

July 18, 1939.

S. RUBEN

2,166,180

ELECTROLYTIC CONDENSER

Filed March 9, 1935

4 Sheets-Sheet 1

Fig. 1

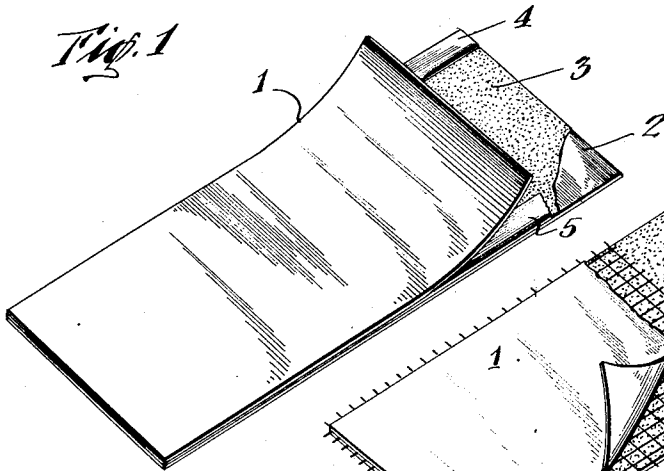


Fig. 2

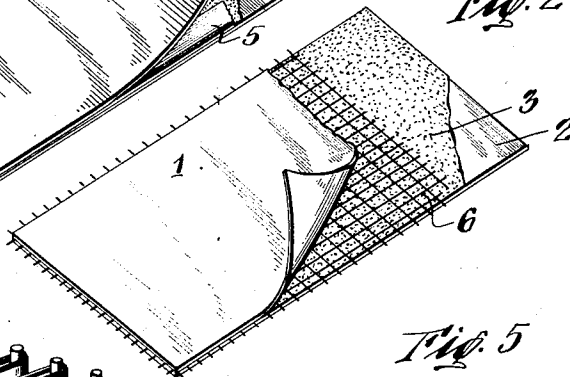


Fig. 3

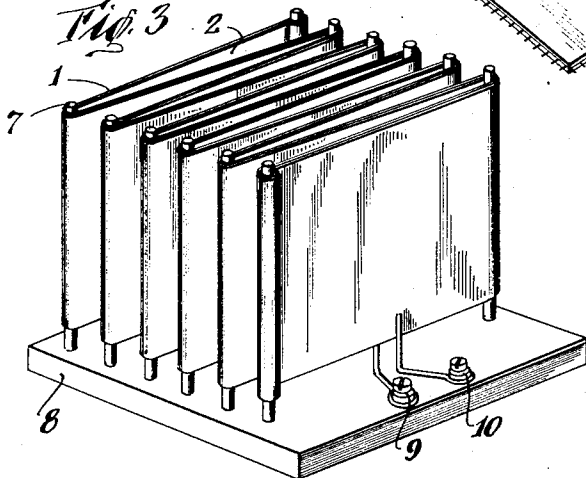


Fig. 5

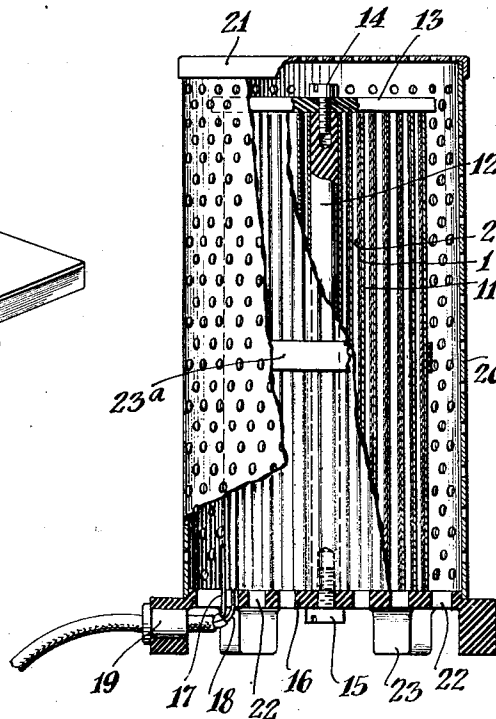
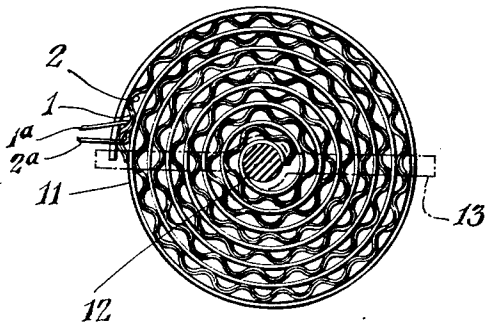


Fig. 4



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Fig. 6

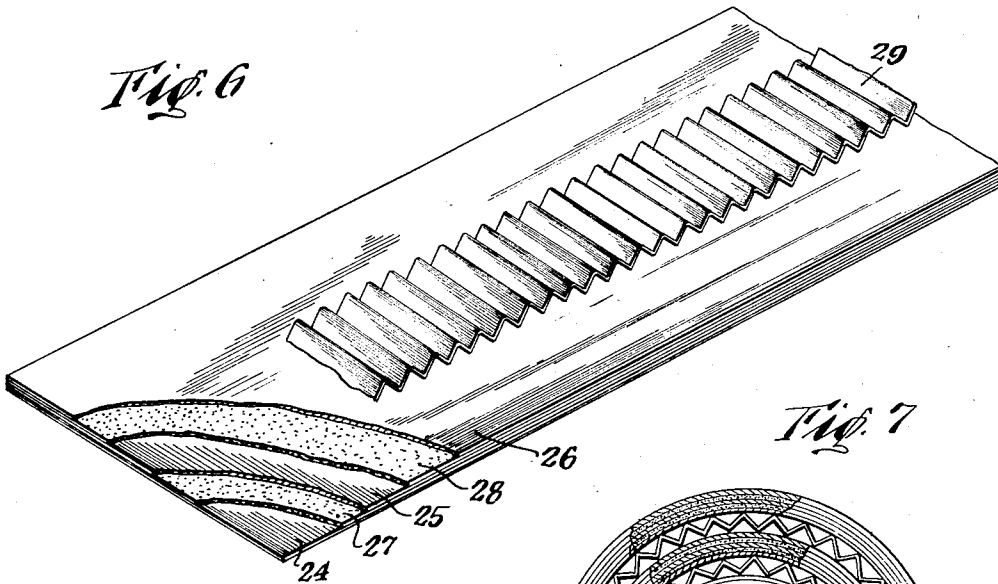


Fig. 7

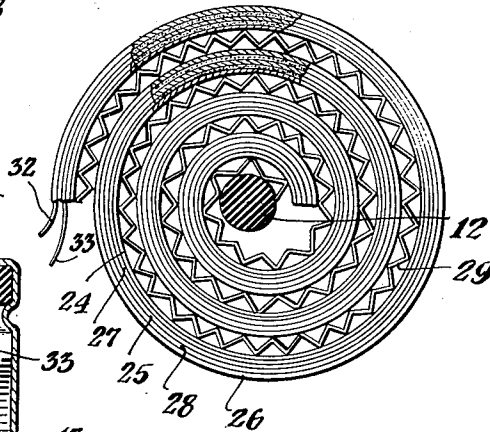
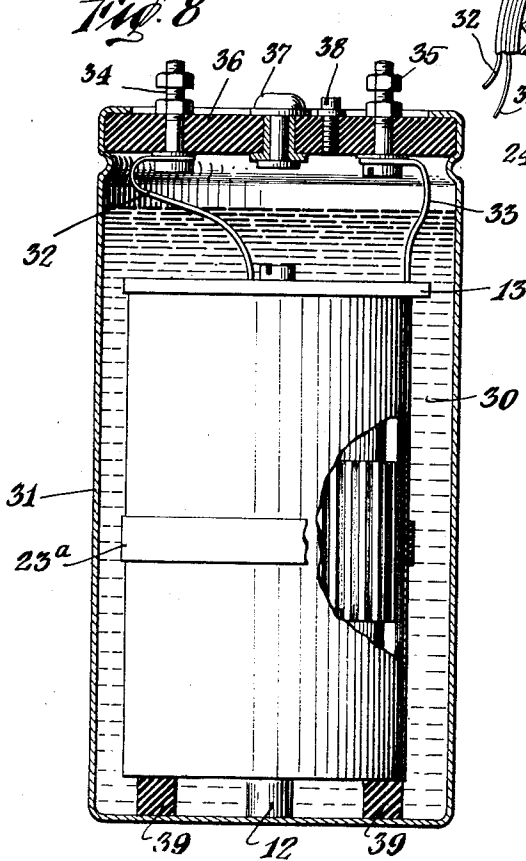


Fig. 8



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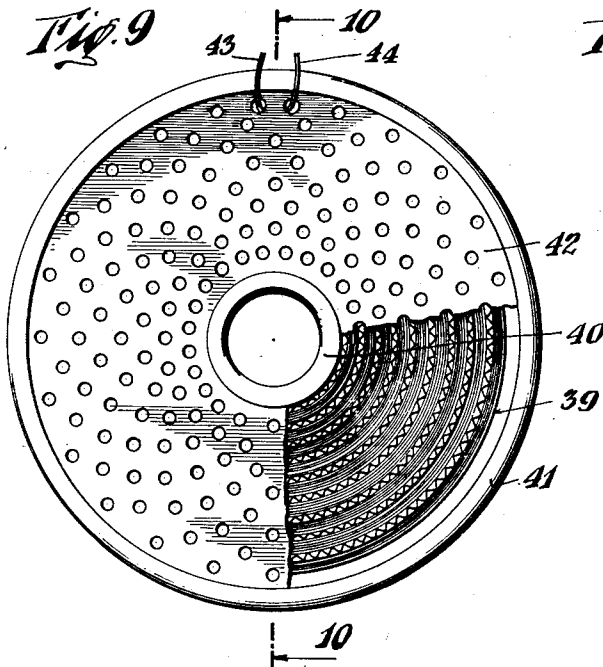
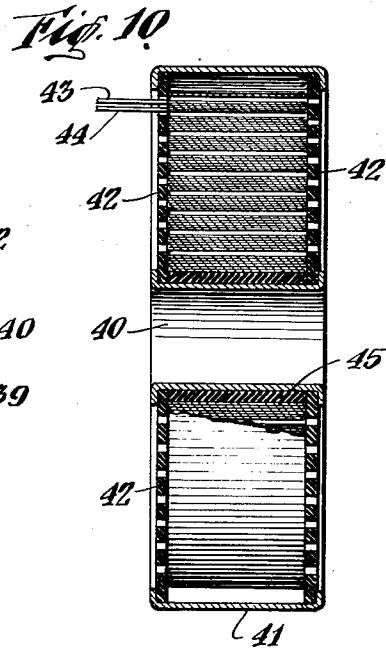
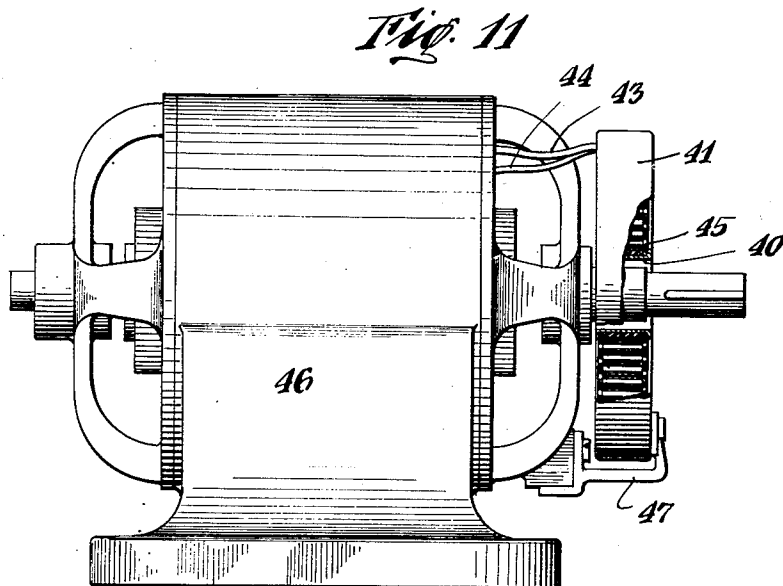
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Filed March 9, 1935

4 Sheets-Sheet 3



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Fig. 12

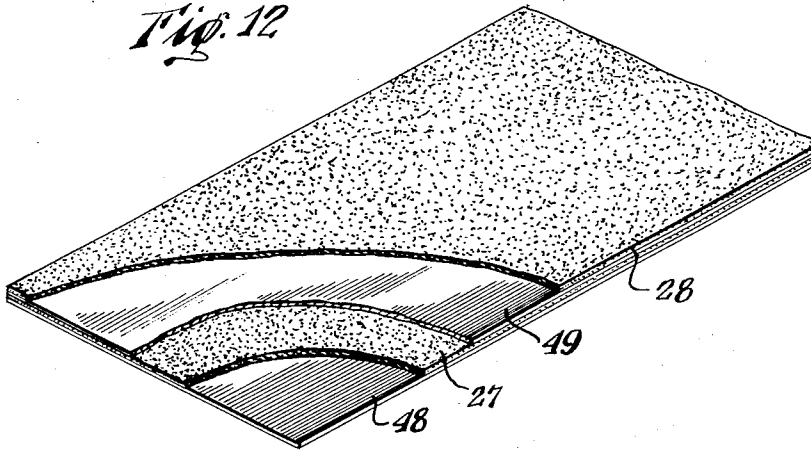


Fig. 13

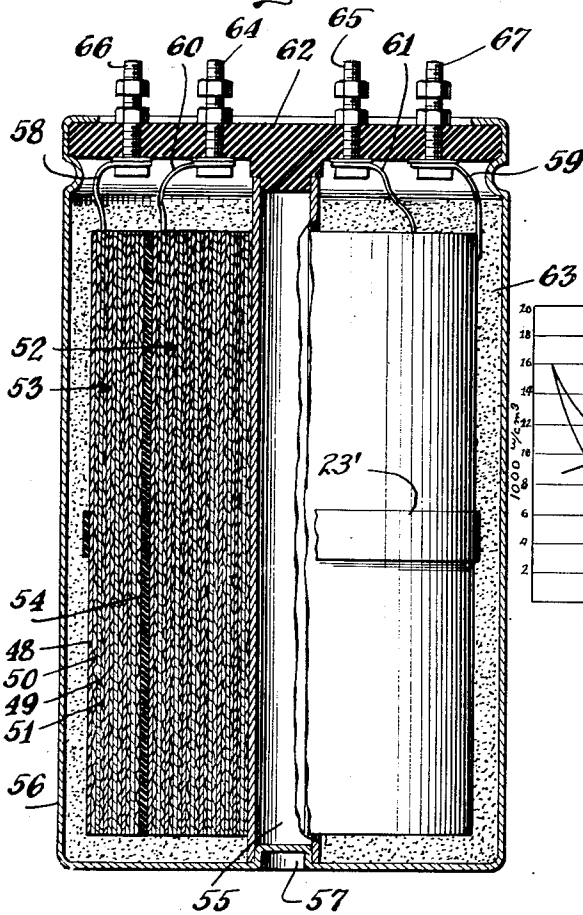
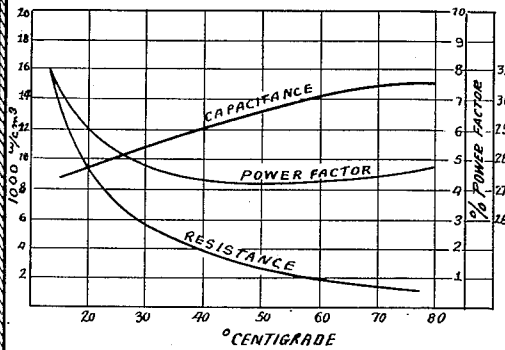


Fig. 14.



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2,166,180

ELECTROLYTIC CONDENSER

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Application March 9, 1935, Serial No. 10,288

13 Claims. (Cl. 175—315)

This invention relates to electrolytic condensers and specifically to improved types of "dry" electrolytic condensers.

The general object of the invention is to provide an electrolytic condenser of the so-called dry type which employs a novel electrolyte and an improved construction especially suitable in connection with such electrolyte.

More specific objects of the invention are to provide a very adhesive electrolyte of very low mobility, high conductivity, and non-corrosive properties which under continuous alternating current operation protects the electrode dielectric oxide films, preventing their disintegration and ultimate dissolution into the electrolyte, which has an inherent low resistance, which is homogeneous, free from crystallization, which is not adversely affected by the atmosphere, which is chemically and physically stable under all operating conditions, and which can be uniformly and economically produced.

An additional object is the provision of improved structures by reason of which condensers of this type may be used for continuous alternating current operation by virtue of the rapid and uniform heat dissipation which is effected.

A further object is the provision of an improved condenser of the type described which does not require sealing, deforms slowly and reforms rapidly, which may be operated throughout wide temperature ranges without excessive variations in electrical characteristics, which remains cool in operation and operates at a low power factor, which does not require expensive containers, and which in general may be said to provide a condenser more suitable for alternating current operation than electrolytic condensers customarily used for such purpose at the present time.

A further object is the provision of an improved electrolyte for electrolytic condensers, lightning arrestors and the like.

Still another object is the provision of a condenser of the rolled type in which a circulation of air or other cooling medium is obtained between the turns of the roll.

Other objects of the invention will be apparent from the following description and accompanying drawings taken in connection with the appended claims.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combination of elements and arrange-

ment of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention as well as for specific fulfillment thereof, reference should be had to the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a perspective view of one form of the condenser of the present invention with parts partially separated and broken away;

Fig. 2 is a view similar to Fig. 1 but with the addition of a reticular spacer;

Fig. 3 is a perspective view of a novel type of condenser construction;

Fig. 4 is an end view of a condenser in rolled form in which the electrodes and electrolyte carrying spacers are corrugated;

Fig. 5 is a view partly cut away of a condenser having the corrugated structure shown in Fig. 4 mounted within a container;

Fig. 6 is a view in perspective of a novel type of condenser construction;

Fig. 7 is a transverse sectional view of the condenser shown in Fig. 6 rolled into coil form;

Fig. 8 shows a condenser of the construction shown in Fig. 6 and Fig. 7 immersed in a cooling fluid within a suitable container;

Fig. 9 is an end view with parts broken away, showing a condenser of the construction shown in Fig. 7 mounted within a novel container;

Fig. 10 is a sectional view on line 10—10 of Fig. 9;

Fig. 11 shows the condenser of Fig. 9 mounted in a novel manner on a motor;

Fig. 12 shows a further modified condenser sheet assembly and

Fig. 13 shows a condenser structure of further modified form, and Fig. 14 is a graph showing condenser operating characteristics.

Like reference characters denote like parts in the several figures of the drawings.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention. In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

In my Patent 1,918,717 I describe an electrolytic condenser comprising electrodes of film-

forming material, at least one of which electrodes has a tacky, electrically conductive film-maintaining composition of a lacquer base material and a plasticizing component miscible therewith.

5 The present condenser is an improvement over the type described in that patent and attains to a higher degree the objects of that patent.

The film-maintaining composition of my present invention preferably comprises a conductive shellac composition and may be produced by reacting shellac with an alkaline material such as borax and plasticizing with a suitable agent as ethylene glycol. The product resulting from heating shellac and borax appears as a clear, dark brown, sticky material which transmits light, which may be thinned down to any degree with water without separation and has other attributes indicating a compound material.

Unlike the electrolyte described in my Patent 1,891,207 and similar electrolytes formed from ethylene glycol or glycerine and the boron compounds, the electrolyte of this invention does not throw crystals out of solution in the presence of water. Neither does the present electrolyte require sealing to prevent hygroscopic absorption with resultant hardening of the surface due to crystal precipitation.

In operating an electrolytic condenser continuously on alternating current, I have found that there are several characteristics which are especially desirable, among which may be mentioned the following:

The electrolyte should preferably be immobile so as to prevent the disintegration and dissolution of the electrode dielectric film therein; it should be of a homogeneous character and of adequate specific resistance to provide uniform electrical conditions over the entire electrode surfaces. The immobility of the electrolyte should not be much reduced at the highest operating temperature of any section of the condenser.

It is also of considerable advantage in the operation of electrolytic condensers on alternating current to employ an electrolyte, the resistance of which is initially high but which at operating temperatures reduces so as to allow a better power factor and which, in combination with a suitable structure to provide adequate heat dissipation, will allow stable continuous operation. Such reduction in resistance should not, however, be accompanied by a large increase in the mobility of the electrolyte, as the electrolyte should remain in such form as to physically adhere to and protect the dielectric film. In condensers of the prior art, operated under conditions tending to bring about a considerable temperature rise, such as operation on continuous alternating current, a reduction in resistance occurs, but is usually accompanied by a phase change or settling out of particles, with resultant localized current effects. The electrolytes of this invention, examples of which are as follows, have been found capable of operating at high temperatures and on continuous alternating current, without flowing, separation or phase change, at the same time maintaining an adequate resistance and possesses properties which otherwise meet the requirements of continuous service operation:

30 grams of borax are dissolved in 120 grams of water and brought to a temperature of 100° C. at which point 30 grams of pure garnet dewaxed shellac is added and the mixture stirred and allowed to boil. When the shellac is entirely dissolved into the borax solution, 40 grams of ethylene glycol are added and the mixture heated to

the boiling point which should be around 130° C. or slightly higher. The product is a dark brown but clear compound which can be applied as a varnish while hot.

It has been found that the quantity of borax which can be added to chemically combine with the shellac is rather definitely limited. For example, when equal parts of borax and shellac by weight are heat mixed in water and combined, free borax crystals are deposited, whereas a mixture of 40% borax and 60% shellac will remain as a homogeneous product and will not indicate excess borax. However, in the preparation of the electrolyte, an excess quantity of borax can be used to insure complete reaction of the shellac, the ethylene glycol combining with the borax so that no borate crystals remain and so that the amount of inert material is held to a minimum. It is important that all of the shellac be combined and taken up in the formation of the new composition.

The electrolyte will be found to weigh about 84 grams which shows a loss equal to the weight of the water, plus about 14% of the weight of the other materials. As the loss in weight of the ethylene glycol and shellac has been found to be very small, when heated separately, it would appear that the water initially added has been driven off as well as a quantity of other matter, probably water, derived from water of crystallization in the borax and that due to reaction of the borax with the glycol.

While it is possible to prepare the electrolyte without water, by heating the shellac in borax dissolved in its own water of crystallization or by heating the shellac in borax dissolved in the polyhydric alcohol, the presence of the water is desirable and facilitates the preparation of the composition. The water tends to more widely distribute the borax and also increase the hydrolysis and better distribution effected by the presence of the water allows a ready and complete reaction with the shellac.

Dependent upon the temperature to which the electrolyte mixture is brought during its preparation, the resistance per cm.³ may be varied over wide limits, as from 1500 ohms to 50,000 ohms, the particular service to which the condenser is to be applied being perhaps the most determining factor. Under conditions where a high operating temperature is to be encountered, a higher initial resistance, such as 15,000 ohms per cm.³, is desirable. In a typical condenser, this would give an initial power factor on 60 cycle 120 volt alternating current of about 6% at 20° C. as indicated by the graph, Figure 14. When such a condenser reaches its operating equilibrium temperature of about 50° C., however, the resistance of the electrolyte drops to about 3,000 ohms per cm.³ or lower, and the power factor drops to about 4.2% and is maintained at such percentage over extended periods of time.

The figures given are dependent, of course, upon the volume of the condenser as determined by its capacitance, mechanical conditions, initial forming potential of the electrodes and surrounding conditions affecting heat dissipation of the unit. The maximum operating temperature will also be governed in part by the amount of plasticizer used, the ratio of shellac to borax, the heat flow point varying with the percent plasticizer. The higher the operating temperature the lower the borax content.

When lower operating temperatures are to be

encountered, initially lower resistance electrolytes may be used with improved power factor.

As the sparking voltage of the condenser is determined in part by the ionic mobility and hydrogen ion concentration, which are in turn dependent to a great extent upon the degree of heat applied to the electrolyte mixture during its preparation, it will be seen that the temperatures employed may be selected to control the specific resistance and ionic mobility of the electrolyte.

When properly prepared, the electrolyte is a very viscous, plastic, varnish-like material and remains indefinitely in this condition. Its consistency may be varied, of course, depending upon the proportions of ingredients and method of preparation, particularly with respect to the temperature to which the composition is heated during its preparation. The electrolyte may be made in the form of a viscous liquid, which will slowly drip, or it may be made sufficiently immobile so that it will adhere to the electrodes without dripping or flowing.

The shellac used is preferably of the dewaxed and purified type as this type of shellac seems to form the clearest compositions with borax. Ordinary shellac, which contains a number of impurities, has been used with satisfactory results, the immobility of the electrolyte serving to minimize the effect of the impurities, which, however, tend to cloud the electrolyte and detract from its clear appearance.

The ethylene glycol probably combines with some of the borax, maintains the plasticized condition of the electrolyte and prevents hardening. A combination of glycol and glycerine has been found to function in a similar manner as have also glycol borates. Triethanolamine, diethylene glycol and triethylene glycol have been substituted for the preferred ethylene glycol plasticizing medium and appear to work fairly satisfactorily.

The amount of glycol which is used preferably ranges between 25% and 50% of the combined weights of the shellac and borax. Electrolytes containing below 25% glycol are difficult to spread and handle while those containing more than 50% glycol flow too easily and especially in an open type condenser would have an impracticable cold flow point. For most applications, 30% to 40% glycol will be found satisfactory although the percentage of glycol usable will, of course, depend upon the amount of excess borax. Sodium carbonate may be substituted for the borax although not as satisfactorily.

Another method of preparing the electrolyte is as follows:

200 grams of shellac and 500 c. c. of water are heated and when the water reaches a boiling point, 50 c. c. of ammonia (28% solution) are slowly added, the mixture being kept at the boiling point. 100 c. c. of ethylene glycol are added and the electrolyte composition heated to 120° C.

Still another method of preparing the electrolyte is to heat together 200 grams of shellac, 10 grams of sodium hydroxide and 500 c. c. of water, the shellac dissolving when a temperature of approximately 100° C. or boiling point is reached. The ethylene glycol is then added and the composition heated to 120° C.

Where the ammonia or alkaline metal hydroxide are employed, the electrolyte may be further acidified if desirable by the addition of glycol borate, citrate or other acidifying agents. The end product, in all cases, appears to be a film

maintaining conductive shellac salt composition. The amount of alkaline material added is that necessary to neutralize the acidity of the shellac.

Due to the physical characteristics of my improved electrolyte, especially its non-flowing varnish-like form and its immunity from atmospheric attack, it is possible to build a condenser structure in which correct ventilation is obtained throughout the entire condenser. Such improved structures may best be described by reference to the drawings shown herein.

In Fig. 1 is depicted a condenser made in accordance with the present invention including an electrode 2 formed from a thin sheet of film forming material, preferably aluminum, provided with a current-blocking film and overlapping strips of edge insulation 4 and 5 of any suitable material such as insulating lacquer strips, "Cellophane" or the like.

The film formed surface of this electrode 2 is covered either by dipping or brushing, with a thin layer 3 preferably comprising the product resulting from heat reacting shellac, borax and ethylene glycol as hereinabove described, the mixture being applied hot in the form of a tacky electrically conductive film-maintaining composition which sticks to the current blocking film and tends to physically protect and maintain the film. The condenser unit is completed by placing adjacent to layer 3 a cooperating electrode 1 of substantially the same composition and form as electrode 2, the sticky layer tending to hold both electrodes in position.

In Fig. 2 is shown the addition of a reticular wide-mesh gauze spacer 6 which serves to further space electrodes 1 and 2 and which replaces edge insulation 4 and 5. A paper or other electrolyte permeable spacer may be substituted for the gauze spacer 6. In the construction of the condenser, the paper or gauze spacer may be impregnated by running through the electrolyte, heated to a temperature of about 80° C. and may then be placed between the electrodes as shown.

In Fig. 3 is shown a form of construction in which condensers of the type shown in Figures 1 or 2 have been mounted on base 8 and wound back and forth between dowel pin supports 7, terminals being brought out at 9 and 10. The construction of the condenser in this form provides maximum cooling and free contact with the air at all points.

In Fig. 4 is shown a construction wherein the condenser section is corrugated and rolled on mandrel 12 into coiled form with separator 11. Separator 11 is preferably in the form of a metal foil coated on both surfaces with an insulating lacquer or varnish. However, if desired, separator 11 may be a single sheet of insulating material such as fibre, resin-impregnated fibre, or the like. Strip 13 holds the ends parallel and allows the condenser to be fastened to a base. Conductors 1a and 2a connect foils 1 and 2, respectively, to the condenser terminals. This construction also permits the free circulation of air between all the condenser turns.

In Figure 5 the corrugated rolled condenser in Fig. 4 is shown mounted within container 20 and is held in place by end strip 13 and insulating base 16 through screws 14 and 15. Insulating base 16 through which are brought condenser terminals 17 and 18, is held in place and protected by bushing 19, is provided with large openings or perforations 22 to allow air circulation. The container 20 may be constructed of any low cost metal and is preferably perforated on sides as shown to allow

circulation of air therethrough, the circulation being further assisted by the large openings 22 in the base and the holes in top 21. The container rests on base 16, this base being provided with
 5 suitable legs or supports 23 for resting on any surface. The condenser roll may be further held together by a rubber band 23a.

The condenser structure shown in Fig. 6 involves the addition of a third foil, a second electrolyte impregnated spacer and another member
 10 which serves as a combined spacer and contactor. In the figure are shown film-forming aluminum foils 24, 25 and 26 between which are electrolyte-impregnated paper spacers 27 and 28. Resting
 15 lengthwise on foil 26 is corrugated narrow aluminum strip 29. When this assembly is rolled into the coil form on mandrel 12 as shown in Fig. 7, the corrugated aluminum spacer 29 serves to electrically connect foils 24 and 26 and also to provide a
 20 wide space for circulation of a cooling medium, in this instance air, between the turns of the roll. Terminal conductors 32 and 33 are, of course, provided for foils 24 plus 26 and foil 25, respectively.

Fig. 8 illustrates the assembly of Figs. 6 and 7
 25 immersed in a cooling fluid such as mineral oil 30 within aluminum container 31. The electrode leads 32 and 33 are attached to terminals 34 and 35 respectively which protrude through "Bakelite" top 36. Vent 38 permits the escape of any excess
 30 gas and the container is filled with the cooling oil through filling screw 38. At 39 are insulating support blocks for supporting the condenser section. In the condenser shown in this figure there is a circulation of cooling oil throughout the
 35 condenser instead of air as shown in Fig. 5, although it is to be understood that the substitution of the oil is merely an alternative procedure, the structure shown in Figures 6 and 7 being ideally suited for operation in air. Band 23a is
 40 provided for additionally holding the roll in place.

In Figs. 9 and 10 is shown the general construction of Figs. 6 and 7 as applied to a condenser of the doughnut type. In this structure, the condenser 39 is wound between aluminum tubes 40
 45 and 41 having perforated fibre end plates 42 through which protrude insulated condenser terminals 43 and 44.

Such a condenser is adapted to be mounted on the end of a motor 46 such as is illustrated in
 50 Fig. 11 so that a continuous air flow is had through the perforations of the fibre ends due to the air circulation set up by the motor.

Figure 12 shows a modified sheet assembly in which electrode foils 48 and 49 are separated and
 55 closely associated with paper spacers 27 and 28 impregnated with the improved varnish-like electrolyte described above.

Fig. 13 shows a dry electrolytic condenser construction particularly adapted for electric motor
 60 operating where one condenser is connected into the motor circuit for starting and another condenser is connected for running or continuous operation.

The condenser elements may preferably be of the form illustrated in Fig. 12, gauze separators 50 and 51 being substituted for the paper spacers 27 and 28. The starting condenser 52 may be wound directly on central tubular support member 55, as shown, conductors 60 and 61 connecting the foils
 70 to terminals 64 and 65, respectively, protruding through "Bakelite" top 62. An insulating sheet 54 is wound about the periphery of condenser 52 and the running condenser 53 is then wound on the outside of sheet 54 as shown. Conductors 58 and 59 connect the condenser electrodes to ter-

minals 66 and 67, respectively, also protruding through top 62.

The roll comprising condensers 52 and 53 is held together in part by band 23a. The unit is enclosed in a suitable sealed container 56 and central
 5 tube 55 is held in position by a suitable pressed in boss 57 in the bottom of container 56 and a corresponding boss on the insulating top 62. The spaces in container 56, surrounding the condenser roll are preferably filled with the conductive
 10 shellac electrolyte 63.

With this construction condenser 52 is in use only for short periods during motor starting after which condenser 53 is put into continuous operation during operation of the motor. Since con-
 15 denser 53 is comparatively close to the outside of the structure and there are no insulating air spaces between the foils of condenser 53 and the container 56 because of the filling 63 of electrolyte, any heat generated is rapidly conducted to the
 20 outside of the container and readily dissipated.

In Fig. 14 the graph illustrates the relation of capacitance and power factor in a condenser employing the preferred electrolyte described
 25 herein, as related to temperature. It also shows the specific resistance variation of the electrolyte with temperature. The curves show the wide range of temperature throughout which a low and constant power factor can be obtained and illustrates the stability of the electrolyte
 30 and particularly its ability to maintain a capacitance film over wide temperature variation.

It will be seen that the electrolytes described herein especially when used with the structures shown, permit the construction of electrolytic
 35 condensers capable of sustained operation on alternating current for capacitor motors, power factor correction, etc.

The structures illustrated are well adapted to allow a continuous operation on alternating or
 40 direct current, the constant flow of air or other cooling medium throughout the condenser section allowing a uniform distribution of heat over the electrodes so that the different sections operate at practically the same temperature. The
 45 preferred type of electrolyte used, due to its non-flowing varnish-like character and because it need not be sealed from the atmosphere, facilitates the use of such structures.

Also, due to the characteristics of the electrolyte, the condenser may be constructed in stack,
 50 roll, spaced or other form and mounted in any position without possibility of failure due to flowing of electrolyte when the condenser heats up, as has occurred when electrolytic condensers of
 55 the prior art have been operated on continuous alternating current service.

Since certain changes in carrying out the above process and in the constructions set forth, which embody the invention, may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting
 65 sense.

What is claimed is:

1. An electrolyte for electrolytic condensers comprising a conductive shellac composition.
2. An electrolyte for electrolytic condensers comprising a conductive shellac salt.
3. An electrolyte for electrolytic condensers comprising an alkali reacted shellac composition.
4. An electrolytic condenser containing an electrolyte having a film maintaining component

comprising the reaction product of shellac and an alkali.

5 5. An electrolytic condenser containing an electrolyte having a film maintaining component comprising the reaction product of shellac and borax.

6. An electrolytic condenser having an electrolyte comprising the reaction product of shellac, an alkali and a plasticizer.

10 7. An electrolytic condenser having an electrolyte comprising the reaction product of shellac, a borate and a plasticizer.

15 8. An electrolytic condenser having an electrolyte comprising the reaction product of shellac, a borate and a viscous alcohol.

9. An electrolytic condenser comprising the reaction product of shellac, borax and an alcohol of the glycol type.

20 10. A dry electrolytic condenser comprising a pair of electrodes, at least one of which is composed of film-forming metal which is filmed, and a viscous varnish-like film-maintaining composition between said electrodes in contact therewith, said composition being formed of shellac, borax and ethylene glycol.

25 11. A dry electrolytic condenser comprising a

pair of closely-spaced electrode layers, at least one of which is composed of film-forming metal which is filmed, and a viscous, varnish-like, water-free film-maintaining electrolyte between said electrodes in contact therewith, said electrolyte comprising a conductive shellac composition. 5

12. A dry electrolytic condenser comprising a pair of closely-spaced electrode layers, at least one of which is composed of film-forming metal which is film-formed, and a viscous, water-free, varnish-like, film-maintaining electrolyte between said electrodes in contact therewith, said electrolyte comprising an alkali-reacted shellac composition which is substantially immobile at ordinary temperatures. 15

13. A dry electrolytic condenser comprising a pair of closely-spaced electrode layers, at least one of which is composed of film-forming metal which is film-formed, and a viscous, water-free, varnish-like, film-maintaining electrolyte between said electrodes in contact therewith, said electrolyte comprising a reaction product of shellac, an alkali and a plasticizer which is substantially immobile at ordinary temperatures. 20

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