May 22, 1934. E. W. ENGLE ET AL 1,959,415

ELECTROLYTIC CONDENSER

Filed March 16, 1928

Fig. 1.

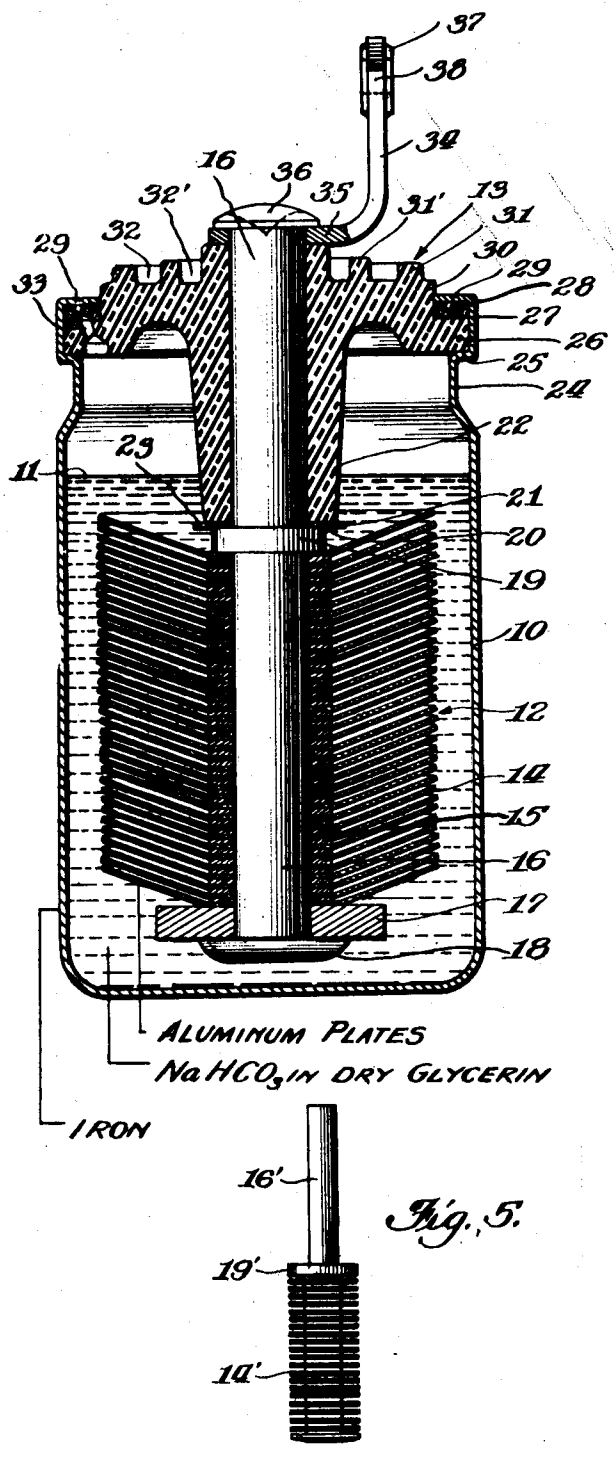


Fig. 2.

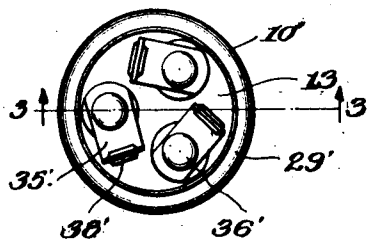


Fig. 3.

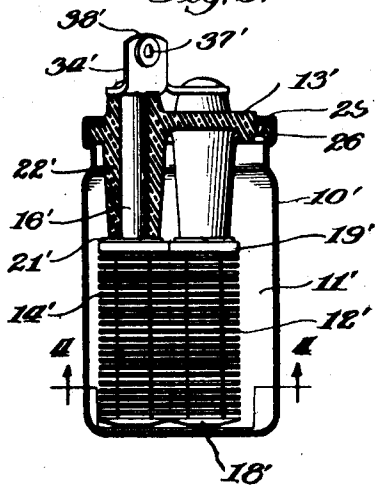


Fig. 4.

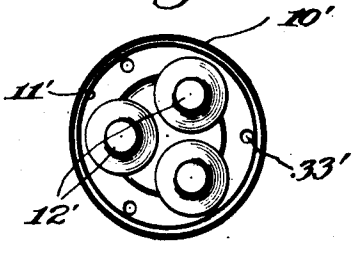


Fig. 5.

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ELECTROLYTIC CONDENSER

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7 Claims. (Cl. 175—315)

This invention pertains to electrolytic condensers and relates more specifically to a uni-directional condenser in which the filmed electrode is immersed in a substantially non-aqueous liquid electrolyte.

The object of our invention is to provide an electrolytic condenser which will have a high capacity per unit volume and a low electrical leakage.

A further object is to provide an electrolytic condenser which maintains its film during periods of idleness and which therefore does not require reforming to the extent that ordinary aqueous solution condensers require it.

A further object is to provide a junction between the filmed electrode and its support which will avoid electrical or chemical action and prevent electrical leakage.

A further object is to provide an improved method of forming the film on the electrodes.

A further object is to provide a novel structure and method of assembling the same which is characterized by its simplicity.

A further object is to reduce the cost of manufacture and assembly of electrical condensers to a minimum.

Other objects will be apparent as the detailed description of our invention proceeds.

Our invention my be briefly characterized as follows:

A drawn steel case encloses a filmed electrode comprising cup-shaped aluminum discs spaced by aluminum washers secured on an aluminum rod which is carried by an inert cover, the edges of which are crimped by the top of the casing to form a liquid-tight assembly. The electrolyte is a substantially dry (non-aqueous) solution of glycerin and sodium bicarbonate. A sleeve extension or stem surrounds the electrode support and extends below the level of the electrolyte, being spaced from the filmed electrode by a mica washer which effectively prevents electrochemical action to initiate chemical decomposition or leakage in the cell. This washer also prevents the electrolytic solution from leaking through the stem.

The invention will be better understood by referring to the accompanying drawing and the following detailed description in which we specifically define a preferred embodiment of the invention. It is to be understood, however, that the following description is illustrative only and that we are not limited to the details given except as defined by the appended claims.

In the accompanying drawing, in which similar parts are indicated by like reference characters,

Figure 1 is a vertical section of our improved electrolytic condenser;

Figure 2 is a top plan view of a modification in which three filmed electrodes are inserted in a single case;

Figure 3 is a vertical section taken along lines 3—3 of Figure 2;

Figure 4 is a horizontal section taken at 4—4 of Figure 3; and

Figure 5 is a detail illustrating the filmed electrode used in the modification of Figures 2 to 4.

As above stated, the condenser comprises a casing 10 which is preferably of drawn steel and which is plated on its exterior surface with cadmium to prevent rusting. It is obvious, however, that any suitable conductor may be used instead of drawn steel.

The case contains an electrolyte 11 which is prepared by heating substantially dry C. P. glycerin (specific gravity not less than 1.252 at 20° C.) to a temperature of about 80° C. and stirring therein 3½% by weight of sodium bicarbonate $NaHCO_3$. About twenty minutes is usually sufficient for completing solution and the glycerin is then allowed to cool to room temperature. We may, of course, use different amounts of glycerin and sodium bicarbonate and/or we may use other acids, bases or salts instead of sodium bicarbonate without departing from the spirit of our invention, the above description being merely of an embodiment which we find at this time gives the best results.

The filmed electrode 12 is held spaced from the case by a suitable cover 13 of any suitable insulator which is non-absorbent and chemicaly inert. Phenolic condensation products are especially suitable for this purpose.

The filmed electrode is comprised of a plurality of stamped aluminum discs 14 which are substantially conical or cup-shaped as shown in Figure 1 with their sides extending upwardly to allow the escape of air bubbles which may be entrapped. These stamped aluminum discs are spaced by suitable washers 15, the alternate discs and washers being arranged on an aluminum rod 16 and held in place by a disc 17 which is secured on the rod by spinning or overturning its end as at 18. The upper disc bears against a collar 19 on the aluminum rod, which collar is preferably turned on the rod and is integral therewith. A loose washer or ring may be used instead of the integral collar, however, if desired.

The cover or electrode support 13 has an extension or stem 22 in the shape of a sleeve surrounding the upper portion of rod 16. In order to prevent chemical or electrolytic action from taking place where the aluminum comes in contact with the cover beneath the surface of the electrolyte (as at 20), we provide a mica washer 21. This apparently simple expedient is of utmost importance in the successful operation of our condenser at the higher voltages because if the aluminum electrode is in contact with a phenolic condensation product at 20 a chemical change appears to be induced in the condensation product so that its surface is carbonized and rendered conductive. This, in turn, causes leakage at 20. The leakage causes sparking, which still further destroys the film at the point of arcing and finally renders the whole condenser inoperative. Our experience has shown us that unless a washer such as mica, celluloid or other inert insulating material separates the filmed surface from the phenolic condensation product the condensers will inevitably fail at this point when the condensers are subjected to high voltages. The importance of having the sleeve extend below the surface of the electrolyte is well known in the art—that is, it prevents surface action due to the combined effect of the air, the sparking, the electrolyte and the electrolytic gases at this point.

The upper part of the casing 10 has an annular depression 24 therein giving a circular seat 25 for holding the outwardly extending annular flange 26 on the support or cover 13. This cover is centered by up-standing walls 27 and when the cover is placed in position and a suitable gasket 28 is placed thereon the upper portion of the walls 27 are crimped against the gasket as at 29 to securely hold the parts together and conceal the gasket, the inner portion of the wall 29 preferably just meeting the vertical wall 30 of the top 13. The gasket 28 is preferably asbestos to which has been added about 10% rubber, although any suitable inert insulating material may be used for this purpose.

The upper surface of the top is provided with a plurality of ridges 31, 31', between which there is a plurality of annular recesses 32, 32'. The purpose of this peculiar construction is to cut down surface conduction and to prevent short-circuiting of the condenser by the electrolyte "creeping" across the top of the condenser—i. e., should the joints around the mica disc 21 or the gasket 28 allow liquid to pass, this liquid will accumulate in the grooves 32, 32' before it can creep from the casing 29 to the aluminum rod 16, thus avoiding electrical leakage.

The cover preferably has a small hole 33 drilled therein under the gasket 28, as shown in Figure 1, to allow any gases to diffuse through or under and around the gasket and to escape. This prevents abnormal pressures from being set up in the cell, and at the same time does not allow electrolyte to flow out if the condenser is turned over.

A terminal lug 34 having an apertured horizontal portion 35 is secured to the aluminum rod, preferably by spinning the rod over the lug as shown in Figure 1. This lug is preferably of aluminum to prevent electrolytic action at this junction should any electrolyte escape. If dissimilar metals were joined at this point a galvanic couple would result and would cause corrosion if any electrolyte escapes. To facilitate the soldering of connecting wires we secure a brass-tinned eyelet 37 in the aperture 38 in the outer end of terminal lug 34.

In Figures 2 to 4 we have shown an embodiment of our invention wherein three smaller electrodes are inserted in a single cell in place of filmed electrode 12 of Figure 1. These electrodes are aluminum rods 18' which have been turned on a lathe to give a shoulder 19' and a plurality of integral spaced discs 14', as shown in Figure 5. By means of a suitable tool this electrode may be turned on a lathe or automatic screw machine by a simple operation and its cost is thereby reduced to a minimum. The cover 13' of this modification has three depending sleeves or stems 22', each surrounding its respective aluminum rod and spaced therefrom by mica washers 21'. The method of assembling the gasket 29' and the terminal lug 34', etc., are analogous to the embodiment shown in Figure 1 and further description is unnecessary.

The filmed electrode comprising the punched discs and spacers alternately arranged on the rod as shown in Figure 1 or the turned aluminum rod as shown in Figure 5 are first subjected to a cleaning operation by treatment with alkaline solution followed by a treatment in an acid solution. The electrodes are immersed in a 5% solution of sodium carbonate heated to approximately 70° C. During this immersion the electrodes are moved back and forth to replace the air between the plates and to allow the sodium carbonate solution to act readily on all the disc surfaces. In a few seconds all grease particles will be removed and the surfaces of the aluminum will show a slight etched or frosted appearance, a frothy evolution of gas taking place. The operation is preferably carried out in iron tanks or kettles and the treatment should require ten or fifteen seconds. In practice this step may be dispensed with as the acid cleaning is ordinarily sufficient to remove all impurities, and to prepare the surface for efficient film forming.

The electrodes are then removed from the soda solution and rinsed in clean water.

The final cleaning solution is prepared by mixing one part by volume of concentrated nitric acid with three parts of water although other acid concentrations may be used if desired. The rinsed plates from the soda solution are immersed in this cold dilute acid for two or three hours. The major purpose of this operation is to remove surface metallic impurities from the aluminum. The chemical action, however, is usually very slight.

The electrodes are next thoroughly rinsed in clean water, followed by rinsing in distilled water, it being absolutely essential that all traces of acid be removed before further proceeding. The acid is preferably removed by blowing out the remaining water with a jet of compressed air. The plates at this stage of the process should be of a uniform silvery gray color although too long an immersion will cause them to appear non-uniform.

After the disc assembly is cleaned the top 13 and the aluminum lug 34 is spun to the other end of the rod 16, care being taken to prevent dirt or impurities of any kind from contaminating the assembly.

The next operation is the A. C. forming which is carried out with total immersion of the plates by means of a suitable clamp in a solution of 2% C. P. sodium bicarbonate in distilled water. The concentration of this solution may be varied depending upon the forming voltage, the more di-

lute solutions being used for higher voltages. All the metal parts other than aluminum must be kept away from the plates during the forming operation and particular care must be taken to keep the copper and brass and other corrosion products away from the plates and out of the bath. This bath is preferably in a steel tank and the plates are immersed therein in two groups, each group being a pole from the A. C. supply. The disc assembly is preferably immersed in the solution so that the surface of the electrolyte comes approximately ⅛" above the top disc.

The input A. C. current supply is regulated to give about one-half ampere per large disc assembly (about 38 discs one inch in diameter) and a corresponding current for electrodes of other areas. The initial potential is about 50 volts and this potential is gradually raised during about five minutes to a value of 290 volts during which interval the current falls to a substantially constant value. The proper rate of forming can be governed by suitable resistance or reactance in series with the current supply as is well known in this art. Preferably the 290 volts is reached in about four minutes and held at this voltage until the current is constant, which probably takes one or two minutes longer. The initial forming with A. C. is important in that it builds up a more rugged film and one less likely to have imperfections or points of weakness.

The groups of A. C. formed plates are next given a D. C. forming which is preferably accomplished by using the steel container as a negative pole and all of the aluminum plates as a positive pole. This forming is carried on in the same tank without disturbing the plates by switching from the A. C. supply to a D. C. supply. The D. C. process requires from two and one-half to three hours in the 2% aqueous solution of sodium carbonate. The temperature should be kept below 40° C. as streaking of the plates is liable to occur at higher temperatures.

Instead of completing the A. C. forming before the D. C. is initiated we may alternate these treatments, progressively increasing the voltage on the A. C. and D. C. on each application and keeping the current substantially constant until the voltage has reached a maximum, then allowing the current to drop to a minimum. By this alternate treatment a very rugged and resistant film is built up on the aluminum electrode.

The electrodes are then carefully removed from the forming tank and are dried by a compressed air jet which thoroughly removes the forming solution. In this operation and in all subsequent operations it is extremely essential that the electrode assemblies be handled with the least possible amount of mechanical abrasion. A break in the film will either make the condenser nonusable or greatly lengthen the time of the necessary final forming operation.

The final forming operation is in a substantially dry solution prepared by dissolving 3½% of sodium bicarbonate in glycerin. It will probably be necessary to heat the glycerin slightly in order to effect solution, a temperature of 80° C. for about twenty minutes usually being required. Care should be taken to keep the glycerin from the top surface of the cover 13 as it is very hard to remove and may cause a leakage and ruin the condenser. The dried electrodes are immersed in this glycerin-sodium bicarbonate solution and allowed to stand for several hours to permit the escape of the air from between the plates. The D. C. potential is then applied and the electrodes are subjected to 250 volts until the leakage reaches the desired minimum.

The formed electrodes are then carefully raised from this bath without removing the electrolyte held by the discs and are slipped into the casing 10 which is previously filled with the same glycerin solution to such a level that the final electrolyte level will be about ⅛ inch above the top plate of the assembly. Special care must be taken in this step to prevent the electrode from touching the side of the casing or any other object.

After the disc assemblies have been inserted in the casing 10 the gasket 28 is inserted and the tops are sealed by crimping the top edge 29 of the container over the gasket. The assembled condensers are then connected to a 250 volt D. C. supply and should show a leakage of less than one mil per assembly. The 250 volt potential is maintained until the current drops to less than $\frac{1}{10}$ of a mil. Defective condensers can be detected by their high leakage.

The final condenser prepared as above described is about 2" high and 1¼" in diameter, has a capacity of 10 microfarads, has a leakage of less than $\frac{1}{10}$ milliamps at 250 volts D. C., is substantially stable—that is, does not require reforming after a period of idleness,—does not deteriorate unduly with age or use, and may be manufactured at a low cost.

While we have described an electrolytic condenser using an aluminum electrode in an electrolyte of sodium bicarbonate in glycerin, it is understood that any suitable filmed electrode, such as tantalum, etc., could be used instead of aluminum, also other alcohols, especially polyhydric alcohols such as ethylene glycol, etc., can be used instead of glycerin, any ionogen may be substituted for the sodium bicarbonate and gelatin or other material may be added to the electrolyte without departing from the spirit of our invention.

We claim:

1. In an electrolytic condenser of the filmed electrode fluid electrolyte type, non-absorbent, phenolic insulating means for preventing corrosion at the point where the electrode enters the solution including a sleeve around a portion of the electrode and extending below the surface of the fluid and an inert insulator interposed between said sleeve and a portion of the electrode which is exposed to the electrolyte.

2. A condenser comprising a filmed aluminum electrode, a fluid electrolyte, a sleeve of a phenolic condensation product surrounding a portion of said electrode and extending below the surface of the electrolyte, and an inert spacer at the end of said condensation product and beneath the surface of said electrolyte, separating said condensation product from said filmed electrode.

3. In an electrolytic condenser comprising an aluminum electrode in a fluid electrolyte, means for preventing surface action and leakage including a sleeve of a phenolic condensation product surrounding said electrode and extending below the surface of the electrolyte and a mica washer spaced between said sleeve and said electrode to form a seal and to prevent chemical action between these elements.

4. A filmed electrode for electrolytic condensers comprising an aluminum rod provided with a collar intermediate its ends, and having both of its ends overturned, discs retained between the collar and one overturned end and a support and

protective sleeve retained between the collar and the other overturned end.

5. An electrolytic condenser comprising in combination a metal casing serving as an electrode, a non-conductive cover for said casing, a rod supported by said cover, a plurality of spaced aluminum discs on said rod, and aluminum spacers maintaining said discs in intimately disposed spaced relation on said rod, said rod, discs and spacers constituting a filmed electrode having an unbroken electrolytic film.

6. An electrolytic condenser comprising an electrolyte, a filmed electrode submerged therein, a phenolic condensation product support for said electrode extending below the surface of said electrolyte, and an inert spacer between said support and said electrode to prevent chemical and electrolytic action therebetween.

7. An electrolytic condenser comprising an electrolyte, a filmed electrode extending therein, a non-absorbent chemically inert sleeve about said electrode and extending into said electrolyte, and an inert spacer between said sleeve and said electrode beneath the surface of said electrolyte whereby chemical and electrolytic action therebetween is prevented.

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