Jan. 5, 1937. S. RUBEN 2,066,912

ELECTROLYTIC CONDENSER

Filed July 7, 1934

Fig. 1

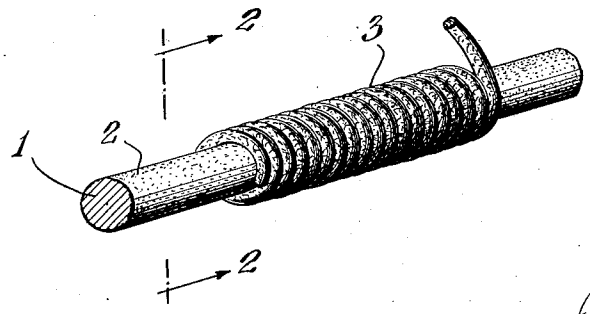


Fig. 2

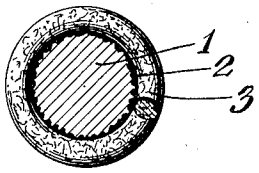


Fig. 3

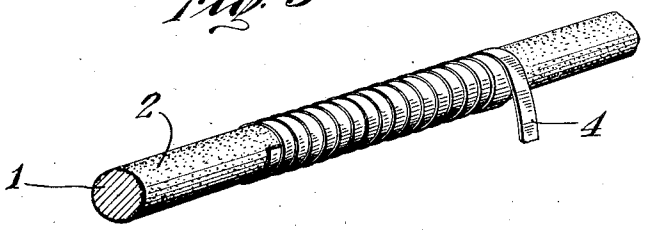
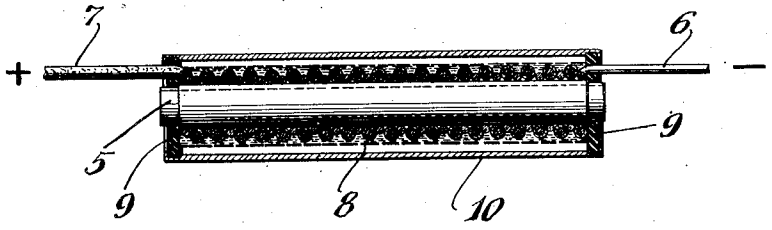


Fig. 4



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ELECTROLYTIC CONDENSER

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7 Claims. (Cl. 175—315)

This invention relates to electrolytic condensers, its advantages are utilized primarily in electrolytic condensers of the "dry" type, although it has a useful application also in condensers of the wet type.

An object of the invention is to provide a dry electrolytic condenser having a wire anode of large capacity.

Another object is to provide an etched anode electrolytic condenser.

Another object is to provide a condenser of the dry electrolytic type in which tab difficulties are eliminated and in which the possibility of corrosion is minimized.

A further object is to provide an improved means of etching condenser electrodes, so that a greater capacity is obtained.

Still another object is to provide a means of controlled etching of condenser electrodes.

In general, the object is to provide an improved condenser in compact form, which easily adapts itself to quantity production and which can be economically built in a variety of forms.

Other objects will be apparent from the disclosure and from the drawing in which

Fig. 1 illustrates a section of an etched wire anode having a cotton spacer wound around its surface;

Fig. 2 illustrates an end cross section of this wire;

Fig. 3 is similar to Fig. 1 except that the cotton winding is replaced with a flat winding of "cellophane" or paper;

Fig. 4 shows a form of the condenser suitable for direct current filter use.

Dry electrolytic condensers have heretofore utilized sheet foil electrodes usually of aluminum ranging in thickness from .002'' to .004'' and in width from one inch to three or four inches. These foils have been spaced by a reticular cloth spacer such as disclosed in my United States Letters Patents 1,710,073 and 1,714,191, or by paper spacer as shown in my United States Letters Patent 1,891,206, or by a regenerated sheet cellulose spacer, for instance, "cellophane" as illustrated in my United States Letters Patent 1,918,716. In the construction of these condensers a spacer of approximately the same dimensions as the foils, is placed on each side of one of the electrodes and the two foils and spacers are then rolled, usually in cylindrical form. Prior to rolling the spacer is impregnated or permeated with a viscous electrolyte so as to afford a conductive path between the electrode foils, although in some cases the condenser roll is assembled and the electrolyte thereafter introduced by impregnation.

It has long been known in the art that if the aluminum plates are etched or otherwise roughened, an increased capacitance is obtained due to increased surface and lower average oxide film thickness formed on such etched plate.

However, the employment of an etching process is limited, due to the fact that the etching solution tends to dissolve the foil and if the maximum benefit arising from the increased area obtained by a deep etching is desired, it is necessary to use a much thicker foil than would otherwise be required. Furthermore, care must be exercised to prevent the etching from being too deeply applied. These limitations are avoided by the method of etching and the type of electrodes used.

A practical factor of importance in condenser manufacture, to which this invention also relates, is the problem of tab or lead corrosion. In the construction described herein, this problem is reduced to a negligible one and the necessity of providing a terminal or tab construction, subject to mechanical weakness or electro-chemical corrosion attack at the joint, is obviated.

My invention comprehends the use of an etched wire of film forming metal such as aluminum or tantalum for one or both of the electrodes, the wire being electrolytically oxidized or formed after the etching has taken place. By the use of wire instead of foil electrodes, the limitation on deep etching is removed and an exceptionally large effective current blocking area is made available without substantially weakening the electrode structure. It will be seen that by using an aluminum wire having a diameter in the order of .040'' or a narrow aluminum tape of the same thickness and preferably not more than .15'' wide, that it is possible to obtain a very deep etching will consequent increased film blocking area.

In order to further avoid too great a reduction in mass of an electrode due to the effect of the etching solution, I find it of considerable advantage to substitute for the pure aluminum foil electrodes of the prior art, an aluminum alloy having a content of a material readily soluble in an etching agent which does not substantially dissolve aluminum, such as nitric acid. For example, by adding 10% magnesium to the pure aluminum and etching the electrode in nitric acid, the magnesium is rapidly etched out and the aluminum, other than becoming slightly oxidized on its surface, is unaffected. For use with a nitric acid etching agent, an alloy of aluminum with one or

more of the metals, calcium, lithium or beryllium may be substituted for the aluminum-magnesium alloy electrode.

Generally, it may be stated, with the film forming metal used, whether aluminum or tantalum, that the material alloyed therewith, should be one which is readily capable of being etched out or dissolved by the etching compound and that the etching compound itself should be such as not to adversely attack or affect the film forming metal base. For instance, in place of the nitric acid I may use sulphuric acid, chromic acid or an acid salt such as aluminum ammonium sulphate.

The anode electrodes (or for alternating current condensers, both electrodes) may be prepared as follows: Where pure aluminum wire is used, (or aluminum having a low percentage tantalum content as described in my co-pending application bearing Serial Number 711,629), it is passed through a solution of caustic soda which dissolves any surface grease and produces a matted surface. It is then passed through an etching solution of hydrochloric and hydrofluoric acids in the order of 5% hydrochloric and 1% hydrofluoric after which the etched wire is passed through nitric acid and water washed. If an aluminum-magnesium alloy wire is used, the wire is merely passed through hot nitric acid and the etching accomplished by the dissolving of the magnesium. The wire is then formed by the customary continuous formation process in an aqueous borax-boric acid solution. After being formed, it is dried and wound with cotton on machines similar to those used for cotton-winding magnet wire. Where it is desired to provide a covering capable of withstanding higher voltages than 450 volts, I prefer to wind the etched formed wire with plasticized "cellophane" strip which in addition to having a very high voltage breakdown, also has a better space factor, as it is flat wound. Paper, silk or synthetic cellulose thread windings may also be used.

The condenser itself may be constructed by winding an uncovered and a covered wire together; if multi-layer windings are to be employed, both wires should be covered. After the condenser has been wound, it should be submerged in a paste or viscous electrolyte, preferably comprising ethylene glycol, ammonium borate and boric acid as described in my United States Letters Patent 1,891,207. The electrolyte should thoroughly impregnate or permeate the spacer used.

After the condenser has been wound, it is placed in a water-proof container, the ends of the electrodes serving as connecting tabs or leads. Opposite ends are used as terminals so as to give a minimum amount of inductance to the winding.

In order to describe a form of the invention in more detail, reference is made to the accompanying drawing (in which like numbers indicate like parts).

In Fig. 1, the aluminum wire (1) having etched oxidized surface (2) is covered with cotton winding (3) which acts as a spacer element and serves to hold the viscous electrolyte (not shown).

In Fig. 3 a strip winding (4) of plasticized nonfibrous regenerated cellulose (such as "cellophane") has been substituted for cotton winding (3) of Fig. 1.

In Fig. 4 is shown a complete etched wire dry electrolytic condenser, the plain uncovered aluminum wire cathode (6) and the cotton covered etched oxidized aluminum anode (7) being wound together on mandrel (5), the terminals being brought out at opposite ends as shown. Viscous borate electrolyte (8) impregnates the condenser which is housed in tube (10) which is spun over the end caps (9) and protects and seals the unit.

Various modifications of the invention will suggest themselves; for instance, if an aluminum container is used, it may serve as the cathode, and wire (6) may be eliminated; or the cathode wire (6) may be grounded to the container, which may then serve as a terminal. The mandrel on which the wire is wound can also be used as the cathode instead of wire (6), provided it too is formed of aluminum. It is apparent also that the type of construction shown, the electrode material and the methods of forming it will have an application and service in condensers of the wet type.

Since certain changes in carrying out the construction of the condenser and its components and obvious substitutions can be made in the materials used without departing from the scope of the invention, it is intended that all matters contained in the above description, or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. An electrode unit for electrolytic condensers comprising an etched aluminum wire and a spacer of absorbent material spirally wound around said wire in at least one layer covering the surface of said wire.

2. An electrode unit for electrolytic condensers comprising a wire of film forming metal having its surface etched so as to increase the area thereof and a spacer of absorbent material spirally wound around said wire like a bandage.

3. An electrode unit for electrolytic condensers comprising a wire composed of a film forming metal the surface of which has been chemically etched to substantially increase the area, said surface having an electrolytically produced oxide current blocking film thereon and a spacer of absorbent material spirally wound around said wire in at least one layer covering the surface of said wire.

4. An electrolytic condenser comprising two electrodes the anode being composed of a wire of film forming metal, the surface of which has been chemically etched to increase the area thereof and an absorbent sheet spacer spirally wound around said wire in at least one layer covering the surface of said wire.

5. An electrolytic wound condenser having an electrode with a cover of fabric spirally wound around the electrode like a bandage in at least one layer and completely enclosing the electrode.

6. In the method of producing an electrolytic condenser the step of winding a strip of porous material around one electrode like a bandage with the turns overlapping.

7. An electrolytic condenser comprising two electrodes, the anode being composed of a wire of film forming metal, the surface of which has been chemically etched to increase the effective area thereof and an absorbent sheet spacer spirally wound in bandage form around at least one of said electrodes in at least one layer covering the surface thereof.

SAMUEL RUBEN.