

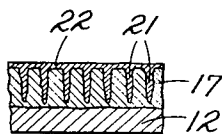
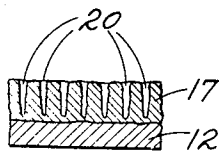
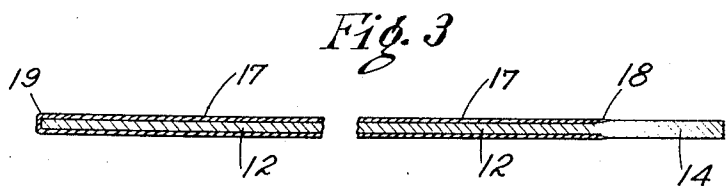
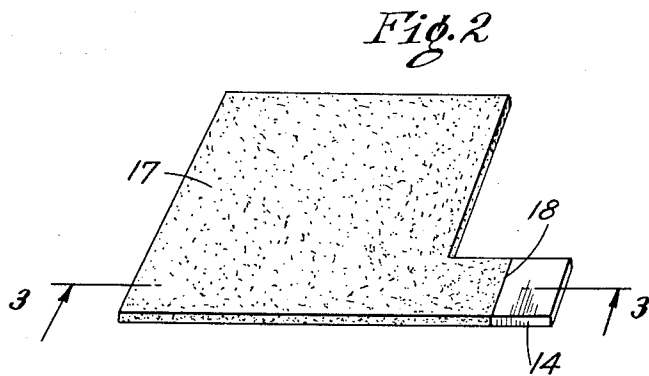
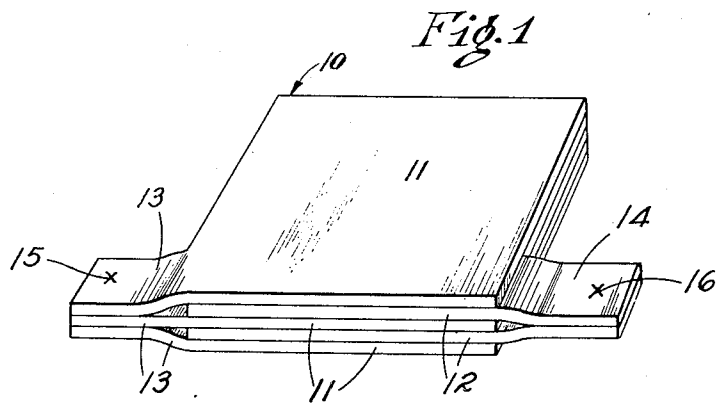
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2,497,066

METHOD OF MAKING CONDENSERS

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METHOD OF MAKING CONDENSERS

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1 Claim. (Cl. 154—80)

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This invention relates to condensers and more particularly to electrostatic condensers in which the dielectric consists in electro-formed oxide coatings on the surfaces of one or more of the plates.

In general the objects of the invention are to produce efficient electrostatic condensers adaptable for wide varieties of uses, to produce condensers of permanent capacity embodying dielectrics of high strength, and to provide methods of making such condensers. Other more specific objects and various advantages of the invention will become apparent from the following description of preferred embodiments thereof.

Preferably I attain the above and other objects of the invention by constructing condensers with one or more plates composed of aluminum or other film-forming metal provided with electro-formed dielectric coatings or films of the type described in the copending application of Joseph B. Brennan and Leona Marsh, Serial No. 243,542, filed December 2, 1938, now Patent No. 2,346,658, issued April 18, 1944. As described in that application dielectric films can be formed on film-forming metals such as aluminum, magnesium, tantalum and their alloys by subjecting the metal to electrolysis as an anode in an aqueous solution of a film-forming electrolyte and a potential condensation product of the urea-formaldehyde type or the phenol-formaldehyde type, and carrying out the electrolysis at a voltage greater than the breakdown voltage of the film, such that sparking takes place on the surface of the metal. For example, the electrolysis may preferably be carried out in an electrolyte of approximately the following composition:

	Parts
Urea	200
Formaldehyde (40% solution by volume)	165
Boric acid	200
Ammonium hydroxide (Sp. Gr. 0.0)	112

The operation is carried out with the aluminum as the anode at a voltage such that sparking takes place over the surface of the metal being treated. The voltage employed may be of the order of 250-500 volts, and the current density may be about 2.6 milliamperes per square centimeter of surface, although the voltage and current may be varied within reasonable limits.

During the forming process the surfaces being formed appear to have tiny blue flames traveling over them, and the operation produces an adherent film, probably composed of oxides and/or hydroxides of the metal being treated, on the surface of the metal. The film or coating is unusual

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and distinctly different from the ordinary oxide coating in that it presents a flat, substantially white, non-metallic appearance. The film is uniform over the entire surface of the part being anodized, is strongly adherent to the underlying metal and is porous and absorptive, although the pores are very minute. The electrolysis may be completed in about 20 minutes, or may be carried out for much longer periods depending on the thickness of film desired. At the completion of the operation, the filmed plates are removed from the electrolyte, washed in water or other suitable solvents to remove the electrolyte therefrom, and dried, whereupon they are ready for incorporation into condensers.

This type of film is peculiarly advantageous in electrostatic condensers. Because of its absorptive properties, it is possible to impregnate the film or coating with various dielectric materials, thereby increasing the dielectric strength of the film; further the nature of the process by which the film is produced is such that the thickness of the films or coatings can be accurately controlled, and films or coatings of widely different thicknesses can be produced.

As noted above, the film-forming operation is carried out at high voltages with sparking taking place over the surfaces being formed. The film-forming operation is thus different from conventional filming operations which are carried out at voltages below the breakdown voltage of the film. The practical limit, therefore, of electrolytic condensers with conventional films is about five or six hundred volts, and the films are extremely thin.

The film which I preferably employ, however, is formed by the sparking or burning-in operation as noted above. The thickness of the film does not depend as much upon the forming voltage as upon the time of treatment. Thus, for example, if the forming operation is carried out for say about 20 minutes, the film will uniformly cover the surface being treated, but will be relatively thin, and have sufficient dielectric strength when removed from the electrolyte and washed and dried to withstand four or five hundred volts. However, if the operation is carried on for a greater length of time, the thickness and dielectric strength of the coating can be increased many fold. For example, if the plate is sufficiently thick a film or coating having a thickness of $\frac{1}{8}$ inch or more can be produced. Such a coating when removed from the electrolyte and dried has a very high dielectric strength which can be further increased by impregnating the porous coating with suitable dielectric materials.

Desired intermediate thicknesses can be obtained by controlling the duration of the film-forming operation. Ordinarily, film thicknesses of a few thousandths of an inch will be sufficient.

Thus by carrying out the forming operation for the proper length of time, dielectric coatings of various thicknesses suitable for various purposes may be produced. Where a condenser of high capacity for low voltage service is required, the film is kept at a minimum thickness. For high voltage service, the thickness is increased, although the capacity per unit of area of the condenser plates will be reduced accordingly.

Referring now to the drawings, Figure 1 somewhat diagrammatically illustrates one form of condenser embodying my invention; Figure 2 is a perspective of one of the plates of the condenser of Figure 1; Figure 3 is a diagrammatic section on an enlarged scale taken on line 3—3 of Figure 2; Figure 4 is a section on a greatly enlarged scale diagrammatically illustrating the probable nature of the film as I understand it, and Figure 5 is a similar illustration showing an impregnated film. In each figure, the thickness of the plates is greater than would ordinarily be employed.

As shown in Figure 1, a condenser 10 embodying my invention may comprise a stack of plates 11 and 12 arranged alternately, the plates 11 being of one polarity and the plates 12 of opposite polarity. In the embodiment shown, the plates 11 may or may not be provided with dielectric films as desired. If unfilmed plates are employed, they may be composed of any suitable metal such as thin aluminum or other conveniently available metal. These plates may be connected to the external circuit through terminal members 13 which may be welded together as at 15.

The intermediate plates 12 are provided with terminal members 14 welded together as at 16 and as shown particularly in Figures 2 and 3, each of these plates is provided with dielectric films or coatings 17 which constitute the dielectric of the condenser, separating the plates 12 from the plates 11. Preferably the dielectric coating does not extend over the entire terminal tab 14, being stopped short as indicated at 18 in Figure 2 so that the plates 12 can readily be connected to the external circuit.

It will be noted that in the condenser shown, if the plates 11 are unfilmed the coating carried by the plates 12 is the only dielectric. The coating is of substantially uniform thickness throughout and covers all of the surfaces of the plate so that there is no likelihood of short circuiting taking place. Thus no additional separators or spacers are required. As shown at 19 in Figure 3, the coating extends around the corners and along the edges of the plate 12 with substantially uniform thickness at these points. Because of its adherent nature and mechanical strength, the coating is not apt to be damaged during the assembly of the condenser, and no great precautions need be taken in handling the condenser plates.

Obviously plates embodying coating made according to my invention can be utilized in condensers of different types. For example, the number of plates in the stack may be varied widely and if desired both sets of plates in the condenser may be provided with dielectric films. For a given thickness of film the dielectric strength of the condenser will be substantially doubled if both sets of plates are filmed. Because of the

adherent nature of the oxide coating, condensers embodying thin plates made according to my invention may be made in rolled form rather than the flat form shown. In producing such condensers aluminum foil may be treated continuously to produce the dielectric coating and rolled up into condensers without requiring any spacing materials between the foils. In such condensers only one of the foils need be provided with the coating, although both foils may be so coated if desired. The completed condensers of various types may be enclosed in suitable boxes or casings.

As noted above, the coating formed on aluminum and other film-forming metals by my method is of high dielectric strength after the metal has been removed from the electrolyte and the coating washed and dried. When dry, the coating evidences the properties of a true dielectric, blocking the flow of current in both directions. The coating also effectively protects the underlying metal from the influences of atmospheric corrosion, and thus condensers embodying plates provided with my dielectric coating are of constant and stable capacity and not subject to deterioration because of atmospheric influences.

While the coating itself is an excellent dielectric material, its dielectric strength and resistance to corrosion may be made even greater by impregnating or sealing the porous coating with suitable dielectric material. The porous nature of the film is such as to permit ready impregnation by various dielectric materials. While I have been unable to determine exactly the construction of the film, the action and characteristics thereof indicate to me that it is of the general nature indicated diagrammatically in Figure 4. As shown in this figure, which is on a greatly enlarged scale, the film 17 is pocketed or traversed by many closely spaced, minute, irregular capillary channels or passages 20 which extend from the outer surface of the film approximately to the underlying base metal. It is the presence of these openings which permits the forming operation to continue until the film is built up to considerable thickness, and the minute capillaries become filled with the dielectric material when the film is impregnated. This is indicated diagrammatically in Figure 5 where the impregnating material indicated at 21 penetrates the openings 20 and overlies the intermediate portions of the film or coatings 17 as indicated at 22. Inasmuch as the film or coating is firmly bonded to the underlying metal 12, the dielectric impregnating material is also bonded thereto by its penetration of the minute capillary openings in the coating.

Any ordinary dielectric materials which can be applied in liquid or paste form may be employed. The films or coatings will readily absorb oils, greases, waxes, varnishes, lacquers, light-sensitive coatings such as albumen and sensitized gelatin, latex and various natural and synthetic rubber materials (all of which are intended to be included within the term "rubber" as used in the claims) natural resins and synthetic resins, condensation products of phenol and formaldehyde and condensation products of urea and formaldehyde. The impregnated plates may be baked or otherwise subjected to heat to cure the impregnating material within the pores of the coating if necessary. Where light sensitive materials are employed, they are preferably ren-

dered insoluble by exposure to light before the plates are assembled into condensers.

Adhesive dielectric materials, such as the various lacquers, resins and condensation products noted above, may be used advantageously in impregnating the films, for when such materials are employed, the impregnating material may be used to bond adjacent plates of the condenser together. Thus the portions 22 of the impregnating material may function to bond the plate 12 either to an unfilmed plate, to a filmed but not impregnated plate or to a similar filmed and impregnated plate. If desired, in producing a condenser of this sort, the plates may be assembled into condenser form and then impregnated with a suitable dielectric material having adhesive characteristics. For example, thermosetting or thermoplastic dielectrics may be injected in fluid form into the condenser assembly. On curing or cooling, the plates of the condenser will firmly bond together by the adhesive dielectric material.

Preferably the impregnation is carried out by first subjecting the plates to be impregnated to a vacuum to remove air from the porous film or coating and then applying the impregnating material. If desired the assembly of plates may be disposed within a container and immersed in a suitable dielectric fluid to provide condensers of the oil or gas types. In such cases, the films or coatings become saturated with the dielectric fluid and serve to space the plates from each other.

I claim:

The method of making condensers which includes the steps of providing an aluminum plate with an adherent, capillary porous, electroformed dielectric film by subjecting the aluminum to electrolysis as an anode in an aqueous solution of a potential condensation product of urea and formaldehyde having boric acid and ammonium hydroxide added thereto, and carrying out the electrolysis at a voltage such that sparking takes place on the surface of the aluminum, assembling the plate with another metallic plate directly juxtaposed thereto, and impregnating the assembly with an adhesive dielectric material.

JOSEPH B. BRENNAN.

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