July 4, 1967 A. G. SAURWEIN 3,329,753

METHOD OF MAKING OPEN-ENDED CATHODES

Filed March 24, 1965

Fig. 1.

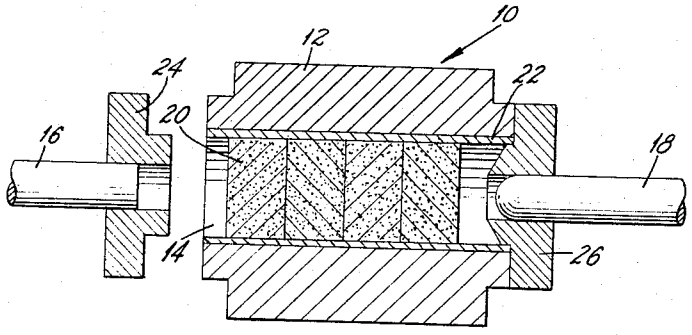



Fig. 2.

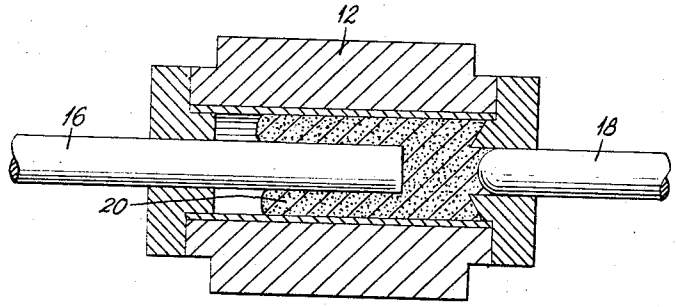



Fig. 3.

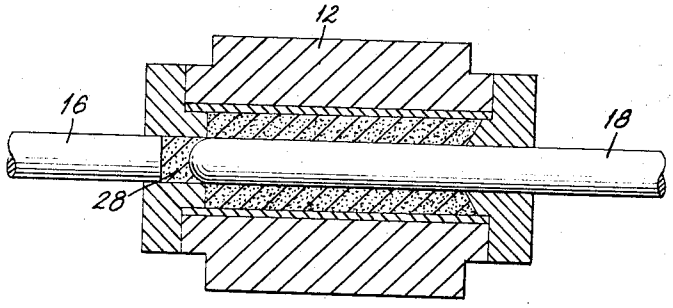
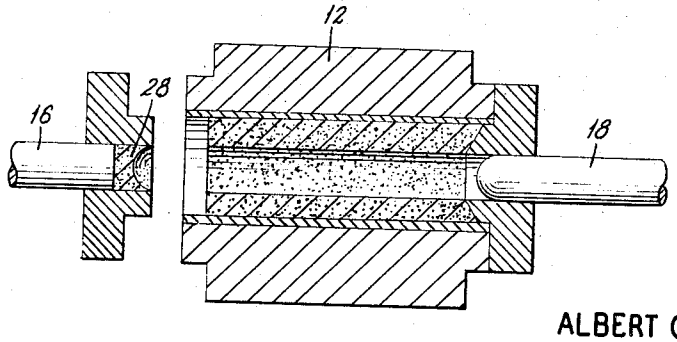



Fig. 4.




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# METHOD OF MAKING OPEN-ENDED CATHODES

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3 Claims. (Cl. 264—120)

This invention relates to a method of compression molding cathodes for use in galvanic cells, and more particularly to a method of molding open-ended or tubular shaped cathodes tightly inside tubular metal shells or containers.

One satisfactory and versatile apparatus for the making of hollow cathodes is disclosed in copending United States application Ser. No. 202,793, filed June 15, 1962, now Patent 3,198,862, the assignee of the subject invention being also the assignee of the above-referred to application. The apparatus disclosed in the copending application comprises a press provided with a movable upper portion containing a ram having passage means for expelling excess cathodic mix from a container in which a cathode is to be formed. The excess cathodic mix is expelled via the passage means when the ram is driven into the cathodic mix and is removed from the apparatus by a suitable vacuum system. The ram prior to being withdrawn from the container is rotated slightly to shear the mix where it enters the passage means.

In the above described method and apparatus, it has been preferred to rotate the ram which operation eliminates the facility to make tubular cathodes of various sizes and shapes other than those of the circular type. The method of the instant invention overcomes such limitation and not only is capable of making open-ended tubes of any shape such as, for instance, square or rectangular but it also eliminates the need for a vacuum system to remove the excess cathodic mix from the apparatus.

It is therefore the principal object of the invention to provide a method of making tubular shaped cathodes of various sizes and shapes inside a tubular-shaped container.

Another object of the invention is to provide a method for making uniform cathodes without precise measurement of the initial mix charge.

Yet a further object of the invention is to provide a method in accordance with the preceding objects which will conform to conventional forms of manufacture, be economically feasible and of relatively simple construction and easy to use with an apparatus that will exhibit long service free of any substantial maintenance.

These objects as well as other objects and advantages of the invention will become subsequently apparent in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawing forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a side elevational view, partly in section, of an apparatus suitable for carrying out the process of the invention;

FIGURE 2 is a similar elevational view in section illustrating the second step of the process after the cathodic mix has been dispensed into the apparatus;

FIGURE 3 is another side elevational view, partly in section, and showing the next to last step of the process prior to removing the formed cathode from the apparatus; and

FIGURE 4 is another side elevational view showing the finished cathode in the mold of the apparatus.

Referring now more specifically to the drawing, the numeral **10** generally designates the apparatus of the instant invention which includes suitable supporting means (not shown).

With attention now directed more particularly to FIGURES 1 and 2 of the drawing, it is seen that the apparatus **10** includes a housing **12** defining a mold cavity **14** and a pair of rams **16** and **18** disposed opposite each other in axial alignment. The rams **16** and **18** which are smaller in diameter than the diameter of the mold cavity **14** are adapted to selectively enter the mold cavity **14** from opposite ends of the housing **12** so as to compress and compact pelletized, cathodic mix material **20** in excess amount around them to form tubular shaped cathodes in place in an open-ended tube or container-electrode **22**. The rams **16** and **18** are of the same diameter and are suitably linearly moved relative to the housing **12** and toward each other by conventional hydraulic presses or the like (not shown). The mold cavity **14** is suitably closed at both ends of the housing **12** during the operation of the apparatus by means of end covers or stripper rings **24** and **26** respectively surrounding rams **16** and **18**.

In the operation of the apparatus, the cathodic mix material **20**, suitably in the form of pellets or preformed disks are preferably inserted first into the container **22** which is then in turn inserted into the mold cavity **14**. Subsequently, the rams **16** and **18** and their associated press machinery are arranged so that in the initial step both stripper rings **24** and **26** are disposed in position so as to close off both ends of the open-ended tube **22**. During the process of the invention ram **18** remains stationary and ram **16** which is pushed into the cathodic mix material **20** from one end of the tube **22** to about two-thirds of same initially packs and densifies the cathodic material **20**. Subsequently, the second ram **18** is then pushed from the other end of the tube **22**, overpowers the initial ram **16** and pushes it all the way back into stripper ring **24** thereby finally forming the cathode-container structure. Excess cathodic mix material **28**, as shown in FIGURES 3 and 4, is trapped between the rams **16** and **18** and is thereafter ejected from the stripper ring **24** when the ram **16** commences a new cycle. Prior to the removal of the finished cathode-container structure from the mold cavity **14** the ram **18** is withdrawn to its initial set-up position, as best shown in FIG. 4. It is readily apparent that the excess cathodic mix material is easily collected as slugs and may be simply crushed and reused.

A unique feature of this invention is the achievement of substantially uniform density throughout the entire length of the formed cathode. This is attributed to the cathodic mix material **20** which is trapped between the rams **16** and **18** under high pressure. The pressure generated by the action of the rams **16** and **18** cause the mix material **20** to squeeze out from between the ends of the rams and to exert an equally high pressure outwardly and radially along the entire length of the inside tube diameter of the tubular-shaped cathode being formed. This method thus provides a molded cathode structure of substantially uniform density and of low internal resistance. It should be realized, of course, that as the ram **18** sweeps across the length of the cathode being formed the mix between the rams **16** and **18** diminishes in volume by densifying the lesser dense areas but ram **18** exerts sufficient force so as to maintain uniform radial pressure of the mix along the entire length of tube **22**. It is desirable to have the leading end of ram **18** rounded or spherical in shape so as to guide and facilitate its entry into the stripper ring **24**.

In this regard it is noted that the cathode mix material moisture level is critical for if the mix is too dry the tubes will wrinkle and tear and if too wet electrolyte will be squeezed out of the mix or mix may flow into the clearances between stripper rings **24** and **26** and tube **22**, and between the rams and the stripper rings, leading to a jamming or seizure of the parts or at least a clean-up problem. The preferred moisture content of the cath-

ode mix material in terms of percent by weight is about 10%.

This double ram molding method of the invention provides cathodes which exhibit a uniform density, are smooth surfaced and generally free from flakes or chips. Cathode densities usually range from about 2.75 grams per cc. to about 2.92 grams per cc. Such density range is achieved by molding ram forces of about 4 tons to about 5 tons for the initial primary ram **16** and of about 12 tons to about 14 tons for the secondary ram **18**; the preformed slugs of cathodic material **20** being preferably densified from about 2.3 grams per cc. to about 2.6 grams per cc.

Cells of the type in which the present invention is applicable are basically of two kinds, viz., the alkaline-manganese dioxide-zinc cells and the so-called "inside-out" Leclanché cells wherein a wax-graphite shell is molded inside an "outer" paper tube. In this regard, the terms open-ended cathode and cathodic mix of the alkaline manganese cells are analogous to the wax-graphite cathode collector shell and graphite-wax mixture of the inside-out Leclanché cells. It should be noted that in the making of the "inside-out" Leclanché cells, there is no active cathode mix involved and the data hereinabove reported concerns alkaline cell mixes which when molded are hard, dry dense; whereas the ram pressures required for Leclanché cells are considerably less since the graphite-wax mixture is much more plastic than the alkaline cell mix.

It will be understood that while the invention has been described with particular reference to preferred embodiments, it is to be understood that it may be otherwise embodied by various changes and alterations all within the full and intended scope of the following claims.

What is claimed is:

1. A method of making an open-ended cathode for use in a dry cell comprising, depositing an excess of cathodic mix in a stationary mold open at opposite ends so as to fill said mold, driving a first ram from one end of said mold through about two-thirds of the longitudinal central portion of said mold so that an annular-shaped cathode is initially formed between the walls of said mold and said ram, driving a second ram of the same diameter and in axial alignment with said first ram from the opposite end of said mold whereby said cathodic mix is uniformly compressed and densified under high pressure between the ends of said rams such that some of said cathodic material radially squeezes out from between the ends of said rams to form a uniformly dense, hollow, open-ended cathode between the walls of said mold and said ram, ejecting the excess of said cathodic mix from said mold, and removing said open-ended cathode from said mold.



2. A method of making an open-ended cathode for use in a dry cell comprising, depositing an excess of cathodic mix in preformed pelletized form in an open-ended container so as to fill said container, positioning said container in a stationary mold open at opposite ends, closing both ends of said mold, imparting a compressive force by means of a ram from one end of said mold so that an annular-shaped cathode is initially formed in part between the inside walls of said container and said ram, imparting a secondary compressive force by means of a second ram from the opposite end of said mold whereby said cathodic mix is compressed under high pressure between said rams such that some of said cathodic material radially squeezes out from between said rams to form a uniformly dense, hollow, open-ended cathode-container structure, ejecting the excess of said cathodic mix from between said rams, and removing said open-ended cathode-container from said mold.

3. A method of making an open-ended cathode for use in a dry cell comprising, depositing an excess of cathodic mix in preformed pelletized form in a stationary mold open at opposite ends so as to fill said mold, closing both ends of said mold, imparting a compressive force by means of a ram from one end of said mold so that an annular-shaped cathode is initially formed in part between the walls of said mold and said ram, imparting a secondary compressive force by means of a second ram from the opposite end of said mold whereby said cathodic mix is compressed under high pressure between the ends of said rams such that some of said cathodic material radially squeezes out from between the ends of said rams to form a uniformly dense, hollow, open-ended cathode, removing said secondary ram from said formed cathode, ejecting the excess of said cathodic mix from said mold, and removing said open-ended cathode from said mold.

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