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MAKE-ALIVE ELECTRODE FOR VAPOR-ELECTRIC CONVERTERS

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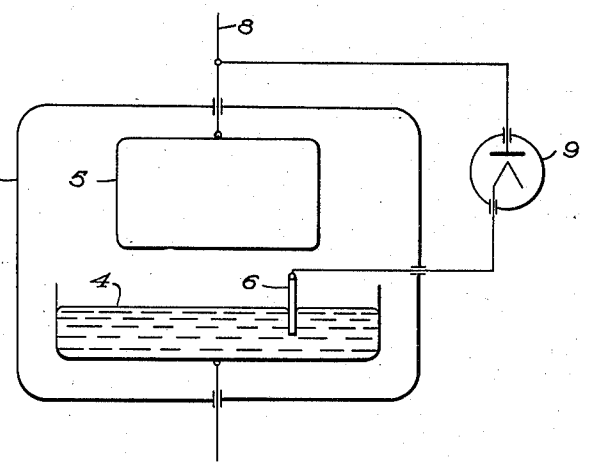


Fig. 1.

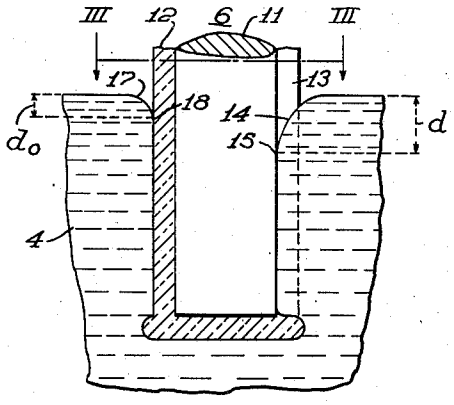


Fig. 2.

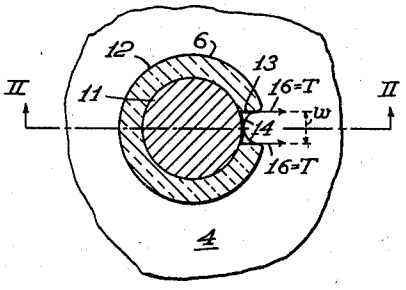


Fig. 3.

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MAKE-ALIVE ELECTRODE FOR VAPOR-ELECTRIC CONVERTERS

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4 Claims. (Cl. 250—27.5)

Our present invention relates to vapor-electric converters, such as mercury-arc rectifiers, of the type utilizing a make-alive electrode projecting into the cathode of the converter, and it has particular relation to an improved form of construction of the make-alive electrode, resulting in improved operation.

The principal object of our invention is to provide a make-alive construction in which the pressure of the contact between the mercury, or other liquid cathode material, and the high-resistance make-alive material, is much lighter than heretofore. More specifically stated, it is an object of our invention to surround the make-alive rod with a longitudinally slotted insulating sheath which causes the mercury to reach the make-alive rod through a convex meniscus, so that the surface-tension of the mercury, at the surface of the meniscus, is pulling away from the make-alive rod, in opposition to the head of mercury dependent upon the depth of the meniscus at any point, as distinguished from previous constructions in which the mercury-surface which was in contact with the sides of the make-alive rod had a concave or circular configuration, embracing the rod, so that the surface-tension of the mercury tends to press the mercury against the make-alive rod, adding its pressure to the mercury-head dependent upon the depth of the various points in the contact. The result of the decreased contact which is achieved by our invention is an increase in the efficiency of the make-alive electrode and a reduction in the necessary current in the make-alive circuit.

With the foregoing and other objects in view, our invention consists in the elements, parts, combinations, apparatus and methods hereinafter described and claimed, and illustrated in the accompanying drawing; wherein

Figure 1 is a diagrammatic view of circuits and apparatus illustrating the general type of combination in which our invention is adapted to be utilized,

Fig. 2 is an enlarged detailed vertical-elevational view showing our improved make-alive electrode in the mercury cathode, the section-plane being indicated by the line II—II in Fig. 3, and

Fig. 3 is a horizontal sectional view thereof, on the line III—III of Fig. 2.

Our invention is applicable to the general type of converter which is illustrated, in Figure 1, as comprising a vaporizable liquid cathode 4, which may be mercury, an anode 5 spaced or separated therefrom, and a make-alive electrode 6 which projects into the cathode 4, all enclosed within a container which is diagrammatically represented at 7. The make-alive 6 may be energized in any one of a number of different ways, Fig. 1 showing a conventional form of circuit in which the make-alive is connected to the anode-lead 8 through a small auxiliary rectifier 9.

The particular form of make-alive electrode 6, which is utilized in our invention, is illustrated, on an enlarged scale, in Figs. 2 and 3. It comprises a rod-like core 11 of a high-resistance make-alive material which may be practically any high resistance material which does not amalgamate with mercury, or in general, with the cathode-material 4, such as boron carbide, or well known make-alive equivalents. This make-alive core or rod 11 is enclosed in a fairly closely fitting, or adhering, sheath 12 of any suitable insulating material which may be quartz, ceramic material, or vitreous material. It is obvious that the material of the insulating sheath 12 should be capable of withstanding the thermal expansions and contractions of the make-alive core 11, as well as the maximum operating temperature which is encountered. The sheath 12 is provided with one or more longitudinal slots 13, one being shown, which extends substantially vertically when the make-alive electrode 6 is immersed into the mercury, in its normal operating position.

The effect of the slotted insulating sheath 12 is to cause the mercury 4 to reach the make-alive core 11, through the vertical slot 13, by means of a meniscus 14 which is convex in cross-section, as shown in Fig. 3. This meniscus has a radius of curvature which, at its greatest, is of the order of one-half of the width w of the slot 13, as shown in Fig. 3. The thickness of the insulating wall of the sheath 12 is preferably of the same order of magnitude as this maximum radius of curvature of the meniscus 14, as also illustrated in Fig. 3, so that the meniscus is capable of just barely lightly touching the make-alive rod 11, with a zero contact-pressure, at the top point 15 (Fig. 2) where it first makes contact.

At this top contact-point 15, the surface-tension T of the mercury (or other cathode-material) pulls the meniscus 14 in a direction away from the make-alive rod 11 with two forces 16, equal to the surface-tension T, as indicated in Fig. 3, and this total force is exactly opposed by the pressure-head due to the weight of a mercury-column corresponding to the depth d of the

point 15, as indicated in Fig. 2. If G is the specific gravity of the mercury or other cathode-material, and w is the width of the slot 13, the formula expressing the equation of forces at the point 15 will be

$$2T=Gwd \quad (1)$$

In the case of mercury, the surface-tension T is .0475 gram per millimeter and the specific gravity G is .0136 gram per square millimeter, so that the formula becomes

$$2x.0475= .0136\ wd$$
$$wd=7, \text{ (in millimeters)} \quad (2)$$

In accordance with our invention, it is desired to have the top contact-point 15 at a depth d of a few millimeters, or anywhere from about 4 millimeters to, say, 20 millimeters, although these limits are by no means critical. These limits correspond to a slot-width w of 1.75 millimeters and .35 millimeter, respectively. The thickness of the insulating sheath 12 should be at least something commensurate with the radius of the meniscus 14, which is $w/2$, giving a minimum sheath-thickness of, say, about 0.1 millimeter. We have found that a slot-width w of 0.6 millimeter is satisfactory, and we should say that the slot-width w should be not more than about 2 millimeters and not less than about 0.2 millimeter, for a mercury cathode.

The functional effect of our invention will best be understood by comparing it with the operation which is obtained with a bare cylindrical member sticking into the mercury, as in the case of previous make-alive electrodes. In Fig. 2, a slot 13 is shown on the right-hand side of the make-alive electrode, and a plain cylindrical wall 12 on the left-hand side.

For the purpose of our present discussion of the contact-pressure between the mercury and the make-alive electrode, we may consider that the plain cylindrical wall 12 on the left-hand side of the figure corresponds to the outer periphery of a plain, prior-art make-alive electrode without the slotted insulating sheath of our present invention. It will be observed that the mercury meniscus 17 brings the top contact-point 18 down to a depth d_0 below the top surface of the mercury. This depth d_0 may be roughly of the order of two millimeters, making the static pressure-head something like .027 gram per square millimeter. At and below this point 18, however, if the outer surface of the make-alive were a plain cylinder having a radius R, the surface of the mercury in contact with it would also be the same cylinder having a radius R millimeters, so that the surface-tension T of the mercury (in grams per millimeter) would tend to constrict this cylindrical surface, with a pressure of T/R grams per square millimeter. If the radius R of the make-alive was, say, two millimeters, the constrictive force of the surface tension of the cylindrical mercury-surface surrounding the make-alive electrode would be .024 gram per square millimeter, or of about the same order of magnitude as the static pressure-head of .027 gram per square millimeter at this top contact-point 18, corresponding to the operation obtained with a plain uncovered make-alive electrode. These two pressures would be additive, giving a total contact-pressure of about .051 gram per square millimeter at the top contact-point 18. From this point down, the contact-pressure between the mercury and the cylindrical outer surface of the make-alive electrode will steadily increase in proportion to the total depth d at any point.

In contrast with this operation of previous make-alive electrodes, the mercury does not get down (or over) to the bottom of our slot 13 until a point 15 is reached, which is below the point 18 at the bottom of the annular meniscus 17, and at this initial, or top, contact-point 15, the mercury-pressure, instead of having a finite positive value of .05 or more grams per square millimeter, will actually have a zero contact-pressure. Under these conditions the convexly curved surface of the mercury meniscus 14 will just barely lightly touch the highest spots of the rough cylindrical surface of the make-alive rod 11. Below this point 15, the contact-pressure of the mercury increases in accordance with the depth of the mercury, being always equal to the total static pressure-head at any depth d, minus the initial static pressure-head of the point 15.

In addition to this reduction in the contact-pressure of the mercury against the surface of the make-alive rod 11, our structure also results in a very considerable reduction in the area of the contacting surface between the mercury and the make-alive rod 11. This contact area starts with a straight line at, and immediately below, the top contact-point 15 (neglecting, for the moment, the inevitable irregularities in the surface of the make-alive rod), and as the depth increases, the static pressure-head gradually flattens out the meniscus 14 so that it makes contact with the make-alive rod 11 over a larger and larger proportion of the total width w of the slot 13. It is plain to see that the total overall contact-pressure of the mercury that comes into contact with a side of the make-alive rod 11 through the vertical slot 13 is very much less than the area of the whole cylindrical surface below the point 18, which would be the contact-surface if our slotted shield 12 were not utilized. This reduction in the contact-area, coupled with our reduction in the contact-pressure, results in a make-alive electrode which operates more effectively, and consumes much less current, or electrical energy, than in previous make-alives.

While we have described our invention in a preferred form of construction utilizing a single slot 13 of uniform width w, formed in an insulating sheath 12 having walls of uniform thickness, and surrounding a make-alive rod 11 of uniform cross-sectional area, it will be obvious that our invention is not limited to these details, and that these and other features may be changed by those skilled in the art without departing from the basic principles of our invention. We desire, therefore, that the appended claims shall be given the broadest construction consistent with their language and the prior art.

We claim as our invention:

1. A make-alive electrode for a vapor-electric converter of a type having a vaporizable liquid cathode, an anode separated from said cathode, and a make-alive electrode projecting into said cathode, said make-alive electrode comprising a rod-like core of a high-resistance make-alive material and a closely fitting slotted sheath of insulating material, said sheath having a thickness of at least about 0.1 millimeter and having a longitudinally extending slot extending through the wall thereof, said slot having a width of at least about 0.2 millimeter and not more than about 2 millimeters, the width of the slot being so dimensioned, within said limits, as to cause the meniscus of the cathode to barely touch said

core with a substantially zero pressure at some point below the level of the cathode.

2. A make-alive electrode for a mercury-arc converter of a type having a mercury cathode, an anode separated from said cathode, and a make-alive electrode projecting into said cathode, said make-alive electrode comprising an approximately smooth-surfaced rod-like core of a high-resistance make-alive material and a closely fitting slotted sheath of insulating material, said sheath having a thickness of at least about 0.1 millimeter and having a longitudinally extending slot extending through the wall thereof, said slot having a width of at least about 0.2 millimeter and not more than about 2 millimeters, the width of the slot being so dimensioned, within said limits, as to cause the meniscus of the cathode to barely touch said core with a substantially zero pressure at some point below the level of the cathode.

3. A vapor-electric converter comprising a vaporizable liquid cathode, an anode separated from said cathode, and a make-alive electrode projecting into said cathode, characterized by said make-alive electrode comprising a rod-like core of a high-resistance make-alive material and a closely fitting slotted sheath of insulating material, said sheath having a longitudinally extending slot extending through the wall thereof and having a width such as to cause the meniscus of the cathode to barely touch said core with a substantially zero pressure at some point below the level of the cathode.

4. A mercury-arc converter comprising a mercury cathode, an anode separated from said cathode, and a make-alive electrode projecting into said cathode, characterized by said make-alive electrode comprising a rod-like core of a high-resistance make-alive material and an enclosing slotted sheath of insulating material, said sheath having a longitudinally extending slot extending through the wall thereof and having a width such as to cause the meniscus of the cathode to barely touch said core with a substantially zero pressure at some point below the level of the cathode.

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