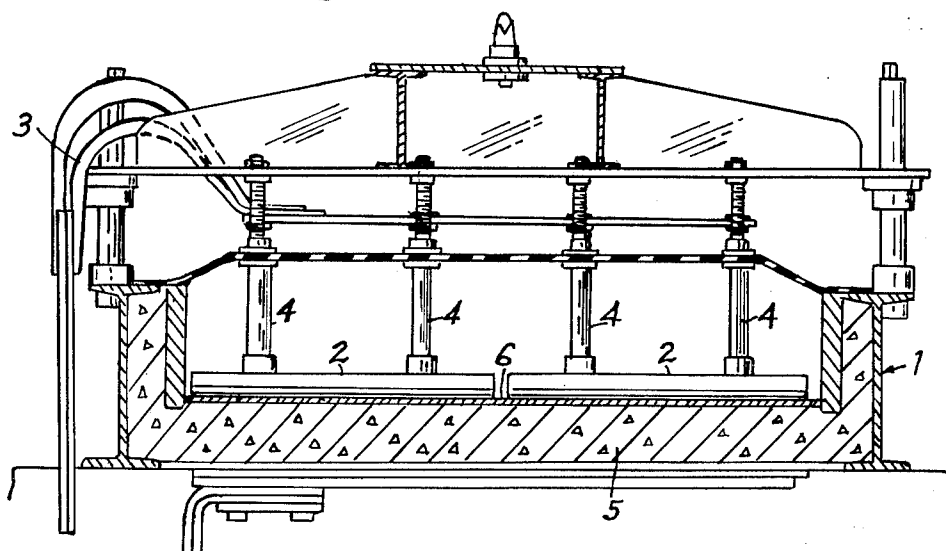


FIG. 5

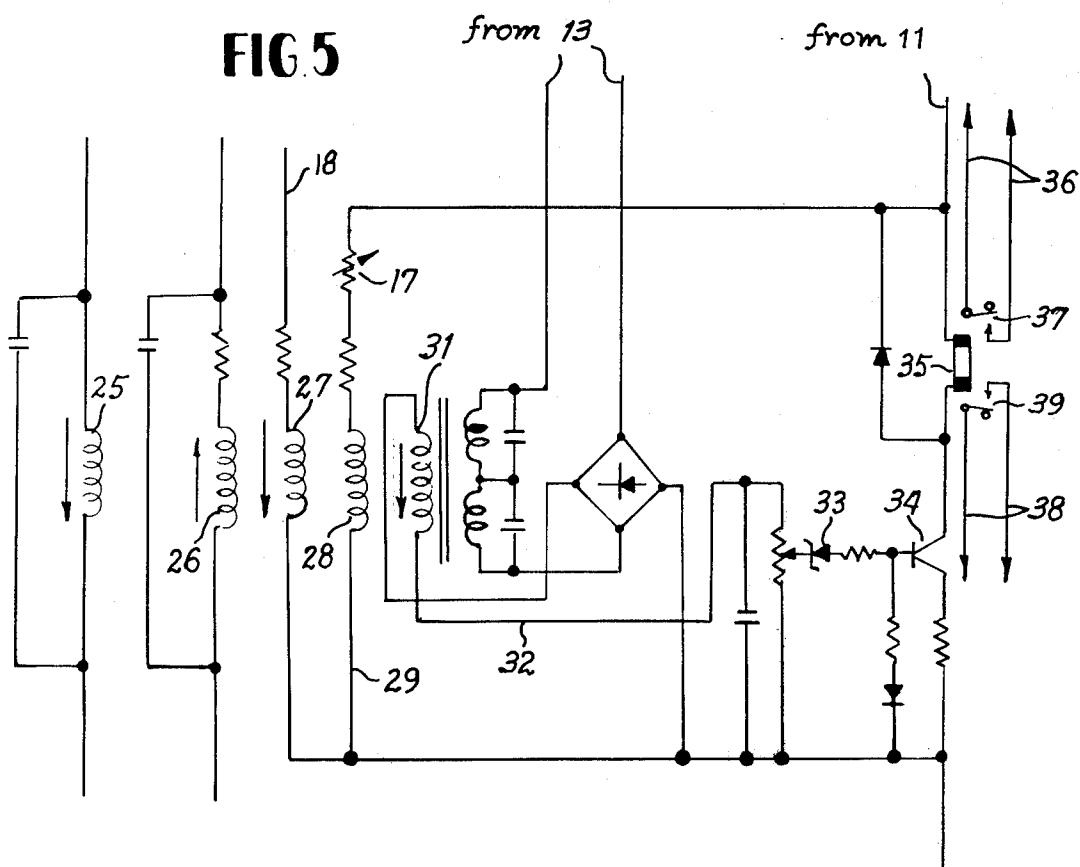


FIG 2

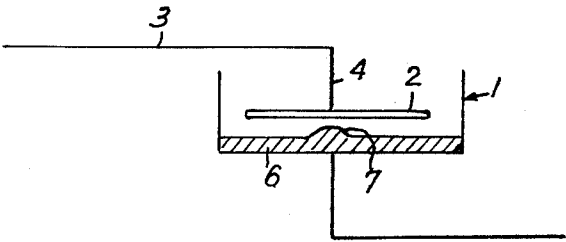


FIG 3

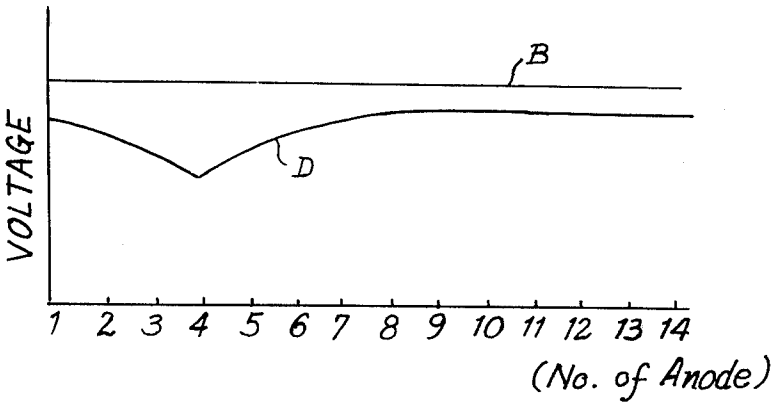
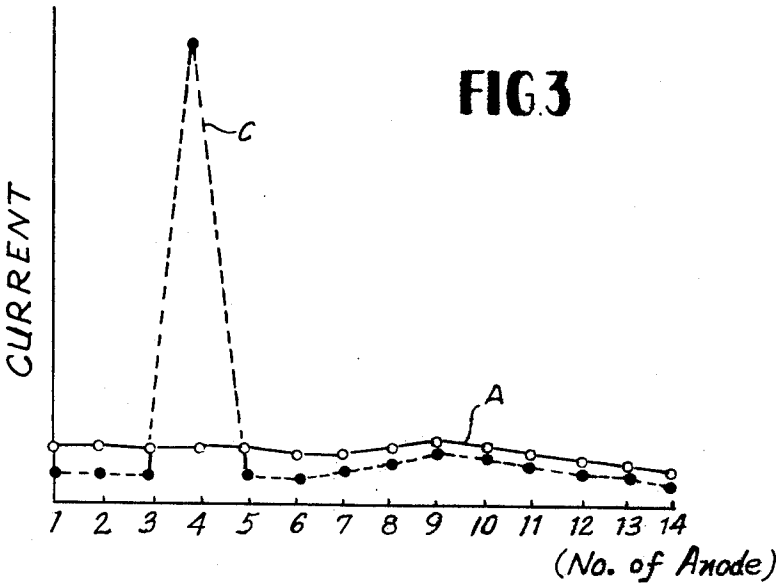
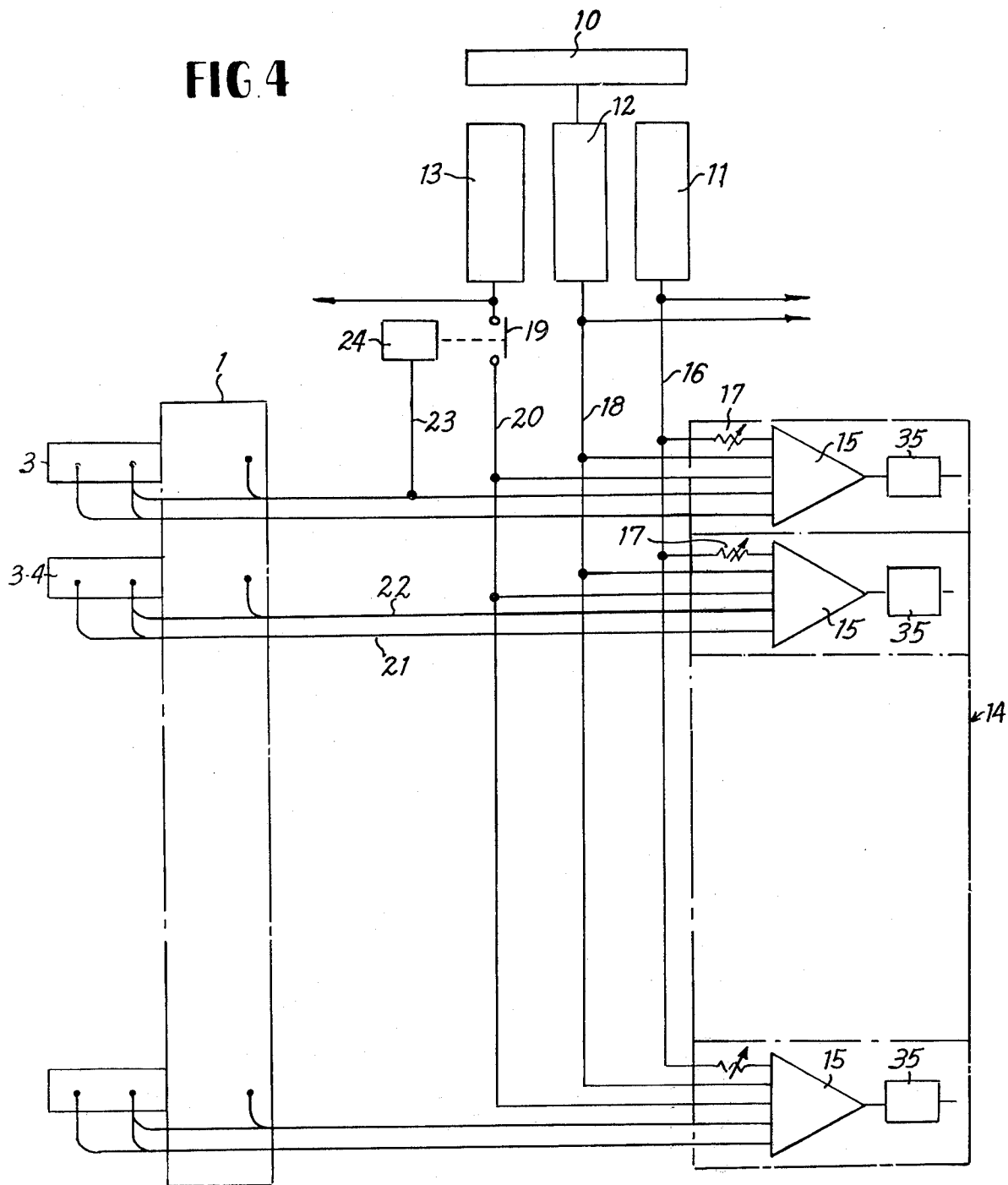


FIG 4



DETECTION SYSTEM FOR PROTECTING ANODES IN FLOWING MERCURY CATHODE ELECTROLYTIC CELLS

This invention relates to detection systems for protecting anodes in flowing mercury cathode horizontal electrolytic cell and more particularly to a detection system for protecting anodes in a flowing mercury cathode electrolytic cell from damages due to a short circuit between the flowing mercury cathode and the anodes which comprise such a material as graphite or titanium.

Horizontal mercury electrolytic cells are well known in the art. In a typical horizontal mercury electrolytic cell, mercury which forms the cathode of the cell is flowed over the bottom of the slightly inclined cell from its one end to the other end in the form of a uniform layer, anodes are arranged above the flowing mercury cathode and spaced therefrom at a short distance, for example, 1.5mm to 3.5mm, and brine is used as the electrolyte to electrolyse it into sodium and chlorine.

There is no problem when the mercury cathode is flowing with its smooth surface, however, a part or parts of the mercury surface are often raised, for example, by foreign matters mixed therewith. In such a case, the space between the anodes and the raised parts of the flowing mercury cathode become narrow, thus the electric current concentrates at such narrow portions and if this condition persists, the anodes will be damaged, consequently the cell will become inoperable.

When the cell is operated with an increased space between the electrodes, it can be operated safely since the current distribution in the cell will be improved and the potentiality in occurrence of the above-mentioned tendency will be reduced, however, such an increased space between the electrodes will lead to an increase of the cell voltage resulting in power loss.

Therefore, protection devices required for the operation of electrolytic cells are preferably capable of reducing the cell voltage as low as possible in a normal operating condition and capable of eliminating any abnormality before anodes are damaged when such an abnormal condition takes place.

Conventional detection systems including so called a bus bar overcurrent detection system which detects the current through bus bars between various electrolytic cells and when the detected current reaches a point higher than a set point, a protection device is operated, and a low voltage detection system which detects the cell voltage at various portions of a cell and when the detected voltage reaches to a point lower than a set point a protection device is operated, however, with such a conventional system for detecting only a single factor, a normal operation condition is not completely distinguishable from an abnormal operating condition, and vice versa. Thus cells should either be set so as to permit an abnormal operating condition to a certain extent or arranged so as to operate at a high safety level more than necessary.

So-called a voltage variation rate detecting system is also well known in the art, which system detects a cell voltage and when the time/variation rate (dv/dt) of the detected voltage reaches to a point higher than a set point, a protection device is actuated. This system is regarded as very reasonable, since in the course to the short-circuiting between the electrodes, the initial time/variation rate (dv/dt) of the cell voltage is extremely low but finally it shows a substantial value,

however, variations in voltage is also caused by other factors, for example, changes of the mercury surface due to the surging of a mercury pump, or changes of the cathode surface due to variations in gaseous chlorine suction pressure. Such a system, therefore, has a disadvantage that it can not protect anodes reliably since it lacks in ability of distinguishing variations in voltage due to the short-circuiting between the electrodes from variations in voltage due to other factors than the short-circuiting.

The object of the present invention, therefore, is to provide a detection system for protecting anodes in flowing mercury cathode electrolytic cells from damages, which system eliminates disadvantages of conventional current detection systems and voltage detection systems and which is capable of distinguishing the normal operation from abnormal operations of cells by detecting it as a combination of voltage and current, such a function has never been fulfilled with conventional systems since the normal operation is not distinguishable from abnormal operations by detecting it either as current or voltage alone.

According to the present invention, there is provided a detection system for protecting anodes in a flowing mercury cathode electrolytic cell in which a plurality of anodes are suspended over the flowing mercury cathode leaving a predetermined space therebetween, which system comprises detecting a bus current, detecting a cell voltage, and generating an output signal when a resultant value of said detected bus current and cell voltage exceeds a predetermined value so that a display lamp or an anode elevator may be actuated by said signal.

A preferred embodiment of the invention has been chosen for purpose of illustration and description and is shown in the accompanying drawings forming a part of this specification, wherein:

FIG. 1 is a vertical sectional view of a typical flowing mercury cathode electrolytic cell to which the present invention may be applied;

FIG. 2 is a schematic diagram showing a part of the cathode is abnormally raised whereby the space between the cathode and an anode is narrowed;

FIG. 3 are graphs respectively showing variations in bus current and cell voltage during the normal operation and at the occurrence of an abnormal relation between the anodes and the cathode in the cell;

FIG. 4 is a circuit diagram of an electrolytic cell in which the present invention is embodied; and

FIG. 5 is a preferred embodiment of the circuit arrangement of the system of the present invention.

Referring to FIG. 1, a typical flowing mercury cathode cell 1 comprises a plurality of, for example, fourteen suspended anodes 2 arranged in two rows. The anodes 2 are fed with current from a power source (not shown) through a bus 3 and bus bars 4. Mercury is introduced into the cell 1 through its inlet end and flows over the bottom wall 5 forming a substantially flat layer 6 flowing toward an outlet end of the cell. The anodes 2 are suspended in the cell leaving a predetermined space between their lower surfaces and the surface of the flowing mercury cathode layer 6 and the space therebetween may be manually or automatically regulated by an anode elevator (not shown).

FIG. 2 shows a condition in which the space between an anode 2 and the cathode 6 is narrowed due to an abnormally raised portion 7 of the cathode. Variations in bus current and cell voltage due to such an abnormal

condition are shown in FIG. 3.

The upper part of FIG. 3 is a graph showing the relationship between the anodes (the order thereof being plotted on the abscissa) and the bus current (on the ordinate), in which curve A shows a substantially uniform current distribution when the space between all of the anodes and the flowing mercury cathode is normally maintained, while the lower part of FIG. 3 is a graph showing a substantially uniform cell voltage distribution curve B during the ideal operating condition of the cell. Curve C shows an increased current when the space between one of the anodes (for example, the fourth anode) and the flowing mercury cathode has been narrowed, and curve D shows a corresponding local voltage drop in such an abnormal condition.

The system of the present invention provides a circuit which detects a bus current of each anode in an electrolytic cell and a corresponding cell voltage between a particular anode and the flowing mercury cathode, and generates an output signal when a resultant value of the detected bus current and cell voltage has reached a set value to indicate an abnormal condition taking place between the particular anode and the cathode so as to prevent the anode from being damaged.

A preferred embodiment of the circuit arrangement of the system of the present invention is shown in FIG. 4 in association with the anodes in the cell 1. The circuit comprises a power circuit and a detector unit, which power circuit is provided with a common power source 10. The output of the common power source 10 is respectively connected in parallel to a stationary bias power source 11, a regulating bias power source 12 and a general power source 13. Preferably the common power source 10 is provided with an automatic voltage regulator to minimize errors due to variations in individual power sources. The stationary bias power source 11 serves to regulate and equalize characteristic differences between amplifiers 15 corresponding to the anodes in the cell, and is connected respectively to the inputs of the amplifiers 15 in the unit 14 by a lead 16 through variable resistors 17 respectively. It is desirable to use magnetic amplifiers as the amplifiers 15.

For the sake of simplification, the fourth anode in the cell and its associated circuit will be described in detail as the representatives and other anodes and their associated circuits.

The regulating bias power source 12 serves to simultaneously regulate various set points which differ depending upon the specification of the cell and the type of the anodes relative to the whole cell, and is connected to the inputs of the amplifiers 15 in the unit 14 through a lead 18.

The general power source 13 serves to actuate the detector unit 14 and is connected to the input side of the unit 14 through a conductor 20 having a switch 19 provided therein. The current from a bus 3 of the cell is fed to the detector unit 14 through a conductor 21. Voltages between the individual anodes and the flowing mercury cathode are respectively fed to the amplifiers 15 respectively through conductors 22. The voltage input conductors 22 are connected to a relay 24 through conductors 23 respectively. The relay 24 serves to actuate the switch 19 provided in the conductor 20 of the general power source 13 and when the feed to the cell is discontinued, the relay 24 actuates the switch 19 to its open position to interrupt the feed to the detector unit 14 to prevent any unintended or er-

roneous actuation of the unit 14 during the discontinuance of the cell.

Referring now to FIG. 5 which shows a diagram of a preferred embodiment of the circuit of the detector unit 14 particularly in association with the fourth anode in the cell.

The current input from a bus 3-4 of the fourth anode passes through a current input winding 25 of the associated amplifier 15 in the direction as shown by an arrow. A voltage between the fourth anode and the cathode permits a current to be passed through a voltage input winding 26 in the direction shown by an arrow. The current fed from the regulating bias power source 12 through the conductor 18 passes through a regulating bias winding 27 in the direction shown by an arrow. The variable resistors 17 serve to regulate the characteristics of individual amplifiers 15 relative to the anodes so as to equalize the outputs of the amplifier unit 14 under a predetermined condition.

The detector unit 15 is fed with current from the general power source 13 through the conductor 20 and the outputs of the amplifiers 15 in the unit 14 are respectively connected to cathode element of Zener diodes 33 through feedback windings 31 and conductors 32. The anode element of each of said diode 33 is connected to the base of a transistor 34 of which collector is in turn connected to a relay 35. When the relay 35 is energized, a contact 37 or 39 in conductor 36 or 38 leading respectively to actuating circuits (not shown) for a display lamp or for an automatic anode elevator for the particular anode, is moved to its closed position.

Turns of each winding of said amplifier are suitably selected so that when the cell is normally operated, i.e. the space between the anodes and the flowing mercury cathode is in normal condition thus a combined value of an input current from the bus to the particular amplifier and an cell voltage which depends upon the electrical characteristic of the cell is below a set point, the relay 35 is maintained in stationary state by the output of the amplifier, and the Zener diode 33 is provided so that when the combined value of the bus current and the cell voltage reaches the set point, the relay 35 is rapidly actuated.

With the arrangement of the present invention as set forth hereinabove, when the space between an anode, for example, the fourth and the flowing mercury cathode is unvaried or normal, the output of the particular amplifier 15 is incapable of energizing the relay 35, since the bus current from the bus 3-4 to the amplifier 15 associated with the fourth anode and the cell voltage remain unvaried. When the space between the fourth anode and the flowing mercury cathode, however, is narrowed due to any abnormality, the current from the bus 3-4 to the amplifier 15 increases (see curve C in FIG. 3) and the cell voltage at the corresponding cell region drops accordingly (see curve D in FIG. 3), whereby the output of the magnetic amplifier 15 is increased until it reaches a Zener voltage (a set value) of the Zener diode 33 and a signal is fed to the base of the transistor 34 to actuate the relay 35. Thus the relay 35 then operates to close the contact 37 in the conductor 36 leading to the circuit for actuating the associated display lamp which indicates the abnormal condition occurred in the fourth anode region, or the contact 39 in the conductor 38 leading to the circuit for actuating the associated automatic anode elevator whereby the space between the fourth anode and the flowing mer-

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cury cathode may be widened to discontinue the short circuit formed therebetween.

As will be evident from the foregoing description, certain aspects of the invention are not limited to the particular details set forth in this specification. It is contemplated that various modifications will occur to those skilled in the art and it is therefore intended that appended claims shall cover such modifications as do not depart from the true spirit and scope of the invention.

What is claimed is:

1. Method for protecting anodes in a horizontal mercury cell by adjusting the distance between a plurality of anodes and the flowing mercury cathode in the cell for electrolyzing a conductive solution wherein each of said anodes are adjustably suspended in said solution, which method comprises detecting the flow of current in a bus line of each anode to provide a first output signal, detecting voltage between each anode and the flowing mercury cathode to provide a second output signal, combining said first and second signals to generate a summation signal, generating an output signal when said summation signal exceeds a predetermined value, and energizing means for adjusting the distance between said anode and the cathode.

2. In an electrolytic cell for electrolyzing a conducting solution, said cell comprising a plurality of anodes having bus bars and a flowing mercury cathode, the improvement wherein control means are present for ad-

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justing the anodecathode spacing for each anode, said control means comprising means for detecting the flow of current in a bus line of each anode to provide a first output signal, means for detecting a voltage between each anode and the flowing mercury cathode to provide a second output signal, means for combining said first and second signals to generate a summation signal, means for generating a reference signal, means for comparing said summation signal and said reference signal, means for generating an output signal when the difference between said summation signal and said reference signal exceeds a predetermined amount, and means energized by said output signal for either signaling or adjusting the anode-cathode spacing.

3. The apparatus of claim 2, in which the means energized comprises a relay which controls a circuit to an automatic anode elevator.

4. The apparatus of claim 3, in which the means energized comprises magnetic amplifiers and Zener diodes adapted to transmit the summation signal to said relay.

5. The apparatus of claim 2, wherein the means for signaling is a display lamp.

6. The apparatus of claim 2, wherein the means energized is an automatic anode elevator.

7. The apparatus of claim 2, in which the means energized comprises a relay which controls a circuit to a display lamp.

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