

May 21, 1935.

J. E. LILIENFELD

2,001,790

ASYMMETRIC CONDENSER AND METHOD OF OPERATING THE SAME

Filed April 22, 1931

6 Sheets-Sheet 1

Fig. 1.

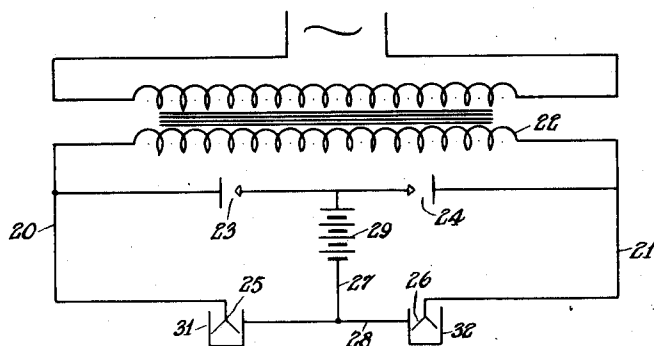


Fig. 2.

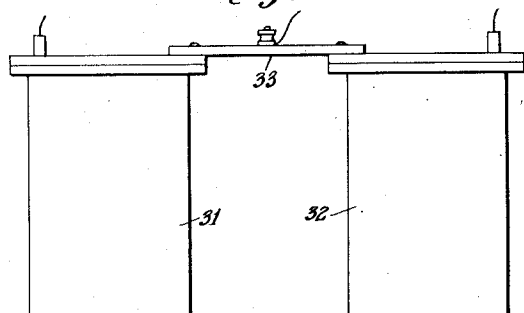
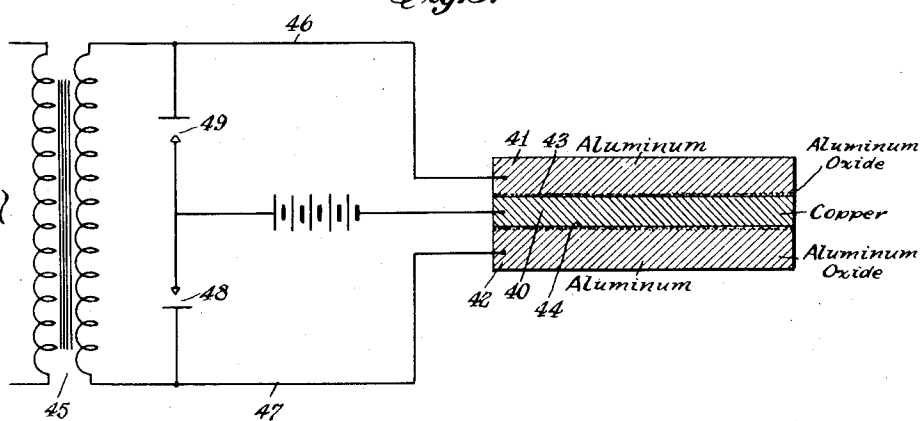


Fig. 3.



INVENTOR
JULIUS EDGAR LILIENFELD
BY *And. P. Schmitt*
ATTORNEY

May 21, 1935.

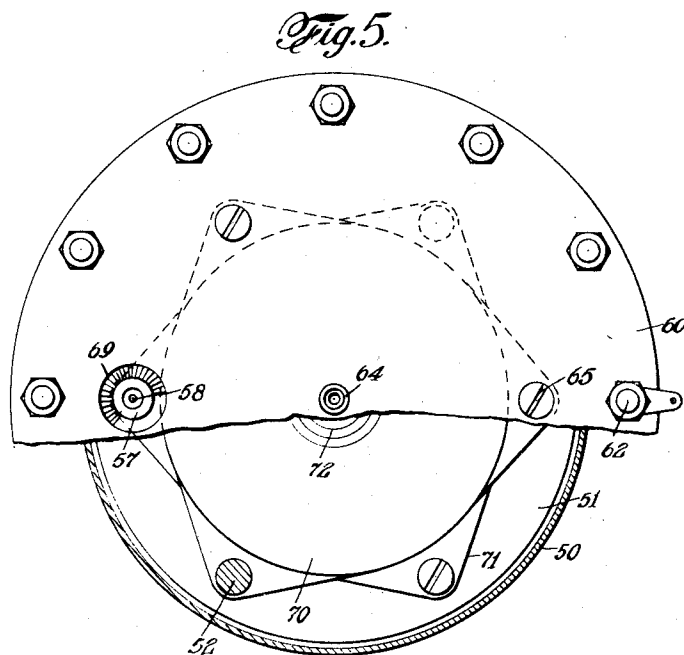
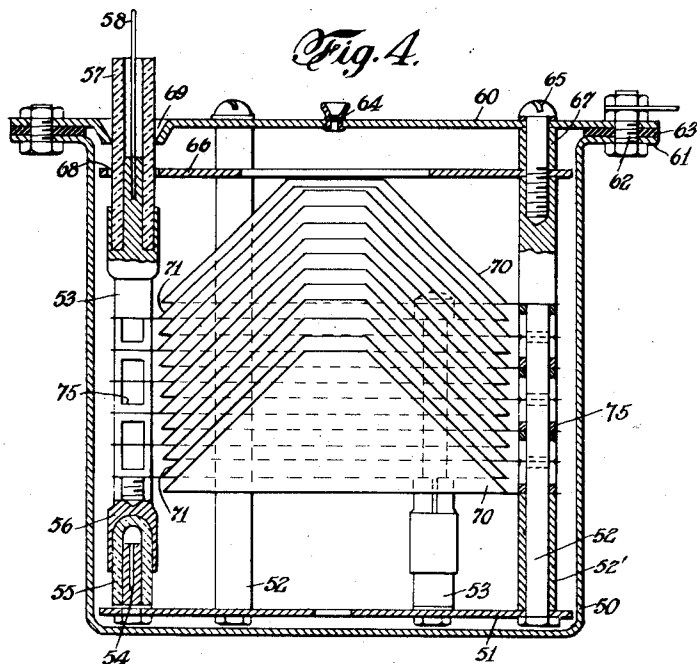
J. E. LILIENFELD

2,001,790

ASYMMETRIC CONDENSER AND METHOD OF OPERATING THE SAME

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6 Sheets-Sheet 2



INVENTOR
JULIUS EDGAR LILIENFELD
BY *Frederick R. Schuch*
ATTORNEY

May 21, 1935.

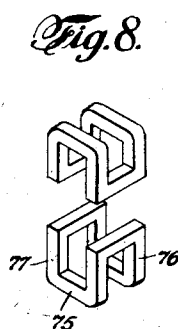
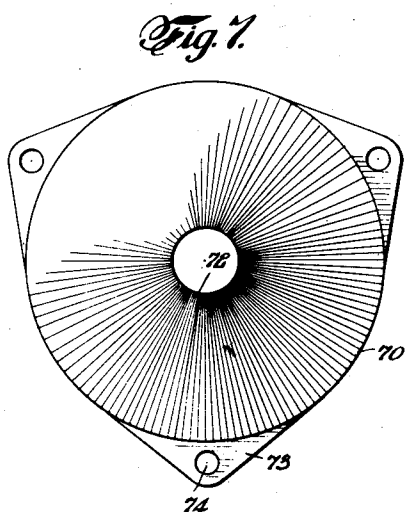
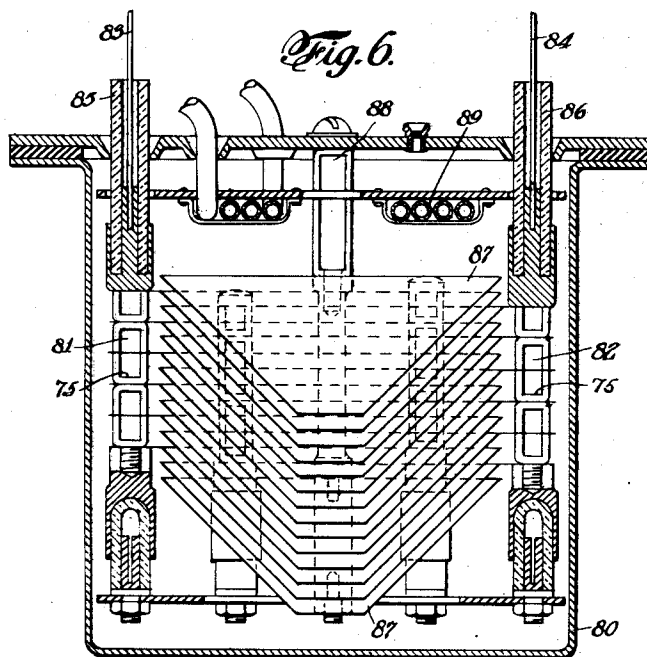
J. E. LILIENFELD

2,001,790

ASYMMETRIC CONDENSER AND METHOD OF OPERATING THE SAME

Filed April 22, 1931

6 Sheets-Sheet 3



INVENTOR
JULIUS EDGAR LILIENFELD
BY *André K. Schust*
ATTORNEY

May 21, 1935.

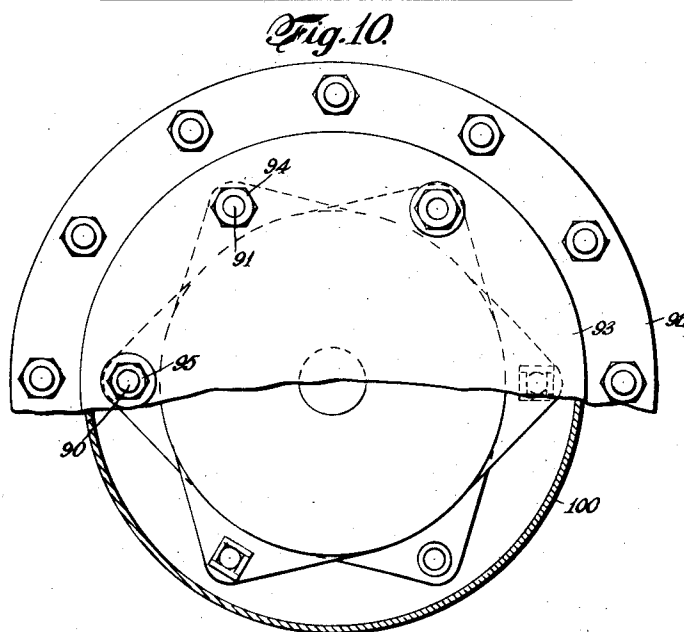
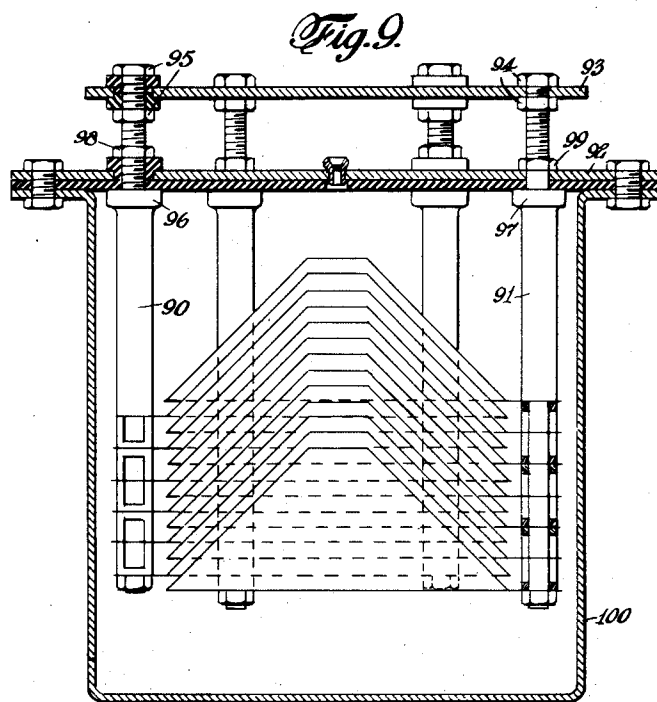
J. E. LILIENFELD

2,001,790

ASYMMETRIC CONDENSER AND METHOD OF OPERATING THE SAME

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INVENTOR
JULIUS EDGAR LILIENFELD
BY *Reddick & Huston*
ATTORNEY

May 21, 1935.

J. E. LILIENFELD

2,001,790

ASYMMETRIC CONDENSER AND METHOD OF OPERATING THE SAME

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Fig. 11.

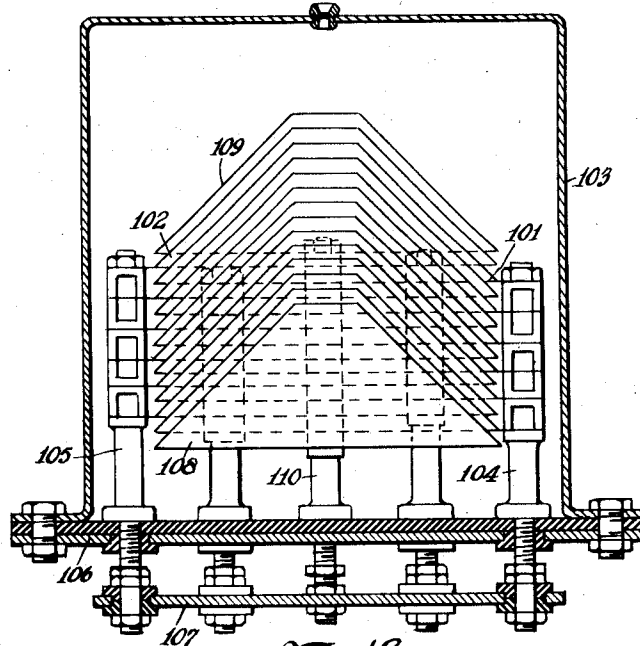
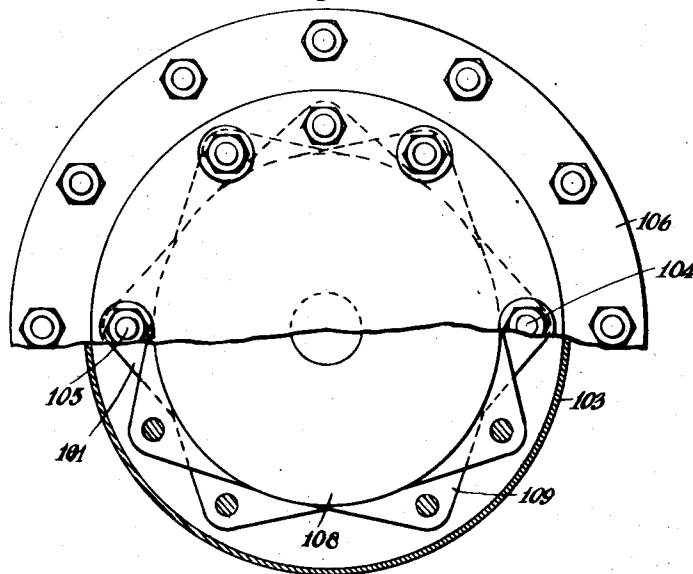


Fig. 12.



INVENTOR
JULIUS EDGAR LILIENFELD

BY *Edw. F. Shuck*
ATTORNEY

May 21, 1935.

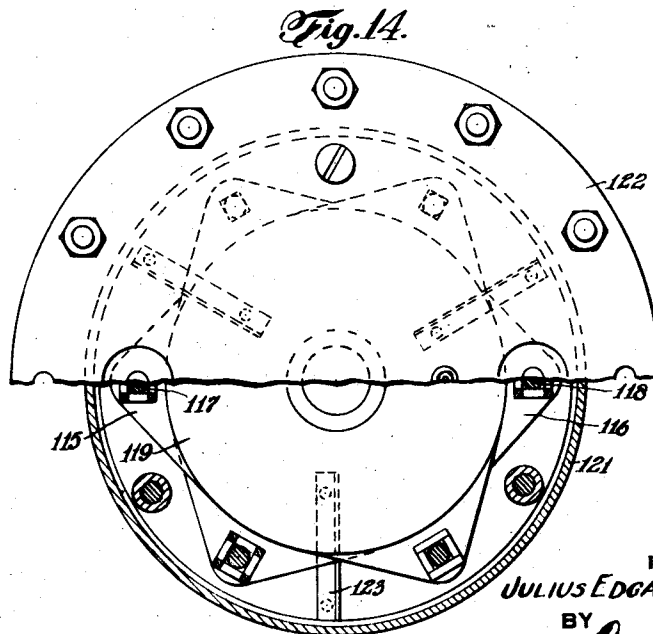
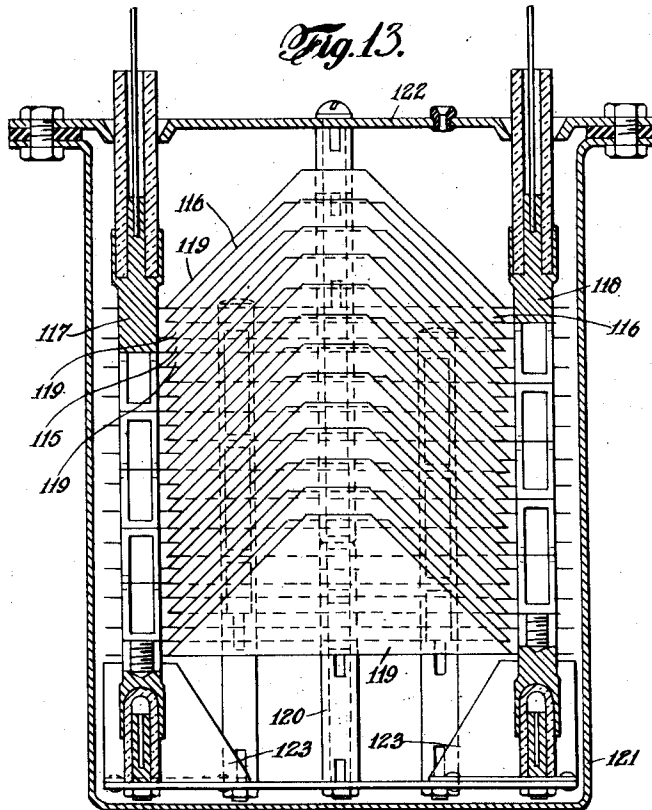
J. E. LILIENFELD

2,001,790

ASYMMETRIC CONDENSER AND METHOD OF OPERATING THE SAME

Filed April 22, 1931

6 Sheets-Sheet 6



INVENTOR
JULIUS EDGAR LILIENFELD
BY *Millard*
ATTORNEY

UNITED STATES PATENT OFFICE

2,001,790

ASYMMETRIC CONDENSER AND METHOD
OF OPERATING THE SAME

Julius Edgar Lilienfeld, Winchester, Mass.

Application April 22, 1931, Serial No. 531,901

7 Claims. (Cl. 175—315)

The invention relates to electrical condensers and to the method of operating the same on alternating current; and the present application is a continuation in part of my prior applications for U. S. Letters Patent Nos. 462,251 and 462,252, filed June 19, 1930.

It has for an object a novel construction of electrolytic condenser, more particularly in the provision of novel electrode members therefor and in an assembly of the same wherein an accurate and close spacing of the electrode elements within a container is possible, and a rugged and substantial structure is secured.

Another object of the invention is to afford a rigid mounting of a multiplicity of electrode elements without sacrificing the accurate and close spacing of the same, and withal to so mount the entire electrode structure that it may be handled as a unit both for formation purposes and for convenient securing of the same in position within a suitable container.

The invention has for an additional object a construction of electrode member which will invite circulation of the electrolyte and whereby, furthermore, any gas evolved will not tend to collect upon the individual electrode elements but will be directed upwardly to the top of the container for electrolyte.

A further object of the invention resides in a novel method of operation of a condenser on alternating current.

The invention has for a still further object the provision of conducting means between the anodic electrodes of a condenser, operated on alternating current, whereby deterioration of the said anodic electrodes is obviated.

It is recognized in the operation of the condenser on alternating current that it is necessary to hold the electrolyte, in the case of an electrolytic condenser, at a voltage negative with respect to the anode voltage. I have found, furthermore, that it is essential that the electrolyte be biased to a very definite and relatively high negative voltage if deterioration of an anode is to be prevented.

Also, I have determined that in order to operate at relatively high voltages the spacing between electrodes must be very narrow as a high resistance electrolyte is required. Moreover, under these conditions, potential differences within the electrolyte between electrodes become aggravated when large electrode surfaces are utilized.

I have further determined that if conducting means be interposed between the anodic elec-

trodes, such differences of potential existing in the electrolyte between the anodes may be equalized and grounded, as by transferring the same to the cathodic electrode.

When substantial potential differences are not thus equalized, there is introduced a path of capacity current resulting in an additional voltage distribution in the intervening medium, as an electrolyte, which may entirely upset the required condition of maintaining the said medium at certain locations at a definite minimum high voltage, and thus will introduce the deterioration action.

Also, to provide a successful alternating current electrolytic condenser, it is necessary to operate with an electrolyte of particularly high resistance, as is more fully set forth in my copending application, Serial No. 515,884, and thus provide for a high-biasing negative voltage.

For instance, using aluminum electrodes and an aqueous electrolyte of a specific resistance of the order of magnitude of 2000 ohms per cu. cm., e. g. a saturated solution of boric acid containing 0.5 grams to 1.0 grams borax per liter and operating on 220 volts A. C. R. M. S. (310 volts peak), the condenser will be exposed to deterioration unless the biasing voltage exceeds an initial value between 100–125 volts, so that for safe commercial operation a bias of at least 150 volts ought to be applied, as is set forth in my copending application, Serial No. 462,252. With higher A. C. voltages, the initial values of the biasing voltages are higher and also electrolytes of a higher resistance are to be used. Similarly with lower A. C. voltages, lower biases and lower resistance electrolytes are to be used.

In carrying out the invention, particularly in the use of an electrolytic condenser on alternating current, there is impressed upon each of a pair of anodes substantially the full line potential, while the cathodic electrode, or electrodes, is continuously maintained at a predetermined minimum potential. The equalization of potential differences in the electrolyte between anodes is effected either by physically separating the anodic electrodes into two individual condenser units by having associated therewith a cathodic electrode and interconnecting said latter electrodes; or, the anodic electrodes may both be immersed in an electrolyte common thereto and to the cathodic electrode if a suitable conducting member be introduced into the electrolyte and interposed between the two said anodic electrodes. In the latter instance, the conducting element may be directly grounded or,

if the cathodic element constitutes also the container for the electrolyte, said conducting element may be electrically interconnected with the container. In the case of two physically separated anodic electrodes as hereinbefore set forth, the associated cathodes are electrically connected; and in both instances, the said cathodes are to be negatively biased to a relatively high direct current voltage—150 volts and higher.

A convenient means for providing the conducting element is set forth in the drawings hereunto annexed and hereinafter more fully described, and wherein there is disclosed a succession of anodes of novel form which are superposed with predetermined spacing. An intermediate conducting element of similar design is also shown interposed and arranged to be grounded or connected to the cathode of a condenser.

The nature of the invention, however, will best be understood when described in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation of the electrical connections involved in the operation of an alternating current condenser in accordance with the invention, and wherein a physical separation of the containers for the anodes is involved.

Fig. 2 is an elevation illustrating an electrolytic A. C. condenser having separated containers as utilized in the arrangement indicated in Fig. 1, and shows also a means for interconnecting the cathodic electrodes thereof.

Fig. 3 is a diagrammatic view illustrating the application of the invention to the operation on alternating current of a dry type of condenser in distinction to the electrolytic type indicated in Figs. 1 and 2 and utilizing a liquid electrolyte.

Fig. 4 is a vertical section; and Fig. 5 a plan view with portion broken away, illustrating the novel arrangement and mounting of the condenser electrodes of an electrolytic condenser.

Fig. 6 is a vertical section through a condenser and illustrates a modification in the positioning of the electrodes.

Fig. 7 is a plan view of the novel electrode member utilized in the condenser.

Fig. 8 is a perspective view of the hollow spacer member utilized in separating electrodes.

Figs. 9, 11 and 13 are vertical sections, and Figs. 10, 12 and 14 plan views, with portion broken away, illustrating modifications in the condenser construction.

Referring to the drawings, more particularly Fig. 1 thereof, an electrolytic condenser of the nature hereinafter set forth is arranged to be connected across the leads 20 and 21, from the secondary of a transformer 22 connected to a source of A. C. (not shown), and to a pair of uni-directional members 23 and 24. The arrangement is such that these uni-directional members oppose each other and that with respect to their polarities the negative terminals of each are connected to the corresponding anodes 25 and 26 of the condenser. These uni-directional elements, or rectifiers, may be of the thermionic type, or may be mercury rectifiers, synchronously operated switches, vibrators and the like; but it is important that they be of a negligibly low impedance.

There is, furthermore, provided a connection 27 from between the said uni-directional members to a cathode conductor 28, whereby a uni-directional member will serve to by-pass the corresponding anode to the cathode (electrolyte) only for current arriving negatively at said anode.

With low impedance of these uni-directional members, it will readily be understood that an anode can then at no time have a potential negative with respect to the electrolyte under the action of the alternating current applied thereto, since a uni-directional element would practically short-circuit the anode to the electrolyte during each half-cycle that arrives negatively at the particular anode. On the other hand, there will be, broadly speaking, no other definition to the potential of the electrolyte except that it cannot possibly be positive at any time with respect to either one of the anodes. This condition being fulfilled, the electrolyte potential will adjust itself according to the capacity and the leak of the anodes and will therefore at all times assume values corresponding to the utmost possible stability of the physical system consisting of the anodes and the electrolyte.

By introducing between said uni-directional members and the electrolyte means for biasing the latter to a predetermined negative value with respect to the anodes, it is possible to apply a stationary bias of sufficient intensity to substantially fix the polarized molecules of the electrolyte in position so that the pulsating field applied to the anodes 25 and 26 will not force too intense a motion upon them. By this expedient, the value of the peak voltages to which the condenser can be subjected may be materially increased.

As a convenient means of affording the desired bias, there may be included in series in the connection 27 a suitable source of D. C. electromotive force such as a storage battery, generator or the like 29 which, moreover, should be of sufficient value to also overcome the voltage drop in the said uni-directional members. Or, a transformer (not shown) may be utilized to effect the required voltage distribution as in the manner more particularly set forth in my copending application for U. S. Letters Patent for Method of operating alternating current electrolytic condenser and circuit thereof, filed June 19, 1930, Serial No. 462,252.

In the superimposing of the alternating current over the direct current bias of the electrolyte in the manner set forth, whereby an anode is short-circuited to the electrolyte only for current arriving negatively at said anode, it will be understood that one of the uni-directional elements may be omitted without essentially disturbing the operation. The advantage, however, of the symmetrical circuit, embodying the two uni-directional members or rectifiers 23 and 24, is that the electrical charge conveyed to the electrolyte is maintained by inflow of negative electricity during each half-cycle and, therefore, more evenly than when but a single rectifier is utilized. In the latter instance, a flow of negative electricity to the electrolyte will occur, of course, only during each second half-cycle.

In the operation of the condensers on A. C., it is essential that provision be made to equalize any potential differences set up in the conducting medium (electrolyte); and, as indicated in Figs. 1 and 2, this is conveniently effected by locating the anodes 25 and 26 in individual physically separated containers, as the containers 31 and 32. These containers may serve at the same time as the cathodes of the condensers—one being associated with each anode or group of anodes. The cathode connection 28 may be constituted as a connecting or bridging bar 33 (Fig. 2), also of copper, and firmly attached to the tops of both containers.

The arrangement for thus causing the electrolyte (cathode) potential to adjust itself according to the capacity and leak of the anodes and for also biasing negatively the electrolyte (cathode)

5 to a predetermined value with respect to the anodes is equally applicable to a "dry" type of condenser. Reference being had to Fig. 3 of the drawings, a condenser is indicated comprising the intermediate plate or cathode 40 as of copper or of unpolarized aluminum, and the anodic outer plates or anodes 41 and 42 which may be of aluminum and are polarized or formed over their inner faces as indicated at 43 and 44, respectively, to afford a dielectric having asymmetric properties. These polarized faces, which are placed in contact with the respective opposite faces of the cathode 40, are connected to the secondary of a transformer 45 through leads 46 and 47, the said cathode being connected across the leads through rectifiers 48 and 49, as in the previously described embodiment. It is to be noted that in this arrangement the single cathodic element serves at the same time as a potential equalizing member between the two anodic elements, which effect was attained in the previously described electrolytic embodiment, and shown in Fig. 1, by separating the condenser into two units whose respective cathodic elements were electrically connected. If desired, thin layers of a viscous electrolyte, such as a solution of glycerine, boric acid and borax, preferably with a solid filler as aluminum dust, may be inserted between the cathode 40 and the anodic outer plates 41 and 42.

35 The said potential equalizing feature, however, may be attained for electrolytic condensers in a single cell, if suitable provision be made for interposing between the anodic elements dipping into the electrolyte a metallic or conducting element grounded or connected to the cathodic element.

A construction of condenser particularly adapted for either divided operation or for operation with all the electrodes dipping into electrolyte of a single container is set forth in Figs. 4-6 and 45 9-14, Figs. 13 and 14 showing a condenser equipped with potential equalizing means.

A very convenient structural arrangement for introducing the potential equalizing elements is set forth in Figs. 13-14, said structure being also of value in the design of electrolytic condensers adapted for direct current purposes and embodying only a single anodic electrode, comprising a plurality of interconnected anodic elements, and set forth in Figs. 4-5 and 9-10.

55 As shown in Figs. 4 and 5, the condenser comprises a container 50 which may be of copper and is designed to retain a suitable electrolyte and the novel electrode structure. This structure comprises a bottom plate 51 from which extend upwardly a plurality of riser members, in the present instance two sets of three each and equidistantly spaced around the vertical axis of the plate. The one set of risers 52 is directly bolted to the plate and the individual risers are designed to retain the cathodic electrodes of the condensers, as hereinafter more fully set forth. The remaining risers 53 are arranged to be insulated from said plate to support the anodic electrodes of the condenser, and to this end an expanding bolt 54 extends upwardly into an insulating bushing 55 which is arranged to be welded to a recessed bushing 56 secured over the lower threaded end of the riser, for example, in the manner more fully set forth in my copending 70 application, Serial No. 515,885.

The upper end of one of the risers is recessed to receive an insulating porcelain bushing 57 welded thereto and through which passes a terminal lead 58 for external connection to the anodes of the condenser. The risers 52 are secured at their upper ends to a mounting plate 60 adapted for securing the entire electrode structure to a flange 61 of the container, as by means of bolts and nuts 62 passing through the flange and plate, a sealing gasket 63 being seated therebetween and the plate 60 being provided also with a centrally disposed vent 64. The plate is secured to the outer ends of the risers 52 by means of screws 65, the riser ends being tapped to receive the screws, and a further and annular baffle plate 66 may be retained by the risers which are shouldered at their outer ends to support said plate with interposed spacing sleeve 67 to retain the latter plate 66 in position. Plate 66, moreover, is perforated as at 68 and the plate 60 at 69 to pass the insulating bushing 57 of a riser 53.

The respective sets of risers 52 and 53 are designed to mount the cathodic and anodic electrode elements respectively, the same being in the nature of frusto-conical plates 70 and 71, for example, of copper and aluminum, respectively. These plates are shown more particularly in Fig. 7 of the drawings being provided at the apex with an axial perforation 72 and having equidistantly spaced basal ears 73 which are provided with perforations 74 to pass the corresponding riser members. In the present embodiment, the arrangement is such that a copper element alternates with an aluminum element, the ears of the respective elements being displaced angularly for attachment to the corresponding risers which are so spaced that a cathodic riser alternates with an anodic riser.

In order to secure a proper and predetermined spacing between the different electrode elements on their respective risers, suitable spacer members are arranged to be mounted over the respective risers to build up the structure, as more particularly shown in Fig. 4 of the drawings, and whereby a very definite and accurate spacing is secured. In the operation of the electrolytic condensers this is an essential feature, particularly where extremely close spacing is a requirement.

A very efficient form of spacer member is disclosed in Fig. 8 of the drawings. The pair of members therein illustrated consists of links 75 turned up at the ends to provide the upstanding parallel portions 76 and 77. In assembling these spacers on a riser, a spacer, for example in the case of riser 53, rests upon the shoulder provided by recessed bushing 56 and in the case of the riser 52, is supported on a sleeve 52' mounted about the lower end of said riser. On top of a spacer member through which the risers pass, as indicated, are located the ears of the electrode elements, followed by a further spacer member in reverse position (located end to end as indicated), then by the ears of another electrode element, etc. These risers, it will be observed, are of an open-work construction so as to invite circulation of the electrolyte through the spaces between the various electrode elements as stacked upon their sets of risers.

In Fig. 6, a modification in the arrangement is illustrated in that not only are the electrode elements shown in a position inverted with respect to those shown in Fig. 4, but the container 80 for electrolyte constitutes in this instance also the 75

cathode of the condenser which is designed for A. C. operation.

The anodic electrodes, therefore, are arranged to be separately mounted, substantially in the manner described in connection with the structure shown in Figs. 4 and 5 upon risers 81 and 82, one of each set having terminal leads 83 and 84 respectively projecting beyond corresponding insulating bushings 85 and 86. Provision is also made for mounting at the top and bottom copper elements 87, as on risers 88; and a cooling coil 89 is mounted in the upper portion of the container 80 over the stack of electrode elements.

Figs. 9 to 12 illustrate a further modification in the external mounting of the risers and whereby formation of the anodic elements may be accomplished satisfactorily after the condenser has been assembled. To this end all of the anodic risers 90 and the cathodic risers 91, Figs. 9 and 10, are caused to extend beyond the cover plate 92 with the risers 90 insulated therefrom. A further plate 93 is rigidly secured to the upper ends of the risers 91 as by means of the nuts 94, and the outer ends of the risers 90 are also held thereto, as by means of the nuts 95, but are insulated from the said plate. The sets of risers 90 and 91, furthermore, are held to the cover plate 92 through respective shoulders 96 and 97 of the risers engaging the underside of cover plate 92 and nuts 98 and 99 working on the threaded outer ends of the said risers to draw the shoulders against said plate. By loosening the nuts 95 and 98 a riser may be caused to be lowered slightly within the container 100 so as to allow of forming also the contact surface of the shoulder 96 and thus obviate deterioration in subsequent operation of the condenser.

In Figs. 11 and 12, two sets of anodic plates 101 and 102 are mounted, in inverted position in container 103, upon corresponding risers 104 and 105 which are similarly secured to the cover plate 106 and an outer plate 107. This condenser is thus adapted for A. C. operation, and upper and lower end plates 108 and 109 as of copper are mounted upon risers 110.

Figs. 13 and 14 illustrate the provision of means, intermediate the two sets of anodic electrodes 115 and 116 mounted on risers 117 and 118 respectively, for equalizing potential differences in the electrolyte between the adjacent plate elements of the said anodic electrodes. This is effected by interposing a conducting member as the conical plates 119 of copper, the same being mounted on corresponding risers 120 and grounded to the container 121 through the cover member 122. Moreover, further equalizing elements are provided at the bottom of the container between the lower ends of the two sets of anodic risers 117 and 118, and may comprise a series of fins 123 projecting radially inward and secured to the bottom of the container.

I claim:

1. In an electrolytic condenser including a container for electrolyte: a stack of spaced frusto-conical electrode plates immersed in the electrolyte and having perforated basal ears for mounting the plates within the container, conducting risers fitting through the perforations of the ears and connecting the plates together, and skeleton spacer members mounted about the risers for maintaining a predetermined separation of the

respective plates and affording a circulation of the electrolyte therethrough.

2. An electrolytic condenser, comprising a cathodic container for an electrolyte, a stack of spaced frusto-conical electrode plates immersed in the electrolyte, perforated at the apex and having basal ears, two sets of equidistantly spaced riser members fitting through the perforations of the ears, intermediate skeleton spacer members mounted upon the respective risers to secure the said plates in predetermined spaced relationship, a third set of riser members spaced between the aforesaid riser members, conducting frusto-conical plates mounted on the third set of riser members and located between successive anode plates, and means connecting the conducting plates to the cathodic container.

3. An electrolytic condenser, comprising a container for electrolyte, an electrode supporting structure embodying a plate adapted to be supported by the top of the container, a base plate within the container, intermediate rods securing the two plates to each other, a succession of electrodes mounted in the electrolyte upon said rods, and hollow spacer members maintaining the plates in predetermined spaced relationship and affording circulation of the electrolyte therebetween and through the spacer members.

4. An electrolytic condenser, comprising a container for electrolyte, an electrode supporting structure embodying a plate adapted to be supported by the top of the container, a base plate within the container, intermediate rods securing the two plates to each other, a succession of separated electrodes mounted in the electrolyte upon said rods in spaced relationship to each other, and conducting fins extending from the base plate between the rods for the anodic electrode elements.

5. An electrolytic condenser, comprising a cathodic container for an electrolyte, a stack of spaced polarized aluminum plates of frusto-conical shape immersed in the electrolyte, perforated at the apex and having basal ears, two sets of equidistantly spaced polarized aluminum riser members fitting through the perforations of the ears, intermediate skeleton spacer members of polarized aluminum mounted upon the respective risers to secure the said plates in predetermined spaced relationship, a third set of riser members spaced between the aforesaid riser members, conducting frusto-conical plates mounted on the third set of riser members and located between successive anode plates, and means connecting the conducting plates to the cathodic container.

6. In an electrolytic condenser including a container for electrolyte: a stack of spaced electrode plates immersed in the electrolyte and having perforated ears for mounting the plates within the container, conducting risers fitting through the perforations of the ears and connecting the plates together, and skeleton spacer members mounted about the risers for maintaining a predetermined separation of the respective plates and affording a circulation of the electrolyte therethrough.

7. An aqueous electrolyte for electrolytic condensers having a specific resistance of the order of magnitude of 2000 ohms per cm³.

JULIUS EDGAR LILIENFELD.