May 1, 1945. R. J. McNITT 2,374,762

METHOD FOR DETECTING FAULTY ELECTROLYTIC CELL OPERATION

Filed Oct. 28, 1941

Fig. 1,

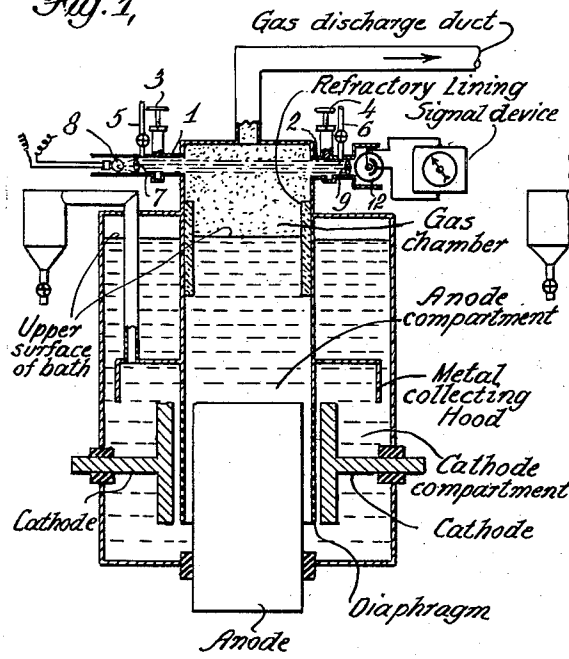
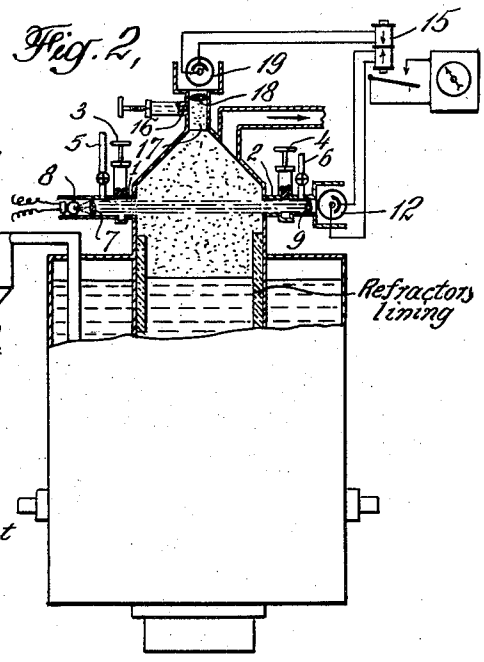


Fig. 2,



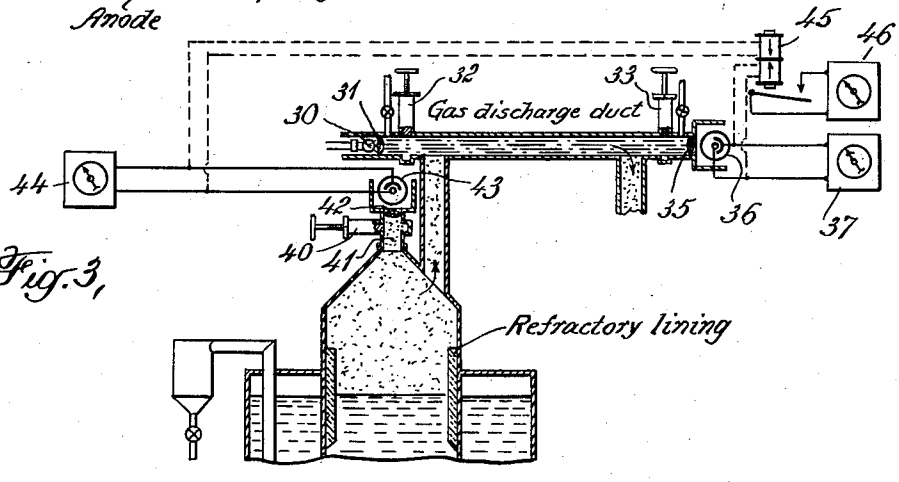
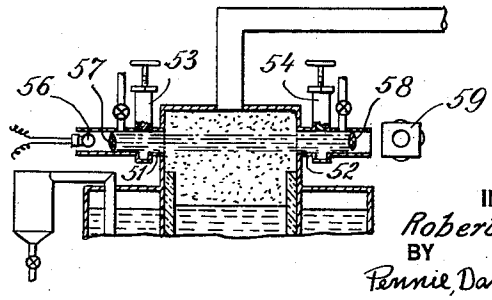


Fig. 3,

Fig. 4.



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METHOD FOR DETECTING FAULTY ELECTROLYTIC CELL OPERATION

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Application October 28, 1941, Serial No. 416,843

5 Claims. (Cl. 204—68)

This invention relates to the electrolysis of fused baths and in particular to the production of light metals by electrolysis in cells of the type having a diaphragm between the anode and the cathode. The invention is particularly adapted to those cells having an enclosed anode compartment the walls of which extend upward from the diaphragm through the surface of the bath and form an enclosed gas chamber above the bath for receiving the gas. The invention aims to provide a method of, and apparatus for, detecting faulty operation of the cell and is based on the utilization of certain phenomena connected with metal burning in the gas chamber to indicate an undesired operating condition in the cell.

In cells of this kind, the diaphragm is sometimes imperfect and some of the light metal passes over into the anode compartment. The diaphragm may be misplaced and in electrical contact with the cathode, and conducting bridges may form between the cathode and the diaphragm, causing more or less of the light metal to be liberated on the anode side of the diaphragm. These conditions may be serious enough to cause a fall in the rate of production of the metal with a corresponding rise of temperature in the bath, or a decrease in the rate of flow of the gases from the anode compartment, and heretofore these symptoms have been relied upon to indicate undesirable operating conditions in the cell, especially due to a faulty condition at the diaphragm.

The light metal entering the anode compartment may be in the form of globules of such size that they are not absorbed immediately by recombination with the gases liberated at the anode, but rise to the surface of the bath in the anode compartment and there burn in reaction with the gas in the gas chamber.

Since burning metal in the gas chamber tends to move towards the refractory lining of the chamber and causes injury to the lining and forms secondary products which enter the electrolyte as harmful impurities, it is important that this condition be found and remedied as early as possible, and inasmuch as light metals may burn in the gas chamber for hours or even days without causing any considerable fall in the rate of production, a more prompt indication of this condition is desirable than that which is afforded by the symptoms of decline in yield and rise in bath temperature mentioned above.

I have observed that when light metals burn at the surface of the bath in the gas chamber a considerable quantity of the product of combustion rises above the bath as a cloud of exceedingly small solid particles. This cloud of dust particles spreads through the chamber and passes out through the discharge duct with the anode gases. As is well known, there are conditions when a considerable quantity of finely divided particles of electrolyte is carried from the bath in the form of dust into the gas chamber and gas discharge duct by the anode gases.

In my copending application Serial No. 416,842, filed October 28, 1941, I describe and claim a method of, and apparatus for, detecting the burning of metal in the gas chamber by utilizing the radiations emitted in the reaction. I employ windows, filters and other media to transmit the radiations out of the gas chamber. When the particles of dust form or exist in the gas chamber in excessive quantities they are deposited on the windows, filters or media employed to detect the presence of burning metal, reducing the efficiency of transmitting the radiations emitted by the burning metal. Even when floating as a cloud in the gas chamber, these particles of dust may interfere more or less seriously with the transmission of the radiations from the burning metal to a radiation-sensitive device and render it quite unreliable.

Under certain operating conditions the concentration of particles of dust carried in the anode gas is fairly uniform and any increase in the concentration may be taken as an indication of an abnormal condition which it is desirable to call to the attention of the operator. Under the action of certain impurities in the electrolyte, a foam rises from the upper surface of the bath and may fill the entire gas chamber. It is very desirable that such an abnormal condition be indicated promptly.

This invention aims to provide a method of, and apparatus for, detecting faulty or undesired conditions in the operation of the cell, and is based upon the utilization of variations in the cloud of dust particles in the anode gas to indicate the operating conditions. In one application of my invention I project a beam of light, ordinary white light, through the gas and out of a window in the gas chamber and use the light from the window to indicate visually variations in the light caused by dust particles in the gas. I may use lenses, prisms, mirrors, fluorescent materials, or other suitable devices to receive the light passing out of the gas chamber to aid in the visual inspection of the light conditions.

In one form of the invention, I project through the anode gas to a suitable radiation-sensitive device a beam of radiations such as the rays of the spectrum, and utilize the effects upon the radiation-sensitive device to indicate the presence of various concentrations of the dust particles in the gas. To this end, for example, I may project the beam of radiations into a bolometer or a photo-electric cell and use the impulses from the bolometer or the photo-electric cell to signal or otherwise indicate variations in the beam due to dust particles.

In order to increase the sensitivity of the apparatus to slight changes in the concentration of dust particles, I may provide a longer path for the light than is ordinarily available in the gas chamber, and to this end, I may pass the gas through a duct of the required length and project the beam of radiations through the gas in the duct to a radiation-sensitive device.

In another embodiment of my invention, I combine the effect of the dust particles in obstructing a projected radiation, together with the effect produced by the radiations emitted from metal burning in the gas chamber, and impose the combined effects on a suitable receiver or detecting device to obtain a reliable indication of certain abnormal or undesired conditions in the cell as immediately manifested by conditions in the gas chamber. In an effective embodiment of the invention for this purpose, I impose the radiations from the burning metal on a photo-electric cell and the projected beam of radiations upon another photo-electric cell, and connect the photo-electric cells to a suitable differential device, such as a differential relay, which is connected to a receiver or indicating device such as an amplifier, electric gong, or the like.

These and other novel features of the invention will be better understood after considering the following discussion taken in conjunction with the accompanying drawing, in which:

Fig. 1 is a sectional side elevation of an electrolytic cell for the electrolysis of a fused salt illustrating an embodiment of the invention;

Figs. 2 and 3 are side elevations, partly in section, of an electrolytic cell similar to that of Fig. 1 illustrating different embodiments of the invention, and

Fig. 4 is a fragmentary sectional side elevation of an electrolytic cell similar to that of Fig. 1 illustrating another embodiment of the invention.

The drawing illustrates more or less diagrammatically the application of the invention to cells that are particularly suitable for the electrolysis of fused salts of light metals, for example, sodium chloride, and the like. It is, of course, understood that the invention is equally applicable to other cells in which the metal may enter the gas collector and react with the collected gas. As shown in the drawing, the cell comprises the usual container for holding the fused bath, one or more cathodes, an anode, and a gas chamber. The gas chamber side-walls project into the fused bath and connect to the diaphragm. The lower portion of the side-walls and the diaphragm divide the cell into anode and cathode compartments. The diaphragm serves to keep the metal which is accumulated at the cathode, in the cathode compartment, and the gases which are liberated at the anode, in the anode compartment. The gas, for example chlorine, when sodium chloride is the fused electrolyte, collects in the gas chamber. During normal operating conditions the metal does not enter the anode compartment, but the diaphragm may become imperfect or misplaced, or conducting bridges may form between the cathode and the diaphragm and the light metal may be liberated on the anode side of the diaphragm from which it floats to the surface of the bath and burns (combines with the chlorine collected in the gas chamber).

As shown in Fig. 1, ducts 1 and 2 are connected to the gas chamber at opposite sides, each having a shut-off valve 3 and 4, and a gas pipe 5 and 6 respectively. Pipe 1 has a lens 7 closing the hole in the duct and a source of radiations such as an electric light 8. The radiations are projected from the lens through the gas chamber into the duct 2 and through the lens 9. A radiation-sensitive device, such as a bolometer or a photo-electric cell 12, is mounted in front of the lens 9 and receives the radiations. The impulses from the radiation-sensitive device may be transmitted to any suitable signal device such as a light, gong or to an amplifier.

In the usual operation of the cell the gas liberated at the anode rises in the anode compartment and is collected in the gas chamber. The metal liberated at the cathode rises and is collected under the hood. The gas entering the gas chamber usually carries along fine particles of the bath. When particles of metal enter the gas chamber and burn, the product of combustion rises above the bath as a cloud of dust. And impurities in the bath may cause a foam to form which fills the gas chamber.

Under normal conditions of operation, there is no foam and the dust particles are not in sufficient concentration to obstruct the radiations entering lens 9. When, however, the radiations become obstructed, the radiation-sensitive device operates the signal device and the undesired condition may be remedied without a loss in efficiency or injury to equipment.

Since ducts 1 and 2 are in horizontal positions, there is a tendency for dust to accumulate therein. In order to remove this dust in a very simple manner, I charge a blast of inert gas through pipes 5 and 6 and blow the dust back into the gas chamber. In order to clean the windows or lenses, as the case may be, the valves 3 and 4 are closed and the windows or lenses are removed for cleaning.

In the cell of Fig. 2, the apparatus for the projection of a beam of light through the gas chamber is similar to that of Fig. 1 with the exception that it connects to a differential relay 15. At the upper part of the gas chamber and above the bath, I mount a shut-off valve 16 over the opening 17 and a removable lens 18 serving as a window over the opening of the valve. A photo-electric cell 19 is mounted over the lens and receives radiations emitted from metal burning in the gas compartment.

The impulses from the photo-electric cell caused by burning metal are transmitted to one coil of the differential relay 15 and the impulses from photo-electric cell 12 caused by variations in the concentration of dust, or by foam, in the gas chamber are transmitted to the other coil of the differential relay.

The apparatus of Fig. 2 is very sensitive to radiations from the burning of metal in the gas chamber because the effect of radiations from the burning metal adds to the effect of clouds of dust rising from the burning metal and obstructing the light projected to cell 12. If sufficient dust accumulates on the lenses 7 and 9 to interfere seriously with the passage of the ray of radiant energy therethrough, the detecting device will set an alarm to call an operator just as though metal were burning in the chamber. If dust accumulates on the lenses 7, 9 or 18, the valves 3, 4 and 16 are closed and the lenses removed for cleaning. If dust accumulates in ducts 1 and 2, it may be removed with a blast of gas through pipes 5 and 6.

The apparatus of Fig. 3 embodies an arrangement of apparatus similar to that of Fig. 2 and

in addition provides for the projection of radiations through a longer path or body of gas than is possible in the usual gas chamber so that the impulses from the radiation-sensitive devices may be made more responsive to lower concentrations of dust particles. I pass the gases from the gas chamber through a gas discharge duct having a source of light 30 at one end which projects the light through a window or lens 31, through the shut-off valve 32, the shut-off valve 33, and lens 35 into the photo-electric cell 36. This photo-electric cell is connected to a signal device 37 in the usual way. Variations in the concentration of dust particles in the gas passing through the gas discharge duct vary the intensity of radiations entering the photo-electric cell and, accordingly, register the conditions in the gas chamber on the signal device. The lenses 31 and 35 may be cleaned in the manner previously described.

The arrangement of a detecting device involving the projection of light rays through the gas discharge duct enables the operator to determine whether or not solid matter, such as dust, has accumulated in the duct to an extent sufficient to interfere with the free discharge of the gas as well as to detect the presence of burning metal.

In order to detect directly the burning of metal in the gas chamber, I mount a shut-off valve 40 over the opening 41 and a lens 42 through which the radiations pass and enter the photo-electric cell 43. Impulses from this photo-electric cell are passed directly to the signal device 44. In an alternative arrangement, I connect the photo-electric cell 36 to one coil of a differential relay 45 and the photo-electric cell 43 to the other coil of the differential relay. This alternative hook-up is very sensitive where small globules of metal burn, since the intensity of radiation is relatively high but is accompanied with little dust. The differential relay and the two photo-electric cells connected thereto conjointly operate the signal device 46 in the manner described in connection with Fig. 2.

The apparatus shown in Fig. 4 comprises ducts 51 and 52 connected to opposite sides of the gas chamber, shut-off valves 53 and 54, an electric light 56, lens or window 57, and a lens or window 58. When the valves 53 and 54 are open, radiations from the light 56 pass through the window where they may be observed by the operator in order to facilitate the visual inspection of the light passing out of the window 58. I may mount any suitable auxiliary device 59, such as a mirror, prism, lens or fluorescent material, in the path of rays projected through the window. It is understood that the lens and window are kept clean in the manner hereinbefore described and that the variations in the concentration of dust particles in the gas cause variations in the intensity of the light and that these variations indicate the conditions in the gas chamber.

In referring in the claims to a gas chamber and to the projection of radiations through the gas chamber, I include not only the gas chamber proper but the gas chamber together with any contiguous extensions thereof and also to the gas discharge duct through which the gases flow from the gas chamber proper.

When I refer herein to a light metal, I mean a metal like sodium or potassium which is less dense than the bath and which rises in the bath to the surface.

I claim:

1. In the operation of an electrolytic cell for the production of a light metal in the electrolysis of a fused salt bath, said cell having a gas chamber for receiving gas liberated at the anode, the method of detecting a failure at the diaphragm resulting in dust particles entering the gas chamber which comprises projecting a beam of radiations through the gas in the chamber to a radiation-sensitive device, and utilizing impulses from the radiation-sensitive device influenced by the dust particles to indicate interruptions in the beam of radiations.

2. In the operation of an electrolytic cell for the production of a light metal in the electrolysis of a fused salt bath, said cell having a gas chamber for receiving gas liberated at the anode, the method of detecting a failure at the diaphragm resulting in dust particles entering the gas chamber which comprises projecting a beam of radiations through the gas to a photo-electric cell, and transmitting impulses from the photo-electric cell to an indicating device.

3. In the operation of an electrolytic cell for the production of a light metal in the electrolysis of a fused salt bath, said cell having a gas chamber for receiving gas liberated at the anode, the method of detecting a failure at the diaphragm resulting in dust particles entering the gas chamber which comprises projecting a beam of radiations through a relatively long body of the gas to a radiation-sensitive device in order to register on the said device slight variations in the concentration of the dust particles in the gas, and utilizing the effects produced upon the radiation-sensitive device as an indication of operating conditions at the diaphragm.

4. In the operation of an electrolytic cell for the production of a light metal in the electrolysis of a fused salt bath, said cell having a gas chamber for receiving gas liberated at the anode, the method of detecting a failure at the diaphragm resulting in dust particles entering the gas chamber which comprises projecting a beam of radiations through the gas in the chamber to a radiation-sensitive device, permitting radiations from metal burning in the gas chamber to contact another radiation-sensitive device, said radiation-sensitive devices being capable of transmitting impulses due to variations in the radiations, and combining the impulses from the said devices to indicate the operating conditions at the diaphragm.

5. In the operation of an electrolytic cell for the production of a light metal in the electrolysis of a fused salt bath, said cell having a gas chamber for receiving gas liberated at the anode, the method of detecting a failure at the diaphragm resulting in dust particles entering the gas chamber which comprises projecting a beam of radiations through the gas in the chamber to a radiation-sensitive device, permitting radiations from metal burning in the gas chamber to contact another radiation-sensitive device, said radiation-sensitive devices being capable of transmitting impulses due to variations in the radiations, and combining the impulses in a differential means to amplify the effect of variations in the radiations.

ROBERT J. McNITT.