Aug. 20, 1935. L. R. LUDWIG ET AL 2,011,643

VAPOR ELECTRIC DEVICE

Filed May 27, 1933

Fig. 1.

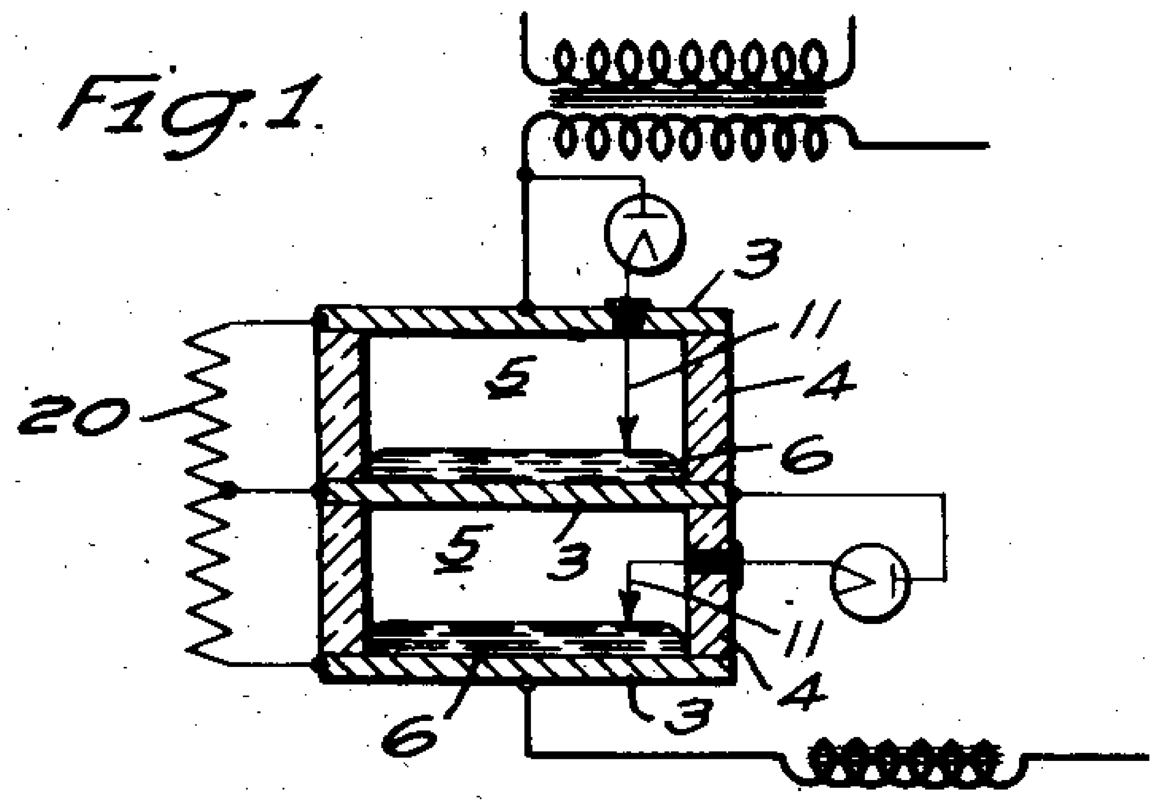


Fig. 2.

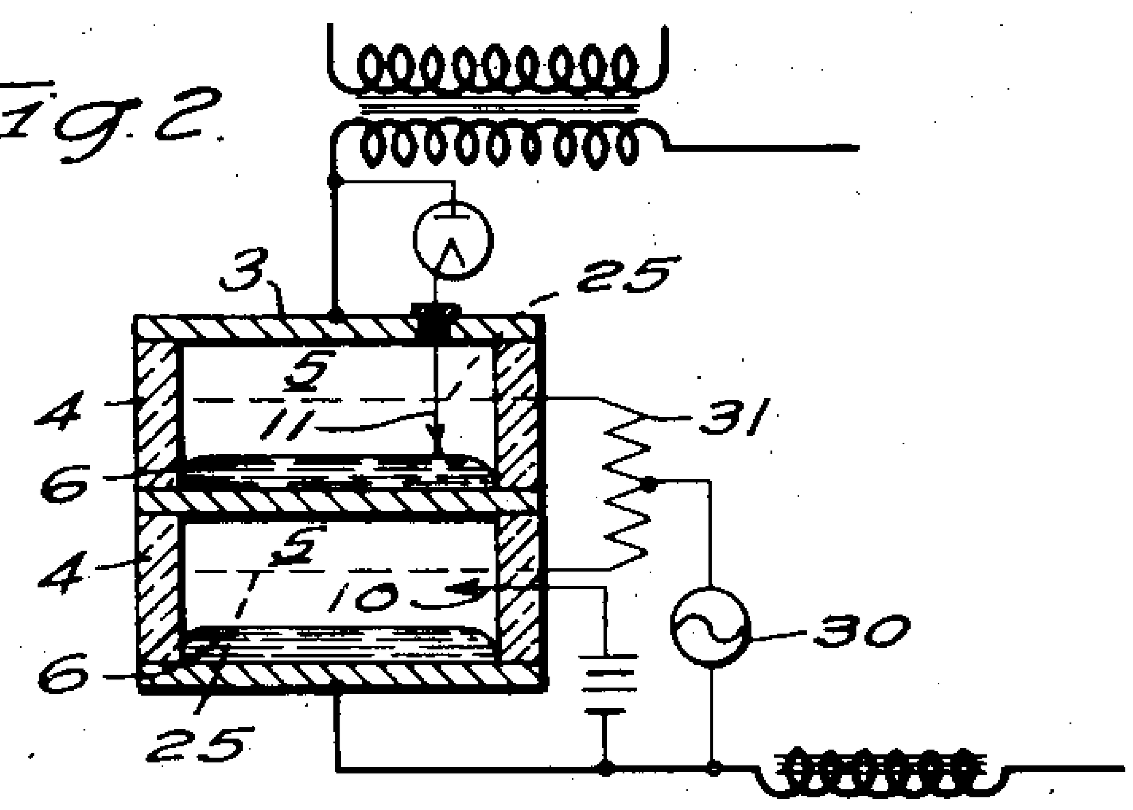


Fig. 3.

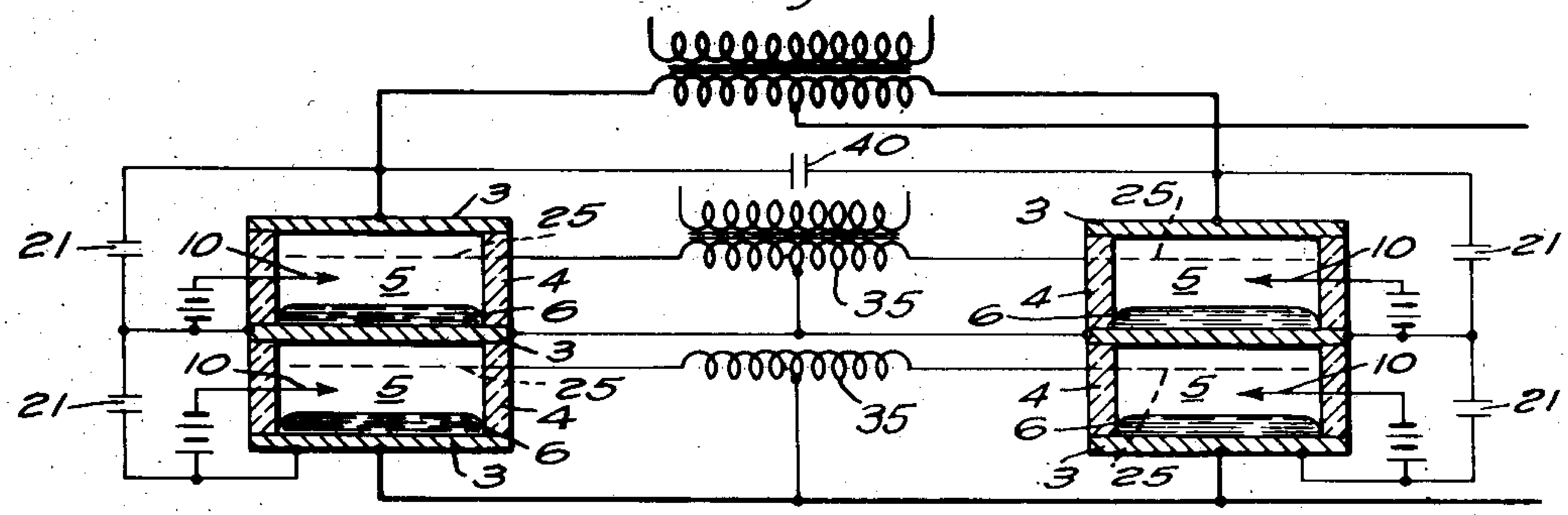
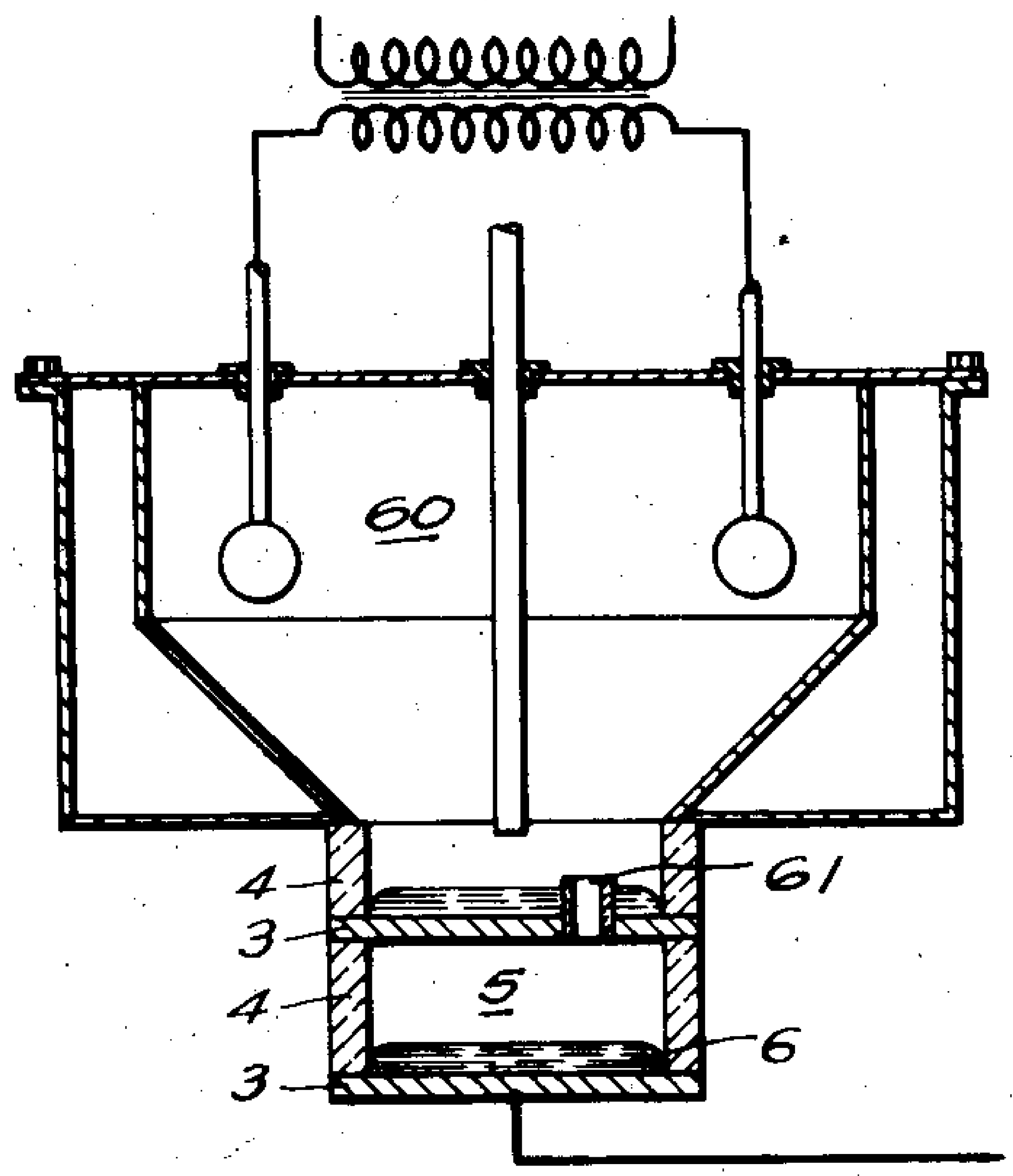


Fig. 4.



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Patented Aug. 20, 1935

2,011,643

UNITED STATES PATENT OFFICE

2,011,643

VAPOR ELECTRIC DEVICE

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Application May 27, 1933, Serial No. 673,240

3 Claims. (Cl. 175—363)

Our invention relates to a vapor electric device and particularly to a mercury arc rectifier or inverter.

In the development of mercury arc rectifiers, the greatest single obstacle has been the tendency of the rectifiers to backfire at random times under load. It has been discovered that the backfires arise from causes which are of relatively short duration with respect to the time intervals during which the rectifier is carrying current. If the rectifier can be prevented from establishing an inverse current arc or backfire during the period of prevalency of the backfire cause, no damage will be done to the rectifier.

Protective devices such as shields or grids have been developed for preventing the formation of backfires; however, these protective devices have resulted in a material increase of the arc drop or losses in the rectifier.

Rectifiers for successful operation have, as heretofore constructed, had a plurality of anodes in a single large container and a plurality of safety devices such as grids, shields, series reactors, and other devices for preventing backfire. These large tanks and their appurtenances have been very costly to construct and difficult to transport and assemble.

Simple rectifiers comprising only a single anode and cathode closely spaced in regard to each other may be constructed very cheaply, transported easily and assembled in almost any space having the desired size regardless of shape. However, the high backfire rate of such simple devices has prevented their utilization.

It is an object of our invention to provide a rectifier which is relatively free from backfires and in which it is unnecessary to use the protective devices, such as grids or shields. Since backfire causes are of a random manner in time, it is highly improbable that two rectifiers will have a backfire cause simultaneously. Consequently, if two simple rectifiers are connected in series, the probability of both rectifiers having a simultaneous backfire cause is very remote. Also, if, for any reason, one of the rectifiers develops a backfire cause, the series rectifier will prevent the inverse or backfire arc, and, accordingly, the backfire cause will vanish without doing any damage to the rectifier.

The following comparison is given to illustrate the enormous gain in reliability by the device according to our invention. It was found that a simple rectifier as used in our invention has a backfire rate of one per minute. Consequently, in a full-wave rectifier, an average of two short circuits per minute may be expected. However, when two such simple rectifiers are placed in series according to our invention, it is necessary that both rectifiers fail simultaneously in order to cause a short circuit. We have found that backfire causes usually last less than 10^{-5} seconds therefore the chance of backfire causes occurring simultaneously in each tube in one minute is

$$\frac{10^{-5}}{60}$$

Hence the two tubes in series will fail simultaneously and cause a short circuit on the average of only one in 60×10^5 minutes or once in 11.4 years, the probability of failure in a full-wave rectifier being, therefore, once in 5.7 years.

It is a further object of our invention to provide a simple rectifier having means to regulate the formation of the rectifying arc so that the output voltage or current of the rectifier can be controlled.

Other objects and advantages of our invention will be apparent from the following detailed description taken in conjunction with the accompanying drawing, in which:

Figure 1 is a schematic illustration of a simple rectifier according to our invention;

Fig. 2 is a modification showing control grids;

Fig. 3 is a further modification; and

Fig. 4 is an illustration of a conventional rectifier modified according to our invention.

Apparatus according to our invention comprises a plurality of discharge chambers directly connected in series. Preferably these discharge chambers are of a simple nature, such as a plurality of conducting plates 3, separated by an insulating ring 4 forming a closed chamber 5. Suitable vaporizing material, such as mercury 6, is placed on the lowermost plate of each chamber 5. Preferably, the two chambers are built as a unit with the bottom plate of the top chamber forming the top plate or anode of the bottom chamber. However, two separate devices may be used. In any event, it is desirable to solidly and directly connect the cathode of one chamber to the anode of the succeeding chamber.

Any suitable means, such as a keep-alive 10 or a make-alive electrode 11, such as disclosed in our copending application Serial No. 620,866, may be used for initiating or maintaining a cathode spot on the vaporizable electrode 6. In some instances, it will probably be found preferable to use a combination of make-alive or keep-alive electrodes in the series-connected rectifying devices.

Our experiments have shown that it is desirable to provide means for equalizing the back-voltage over the series-connected rectifiers. For this purpose, we prefer to use a high resistance 20 connected in parallel with each of the series-connected devices but may use an energy-storing device, such as a capacitor 21.

Suitable control grids 25 may be introduced into the rectifier chamber 5 in order to control the initiation of the rectifying arc. The grids 25 may be placed in one or both of the series-connected devices. If in both devices, suitable means should be provided for simultaneously releasing both grids.

In the modification shown in Fig. 2, both grids are controlled from a single control source 30, the grids being separated by a high resistance 31 of the order of 20,000 ohms, so that in case a backfire should develop to the grid 25 in one of the chambers 5, the resistance 31 will prevent the loss of control by the grid 25 in the remaining chamber.

In the modification shown in Fig. 3, separate grid control sources, such as transformers 35, are used. Preferably, both transformers are excited from the single primary feed from a suitable frequency in order to insure simultaneous operation of both grids.

In the modification according to Fig. 4, each of the grids 25 is provided with a separate source 36 of excitation current. Preferably, the transformers 36 are supplied in parallel to insure simultaneous operation.

In the modification according to Fig. 3, a commutating condenser 40 has been introduced across the supply transformer so that the rectifier may be operated inverted to supply an alternating-current line with energy from a direct-current line. Obviously, this condenser 40 could be eliminated if it was desired to operate the device only to transfer energy from the alternating-current to the direct-current side. When operating as an inverter, the output frequency of the rectifier system can be controlled by supplying energy of the desired frequency to the controlled grid 25. When operating from the alternating-current to the direct-current side, the direct-current voltage may be controlled by varying the phase relation of the grid voltage and the alternating-current supply voltage.

In the modification according to Fig. 5, a simple rectifier 5 has been connected in series with the usual multi-anode rectifier 60. Preferably, a suitable pumping connection 61 is provided between the simple rectifier and the multi-anode chamber 60, so that no auxiliary pumping equipment is needed for the simple rectifier. Since the simple rectifier 5 will carry only direct-current, the arc drop is very low and adds but little to the losses of the rectifier as a whole. Since the simple rectifier 5 carries only direct current, no backfires can originate therein. However, the multi-anode chamber 60 will be subject to backfires as before the attachment of our invention. However, in case a backfire should occur in the multi-anode rectifier, the series rectifier will prevent current flowing from the direct-current circuit and prevent damage on the circuit as well as materially reduce the damage that might result to the rectifier.

Also in case there are other rectifiers feeding the direct-current line, they will not be involved in any way in the backfire in the multi-anode rectifier. Since the backfire in the multi-anode rectifier is limited to the short circuit current of its own transformer, little damage will be experienced. Also a considerable saving in the rectifier equipment will result as the high-speed direct-current circuit breaker is unnecessary in the operation of rectifiers provided with our invention.

While we have shown and described specific embodiments of our invention, it is apparent that changes and modifications can be made therein without departing from the spirit and scope of our invention. We desire, therefore, that only such limitations shall be imposed as are necessitated by the prior art or as may be embodied in the accompanying claims.

We claim as our invention:

1. A system for converting direct current to alternating current comprising a direct current circuit, an alternating current circuit, an inductance coupling said circuits, a plurality of rectifier means for controlling current flow through said inductance, each rectifier means comprising a plurality of series-connected discharge devices, means for controlling the initiation of current-carrying arcs in the series-connected devices, means for extinguishing the current-carrying arc, and energy-storing devices in parallel with each of said discharge devices.

2. A vapor electric system comprising an alternating current circuit, a direct current circuit, a rectifying device for transferring energy between said circuits, said device comprising a plurality of series-connected discharge chambers, a vaporizable cathode in each of said chambers, an anode closely spaced in respect to said cathode in each of said chambers, the cathode in one of said chambers being directly connected to the anode of the other, and means in each of said chambers for controlling the initiation of a current-carrying arc therein.

3. An element for a vapor-electric device having a high service reliability comprising a unitary discharge structure, a plate for dividing said structure into a plurality of discharge chambers, an anode and a vaporizing cathode in each of said chambers, said dividing plate forming the bottom of one chamber and the anode of the other.

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