P. C. HEWITT.

APPARATUS FOR TRANSFORMING ELECTRICAL ENERGY.

APPLICATION FILED JAN. 30, 1905.

1,121,360. Patented Dec. 15, 1914.

2 SHEETS—SHEET 1.

Fig. 1

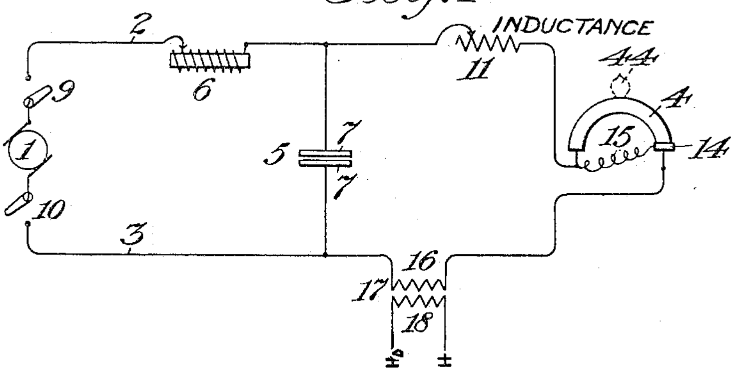


Fig. 2

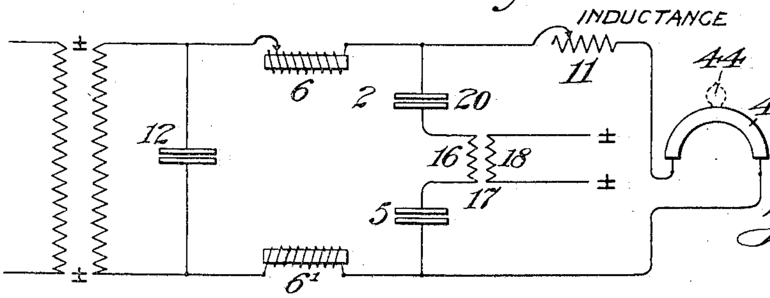


Fig. 3

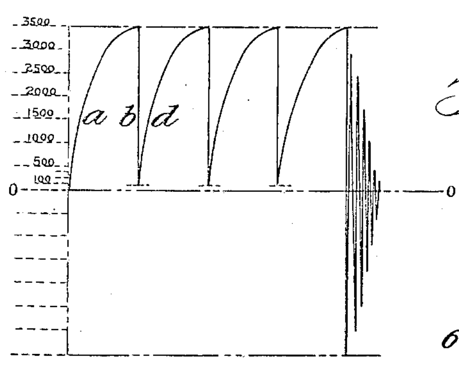


Fig. 4

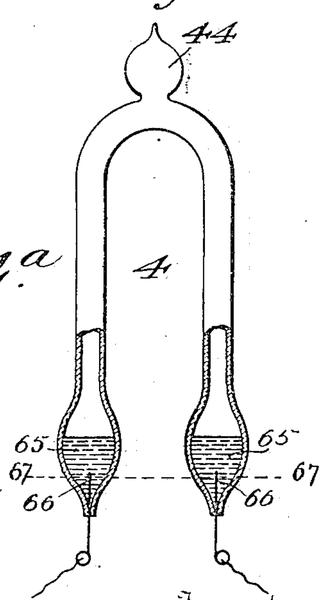
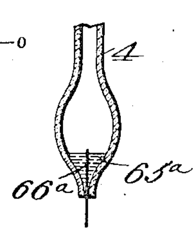


Fig. 4a



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2 SHEETS—SHEET 2.

Fig. 5

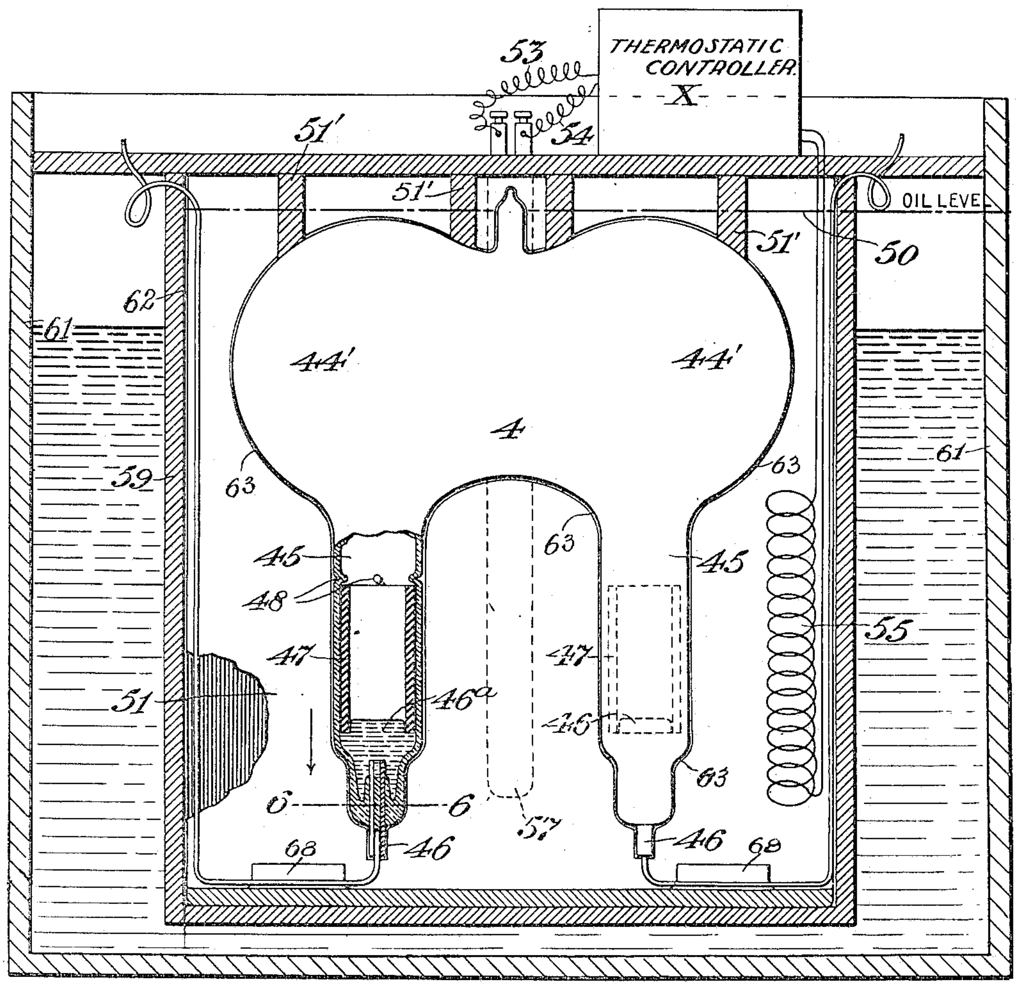

Fig. 6

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UNITED STATES PATENT OFFICE.

PETER COOPER HEWITT, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO COOPER HEWITT ELECTRIC COMPANY, OF HOBOKEN, NEW JERSEY, A CORPORATION OF NEW JERSEY.

APPARATUS FOR TRANSFORMING ELECTRICAL ENERGY.

1,121,360. Specification of Letters Patent. **Patented Dec. 15, 1914.**

Application filed January 30, 1905. Serial No. 243,217.

To all whom it may concern:

Be it known that I, PETER COOPER HEWITT, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Apparatus for Transforming Electrical Energy, of which the following is a specification.

My present application relates to the same general subject matter as co-pending applications which have resulted in Patents Nos. 780,999, 781,000, 781,603, and 781,605 granted January 31, 1905, and many of the general features and desirable methods of construction and association with energizing circuits and sources of power will be understood from said patents. The device itself, the desirable methods of manufacture thereof and many of the generic features of its peculiar operation may be more fully understood from patents numbered 682,690 to 682,699 inclusive issued to me on the 7th day of September, 1901.

One feature of my apparatus is that the gas between the electrodes acts as a true vapor conductor after the circuit is once established through the vapor, and when this conductor is made of very low resistance, practically a short circuit is formed. Since the vapor resistance factors are known and the conditions they are subject to, the action can always be depended upon. By the passage of current, the electrical pressure or voltage is lowered to a point where the resistance to starting reforms, whereupon the checked current rebuilds or reestablishes itself, its electrical pressure rising until the breaking down pressure is again attained, after which the same succession of actions is repeated.

By utilizing the described apparatus in the manner indicated, periodic currents of high frequency can be produced by reason of the fact that its action is very quick and uniform. It is especially adapted to the work of creating currents of definite time periods and rapid alternations. I have found for instance that, with a device consisting of an inclosed mercury vapor organized in the manner described in my patents above referred to, and provided with a condenser and a reactive device suitably placed and adjusted with reference thereto, it is possible to produce such currents, the action being in the first instance to apply to the terminals of the vapor gap a potential difference sufficient to overcome the initial resistance, whereupon a rapid fall of potential takes place until it reaches a point where it is insufficient to overcome the reduced resistance of the vapor gap. At this point the current ceases to flow, the break in current flow being abrupt on account of the immediate reëstablishment of the initial resistance of the vapor. Thereafter, the applied potential rises until it reaches the breaking down pressure of the initial resistance and then the same cycle of operations is repeated.

The intermittent or vibratory currents produced in the circuit by the circuit-breaker thus described may be applied to use in the vapor or gas gap itself, or they may be applied to other apparatus, or to both simultaneously. For example, one application of the present invention would be to serve the purposes of furnishing a periodic current for wireless telegraphy, and another for producing rapidly varying currents for the purpose of producing light by induction, and still another application would be that of producing light, say in the vapor gap itself, by means of successive electrical impulses of relatively high electro-motive-force, causing a high illumination of the vapor or gas, at such rapid intervals that the physiological impression is that of continuous illumination.

In making the last named application of my invention, I cause the intermittent currents produced by the intermittent action of my apparatus to act upon the vapor in the gap in such a way as to produce a brilliant light. To this end the density of the vapor and the dimensions of the container are suitably proportioned to each other for my purpose, as set forth in a general way in my said patents of September 17, 1901. But whereas, in the inventions set forth in the said patents, the vapor is intended to be affected by a flow of current of given value at a certain potential, the purpose in the present instance is to affect the gas or vapor by an intermittent flow of a current of practically the same value, but of higher potential, the energy represented by the intervals between the impulses being intermittently withdrawn from action and reappearing in the form of an increased quantity in the rapid periodic currents. The result is an increased brilliancy on the part of the lamp due to this increased consumption of energy per unit of time, while the effect upon the eye becomes that of a light due to a continuous flow of current of greater quantity.

As inclosed vapor conductor devices having the above characteristics, and for the purpose in view, I have shown herein a form which I have heretofore used for this purpose and also for the purpose of giving light. I also show herein a modified form of the device which I have especially constructed and invented for use as a discharge device or interrupter for heavy currents used for power purposes, the location and arrangement of the device being devised with a view to such purpose rather than with a view to giving light.

In the accompanying drawings illustrating certain applications of my invention, Figure 1 is a diagram showing a general organization of the apparatus; Fig. 2 shows a modification; Fig. 3 shows a theoretical diagram; Fig. 4 shows partly in vertical section a form of the discharge device of symmetrical construction, having similar electrodes or terminals composed of bodies of volatile liquid, such as mercury; Fig. 4ª is a similar view of a modified arrangement for terminals such as shown in Fig. 4; Fig. 5 is a vertical section showing a modified form of discharge device involving somewhat the same elements as that of Fig. 4 but of different proportion and immersed in a temperature controlling bath, which bath is controlled by a thermostat and temperature changing means. Fig. 6 is a section on the line 6—6, Fig. 5.

Referring to the drawings, 1 represents any convenient source of electrical energy, as for instance, a continuous current generator, which for convenience may be assumed in this particular instance to be of 3500 volts. As indicated in Fig. 2 the source of energy may, however, be an alternating source, since in the operation of the device the time periods involved are usually such that an alternating current operates functionally as if it were that which indeed it is, namely, a direct current in one direction for a time which is periodically reversed and flows in the opposite direction for an equal length of time. The times referred to are those of a half cycle of the generator and are very long as compared with the times of oscillation of the condenser discharge.

2 and 3 represent main conductors leading from the generator.

4 represents an electric device of the character described in my prior patents. This is connected at any convenient point between the conductors 2 and 3. A condenser, 5, or other suitable device or means affording an electrical capacity for accumulating or restoring energy is connected across the terminals of the device 4. An inductive resistance 6 is connected in the line 2 between one plate 7, of the condenser 5 and the source 1 of current. It is to be understood that by referring to a condenser, I mean to include other suitable means for securing the requisite electrical capacity.

Assuming that the circuit of the generator is closed by the switches 9 and 10, there will be a sudden rush of current through the lines 2 and 3, tending to charge the plate 7, 7, of the condenser 5. The inductive resistance 6, opposes a counter electro-motive-force to the applied electro-motive-force thus temporarily resisting the flow of current beyond that resistance. The condenser 5 thus becomes gradually charged as the electro-motive-force at its terminals rises.

Assuming that the device 4 will be traversed by a current under the influence of a difference of potential of 3500 volts, then as soon as the condenser 5 has attained its charge, a current will traverse the device, but the moment such current does traverse the device, the difference of potential at its terminal is enormously reduced. Practically, it may be made to drop as low as 100 volts, or even below 20 volts. Thereupon the condenser 5 discharges or feeds the circuit between itself and the device. The reactive coil 6 may serve to prevent at this time too great a discharge from the source of current. On the discharge of the condenser, the passage of current through the device will cease and the operation be repeated causing rapidly succeeding impulses of current to traverse the device. Each succeeding impulse will be at a potential of say 3500 volts and the light emitted by the device will be of a brilliancy due to the product of the average voltage into the current during the successive time intervals of current flow.

It is characteristic of these devices that they may be constructed not to pass an appreciable amount of current below a given voltage which can be predetermined and, therefore, at the end of certain definite periods, the current ceases to pass. Accordingly, the device has a definite consumption period between the extreme higher limit of applied electro-motive-force and the lowest limit at which the device will take current. What is perceptible to the eye is the luminous vibrations due to those successive passages of current, the intervals of no current being undiscernible by reason of the rapidity with which the intervals follow each other. It is also characteristic of apparatus of this type, whether used as a lamp or as a discharge gap, that it may be so dimensioned with relation to the vapor column that the heat radiation will be equal to the heat absorbed under ordinary conditions. That is to say, the temperature may be maintained constant, thus securing constant density in the gas or vapor. The enlargement represented by the chamber 44 at the top of the devices 4 in Figs. 1 and 2 is usually employed as contributing to the maintenance of stable temperature and density.

Special means for maintaining a constant temperature may be applied to the apparatus when it is used in place of a spark gap. Such means may be an oil or water bath maintained at constant temperature by a thermostatic controlling means for heating or cooling the liquid according as the tendency of the apparatus used is to work too hot or too cold. This will be described more fully hereinafter.

The period of the condenser may be varied by an inductance device, 11, placed in the condenser circuit. An additional condenser, 12, placed between the source and the condenser 5, may serve to assist the speed of charge and discharge through the inductance 6. A similar inductance 6′ may be included in the branch 3, if desired.

In my devices the starting may be facilitated by the use of a band, 14, placed in the neighborhood of the negative electrode upon the exterior of the device and connected by a conductor, 15, with the positive electrode or the conductor leading thereto, and is useful where lower initial voltages are to be used.

The conditions under which the vapor constituting the path is placed make it possible to predetermine and control the voltage required to break down the resistance of the gap, which always remains the same in any given apparatus under the same conditions. The general character of the lamp in these particulars may be predetermined by its size and proportion of its structure and the condition of vapor density attained at the time of sealing off the lamp. After a given device has been constructed with predetermined characteristics these may be modified in operation by modifying the temperature of the electrode or of the lamp or of its rate of heat loss and the characteristic electrode phenomena may be modified, increased or diminished by devices external to the electrode, as by the action of the starting band.

By inserting the primary coil, 16, of a converter, 17, in one of the conductors, for instance 3, as shown in Fig. 1, an alternating current may be produced in a secondary circuit, 18 which in turn may be used for any desired purpose. The primary coil 16 in this case may be utilized as an inductance device for retarding the period of the condenser circuits.

In Fig. 2 I show the primary 16 of the converter 17 connected up between two condensers 5 and 20 connected in series across the terminals of the device 4. I have also indicated the source in this case as an alternating current source though it may be direct as also the source in Fig. 1 may be alternating.

In Fig. 3 I have shown in diagram the theoretical curve illustrative of the differences of potential and the changes therein which may occur. The changes illustrated occur in a very short space of time and are such as would be caused where the supply was from a constant current direct source, though as previously explained such diagram is equally illustrative of the changes which would occur during a portion of a half cycle of a flat top alternating current source. It will be understood that during the other half cycle the curves will be symmetrical with those shown and on the other side of the zero line. When the circuit is closed there is a rise of potential at the terminals of the device from zero to 3500 volts as shown by the portion *a* of the curve. Thereupon current traversing the device, the condenser discharges, dropping the current to 100 volts as indicated by the portion *b* of the curve. The voltage then again rises to 3500 volts as indicated by the portion *d* of the curve, the rate of charging being dependent upon the amount of self-induction or resistance in the circuit between the condenser and the source. By varying this self-induction, the portion *d* of the curve may be made more or less abrupt and by varying the inductive capacity of the circuit between the condenser and the device, the portion *b* of the curve representing the operation of the device may be more or less prolonged. The lines drawn above and below the zero line near the end of Fig. 3 are designed to illustrate the gradually decreasing surgings of the condenser current during the interval of each of the above described discharges in the discharge circuit.

By properly adjusting the capacity of the condenser, the circuit, and also the inductance, almost any required definite period of charge and discharge may be secured. The condenser 5, may be made to act either by reason of its own natural period of oscillation or governed by the charge which it receives from the line as controlled by the line.

The currents developed in the circuit and hereinbefore described as utilized for increasing the luminosity of one of my lamps may in addition be used for other purposes, or the quality of my apparatus as a light-giving body may be fully subservient to the development of currents for other purposes. In other words, I may, in some instances, construct a gas or vapor apparatus having the primary object of controlling the rate of currents developed in the system, which currents may or may not operate to give light in the apparatus.

In Fig. 4 I have shown an inclosed vapor conductor discharge device 4 wherein the mechanical and electrical arrangement is symmetrical, the terminals or electrodes, 65, 65 being similar in construction and in material and preferably formed of bodies of liquid preferably metallic, preferably volatile and preferably of mercury. In this arrangement, however, it is possible to project the leading in wires, 66, 66, a sufficient distance within the tube or to decrease the body of mercury to a sufficient degree so that the leading in conductors will project beyond the mercury, as indicated in Fig. 4^a, wherein an extension of the terminal 66^a is shown projecting beyond the surface of the mercury 65^a. In the latter case the amount of mercury as indicated by the dotted lines 67—67 may be so small that when volatilized it will just produce the required vapor density within the tube. This discharge device may be utilized for power purposes or for giving light, the operation being substantially the same in either case though some modification may be made according as the light giving or power purpose is the one most prominently in view.

Fig. 5 shows a device having some of the characteristic features mentioned above in connection with Fig. 4 but the proportions are different as are certain details of construction. It is designed particularly for power purposes. It consists of a twin globular construction, 44^1, 44^1, having two tubular projections 45 for the electrodes. The terminals 46 consist of metallic sheets bent in the form of cylinders unclosed or slit on one side thoroughly sealed in to comparatively massive glass walls. Above the point of entrance the electrode chamber is enlarged somewhat and for some distance is cylindrical. The terminals project into and are preferably covered by a suitable quantity of mercury 46^a which serves as the true electrode of the device.

I have found that discharge devices of this type show a tendency to develop a condition wherein most of the current comes off of the mercury at the line of contact thereof with the glass wall, though this tendency is not so great where direct currents are used particularly large quantity direct currents. The tendency referred to is nevertheless a difficulty and objection to be overcome. It may be partly obviated by agitating the device, but it may be more completely obviated by the construction shown herein. The difficulty referred to consists in this, that most varieties of glass capable of being used for the purpose are chemically active or capable of physical change of state under the conditions established where the current comes off of the mercury adjacent to the glass, and objectionable evolution of gas under the action of the current changes the character of electrical reaction of the device, impairing and deteriorating the same. This could be obviated if the part of the device containing the mercury were made of material which does not undergo physical or chemical change of state, or of porcelain of good quality or of glass free from peroxids, that is, in which the silica is fixed as in quartz. This part of the device might even be of conducting material provided it carried no gas and was incapable of evolving any under the conditions. The discovery of each of the above means of obviating the difficulty referred to is original with me and I claim them all broadly. For practical purposes combining structural economy and electrical efficiency I prefer, however, to provide an open ended porcelain cylinder 47 of slightly smaller external diameter than the internal diameter of the cylindrical mercury containing chamber and of about the proportion shown. It should fit such chamber sufficiently loosely to be free from tight engagement with the walls thereof under all conditions of different expansions under different conditions. As constructed it is free to move slightly in a longitudinal direction but is prevented from excessive movement by the contraction of the chamber at the bottom and the internally projecting indentations or beads 48 at the top. The proportions are such in the form constructed by me that the porcelain cylinder is partially or wholly supported by and floats upon the mercury. By reason of the close fit of the cylinder and chamber, there is a capillary depression action upon the mercury at the circumference but within the cylinder the internal diameter being comparatively large the mercury rises to a considerably greater height as indicated at 46^a. The material of the cylinder is preferably fine quality unglazed porcelain free from all gas bearing material. The platinum leading-in cylinders are massive and adapted to carry large quantities of current. As shown in Fig. 5 this device is placed in a case 59 containing an amount of oil or similar liquid 50 necessary to submerge the entire device or so much thereof as it may be necessary to submerge under any given conditions to produce the required rate of heat loss. A longitudinal partition or centering piece 51 formed to fit the longitudinal outline of the discharge device as shown at 63, 63 and transverse pieces 51^1 51^1 above the device and also fitting the same serve to hold the latter securely in position and to hold the same submerged when the tank is filled with the liquid.

Within the box or case, and preferably in the body of the liquid, is a thermostat 57 which may be adjusted for any desired temperature, the same being of any known or usual construction. Wires 53, 54 connect the thermostat in circuit with suitable controlling mechanism in the case X. This mechanism serves to control the heating or cooling of the liquid as may be necessary to maintain it at the desired temperature to suit the existing conditions. In the form shown it is usually found desirable to provide means for heating the liquid instead of cooling it, the best working condition of the discharge device being for purposes for which I have used it, a temperature above the normal temperature of the surroundings and this condition of lower temperature of surroundings may be secured by artificial refrigeration, if desired. The specific temperature changing means which I have shown is therefore a heating means, namely, a heating coil diagrammatically indicated at 55. Control of this by the thermostat may be effected by simple electrical mechanism of any desired construction.

With the arangement of Fig. 5, perfectly uniform, efficient transformation of relatively powerful currents may be effected, the apparatus being stable, permanent and free from practical defect of all kinds.

While considerable variation in the proportions and details of construction of the above device are possible I prefer to make the body thereof of comparatively large cross section and short length as shown, since this gives good results probably because of the low resistance, large radiating and conducting surface and space outside of the direct path of the current into which impurities may be expelled. The oil bath also permits of considerable variation and the longitudinal support and top support for holding the device in place and depressing it in the oil may be made in one piece with the cover and removable therewith. It is obvious that the tank may be provided with any usual or well known means for insuring circulation of the liquid either internally or to and from an outside reservoir and cooling devices may be employed in connection with the latter. The condenser and supply circuits also permit of variation and the adjustable inductances 6, 6, 6′ and 11, 11 shown in each, may in some cases be merely lengths of wire especially where the range of the lamp from breaking down to interrupting voltages is not wide.

The condensers when used with an alternating source of supply may be adjusted to resonance therewith,

A wide range of usefulness for the apparatus for maintaining constant bath temperatures by heating as in Fig. 5, may be made available by artificially refrigerating the entire device by any suitable means, as by a refrigerator casing 61, indicated on said figure. The thermostatically controlled heating means may then operate to maintain the bath at any required temperature above that of the surroundings, which latter may be anything desired, down to the lowest temperature attainable by any known agent, as for instance by liquid air.

I claim as my invention—

1. A periodic discharging device for a capacity circuit, consisting of a suitable container, similar electrodes and a conducting gas or vapor inclosed therein, together with means for maintaining a constant temperature of the wall adjacent the surface of the negative electrode.

2. A periodic discharging device for a capacity circuit, consisting of a suitable container, similar electrodes and a conducting gas or vapor inclosed therein, together with means for maintaining said container at a desired temperature.

3. A periodic discharging device for a capacity circuit, consisting of similar electrodes and a conducting gas or vapor, a suitable container inclosing the same, and means for maintaining constant temperature.

4. A discharge gap or interrupter for a capacity circuit consisting of similar electrodes and a conducting medium between the electrodes, together with means for cooling both of the electrodes.

5. A discharge gap or interrupter for a capacity circuit consisting of liquid electrodes and a conducting medium between the electrodes, together with means for maintaining a constant temperature at both electrodes.

6. A discharge gap or interrupter for a capacity circuit consisting of similar electrodes, a conducting medium between the electrodes, and means for maintaining a desired temperature at both of the electrodes.

7. A discharge gap or interrupter for an alternating capacity circuit having two liquid terminals serially arranged in said circuit for continuous operation thereon, together with means for confining and condensing the vapor of said liquid at a rate equal to the normal rate of evaporation under continuous running conditions.

8. A discharge device or interrupter having an electrode chamber adapted to retain a conducting liquid, in combination with a wall or lining formed of material free from gas under the conditions of operation, said wall conforming to and loosely fitting said chamber, the longitudinal length or extent of said lining being greater than its diameter.

9. A discharge device or interrupter having an electrode chamber adapted to retain a conducting liquid, in combination with a wall or lining formed of material free from gas under the conditions of operation, said wall conforming to and loosely fitting said chamber, the longitudinal length or extent of said lining being greater than the diameter thereof together with means for limiting or preventing longitudinal movement of said lining in said chamber.

10. A discharge device or interrupter having an electrode chamber and a body of conducting liquid therein, in combination with a wall or lining formed of material free from gas under the conditions of operation, formed and arranged to fit said chamber closely, but not immovably, and extending above said liquid from a point below the level thereof, together with means for limiting or preventing longitudinal movement of said lining in said chamber.

11. A vapor electric device having a liquid electrode, and a sleeve of material free from gas under the conditions of operation, separate from, yet closely fitting to, the walls of the container, said sleeve having walls thin as compared with the circular cross-section inclosed thereby, of a length greater than its diameter and arranged so as to extend above the surface of the liquid, for the purposes described.

12. A vapor electric device having a liquid electrode, and a sleeve of non-conducting material free from gas under the conditions of operation, separate from, yet closely fitting to, the walls of the container, said sleeve having walls thin as compared with the circular cross-section inclosed thereby, of a length greater than its diameter and arranged so as to extend above the surface of the liquid, for the purposes described.

13. A vapor electric device comprising an evacuated container having a liquid electrode and an unglazed porcelain wall bounding the electrode surface of said liquid, for the purpose described.

14. A vapor electric device having an electrode chamber and a conducting liquid therein, in combination with an unglazed porcelain sleeve having thin walls closely fitting said chamber and extending a considerable distance above the surface of the liquid, for the purpose described.

15. A discharge device or interrupter having a cylindrical glass electrode chamber, mercury therein, and an unglazed porcelain cylinder having thin walls closely fitting said glass chamber and extending above the surface of the mercury, for the purpose described.

16. An hermetically sealed glass inclosure comprising a body portion of large cross-section and two downwardly extending electrode chambers of smaller diameter and of greater length than diameter, in combination with bodies of conducting liquid adapted to form electrode surfaces at a level considerably below the junction of said downwardly extending chambers with said body portion, together with protecting sleeves or linings of a material free from gas under the conditions of operation and formed and proportioned so that the walls thereof are thin as compared with the diameter of the vapor path therethrough, for the purpose described.

17. A discharge device or interrupter comprising an hermetically sealed glass inclosure comprising a body portion of large cross-section and two downwardly extending electrode chambers of considerably smaller diameter and of greater length than diameter, in combination with bodies of conducting liquid adapted to form electrode surfaces at a level considerably below the junction of said downwardly extending chambers with said body portion, and protecting the sleeves or linings of a material free from gas under the conditions of operation, formed and proportioned so as to protect the walls of said electrode chambers above the electrode surfaces of the said bodies of liquid.

18. A discharge device or interrupter for a capacity circuit, in combination with an oil bath, means for heating the same above the temperature of its surroundings, and means for artificially refrigerating said surroundings.

19. A discharge device or interrupter for a capacity circuit, in combination with a temperature modifying agent operatively related to the latter, and means for controlling the temperature of said agent together with means for refrigerating the surroundings.

20. A discharge device or interrupter for a capacity circuit, in combination with a temperature modifying agent operatively related to the latter, and means for controlling automatically the temperature of said agent together with means for refrigerating the surroundings.

21. A discharge device or interrupter for a capacity circuit, in combination with a temperature modifying agent operatively related to the latter, and means for automatically applying heat to maintain a desired temperature of said agent and means for refrigerating the surroundings.

22. The combination with a discharge circuit, a discharge device or interrupter for a capacity circuit, in combination with a temperature modifying agent operatively related to the latter, and means for maintaining constant the temperature of said agent and means for refrigerating the surroundings.

23. A discharge device or interrupter for a capacity circuit comprising a sealed inclosure having a short body portion of large cross section and inclosures of smaller cross section intermediate the length and projecting from the same side of said body portion, said inclosures being adapted to contain mercury.

24. A discharge device or interrupter for a capacity circuit comprising a sealed inclosure having a short body portion of large cross section and inclosures of smaller cross section intermediate the length of and projecting from the same side of said body portion and adapted to contain similar electrodes.

25. A discharge device or interrupter for a capacity circuit comprising a sealed inclosure having a short body of large cross section and electrode inclosures of smaller cross section projecting from said body portion upon the same side thereof, said electrode inclosures containing similar liquid electrodes of similar material together with similar porcelain cylinders in each for defining the active surfaces of each of said liquid electrodes.

26. A discharge device or interrupter for a capacity circuit comprising a sealed inclosure having a short body portion of large cross section and electrode inclosures of smaller cross section projecting from said body portion upon the same side thereof, mercury in each of said electrode inclosures and porcelain cylinders in each floating upon said mercury electrodes and defining the active surfaces of each.

Signed at New York city, in the county of New York, and State of New York this 28th day of January, A. D. 1905.

PETER COOPER HEWITT.

Witnesses:

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Wm. H. Capel.