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H. I. DANZIGER ET AL

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ELECTROLYTIC CONDENSER BODY AND METHOD OF MAKING THE SAME

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Fig. 1

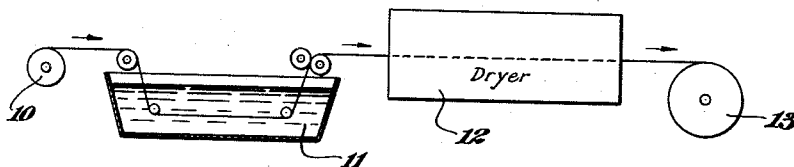


Fig. 2

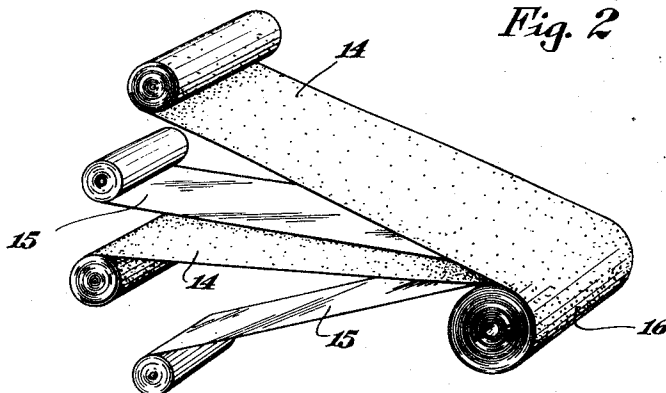


Fig. 3

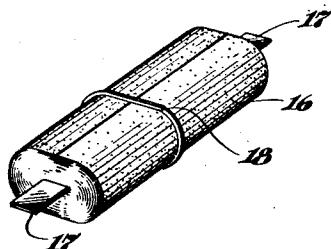
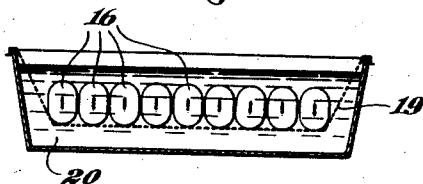


Fig. 4



INVENTORS
Harold I. Danziger,
Aniello Di Giacomo,
BY *Frederick Breitenfeld*
ATTORNEY.

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ELECTROLYTIC CONDENSER BODY AND
METHOD OF MAKING THE SAMEHarold I. Danziger, Westwood, N. J., and Aniello
Di Giacomo, New York, N. Y.; said Di Giacomo
assignor to said Danziger

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16 Claims. (Cl. 175—315)

Our present invention relates generally to electrolytic condensers or cells, and has particular reference to an improved method of manufacturing such devices.

5 The type of article to which our invention relates consists, essentially, of two foil strips or elements composed of filmable material such as aluminum and a plurality of fibrous spacing strips or elements arranged in alternate relation
10 to the foil strips, the spacing elements being impregnated with or otherwise carrying a film-forming electrolyte in pasty or semi-solid condition. The foil strips and the spacing strips are customarily assembled in interwound relation
15 ship to form a sort of cylindrical body which is adapted to be inserted into a suitable container of cardboard, metal, or other material. When assembled and constructed for the purpose of serving as a capacitance, the finished device is
20 referred to generally as a "dry electrolytic condenser".

In customary practice, at least one of the foil strips is preliminarily treated to provide an electrolytic film thereon, the characteristics of such
25 a film being well known in the art, including an asymmetric resistance, a high dielectric strength, and an ability to maintain itself under proper conditions and in contact with the film-forming salt or similar ionizable electrolyte.

30 The electrolytes that are employed are of varied types, and ammonium borate is a typical salt having a film-forming ability. The salt is carried or dissolved in a non-aqueous medium, usually and preferably comprising a polyhydric
35 alcohol.

One of the difficulties heretofore encountered in manufacturing articles of the foregoing character arises from the requirement that the salt be uniformly distributed over the entire area of
40 the filmed foil. It is a particular object of our present invention to provide an improved device, and method of making the same, in which salt or similar film-forming electrolyte is distributed with greater uniformity throughout the entire
45 body.

One of the principal objects of our invention lies in the provision of a process which permits wound electrolytic bodies of the foregoing character to be constructed on a winding machine,
50 much in the same manner as ordinary so-called paper-dielectric condensers or the like are formed. A more specific object lies in the provision of a procedure which permits paper to be used as the spacing medium between the foil strips.

Gauze or similar fabric has heretofore been employed, either alone or in combination with paper, to separate the foil layers of an electrolytic cell or condenser. The reason why paper alone has not been found satisfactory, heretofore, is because of the difficulty, hereinbefore
5 mentioned, of uniformly impregnating the same with the required electrolyte. Where the body is completely wound, and then subjected to an impregnation with the electrolyte, the paper performs a sort of filtering function which leaves
10 the salt densely impregnated near the edges of the paper and permits only a very dilute solution to penetrate into the interior of the body. Sometimes only the solvent itself is capable of penetration into the interior portions of the wound
15 body, and in some cases even the solvent does not reach into all of the innermost portions of the body.

Where gauze is employed as the spacing medium this same difficulty is encountered, and this fact has led to the practice of rolling the condenser bodies together out of cut lengths of foil and gauze. This discontinuous manner of forming the bodies is obviously inefficient but has the
25 advantage of permitting the gauze layers to be smeared with the electrolyte prior to the rolling procedure. The smearing step is, however, sloppy and inefficient.

In accordance with our present invention, we
30 have provided a method of manufacturing electrolytic cells, such as condensers, in which there is no necessity for discontinuous winding of the bodies, and all smearing operations or equivalent inefficient and messy procedures are eliminated.
35 The present invention makes it possible to dispense entirely with gauze, if desired, whereby cells of greatly reduced physical size may be produced having, nevertheless, equivalent electrical characteristics.

One of the features of our invention lies in preliminarily incorporating, with a fibrous spacing strip, a film-forming salt in dry form uniformly distributed throughout the fibers. This preliminary procedure may be carried out
40 either by an impregnation of the spacing strip after the latter has been initially manufactured, or it may be combined with the initial manufacture of the spacing strip. In either event, the procedure is such that a long continuous strip
45 of material may be preliminarily treated long prior to the actual winding of the separate bodies. Supply reels of the treated material may be independently manufactured and stored indefinitely for subsequent use.
55

Another feature of our invention lies in subjecting the wound bodies to an impregnation under heat and vacuum, the vacuum being maintained during the impregnation procedure so that a thorough penetration of the impregnating medium into the innermost fibers of the body is assured.

We achieve the foregoing objects, and such other objects as may hereinafter appear or be pointed out, in the manner illustratively exemplified in the accompanying drawing, wherein—

Figure 1 is a diagrammatic view of one manner of carrying out the preliminary treatment of the spacing medium;

Figure 2 is a diagrammatic view of the manner in which a condenser body or the like may be wound;

Figure 3 is a perspective view of a wound body; and

Figure 4 is a diagrammatic view showing one manner of accomplishing the final impregnation.

To illustrate the general capabilities of our invention, we have shown at 10 a reel of paper which is directed through a bath 11, thence through a drying process 12, and ultimately onto a supply reel 13. The bath 11 may consist, by way of example, of a saturated, aqueous solution of ammonium borate. The paper is caused to pass through this bath at a rate sufficient to subject each portion of the paper to the bath for a period of about fifteen to thirty seconds. This is sufficient for the paper to become thoroughly impregnated with the salt. When the impregnated strip emerges from the bath, it is subjected to a drying process which may consist, for example, of passing the strip through a dryer, as indicated in Figure 1, or by simply causing the paper to pass over or between heating rollers or elements. It is advisable that each portion of the paper be subjected to an ambient temperature of approximately 80° C. for a period of about fifteen seconds.

The resultant strip, wound upon the supply reel 13, is uniformly and thoroughly impregnated with the salt, such as ammonium borate, in dry form. The supply reel may be formed long prior to the period at which it is to be used, and, in fact, it is preferable to provide a number of supply reels and to store them for use as and when required.

In Figure 2, we have illustrated, diagrammatically, the manner in which an electrolytic cell such as a condenser is thereafter formed. The numerals 14 are applied to pretreated fibrous spacing strips of the character indicated in Figure 1 at the reel 13. The numerals 15 are applied to strips of filmable foil, such as aluminum, and it will be understood that at least one of these strips will have been pretreated to form an electrolytic film thereon. The strips are interwound to form a wound body 16, and it will be observed that the fibrous spacing strips preferably project at opposite ends of the body, thereby completely enveloping and concealing the foil strips. In the completed wound body, connection tabs 17 are caused to project from opposite ends, these tabs being of conductive material and establishing electrical connection with the two foil strips, respectively.

The wound body may be kept in wound condition either by means of an ordinary rubber band, such as that shown at 18 in Figure 3, or in any other convenient manner. The bodies may re-

main cylindrical or they may be somewhat compressed, as shown in Figure 3.

The winding procedure of Figure 2 is preferably carried out on a winding machine, and it will be understood that Figure 2 is purely diagrammatic. Supply reels of the treated spacing material, such as the reel 13 of Figure 1, are mounted upon the winding machine, along with similar supply reels of foil. The several strips are fed to a mandrel, and during the operation of the machine the mandrel serves to wind up the body 16. After predetermined lengths of the material have been wound, the strips are severed, either mechanically or by hand, the wound body is removed from the mandrel, and the next succeeding winding operation is then started.

If desired, more than a single spacing strip may be used between the foil strips, but it is entirely satisfactory and in most cases preferable to employ only a single spacing strip.

Despite the fact that the spacing strips have been preliminarily treated, so that they incorporate throughout their fibers an ionizable film-forming salt, the winding of the bodies on a winding machine may be efficiently and satisfactorily carried out because of the fact that the salt is disposed within the fibers of the strips in dry form. The ordinary type of preliminary smearing operation would be utterly unfeasible in the winding of a body by means of a winding machine.

After a number of bodies 16 have been formed, as hereinbefore described, they are grouped together in trays or in racks and are subjected to an impregnation with a medium which comprises a non-aqueous solvent for the salt, preferably a polyhydric alcohol. In Figure 4 we have diagrammatically shown a plurality of bodies 16 suspended in a tray or rack 19 and immersed within an impregnating medium 20 of the character mentioned. Since the impregnating medium is of thinner consistency than would have to be the case if the spacing strips were not preliminarily treated, no difficulty is encountered in causing a complete permeation of the bodies with the impregnating medium. While this medium may consist entirely of the solvent alone, it is preferable to incorporate with the solvent an additional quantity of the ionizable film-forming salt. For example, the impregnating solution may consist of a suitable amount of powdered ammonium borate dissolved in ethylene glycol, glycerine, or a mixture thereof. This solution may be satisfactorily prepared by heating the solvent to a temperature of about 90° C. and then slowly admixing the ammonium borate, under continuous stirring, until the solution reaches a temperature of about 122° C.

The impregnating medium, regardless of the amount of additional salt which it carries, permeates into the innermost portions of the wound bodies; and the dry salt which was preliminarily incorporated with the spacing strips is immediately picked up and dissolved by the non-aqueous solvent; so that the resultant body is thoroughly and uniformly impregnated with a non-aqueous medium carrying the film-forming salt in solution.

In accordance with our invention, the impregnation illustrated in Figure 4 is preferably carried out under heat and vacuum. This may be accomplished, for example, by placing the bodies, in a suitable rack, into a vacuum tank, the latter being heated to a temperature of about 50° C. Simultaneously, a vacuum of about seven hundred forty-five millimeters is drawn, and this tem-

perature and vacuum are maintained for a period of about one hour. During this period, a large percentage of the air and moisture that may still be present in the wound bodies is withdrawn. The impregnating medium, having been previously prepared and heated to about 85° C., is then drawn into the vacuum tank. During this operation, the vacuum is decreased to about three hundred ten millimeters, and the temperature is raised to about 85° C. This temperature and vacuum are then maintained for a period of about one hour.

After the impregnation procedure, the wound and impregnated bodies are removed from the tank, assembled in containers of cardboard or other material, and finally aged to about five hundred volts (D. C.) for a period of about three hours.

So far as the heat and vacuum treatment is concerned, it has proven to be of advantage even in cases where the spacing strips have not been preliminarily impregnated with the salt in dry form, as illustrated in Figure 1. In other words, the heat and vacuum treatment has advantages independent of the preliminary treatment of the spacing strips; and bodies that are wound with untreated spacing strips, and ultimately impregnated under heat and vacuum, are more satisfactory and have better characteristics than those which are impregnated by ordinary methods.

We prefer, however, to carry out our present invention by the combined pretreatment of the spacing strips and the ultimate impregnation under heat and vacuum.

Tests have shown that the present procedure is of marked efficiency and benefit. For example, while the capacity of a body formed of untreated spacing strips and impregnated by ordinary methods may be approximately 7.7 microfarads, the same body formed with pretreated spacing strips proves to have a capacity of 8.15 microfarads. Similarly, the same body, composed of untreated spacing strips but impregnated under vacuum and heat, has a capacity of about 8.14 microfarads; and the same body, wound with pretreated spacing strips and impregnated under heat and vacuum, has a capacity of approximately 8.5 microfarads.

Similar results are found in testing for power factor losses. With an ordinary body, composed of untreated spacing strips and impregnated by ordinary methods, the power factor loss was found to be about 7.3%. The use of pretreated spacing strips reduces this loss to about 3.9%, and the heat and vacuum treatment (with untreated spacing strips) reduces this loss to about 2%.

Where the breakdown voltage of an ordinary body was about five hundred twenty-five volts, the same body composed of pretreated spacing strips had a breakdown voltage of six hundred fifty volts. The same body formed of untreated spacing strips and subjected to heat and vacuum had a breakdown voltage of about six hundred volts. Where the body was formed with pretreated spacing strips and then impregnated under heat and vacuum, the breakdown voltage was as high as seven hundred twenty-five volts.

Similarly advantageous results are demonstrated after subjecting the bodies to one thousand hours of so-called "life test". This test consists of subjecting the bodies to a D. C. potential of about four hundred volts, with a superimposed A. C. ripple of about fifty volts, sixty cycles. The ambient temperature is about 60° C.

Whereas the life test reduces the capacity of

the ordinary body by about 33%, the capacity of a body formed with pretreated spacing strips was reduced only 10%; and the capacity of a body impregnated under heat and vacuum was reduced only 13.5%. A body formed with pretreated spacing strips and impregnated under heat and vacuum suffered a reduction in capacity of only 4.8%.

The power factor loss of an ordinary body, subjected to life test, increased 250%. The loss suffered by the same body, formed with pretreated spacing strips, increased only 100%. A body formed of untreated spacing strips and subjected to heat and vacuum suffered an increase of power factor loss of 135%. A body formed with pretreated spacing strips and then impregnated under heat and vacuum had its power factor loss increased by only 87% after life test.

The advantages of the present invention may be summarized as follows:

1. The ionizable film-forming salt is thoroughly and uniformly distributed throughout the entire area of the spacing strips.
2. By virtue of the fact that a portion of the salt is preliminarily distributed, less of the salt is required in the ultimate impregnating solution and better impregnation, therefore, results.
3. By virtue of the uniform and thorough impregnation, the breakdown voltage is increased by about one hundred twenty-five volts D. C. with ordinary impregnation, and by about two hundred volts D. C. with heat and vacuum impregnation.
4. The breakdown potential is practically the same throughout the entire section of the wound body.
5. The life of the resultant body is increased about five-fold.
6. The capacity of a body formed by the present method is about 10% greater than that of a body formed without pretreatment of the spacing strips or vacuum impregnation.
7. The power factor loss is correspondingly reduced to less than one-third of what it would be without the procedural steps of the present invention.
8. Life tests show a lesser reduction in capacity, and a lesser increase in power factor loss, than would be the case if the present procedural steps were not resorted to.

While our invention is particularly desirable and beneficial in forming bodies with paper spacing strips, rather than gauze, nevertheless it will be understood that the invention is equally applicable to gauze where resultant small-size is not an important thing to be accomplished. Accordingly, unless otherwise specified herein and in the appended claims, it will be understood that the terms "paper" and "gauze" are intended to designate equivalents of one another. Similarly, while the preliminary treatment of the spacing strips has been described as involving an "aqueous" solution of a salt, nevertheless it will be understood that any equivalent evaporizable or removable solvent could be employed.

The reference to ammonium borate as the film-forming salt is not intended to preclude the use, in carrying out our present invention, of other equivalent salts or substances, these ionizable materials being well known per se in the art.

Where the spacing strips are composed of paper, the incorporation therewith of the salt may be accomplished during the manufacture of the paper, as, for example, by incorporating the same with the paper pulp in the beater or at any other

stage preliminary to the actual formation of the paper web.

In general, it will be understood that changes in the details, herein described and illustrated for the purpose of explaining the nature of our invention, may be made by those skilled in the art without departing from the spirit and scope of the invention as expressed in the appended claims. It is, therefore, intended that these details be interpreted as illustrative, and not in a limiting sense.

Having thus described our invention, and illustrated its use, what we claim as new and desire to secure by Letters Patent is—

1. In the manufacture of an electrolytic condenser body comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first incorporating a film-forming salt in dry form with the fibres of the spacing strips, then forming the condenser body, and then impregnating the body with a medium comprising a non-aqueous solvent for said salt.

2. In the manufacture of an electrolytic condenser body comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first incorporating a film-forming salt in dry form with the fibres of the spacing strips, then forming the condenser body, and then impregnating the body with a medium comprising a polyhydric alcohol.

3. In the manufacture of an electrolytic condenser body comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first incorporating a film-forming salt in dry form with the fibres of the spacing strips, then forming the condenser body, and then impregnating the body with a medium consisting of additional film-forming salt dissolved in a non-aqueous solvent.

4. In the manufacture of an electrolytic condenser body comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first incorporating a film-forming salt in dry form with the fibres of the spacing strips, then forming the condenser body, and then impregnating the body with a medium consisting of additional film-forming salt dissolved in a polyhydric alcohol.

5. In the manufacture of an electrolytic condenser body comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first soaking the spacing strips in an aqueous solution of a film-forming salt, then driving off the water so as to leave the fibres impregnated with the salt in dry form, then forming the condenser body, and then impregnating the body with a medium comprising a non-aqueous solvent for said salt.

6. In the manufacture of an electrolytic condenser body comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first soaking the spacing strips in an aqueous solution of a film-forming salt, then driving off the water so as to leave the fibres impregnated with the salt in dry form, then forming the condenser body, and then impregnating the body with a medium consisting of additional film-forming salt dissolved in a non-aqueous solvent.

7. In the manufacture of an electrolytic condenser comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first incorporating a film-forming salt in dry form with the fibres of the spacing strips, then forming the condenser body, then subjecting the

body to heat and vacuum, and then, while maintaining the heat and vacuum, impregnating the body with a medium comprising a non-aqueous solvent for said salt.

8. In the manufacture of an electrolytic condenser comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first incorporating a film-forming salt in dry form with the fibres of the spacing strips, then forming the condenser body, then subjecting the body to heat and vacuum, and then, while maintaining the heat and vacuum, impregnating the body with a medium consisting of additional film-forming salt dissolved in a non-aqueous solvent.

9. In the manufacture of an electrolytic condenser comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first soaking the spacing strips in an aqueous solution of a film-forming salt, then driving off the water so as to leave the fibres impregnated with the salt in dry form, then forming the condenser body, then subjecting the body to heat and vacuum, and then, while maintaining the heat and vacuum, impregnating the body with a medium comprising a non-aqueous solvent for said salt.

10. A method of making electrolytic condenser bodies which consists in forming supply reels of continuous strips of fibrous material having a film-forming salt uniformly incorporated with the fibres in dry form, forming supply reels of continuous strips of filmable foil, at least one of of the foil strips being filmed, interwinding in alternate relation the foil and fibrous strips emanating from said reels, so as to successively form wound bodies, severing said strips after each successive body of desired size has been wound, and then impregnating said bodies with a medium comprising a non-aqueous solvent for said salt.

11. In the manufacture of an electrolytic condenser body comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first soaking the spacing strips in an aqueous solution of a film-forming salt, then driving off the water so as to leave the fibres impregnated with the salt in dry form, then forming the condenser body, and then impregnating the body with a medium comprising a polyhydric alcohol.

12. In the manufacture of an electrolytic condenser body comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first soaking the spacing strips in an aqueous solution of a film-forming salt, then driving off the water so as to leave the fibres impregnated with the salt in dry form, then forming the condenser body, and then impregnating the body with a medium consisting of additional film-forming salt dissolved in a polyhydric alcohol.

13. In the manufacture of an electrolytic condenser comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first incorporating a film-forming salt in dry form with the fibres of the spacing strips, then forming the condenser body, then subjecting the body to heat and vacuum, and then, while maintaining the heat and vacuum, impregnating the body with a medium comprising a polyhydric alcohol.

14. In the manufacture of an electrolytic condenser comprising interwound filmable foil and fibrous spacing strips, the steps which consist in

first incorporating a film-forming salt in dry form with the fibres of the spacing strips, then forming the condenser body, then subjecting the body to heat and vacuum, and then, while maintaining the heat and vacuum, impregnating the body with a medium consisting of additional film-forming salt dissolved in a polyhydric alcohol.

15. In the manufacture of an electrolytic condenser comprising interwound filmable foil and fibrous spacing strips, the steps which consist in first soaking the spacing strips in an aqueous solution of a film-forming salt, then driving off the water so as to leave the fibres impregnated with the salt in dry form, then forming the condenser body, then subjecting the body to heat and vacuum, and then, while maintaining the

heat and vacuum, impregnating the body with a medium comprising a polyhydric alcohol.

16. A method of making electrolytic condenser bodies which consists in forming supply reels of continuous strips of fibrous material having a film-forming salt uniformly incorporated with the fibres in dry form, forming supply reels of continuous strips of filmable foil, at least one of the foil strips being filmed, interwinding in alternate relation the foil and fibrous strips emanating from said reels, so as to successively form wound bodies, severing said strips after each successive body of desired size has been wound, and then impregnating said bodies with a medium comprising a polyhydric alcohol.

ANIELLO DI GIACOMO.
HAROLD I. DANZIGER.