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**Miyamaoto et al.**

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# [54] METHOD AND SYSTEM FOR PREVENTING SHORT-CIRCUITS IN MERCURY CATHODE ELECTROLYTIC CELLS

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[52] **U.S. Cl.** .................................. **204/99,** 204/225
[51] **Int. Cl.** ........................... **C01d 1/14,** B01k 3/00
[58] **Field of Search** .............................. 204/99, 225

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[57] **ABSTRACT**

A method of foreseeing a short-circuit between an anode and a cathode of a mercury cathode type electrolytic cell in the process of electrolyzing alkali chlorides which comprises measuring the voltage change per unit time or the rate of voltage change with respect to the voltage between the anode and the cathode, and producing an informational signal when the rate of voltage change exceeds a predetermined threshold value, thereby foreseeing a short-circuit between the anode and the cathode immediately before it occurs, the informational signal being utilized not only for abruptly moving the anode upwardly so as to prevent the electrolytic cell from damage caused by the short-circuit between the anode and the cathode but also for adjusting the distance between the anode and the cathode so as to secure high electric power efficiency and safety operation of the electrolytic cell. In the adjusting of the distance between the anode and the cathode, the anode is moved downward towards the cathode at a relatively low speed until the generation of the informational signal while the rate of voltage change is being observed and upon the generation of the informational signal, the anode stops its downward movement and is simultaneously moved upwardly at a relatively high speed, then stopping its upward movement at a point remote by a predetermined distance from the position of the anode where the informational signal is produced, thereby to finally obtain the most logical distance between the anode and the cathode.

**2 Claims, 4 Drawing Figures**

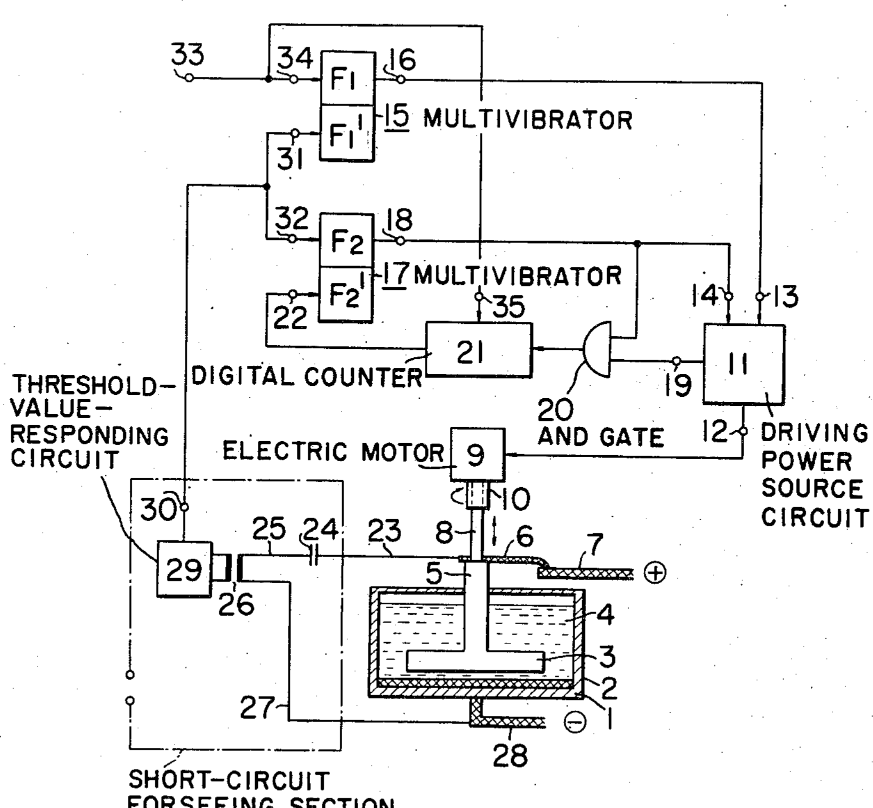
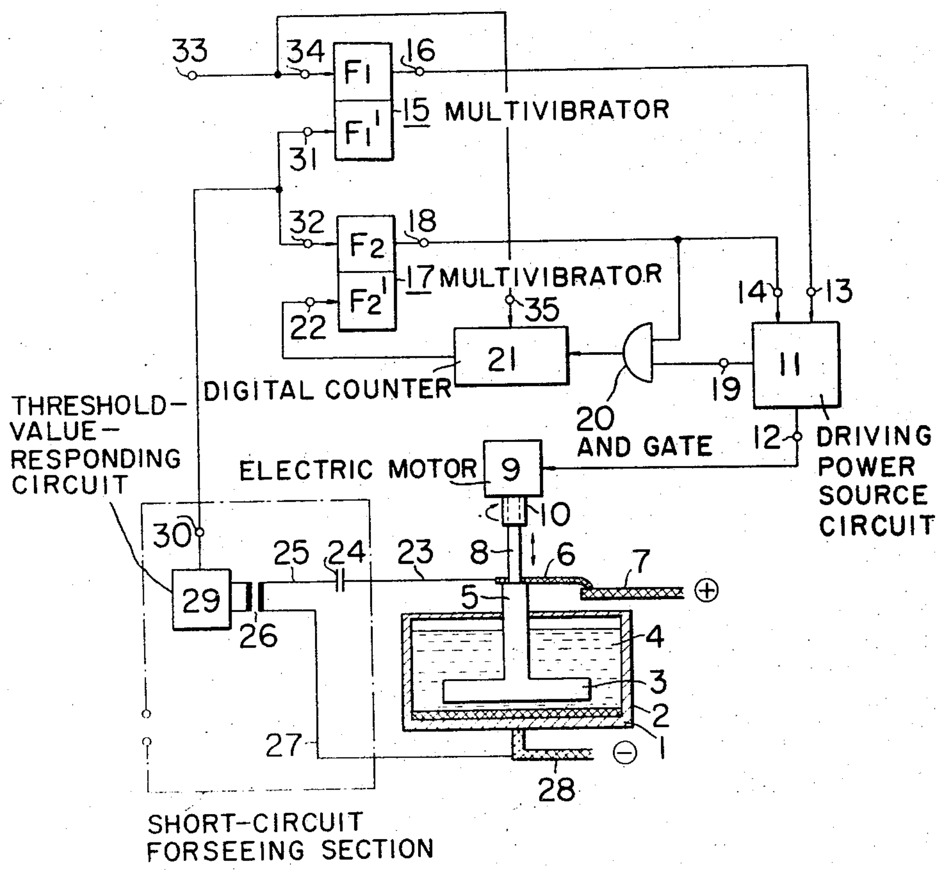


FIG. 1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34
16
F1
F1'
15 MULTIVIBRATOR
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F2
F2'
17 MULTIVIBRATOR
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13
22
21
11
DIGITAL COUNTER
19
20
AND GATE
12
DRIVING POWER SOURCE CIRCUIT
THRESHOLD-VALUE-RESPONDING CIRCUIT
ELECTRIC MOTOR
9
10
30
25
24
23
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29
26
3
2
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1
28
SHORT-CIRCUIT FORSEEING SECTION

FIG. 2

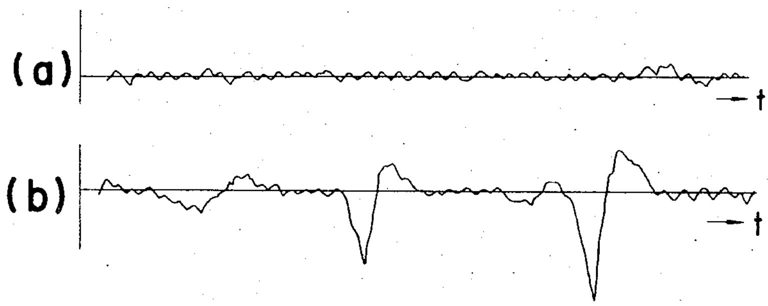



FIG. 3

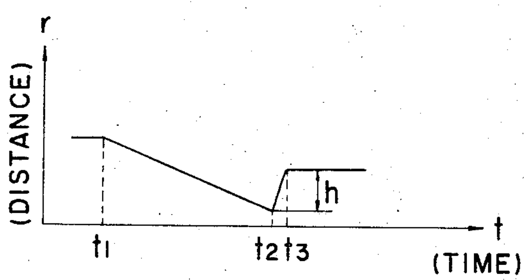
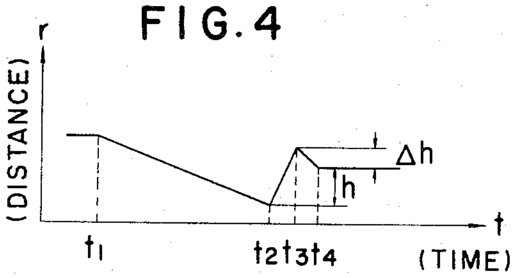



FIG. 4



# METHOD AND SYSTEM FOR PREVENTING SHORT-CIRCUITS IN MERCURY CATHODE ELECTROLYTIC CELLS

## BACKGROUND OF THE INVENTION

The present invention relates to a mercury cathode type electrolytic cell used for electrolysis of alkali chlorides, and more particularly to a method of foreseeing a short-circuit between an anode and a cathode of the electrolytic cell before the short-circuit occurs and of adjusting or regulating continuously the distance between the anode and the cathode.

It is well-known that it is of utmost importance to make the distance between the anode and the cathode as small as possible so as to obtain maximum electric power efficiency in the process of electrolysis of alkali chlorides by means of the mercury cathode type electrolytic cell. Furthermore, it is also well-known that since an anode made of graphite is consumed during the operation of the electrolytic cell, it is necessary to adjust the distance between the graphite anode and the cathode to the most appropriate value in using such a graphite anode. In addition, because of the requirement for a higher electric current efficiency in electrolysis at present, even when an anticorrosive, nonconsumable anode which is made by coating a metallic base with novel metal and is being used now in the industry is employed in the electrolytic cell, it is still necessary to properly adjust the distance between the anode and the cathode at the beginning of the operation and according to the variation of electrolysis conditions such as current density and to the variation of conditions of electrode surfaces in the course of the operation.

However, in making the distance between the anode and the cathode as short as possible in order to maximize the electric power efficiency, it is necessary to provide a special device for the prevention of short-circuits because the possibility of short-circuit of the anode and the cathode is increased greatly with decrease in the distance therebetween. The reasons for this are: the fluidizing of the mercury cathode; the rise of the mercury cathode surface attracted by the anode, which approaches the cathode; the microscopically non-uniform distribution of current density due to the deposition of impurities from the electrolyte; the microscopically non-uniform anode surface in composition and shape; and the variation of the distance between the anode and the cathode caused by slight variation of the electrolytic conditions and by slight vibrations of the anode or the cathode.

Once the short-circuit has occurred partially between the anode and the cathode, it is spread by the rise of the cathode surface, which often results in a disastrous burning of the electrolytic cell. Especially in the use of an anode coated with the novel metal in the electrolytic cell, the short-circuiting and fusing of the electrodes cause a great loss or damage to electrolytic cell. Therefore, one of the important requirements in the operation of the electrolytic cell is to eliminate completely such short circuits.

Furthermore, in the case when a number of large electrolytic cells are operated with high current density the operation must be conducted with high degree of safety, precision and automatization.

In general, a conventional method of detecting the short-circuit between the anode and the cathode of an electrolytic cell comprises: observing the voltage of the electric cell or the voltage (or current) between the anode and the cathode and regarding as the short-circuit the voltage drop in which the voltage becomes lower than a predetermined value. However, in the case where a number of anodes are provided in one electrolytic cell, it is rare that a partial or local short circuit caused between the anode and the cathode is detected as a reduction in the voltage of the electrolytic cell or the voltage between the anode and the cathode.

As is obvious from the above description, in the conventional method, the short-circuit caused between the anode and the cathode is not foreseen but detected. Therefore, however high the response speed of an anode-driving device which drives the anode up and down is, the fact that the anode is moved upward by the anode-driving device after detection of the short-circuit will inevitably give rise to complete or partial damage to the electrodes or the electrolytic cell. In order to eliminate this damage, it is necessary to keep the distance between the anode and the cathode excessively large. Accordingly, in the conventional method it is impossible to obtain maximum electric power efficiency in the industrial operation of the electrolytic cell.

## SUMMARY OF THE INVENTION

It is accordingly a primary object of the present invention to eliminate all of the drawbacks of the above-described conventional method of electrolyzing alkali chlorides by a mercury cathode type electrolytic cell.

Another object of the present invention is to provide a method of foreseeing or forecasting a short-circuit between an anode and a cathode of a mercury cathode electrolytic cell.

A further object of the present invention is to provide a method of precisely or definitely and quickly detecting a specific electrical phenomenon caused immediately before a short-circuit of an anode and a cathode of a mercury cathode electrolytic cell thereby to foresee the short-circuit before it occurs.

A still further object of the present invention is to provide a method of logically adjusting or regulating the distance between an anode and a cathode by the utilization of the above-described short-circuit-foreseeing method for the operation of a mercury cathode electrolytic cell, thereby to enhance the electric power efficiency and safety in operation of the electrolytic cell.

A specific object of the present invention is to provide a method of optimally adjusting or regulating the distance between an anode and a cathode of a mercury cathode electrolytic cell by lowering or moving downward the anode twice toward the cathode thereby to make the distance shorter without risk of a short-circuit.

The foregoing objects and other objects as well as the characteristic features of the present invention will become more apparent from the following detailed description and the appended claims when read in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a schematic block diagram showing one embodiment of the present invention which realizes a method of foreseeing a short-circuit between the anode and the cathode (or detecting a specific voltage variation which occurs immediately before the short-circuit) of an electrolytic cell and of adjusting or regulating the distance between the anode and the cathode;

FIG. 2 is a voltage-time graph indicating input signals of a threshold-value-responding circuit in a short-circuit-foreseeing section (or, a section detecting a voltage change immediately before a short-circuit between the anode and the cathode);

FIG. 3 is a graphical representation indicating the variation of the distance between an anode and a cathode with time in the example illustrated in FIG. 1; and

FIG. 4 is a similar representation indicating the variation of the distance between an anode and a cathode with time in another embodiment of the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

As conducive to a full understanding of the present invention, the principle or basis thereof will first be briefly described.

In a mercury cathode type alkali chloride electrolytic cell, when the anode and cathode come close to each other and they are in a condition which occurs immediately before a short-circuit, a specific pulse of the voltage variation or impulsive voltage in the voltage variation appears which is completely different from a slight voltage variation detected during a period when the anode and the cathode are not in the condition which occurs immediately before the short-circuit, that is, during a period when they are in normal condition.

The voltage change per an extremely short period of time that is, the rate of voltage change (or the speed of voltage change) in the above-described specific pulsive or impulsive voltage variation (voltage drop and restoration) is considerably greater than that in a minute voltage change detected during the period when the short-circuit does not occur between the anode and the cathode. Such a rate of voltage change is maintained for only a considerably short period of time, and the voltage drop is smaller than that caused by the short-circuit. Moreover, the voltage between the anode and the cathode is restored back to its original value immediately after the voltage drop.

The above-described electrical phenomenon was discovered by the present inventors and has been utilized for providing the method of forseeing the short-circuit between the anode and the cathode through a study of the method of detecting precisely and quickly the specific voltage variation caused immediately before the short circuit. More specifically, in the method of foreseeing the short-circuit according to the present invention, the rate of voltage change with respect to the voltage between the anode and the cathode of the electrolytic cell is measured, and when the rate thus measured exceeds a predetermined threshold value, an informational signal is produced and utilized to determine that the anode and the cathode are in the condition which occurs immediately before the short circuit.

Furthermore, it has been found by the inventors by the utilization of the above-described method of foreseeing the short-circuit between the anode and the cathode that the logical distance between the anode and cathode for enhancing the electric power efficiency and safety in operation of an ordinary mercury cathode electrolytic cell is slightly greater than the distance between the anode and the cathode at which the anode and the cathode are determined to be immediately before the short-circuit. The method of adjusting or regulating the distance between the anode and the cathode is thus completed by studying the specific phenomenon and the application of the specific phenomenon for precise and rapid adjustment of the distance between the anode and the cathode at which they are in the condition which occurs immediately before the short-circuit.

More specifically, the method of adjusting or regulating the distance between the anode and the cathode of the electrolytic cell according to the present invention comprises moving the anode downward toward the cathode at a relatively low speed while observing the rate of voltage change with respect to the voltage between the anode and the cathode, producing an informational signal when the rate of decrease of the voltage exceeds a predetermined threshold value, stopping the downward movement of the anode upon production of the informational signal, then immediately moving the anode upward at a speed higher than the speed of the downward movement of the anode and higher than the rising speed of the cathode surface, and thereafter stopping the anode again at a point remote by a predetermined distance from the position of the anode where the informational signal has been produced.

Moreover, it has been found by the inventors that a more precisely appropriate distance between the anode and the cathode of the electrolytic cell can be obtained by the following method.

The anode is moved downward towards the cathode at a relatively low speed while the rate of voltage change with respect to the voltage between the anode and the cathode is observed, and when this rate exceeds a predetermined threshold value, an informational signal is produced thereby to stop the downward movement of the anode. Immediately after the stopping of the movement of the anode, the anode is moved upward at a speed higher than the speed of the downward movement of the anode and higher than the rising speed of the cathode surface until the anode reaches a position slightly above its final position, at which the anode will be positioned, in order to effectively eliminate the influence of the rise of the cathode surface, and then the anode is moved downward toward the cathode again at a speed lower than the speed of the upward movement of the anode until the anode reaches the final position higher by a predetermined distance than the position of the anode where the informational signal has been produced.

In the present invention, the specific voltage variation which appears immediately before the short-circuit of the anode and the cathode, and which is utilized to foresee the short-circuit and is used as a signal for the adjustment of the distance between the anode and the cathode is not a voltage drop phenomenon which simply appears in inverse proportion to the distance between the anode and the cathode, nor a voltage variation, which is slight in variation speed, such as a voltage ripple caused by the incomplete rectification of an alternate current electrical source, nor a voltage drop phenomenon between the anode and the cathode caused by a partial or local contact therebetween. The specific voltage variation may be observed directly by an appropriate observing device, for instance an oscillograph inserted between the lead wires **23** and **27** shown in FIG. **1**, where a specific voltage drop of 30–80 in V in a short time of 0.5–2.0 milliseconds is observed. However the specific voltage variation may be more clearly detected as a stable signal by the measuring of the rate of voltage change where the influence of the ordinary slight voltage ripple is reduced.

FIG. **2**(*b*) shows the pulses obtained by measuring the rate of the voltage variation and are obtained, for instance, by measuring at the lead wires **25** and **27** shown in FIG. **1**. In the FIG. **2**(*b*), the rate of increase of the voltage is shown in the upper part of the *x* axis, and the rate of decrease of the voltage is shown in the lower part of the *x* axis. As is apparent from FIG. **2**(*b*), the pulse of the rate of decrease of voltage is greater and more sharp than that of the rate of increase of voltage. Therefore, it is preferable to use the rate of decrease of the voltage as the informational signal or input signal. In this case, the short-circuit of the electrodes is forecast when the rate of decrease of the voltage exceeds the predetermined threshold value. Therefore, by referring to the difference between these rates it is a simple matter to predetermine the threshold value for the rate of voltage change in order to distingish the specific voltage variation from the ordinary slight voltage variation.

The reason why such a specific voltage variation occurs is not clear at present, but the occurrence of the specific voltage variation seems to be related to an electrochemical reaction caused when the distance between the anode and the cathode is being reduced and to be correlated to the creation and growth of chlorine gas bubbles produced when both the anode and the cathode are brought extremely close to each other.

With reference now to FIG. **1**, there is schematically shown one example of the electrolytic cell system suitable for carrying out the method of the present invention which will become more apparent from the following description. In order to simplify the drawing, FIG. **1** illustrates schematically an electrolytic cell having only one anode.

The electrolytic cell comprises a vessel **1** covered with a layer of mercury **2** which is used as a cathode and continuously fed into the vessel **1**, and an anode **3** which is properly spaced in an alkali chloride electrolyte **4**, which is also supplied continuously into the vessel **1**, from the surface of the mercury layer **2**. The aqueous alkali chloride solution is electrolized continuously by a direct current flowing between the anode **3** and the cathode **2**. As a result, chlorine gas is produced at the anode side, while at a deflocculation part (not shown in FIG. **1**), hydrogen gas is produced and an aqueous alkali solution is produced and discharged, the mercury being circulated.

The anode **3** is connected to an anode bus bar **7** through a vertical metal rod **5** and a lead wire **6**. Furthermore, the anode **3** together with many other anodes is mechanically connected through the metal rod **5** to an anode-supporting frame (not shown in FIG. **1**) which is moved up and down by means of an impellant shaft **8**. This shaft **8** is provided with a threaded part which is engaged with a threaded rotary shaft **10** of an operating electric motor **9**, whereby the rotary motion of the electric motor **9** is transmitted as a linear motion to the impellant shaft **8**.

A so-called step motor driven by pulses may be employed as the electric motor **9**. The step motor **9** is connected to an output terminal **12** of a driving power source circuit **11**. This power source circuit **11** drives the electric motor **9** so as to move the anode **3** downward when a control signal is introduced to a control input terminal **13** of the power source circuit **11** and to move the anode **3** upward when another control signal is introduced to another control input terminal **14** of the power source circuit **11**. The control input terminal **13** of the driving power source circuit **11** is connected to the output terminal **16** of a bi-stable multivibrator **15**, while the control input terminal **14** is connected to the output terminal **18** of another bi-stable multivibrator **17**.

From an additional output terminal **19** of the driving power source circuit **11**, there appears a train of pulses having a frequency proportional to the rotational frequency of the electric motor **9**. The train of pulses together with a signal from the output terminal **18** of the bi-stable multivibrator **17** is applied to the input terminals of an AND gate **20**. The output terminal of the AND gate **20** is connected to an input terminal of a digital counter **21**. This digital counter **21** produces an output signal at its output terminal when the count of the digital counter **21** reaches a predetermined counting value. The output signal thus produced is introduced to a resetting input terminal **22** of the bi-stable multivibrator **17**.

Referring to the electrolytic cell again, a lead wire **23** is connected at its one end to a conductor of the anode side of the electrolytic cell, for instance to a proper point of the lead wire **6**, while the other end of the lead wire **23** is connected to one terminal of a capacitor **24**. The other terminal of the capacitor **24** is connected through another lead wire **25** to one end of the primary winding of an insulating transformer **26**. The other end of the primary winding is connected through another lead wire **27** to a bus bar **28** provided on the cathode **2** side.

The secondary winding of the insulating transformer **26** is connected to the input terminal of a threshold-value-responding circuit **29** whose output terminal is connected to both a resetting input terminal **31** of the bi-stable multi-vibrator **15** and a resetting input terminal **32** of the bi-stable multi-vibrator **17**. Reference numeral **33** designates an input terminal through which an anode-lowering command signal is applied when the voltage of the electrolytic cell is brought to a level higher than a predetermined value or at a predetermined time interval. This input terminal **33** is connected to both a setting input terminal **34** of the bistable multi-vibrator **15** and a resetting input terminal **35** of the counter **21**.

A short-circuit-foreseeing section which is adapted to detect a specific voltage immediately before the short-circuit between the anode, and the cathode which is one of the essential features of the present invention, is shown within a broken-line enclosure in FIG. **1**. The short-circuit-foreseeing section comprises the threshold-value-responding circuit **29** which is connected or correlated electrically with the measuring device, the insulating transformer **26** and the capacitor **24**, all of which have been described above.

The capacitor **24** differentiates the rate of voltage change with respect to the voltage between the anode and cathode, while and electric current proportional to the differential value of the rate of voltage change is supplied through the insulating transformer **26** to the input terminal of the threshold-value-responding circuit **29**. In other words, the capacitor **24** serves to interrupt an electrical component (a D.C. component), which varies slowly, and to pass an electrical component which varies quickly and more abraptly. The electrical component varying abruptly is applied to the input terminal of the threshold-value-responding circuit **29**. This threshold-value-responding circuit **29** generates and dispatches and output signal when the input signal exceeds a predetermined value with its polarity corresponding to the reduction of the voltage between the anode and the cathode. **27** no variation in the and the cathode, the voltage between the anode and the cathode contains a voltage pulsation, or a voltage ripple component originated from the voltage ripple of the rectified power source of the electrolytic apparatus. This voltage ripple component passing through the capacitor **24** has a waveform as shown in FIG. **2**(*a*) and is delivered to the input terminal of the threshold-value-responding circuit **29**. However, such a voltage ripple component cannot actuate the circuit **29** because there is a non-sensitive range within which the circuit does not sense the voltage ripple component provided in the circuit **29**.

However, when the anode and the cathode come extremely close to each other so that they are in the condition immediately before the short-circuit occurring immediately before the short-circuit an input signal or a signal introduced to the input terminal of the threshold-value-responding circuit **29** becomes as shown in FIG. **2**(*b*). In other words, a great pulse component of voltage variation is intermittently superimposed on the slight ripple component shown in FIG. **2**(*a*). As a result, the input signal of the circuit **29** is varied considerably. The pulse component of voltage variation is sufficient to exceed the predetermined threshold value of the threshold-value-responding circuit **29** thereby to actuate the latter.

As is described before the reason why such a pulse component of voltage variation is thus generated intermittently at the time immediately before the both electrodes are short-circuited is unknown at present, but probably the impulsive voltage variation component is generated in connection with an electro-chemical reaction such as the creation or growth of chlorine bubbles which are caused when the both electrodes come extremely close to each other.

Referring to FIG. **1** again, the operation in continuously adjusting the distance between the two electrodes will be described.

Before the adjustment of the distance between the two electrodes, the bi-stable multivibrators **15** and **17** are initially reset so that there exists no output signal at their output terminals **16** and **18**, that is, flip-flops $F_1$ and $F_2$ are in the state of "0." Then, a pulse signal having a short time duraton is applied as the anode-lowering command signal to the input terminal **33**. This signal is applied through the input terminal **35** to the counter **21** so that the counter **21** will be in the 0 state, and at the same time the signal serves to change the states of the bi-stable multi-vibrator **15**. As a result, an output signal appears at the output terminal **16** of the multi-vibrator **15**.

This output signal at the output terminal **16** is applied through the control input terminal **13** to the driving power source circuit **11** thereby to activate the latter, whereby the driving power source circuit **11** is operated so as to move the anode downward. In this connection, it is preferable to select the anode-descending speed at a slow speed of the order of from 0.5 to 1.5 mm/min (for instance, 1.0 mm/min).

When the anode **3** comes extremely close to the cathode surface **2** so that they are in the condition occurring immediately before the short-circuit, the pulsive voltage variation componet described before is introduced to the input terminal of the threshold-value-responding circuit **29** thereby to produce an output signal from the latter. The output signal thus produced is applied to the input terminal **31** thereby to change the states of the bi-stable multi-vibrator **15**. As a result, the signal introduced to the input terminal **13** of the circuit **11** from the output terminal **16** of the multi-vibrator **15** disappears, and the driving operation of the electric motor **9** to move the anode downward stops.

At the same time, the output signal of the threshold-value-responding circuit **29** is applied to the input terminal **32** of the multi-vibrator **17** thereby to change the states of the multi-vibrator **17**. As a result, an output signal is produced at the output terminal **18** of the multi-vibrator **17**. The output signal thus produced is introduced to the input terminal **14** of the driving power source circuit **11** whereby the electric motor **9** is driven to move the anode **3** upward. In this case, it is preferable to select the anode-ascending speed at from 2 to 15 mm/min, for instance, 10 mm/min, which is much greater than the anode-descending speed.

As soon as the electric motor **9** starts driving the anode downward, the AND gate **20** is opened by the output signal from the terminal **18** and a train of pulses having a frequency proportional to the rotational frequency of the electric motor **9** is delivered through the output terminal **19** of the circuit **11** and the AND gate **20** to the digital counter **21** and is then counted by the counter **21**. When the count of the counter **21** reaches the predetermined counting value, the counter **21** produces an output signal which resets the bi-stable multi-vibrator **17**.

As a result, the signal which has been introduced to the control input terminal **14** of the driving power source circuit **11** from the output terminal **18** of the bi-stable multi-vibrator **17** disappears and the operation of the electric motor driving the anode upward stops. In this connection, it is preferable to select the predetermined counting value of the counter **21** so that the anode **3** stops at a position for instance 0.1 to 1.0 mm above the position of the anode where the condition that both the electrodes are immediately before the short-circuit is detected.

FIG. **3** is a graphic diagram illustrating the relationships of a distance *r* between the electrodes with respect to time *t* in adjusting the distance between the electrodes of the embodiment shown in FIG. **1**. FIG. **4** is also a graphical representation indicating the relationship of the distance *r* between electrodes with respect to time *t* in another embodiment (not shown in FIG. **1**) of the present invention.

In the case of FIG. **4**, the operation of regulating the distance from the time $t_1$, where the anode-lowering command signal is applied, to the time $t_2$, where the condition that both the electrodes are in the condition which occurs immediately before the short circuit, is the same as that in FIG. **3.** However, during the period of time from the time $t_2$ to the time $t_3$, the anode is moved upward by a distance $h + \Delta h$ of, for instance, 1.0 to 2.0 mm, exceeding the appropriate distance $h$ of, for instance, 0.1 to 1.0 mm, and during the period of time from the time $t_3$ to the time $t_4$, the anode is moved downward by the distance $\Delta h$ to obtain the appropriate distance $h$.

When the anode is brought into close proximity relative to the cathode surface so that they are in the condition occurring immediately before the short-circuit, a partial rise of the cathode surface is transiently caused. However, in the case shown in FIG. **4,** after the anode has been moved upward to the position where such phenomenon as described above is not caused, the anode is moved downward thereby to obtain an appropriate distance between the anode and the cathode. Therefore, the case of FIG. **4.** is advantageous in that the appropriate distance in FIG. **4** can be made less than that in FIG. **3.**

FIG. **1** shows the electrolytic cell having only one anode in order to simplify the description. However, in the case of a number of electrolytic cells which are operated in a unit plant, each electrolytic cell having a number of anodes, is divided into a proper number of blocks each of which has an anode-supporting frame for a group of anodes belonging to the block, the anode-supporting frame being provided, at a proper position of the electrolytic cell, with an operating device adapted to move the anodes upward and downward. In addition to the above, in each block, the input terminal which is the measuring means for the measurement of the rate of voltage change and the forecasting of the short-circuit of the electrodes is settled. In this case, the input terminals of all blocks are connected jointly with the threshold value-responding circuit **29** through a switching circuit (not shown in FIG. **1**) which switches the connection between a input terminal of each block and the threshold value-responding circuit one by one alternatively, and the operating devices of all blocks are also connected jointly with the driving power source circuit through a switching circuit which switches alternatively the connection between an operating device of each block and the driving power source circuit thereby the adusting the distance between the electrodes for all of the blocks of the many electrolytic cells continuously or periodically, using commonly one unit of the control system as shown in FIG. **1.**

According to the present invention, the condition that the anode and the cathode are in the condition occurring immediately before the short-circuit can be precisely and quickly detected, whereby the adjustment of the distance between the anode and the cathode is carried out automatically and properly while the short-circuit between the anode and the cathode being avoided, and the operation of the electrolytic cells can be conducted safely and economically.

The following are the results of the operations of sodium chloride solution electrolytic cells with graphite anodes and mercury cathodes which were actually conducted with an electrolyzing current of 100,000 amperes in accordance with the operational conditions of the electrolytic system described above with reference to the system shown in FIG. **1** and the control method of the electrodes described with reference to FIG. **4.**

1. Adjustment Conditions

One electrolytic cell was divided into four blocks, and the distances of the electrodes were adjusted one by one and furthermore adjusted repeatedly with a period of 12 hours.

| | | |
|---|---|---|
| (1) | Anode-descending speed | 1.0 mm/min. |
| (2) | Anode-ascending speed | 10.0 mm/min. |
| (3) | Distance of anode ascent | 1.6 mm |
| (3) | Distance anode descents again | 0.8 mm |
| (4) | Distance from the point where the informational signal is produced to the final stop position of the anode | 0.8 mm |
| (6) | Threshold value predetermined for detecting the voltage variation caused by the fact that the electrodes are about to short-circuit | |
| | Rate of voltage change: | 4mV/m sec |
| | Time width: | 4 m sec |

2. Results of Adjustments

The adjustments of the inter-electrode distances were repeatedly conducted 10 times, as a result of which the differences, in the inter-electrode distance, of the blocks are greatly reduced, and the electrolytic cell voltages of all of the blocks were maintained in a low and narrow voltage range of 4.00 V to 4.03 V, resulting in a satisfactory electrolytic operation with no short-circuit phenomenon. In addition, the efficiency of the electric current is not reduced and is maintained in a range of 94.7 percent to 95.1 percent.

We claim:

**1.** A method of adjusting the distance between the anode and the cathode of a mercury cathode electrolytic cell, which method comprises the steps of: lowering the anode toward the cathode at a predetermined speed while observing the rate of voltage change with respect to the voltage between the anode and the cathode; producing an informational signal at a position of the anode with respect to the cathode when the rate of voltage change exceeds a predetermined threshold value; stopping and raising said anode at a speed substantially higher than said predetermined speed immediately after receiving the informational signal; and then stopping said anode at a position remote upwardly by a predetermined distance from said position of the anode with respect to the cathode, where said informational signal is produced.

**2.** A method of adjusting the distance between the anode and the cathode of a mercury cathode electrolytic cell, which method comprises the steps of: lowering the anode toward the cathode at a predetermined speed while observing the rate of voltage change with respect to the voltage between the anode and the cathode; producing an informational signal at a position of the anode with respect to the cathode, when the rate of voltage change exceeds a predetermined threshold value; stopping and raising said anode at a speed substantially higher than said predetermined speed immediately after producing the informational signal to a position higher than the predetermined finally stopping position; then lowering said anode close to the cathode at said predetermined speed; and stopping the anode at a position remote upwardly by a predetermined distance from said position of the anode with respect to the cathode where said informational signal is produced.

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