

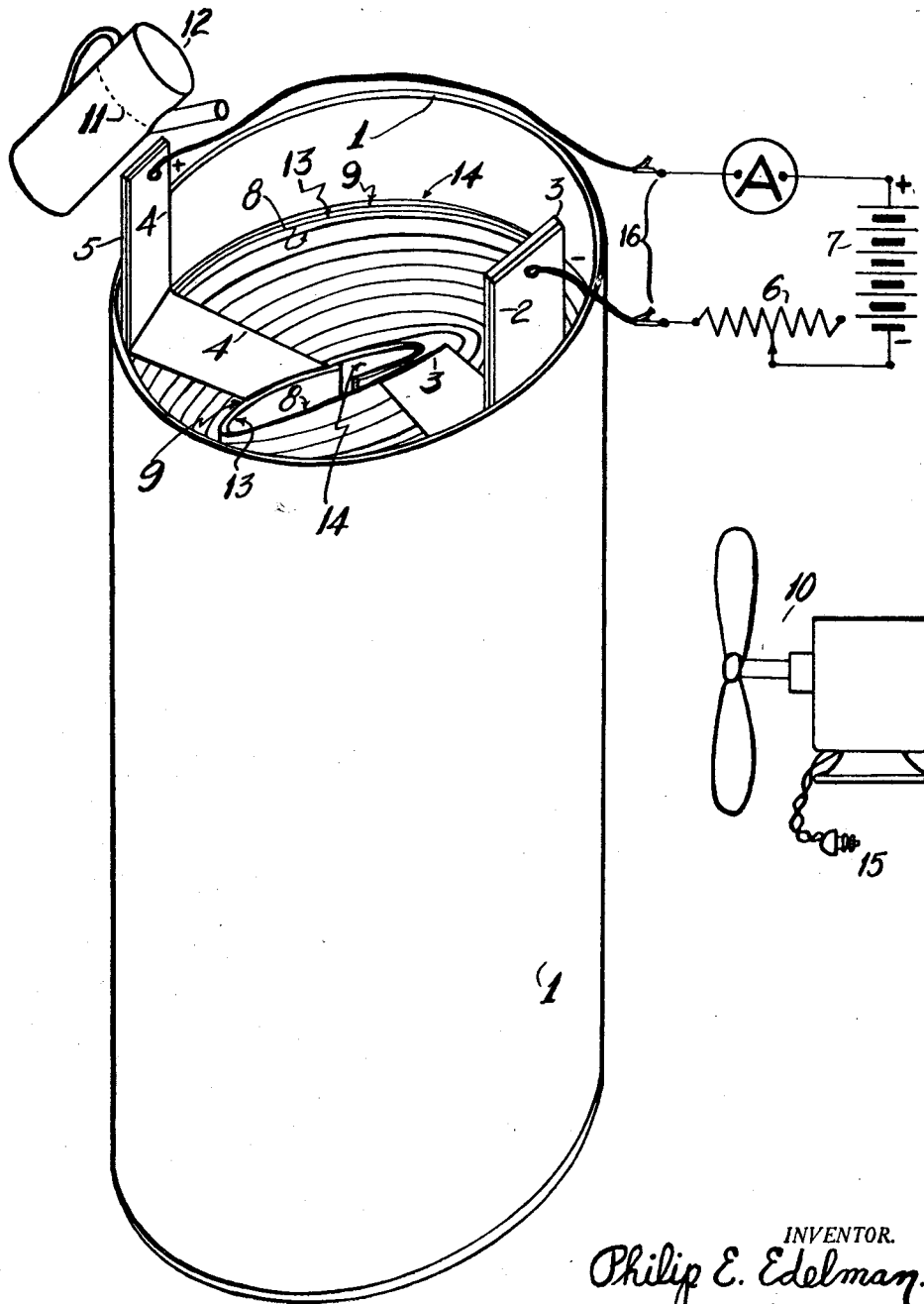
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PROCESSING OF ELECTRICAL CONDENSERS

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This invention relates to the process of manufacturing electrical condensers of high capacity, small bulk, and dry solid type suitable for use in radio battery eliminator circuits and other electrical apparatus, and for has its object the production of uniformly good condensers of durable quality requiring no watering or servicing attention. To obtain large capacity in small bulk at reasonable expense, paraffin paper type condensers are unsuitable, as are also wet condensers employing liquids, pastes, or jellies therein. Confronted by the necessity of preparing condensers of uniform quality at low cost I have conceived that they can be produced electrochemically in solid form resembling a rock in hardness and permanently sealed for use in service with free liquid absent therein, thus preventing the electrodes thereof from corrosion or solution into the active dielectric material employed.

My method for producing such condensers should not be confused with electrolytic wet condensers using solutions, pastes or jellies as the terminal product is a solid mass in texture, affording higher capacity, greater dielectric value, permanent stability, and uniformity in production. Heretofore electrolytically prepared condensers have been defeated on the point of durability because no provision has been made to prevent the metal electrodes employed dissolving into the solution employed. I have conceived that the way to avoid this is to remove all free liquid which can react chemically with the metal electrodes during the processing so that the terminal product is substantially a solid material with no uncombined moisture or liquid capable of further solvent action thereon. I accomplish this by employing a chemical mixture preferably made up from salts which can be prepared as a hot liquid from which interlocking crystals will form on cooling and simultaneously passing forming electric current therethrough while crystallization takes place, preferably increasing the voltage at which the electric current is applied at the time crystallization commences. I prefer to employ a basic salt mixture containing ammonium and for example may use ammonium phosphate, or ammonium phosphate mixed with sodium phosphate, or ammonium phosphate mixed with ammonium borate, employing concentrations thereof which are liquid at high temperature such as 100 degrees C. and be-

come a solid mass of crystals upon cooling down to room temperature.

Various changes and modifications may be made within the scope of the appended claims and I will now describe by way of example, a suitable mode of processing such electrical condensers in accordance with my invention.

Reference is made to the accompanying drawing of which the figure is a schematic diagram illustrating a suitable processing of a condenser, it being understood that a plurality of condensers can be processed simultaneously, additional units being connected to clip terminals 16. The positive electrode 9 and negative electrode 8 are held in container 1 spaced by blotter sheets 13 and 14. Inner terminal 4 and outer terminal 5 of sheet 9 comprise the positive terminal connection for sheet metal 9 and may be conveniently formed at the respective ends of said sheet 9. Similar inner and outer strips 3, 2 respectively are formed from the ends of negative metal sheet 8 and comprise the negative terminal. An adjustable rheostat 6 serves to regulate the current flow from battery 7 to terminals 16 which are fastened to strips 5, 4 and 2, 3 respectively. The chemical 11 in pour pot 12 can thus be applied to impregnate sheets 13, and 14 and cover metal sheets 8 and 9 except at the top of terminals 4, 5 and 2, 3 respectively which are subsequently covered with protective pitch sealing material as hereinafter set forth when the container 1 is sealed. A fan 10 can be connected via plug 15 to a supply line to facilitate cooling of the contents of container 1.

A condenser consists of electrodes separated by a dielectric material and it is known that the dielectric value determines the capacity as also does the area of the electrodes and the effective distance therebetween. However in electrochemically formed condensers the distance between electrodes which is effective comprises a minute layer formed on one of the electrodes by the decomposition effect of forming electric current sent thru the condenser. I find that the dielectric constant can be greatly increased by operating the condenser at pressure greater than atmospheric pressure, thus forcing the minute layer at the electrode into intimate contact therewith.

I can make condensers for either high or low voltage operating service for use in

either "B" or "A" radio power units. For example, a condenser suitable for use in an "A" eliminator device may be prepared as follows:

- 5 Two sheet aluminum strips each of .008" thickness are prepared interleaved with two sheet strips of cotton linter blotter paper or other suitable absorbent fibrous material. Terminal strips are taken out at each end
- 10 of each aluminum strip so that electric current can be fed therethrough from both ends of each strip. These strips are substantially wound in convolutions with the blotter paper separating the aluminum strips, making the outer contour of the winding an elliptical
- 15 oval shape. The aluminum sheets may each comprise a strip $7\frac{1}{2}$ inches wide and 8 feet long with the terminal strips thereof 1 inch wide and 5 inches long at each end thereof.
- 20 The blotter strips may each comprise white blotter prepared from cotton linters known in the paper trade as 80 pound stock soft rolled grade, 8 inches wide and $8\frac{1}{2}$ feet long. Two aluminum strips and two blotter
- 25 strips are used for each condenser.

- When so wound, the aluminum and blotter strips are preferably placed in a container which is proofed against the destructive
- 30 action of a hot liquid and shaped to fit the outer contour of the winding. Thus for the above stated winding a paper can 9 inches high with cross section in the form of an oval about $2\frac{1}{2}$ inches wide and 4 inches long is suitable when wound with five ply
- 35 paper coated with asphalt pitch, capped with aluminum end piece and coated with a heat resisting wax containing paraffin.

- The condenser winding is placed in the said container so that the terminal strips
- 40 project out from the top thereof while the container holds the winding in place. A hot chemical mixture in liquefied form is now poured into the container to impregnate the blotter strips therein. This mixture may
- 45 comprise one part by volume of ammonium phosphate to eight parts of sodium phosphate intermixed and heated to boiling point with the addition of only a little distilled water sufficient to make up for evaporation
- 50 loss occurring during the processing. At about 100 degrees centigrade a clear hot liquid results from which the top scum thereon caused by impurities may be removed. This liquid will only remain in liquid form
- 55 while hot and upon cooling the salts crystallize out as a solid interlinked mass of crystals.

- When the chemical mixture aforesaid has been poured into the container, direct flow-
- 60 ing current at six to eight volts pressure is applied between the wound aluminum sheets. Connection from a source of direct current is made to both the inner and outer terminal strips of one aluminum sheet at common po-
- 65 tential, so that current flows well distributed

therefrom thru the chemical mass held in the blotter sheets to the other aluminum strip which similarly has its inner and outer terminal ends connected at common potential. The forming current thus polarizes one 70 aluminum strip positive and the other remains negative thereto. At first a large current will flow, for example 10 amperes. However as forming action begins this current will reduce automatically to one or two 75 amperes. After the chemical mixture begins to cool sufficiently so that crystallization commences as may be determined by observation, I prefer to immediately raise the voltage at which the forming current is applied. This sudden change of applied volt- 80 age greatly reduces the time required for formation when applied just at the instant crystals begin to form in the container. The voltage selected should be slightly higher 85 than the voltage at which the condenser is to be operated in service. For example if this condenser is to withstand 12 volts in operating service, the terminal voltage applied after crystallization starts may be 13 volts. 90 During the forming action some of the aluminum combines chemically with the chemical mixture and energetic bubbling may be observed. It is necessary to continue the forming until such bubbling can no longer be observed at which time the chemical mixture will have become a substantially solid mass containing no uncombined solvent liquid. The aluminum sheets will thereafter not be able to dissolve in or combine with 100 the chemical mixture to further reduce the thickness of the aluminum sheets as the solid mass becomes highly resistant to such further corrosive action thereon. Electrical current can however freely flow between the aluminum sheets thru the chemical crystals held in the blotter paper, the direction of flow being now polarized according to the direction at which the forming electric current was applied. The condenser in the container is now sealed from the atmosphere by pouring molten pitch in at the top over the condenser, after which the condenser is able to operate at pressure greater than atmospheric pressure as aforesaid. The increased 115 pressure is self produced in the condenser during service thereof due to chemical, electrochemical, or molecular expansion changes inherent therein, but sufficient excess pressure to burst the container seal is not attained due to the elimination of excess liquid from the chemical mixture during the processing aforesaid. Such a condenser can be employed in a battery eliminator or other electrical circuit mounted in any position, 125 vertical or horizontal as there is nothing to spill therefrom. It will have high capacity of the order of 4000 microfarads, good dielectric strength, and durability with minimum leakage current. The measured leak- 130

age current of such a condenser is of the order of one milliamperes at ten volts applied in the correct sense according to the polarization of the condenser. In the reverse direction, a large current can flow. Such a condenser is very well suited in a circuit for filtering out alternating current fluctuations from rectified current supply. A condenser for service on higher voltage can be similarly prepared except that less area is usually required in the sheets used and the chemical mixture is preferably comprised by ammonium phosphate mixed with ammonium borate with the latter salt in a minority proportion in the mixture. Various other chemicals or metal sheets may be applied in a similar processing as long as the requisite steps pointed out are observed so that the metal will not be lost in service by going into solution with the chemical mixture employed. The forming current should be applied at a voltage greater than the service voltage on which the condenser is to be used and not brought to such value until crystallization has started in the chemical mixture employed.

A condenser for use in a "B" eliminator may comprise two aluminum strips 1" wide wound interleaved with blotter paper with the length 40 inches, similarly treated, the chemical mixture used being preferably one part by volume of ammonium phosphate to one third part by volume of ammonium borate. Whatever chemical salts are selected, they should be capable of forming interlocked crystals resembling a solid mass at room temperature and not individual or independent separated crystals. It is advantageous to progressively increase the voltage at which the forming electrical current is applied by increments as the crystallization progresses. If a large mass condenser is to be made this way external cooling may be advantageously applied to hasten the formation of the crystals, as for example an air blast or cold water bath external to the container. In any case it is very advantageous to change the pressure forcing the electric forming current thru the mass at the time when crystallization commences and to continue the flow of forming current until substantially a solid mass of crystal results so that thereafter said crystals have substantially no opportunity to react chemically to destroy the aluminum sheets exposed thereto. A very stable condenser results when this precaution is observed whereas otherwise, an incompletely formed condenser may burst the container in operating service. The container should not be sealed until a substantially rock like mass results therein. It is important to have the container conform in shape to the outer boundary of the convolution winding so as to exert sufficient mechanical retaining force thereon during

service. It is important that the forming current be applied simultaneously as the crystallization occurs, if a good condenser is desired. It is advantageous to have ammonium in the chemical mixture employed as same has a beneficial action on the aluminum sheets tending to resist solvent action of the chemical mixture thereon.

I have now set forth the steps of my method of processing condensers. The exact mechanical dimensions are not important as long as the principles set forth are observed. It may be remarked that chemical salts prepared in a solid interlocked mass in this manner have conductivity properties different than in the case of an electrolyte consisting largely of water. The salts in the completed condenser contain substantially only their own water of crystallization and no free uncombined liquid is present. The blotter paper exerts a cooperating action tending to preserve the chemical mass at its best operating efficiency. The chemical mass in the blotter paper has conduction characteristics more resembling the conductivity of a metal conductor than that of a liquid electrolyte and undoubtedly includes a certain amount of aluminum combined electrochemically therewith during the forming process because a characteristic dark color can be observed on the originally white blotter sheets when the condenser is completely formed. This differs from the whitish metallic film noticed on aluminum in electrolytic wet solution type of condensers.

I claim:

1. The process of preparing an electrical condenser which consists in subjecting aluminum to the forming action of electric current in the presence of chemical crystals concentrated as a hot liquid when the electric current is first applied and progressively increasing the voltage maintaining said electric current as crystallization proceeds therein until a substantially solid state is reached thereby.

2. The process of preparing an electrical condenser which consists in subjecting aluminum sheets to the forming action of electric current in the presence of chemical crystals concentrated as a hot liquid with which said aluminum material can react when electric current is first applied and progressively continuing said electric current under the pressure of increased voltage as said chemical crystals form from said liquid until a substantially solid crystal mass results therefrom highly resistant to further reaction with said aluminum to an extent which substantially prevents chemical combination of said crystals and aluminum thereafter.

3. The process of preparing a stabilized electrical condenser which consists in passing electric current between aluminum sheets exposed to a chemical mixture maintained

in liquid state when said current is first applied and changing the pressure at which said current is applied to a higher voltage as crystallization occurs in said chemical mixture, continuing this treatment until a substantially solid mass of crystals results from said chemical mixture to an extent which substantially prevents further chemical reaction thereof into molecular combination with said aluminum thereafter.

4. The process of preparing a stabilized electrical condenser of high dielectric value which consists in forcing forming electric current between aluminum sheets exposed to ammonium salts maintained in liquid state when said current is first applied, raising the voltage at which said current is applied when said ammonium salts begin to crystallize therefrom and continuing the forming electric current until a substantially solid mass of crystals results through which electric current can thereafter flow with substantially no further solvent action of said salts on said aluminum.

5. The process of preparing a stabilized electrical condenser of high capacity which consists in forcing forming electric current between aluminum sheets exposed to a salt mixture containing ammonium and maintained in liquid state when said current is first applied, cooling said salt mixture to crystallize same into the solid state thereof and simultaneously raising the voltage at which said electric current is applied as said cooling progresses down to room temperature, until a substantially solid mass of crystals without free liquid results, highly resistant to further solvent action on said aluminum when electrical current is thereafter passed between said aluminum sheets.

6. The method of producing electrical condensers which comprises winding aluminum sheets and blotter paper in convolutions, placing same in a container, then pouring chemical salts in substantially molten state therein to impregnate said blotter paper therewith, then passing electrical current between said aluminum sheets and continuing said latter treatment until said salts crystallize as a substantially solid mass therein.

7. The process for making an electrical condenser which comprises sandwiching aluminum sheets and blotter paper and placing same in a container proofed against the thermic destruction of a hot liquid, then pouring a liquefied chemical into said container to impregnate said blotter paper therewith, then passing electric current between said aluminum sheets, then, as crystals begin to form in said container increasing the voltage at which said electric current is applied, continuing this treatment until gas bubbles are no longer noticed in said container, and sealing said container contents from the atmosphere thereafter.

8. The process for production of electrical condensers suitable for service in battery eliminator circuits which comprises preparing adjacent sheets of metal and fibrous absorbing material in a container, pouring hot chemical liquefied salts in said container, simultaneously cooling said salts to crystallize same and passing electric current there-through, continuing the treatment until a substantially rock like mass is attained without free liquid in said container, and then sealing the contents of said container from the atmosphere.

9. The process of producing a condenser suitable for radio power battery eliminator circuits which comprises preparing adjacently disposed sheets of aluminum and fibrous absorbing material in a container into which a liquefied chemical capable of forming interlocking crystals is poured, solidifying said chemical and simultaneously passing electric current therethrough until such time as there is substantially no further solvent action thereof on said aluminum, then sealing said container to maintain the contents thereof under a pressure suitable for the service thereof and greater than atmospheric pressure.

10. The process for making an electrical condenser which comprises placing sheets of fibrous absorbent material and cooperating metal sheets in a container, pouring a hot chemical mixture in said container and reacting same with said aluminum under the influence of electric current applied initially at a pressure of about eight volts and finally at a higher voltage, continuing the treatment until said chemical mixture has cooled down to a substantially solid mass including no free liquid other than the self contained water of crystallization thereof, and thereafter sealing said container to maintain a pressure therein higher than atmospheric pressure.

11. The process for making an electrical condenser of small bulk and large capacity constructed as a unit of solidity resembling a rock in hardness which comprises winding convolutions of metal adjacent to porous sheets, holding same in a container, pouring a liquid chemical capable of crystallizing into solid state therein, feeding electric current between said metal convolutions so that said current flows in said metal from both the inner and outer portions of said convolutions and through said chemical as crystals form therein, whereby the current density at said inner and outer portions of said convolutions is approximately equalized, and sealing said container when crystallization is completed.

12. The process for making an electrical condenser of small bulk and large capacity which comprises assembling metal and fibrous sheets in a container, pouring a

chemical therein capable of forming inter-linked crystals upon cooling from the liquid state attained when poured, cooling said chemical and simultaneously passing electrical current therethrough, increasing the voltage forcing said electrical current through said chemical after crystallization thereof starts, and terminating said treatment after the contents of said container no longer include free liquid from said chemical.

13. The method and process of making an electrical condenser of small bulk, large capacity, high dielectric strength and stability, which consists in assembling sheets of metal interleaved with fibrous absorbent sheets in a container, impregnating said fibrous sheets with a chemical mixture capable of reacting with said metal sheets, simultaneously passing electric current through and crystallizing said chemical mixture to substantially solid form resembling a rock in hardness and incapable of dissolving action on said metal sheets after reaching said solid form, and thereafter sealing said container from the atmosphere to permit its contents to operate under a pressure which is different than atmospheric pressure.

14. The method of and process of making an electrical condenser of small bulk, large capacity, high dielectric strength, and stability which consists in winding sheets of aluminum alternated with sheets of blotter paper so that the outer contour of said winding resembles an elliptical oval, bringing out inner and outer terminals from the respective inner and outer ends of each aluminum sheet, placing said winding in a container, pouring liquefied salts containing ammonium therein, feeding electric current through said salts in said container while maintaining both the inner and outer aforesaid terminals of each particular aluminum sheet at common potential whereby approximately uniformly distributed current density is maintained at each instant of time along the surface of each particular sheet of aluminum, crystallizing said chemical salts and increasing the electrical current flow there-through during the time when crystallization commences, and sealing the contents of said container from the atmosphere after crystallization is substantially completed.

In witness whereof I have hereunto set my hand this 7th day of May, 1927.

PHILIP E. EDELMAN.