Dec. 9, 1947. A. VANG 2,432,219

SELF-SYNCHRONIZING TUBE DISCHARGE CONTROL SYSTEM

Filed Feb. 20, 1946

Fig. 1.

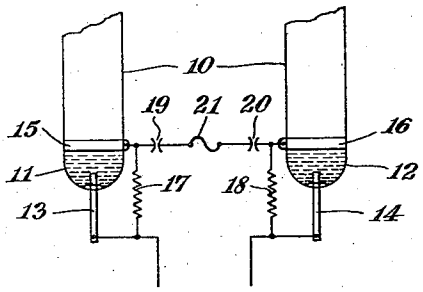


Fig. 2.

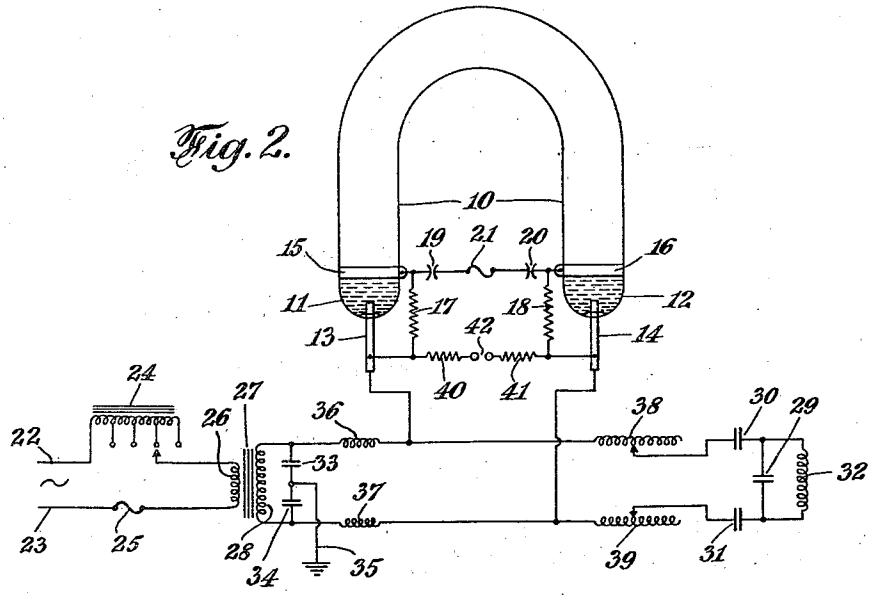


Fig. 4.

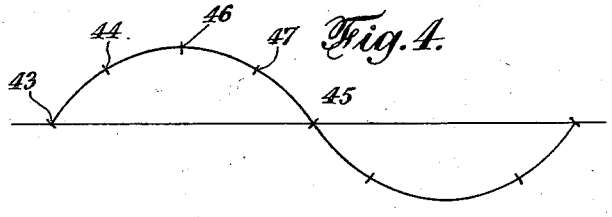
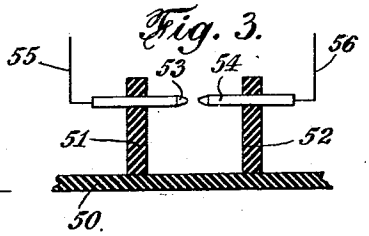


Fig. 3.



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SELF-SYNCHRONIZING TUBE DISCHARGE CONTROL SYSTEM

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9 Claims. (Cl. 315—57)

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This invention relates to new and useful improvements in the ignition of electrical discharge tubes, particularly of the metallic vapor type.

More particularly, this invention relates to a method and apparatus for igniting discharge tubes at predetermined points with respect either to the cycle of the alternating current feeding the tube, or with respect to the charge acquired by an electrostatic condenser, which is arranged to discharge through the tube.

In the art of setting up oscillatory currents of relatively high frequency by means of the disruptive discharge of a condenser, the earliest method employed was that of allowing the disruptive discharge to take place through an open or exposed gaseous medium, such as air, hydrogen, or the like. Due to the difficulty of determining the exact potential at which such discharge would take place, especially when the discharges were repetitive in nature, various artifices were employed. In general, the use, as a discharge medium, of air or other non-conductive gases has been abandoned in favor of the employment of a conductive gaseous discharge medium, such as a metallic vapor, for example, the vapor of mercury.

The present invention is applicable to a variety of discharge devices employing gaseous media, but is especially adaptable for use with disruptive discharge devices wherein the instant of the discharge is determined by a so-called trigger device, which initiates the ionization of the gas in which the discharge takes place.

More particularly, this invention is adaptable for use in connection with mercury vapor discharge tubes employing one or more ancillary electrodes, to which electrodes are applied triggering potentials, which serve to determine the instant at which the main discharge takes place in the tube, to a relatively high degree of accuracy with respect to the time factors involved. Such discharge devices are well known in the art and assume a variety of forms, being known under various trade names, such as "Ignitron" or "Trignitron."

One object of this invention is to provide a system for igniting a vapor discharge tube by trigger potentials derived automatically from the same source of potential which charges the condenser employed in the high frequency circuit excited by the main disruptive discharge through the tube.

Another object of this invention is to provide a system for synchronizing disruptive discharges through metallic vapor tubes with the cyclic potentials developed upon an electrostatic condenser.

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Yet another object of this invention is to provide a system wherein a condenser is charged from a source of varying potential and is connected to a disruptive discharge tube, but is prevented from discharging through such tube until the potential acquired by the condenser has reached a certain predetermined value.

Still another object of this invention is to provide a converter of low frequency alternating current to high frequency alternating current employing a disruptive discharge tube, in which system the condenser may be allowed to acquire any charge potential equal to or less than the maximum voltage impressed thereupon, before the disruptive discharge takes place.

A still further object of this invention is to provide an automatically functioning device connected between a disruptive discharge tube and a capacitor charged thereby, which will permit the capacitor to acquire a charge, and consequently an energy content, to any desired degree permitted by the energy available to charge the capacitor and which will then automatically and repetitively cause the disruptive discharge tube to ignite.

Another purpose of this invention is to permit automatic and relatively simple control of the break-down potential of a disruptive discharge tube with reference to the peak voltage of an alternating current source.

Another purpose of this invention is to provide a disruptive discharge tube system of the type employing an igniting electrode, in which the trigger voltage applied to this electrode is delayed to any desired degree with respect to the voltage rise in the main power circuit to be discharged through the tube.

Yet another purpose of this invention is to combine, in a single system, a main discharge taking place through a metallic vapor, with an ancillary disruptive discharge taking place through a gas; this ancillary discharge being of relatively low power and being utilized solely for control purposes.

Still another purpose of this invention is to provide a disruptive discharge frequency conversion system, powered from an alternating current source, in which the number of discharges occurring in each cycle of the alternating current may be varied at will over extremely wide limits.

An additional object of this invention is to provide a disruptive discharge system of the type in which alternating current is utilized to charge a

condenser, wherein the condenser may be made to discharge, for the generation of high frequency oscillations, more than a single time per half cycle of the charging current.

A further purpose of this invention is to increase the efficiency of disruptive discharge frequency conversion systems, by permitting a close and facile control of the frequency of condenser discharge, with respect to the condenser charging current.

Further objects and advantages of this invention will be apparent to those skilled in the art, from the hereunto appended drawings.

With the above and other objects in view, this invention consists of the novel features of construction, combination, and arrangement of parts hereinafter fully described, claimed, and illustrated in the accompanying drawings, forming part of this application, and in which similar characters of reference indicate corresponding parts in all views, and in which:

Figure 1 is a partly schematic view of this invention as applied to a disruptive discharge tube of the type employing dual pools of mercury.

Figure 2 is a partly schematic showing of a complete frequency conversion device employing a mercury discharge tube and incorporating this invention.

Figure 3 shows one possible form of a gaseous disruptive discharge device which may be used with this invention.

Figure 4 shows, diagrammatically, one possible relationship between a sine wave alternating current and a plurality of disruptive discharges, obtained by the use of the present invention.

In Figure 1 are shown the lower ends 10, 10 of a mercury discharge tube, having dual pools of mercury, shown at 11 and 12 respectively. A tube of this type is shown in United States Patent 2,287,541, issued to the applicant. In the mercury pools are located the respective electrodes 13 and 14, through which passes the main discharge of the tube. These electrodes may be connected to any source of potential which varies in potential from a value lower than a predetermined minimum, to a second predetermined value at which it is desired that the tube discharge takes place.

The lower extremities 10, 10 of the tube, adjacent to the respective mercury pools therein, are embraced by starting bands. Band 15 is connected via resistor 17 to the conductor supplying potential to the electrode 13, while band 16 is similarly connected via resistor 18 to the conductor supplying potential to electrode 14.

Resistors 17 and 18 render it impossible for the respective ignition bands to which they are connected to acquire a potential different from that of the corresponding main electrode, except when such potential is continuously supplied to the band, since any interruption of this supply will cause the potential upon the band to discharge via the corresponding leakage resistor.

Spark gaps 19 and 20 are connected in series, preferably with a safety fuse 21 interposed therebetween, between bands 15 and 16.

In the operation of this device, let it be assumed that the potential between electrodes 13 and 14 is insufficient to cause automatic ignition of the tube by direct ionization of the mercury vapor present between the two pools. It is also to be assumed that such potential, which is supplied to ignition bands 15 and 16 via resistors 17 and 18 respectively, is insufficient to cause ionization of the gaseous discharge medium present in the spark gaps 19 and 20; these gaps being adjusted as to length, so that this condition is met.

As the potential between electrodes 13 and 14 increases, the point will be reached where gaseous ionization over gaps 19 and 20 will suffice to bring about a disruptive discharge over these gaps; the gaps being set so that such discharge will represent a difference of potential of the maximum value desired. It is assumed that the potential required to initiate direct ionization between the two pools of mercury is substantially in excess of the value required to initiate discharges through gaps 19 and 20. When the disruptive discharge over gaps 19 and 20 takes place, there will be a momentary application to each ignition band of the potential carried by the main electrode which is in the mercury pool at the other end of the tube from this particular band. Resistors 17 and 18 are made sufficiently high in value so that the current passing through gaps 19 and 20 will be of a relatively low order of magnitude, compared with the main discharge current. Furthermore, this current is limited in value by the safety fuse 21, which will open the circuit in case that an arc be established over the two gaps, in lieu of the desired spark type discharge.

The substantially instantaneous change of potential upon ignition bands 15 and 16, with respect to the mercury pools adjacent thereto, will cause an initiation of the main discharge between the two pools, for reasons and in a fashion familiar in the art. The establishment of the main disruptive discharge by the ignition process, just described, will lower the effective potential between electrodes 13 and 14 to a point where not only the spark discharges of gaps 19 and 20 will be suppressed, but also to a point where the main mercury vapor discharge can no longer continue. The stoppage of the main discharge will then restore the system to the condition originally assumed, and the next cyclic building up of potential difference between electrodes 13 and 14 will bring about a recurrence of the operative cycle just described.

Reference is now made to Figure 2, where the complete frequency conversion system includes a source of alternating current (not shown) which supplies energy to conductors 22 and 23, having respectively in series therewith, adjustable choke coil 24 and protective fuse 25. After passing through these regulatory and safety elements, the power is fed into the primary winding 26 of transformer 27, which delivers from the secondary winding 28 a voltage sufficient to charge the electrostatic capacitive system represented by condensers 30 and 31 in series with one another. While condenser 29 is the main tank circuit condenser of the high frequency portion of the system, it is directly shunted by high frequency inductance 32, so that condenser 29 cannot in itself acquire an electrostatic charge at the relatively low frequency of the power supply circuit.

Shunted across winding 28 is a second protective system, comprising condensers 33 and 34 connected in series with one another and having their point or interconnection grounded at 35. Additionally, there are provided high frequency choke coils 36 and 37 connected directly in series with winding 28, so that high frequency current is barred from retrograde passage into the power supply system by the combined connection thereto of condensers 33 and 34 and choke coils 36 and 37.

The disruptive discharge tube used in the device of Figure 2 is similar to that already shown and described in connection with Figure 1, and the

elements already described are indicated by identical reference numerals. The electrodes of the tube are connected in series with transformer secondary 28 and choke coils 36 and 37. The tube is also in series with the high frequency circuit comprising condensers 29, 30, and 31, together with adjustable inductances 38 and 39. Directly across the electrodes of the tube is connected a safety discharge circuit comprising resistors 40 and 41 connected at one end of each to the respective main electrodes of the tube and a spark gap 42, connected between the free extremities of these resistors.

The device, just described, operates as follows, additional reference being now made to Figure 4. As the alternating current feeding transformer 27 rises from the zero point 43, it will cause condensers 30 and 31 to acquire an increasing charge. The potential across these condensers appears simultaneously across the main discharge electrodes of the tube and via resistors 17 and 18, across spark gaps 19 and 20. When a predetermined point for discharge, namely the potential indicated at the point 44 is reached, gas ionization takes place over gaps 19 and 20, as already explained in Figure 1. The resulting spark discharge over these gaps causes the appearance upon the respective starting bands 15 and 16 of potentials which determine the initiation of the main discharge via electrodes 13 and 14, and the mercury pools connected respectively thereof.

The occurrence of the main discharge through the tube, in the disruptive fashion just described, causes high frequency oscillations to be set up in the tuned circuit comprising inductances 38 and 39, condensers 30 and 31 and the main tank condenser 29, for the reason that inductance coil 32 no longer functions as a short circuit for condenser 29 at these high frequencies, as those elements constitute a resonant circuit at such frequencies. Condenser 29 and coil 32 are preferably made of relatively low resistance, and the high frequency currents flowing in the closed or tank circuit comprised thereby are consequently of relatively great intensity. The high frequency circuit comprising condensers 30 and 31, together with inductances 38 and 39, is completed through the relatively low resistance of the main tube discharge, and may be considered to be capacitively coupled to the tank circuit via condenser 29. While the high frequency phenomena, just described, are taking place, the main discharge through the tube will continue. However, the high frequency currents will fall to zero value in a time dependent, inter alia, upon the electrical constants of the high frequency circuits and the damping thereof. Meanwhile, the main discharge through the tube constitutes virtually a short circuit across the secondary of transformer 27, since the impedance of choke coils 36 and 37 to the low frequency charging current is almost nil. The increase of current through the primary winding 26 of the transformer is held to a safe value by the adjustable choke coil 24. The net result of these low frequency phenomena is that the potential appearing between main electrodes 13 and 14 will fall to a value sufficiently low to extinguish the spark discharges taking place over gaps 19 and 20. This means that the end of the high frequency discharge will cause the extinguishing of the main tube discharge, thus removing the effective low frequency short circuit from transformer 27. Since this is assumed to take place at the point indicated by reference numeral 44, and since the high frequency discharge lasts for only a very brief interval compared with the low frequency sine wave, the charging current will continue to rise beyond point 44 to a peak value 46.

Depending upon the relative values of the capacities to be charged and the total impedance in the circuit, condensers 30 and 31 may acquire a charge sufficient at least once more to initiate a disruptive discharge through the tube, before the sine wave is reduced to a second zero point, indicated at 45. Such subsequent discharges may be determined as to number and time of occurrence by a suitable choice of circuit constants, suitable adjustment of choke coil 24, and suitable adjustment of spark gaps 19 and 20, so that they will take place at any desired potential values, for instance at the peak value 46 or at a value 47, which may be made equal in voltage to that of the point 44, if so desired. It is to be understood that the energy output of the system may be varied by adjusting the number and frequency of such multiple disruptive condenser discharges, and that maximum output usually obtains for a certain frequency of the multiple discharges, best determined in any given case by actual adjustment of the factors previously enumerated.

Safety spark gap 42 functions to prevent voltage surges of unduly great value in case that the discharge tube fails properly to ignite, as might be caused, for instance, by the fusion of the protective device 21, which would prevent the proper ignition of the tube until such elements were replaced. The discharge through gap 42 is limited by resistors 40 and 41 to such value as will not constitute an undue load upon transformer 27, and preferably to a value which will prevent the formation of an actual arc over gap 42. Spark gap 42 performs the additional function of dissipating unduly high voltages which may be caused, inter alia, by a failure properly to resonate the tank circuit with the tuned circuit connected to the discharge tube, or by a sudden removal of the work load, when the system is adjusted for a relatively high output.

The gas ionization gaps 19 and 20 may be constructed, as shown in Figure 3, where the base 50 of insulating material is provided with two supporting members 51 and 52 of insulating material. The spark gap electrodes 53 and 54 pass through members 51 and 52 respectively, and are conveniently arranged to slide horizontally through. Lead wires 55 and 56 are attached to the respective electrodes. It is to be understood that any other form of spark gap suitable for handling the potentials and currents involved may be employed. In certain cases it is found desirable to arrange a micrometer type of adjustment for at least one electrode.

While I have shown and described certain embodiments of my invention, many changes and modifications thereof will be apparent to those skilled in the art, within the scope of the hereunto appended claims, and I am, therefore, not limited to the exact constructions and arrangements herein shown and described.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A disruptive discharge tube ignition system, including a starting electrode adjacent to one end of said tube, a resistor extending from said electrode to the main tube electrode located at said end, whereby said starting electrode and said main electrode are maintained at substantially equal potentials, and a spark gap extending between said starting electrode and a point of the

circuit feeding said tube, which point is substantially at the potential of the opposite one of the main electrodes of said tube, whereby increase of the potential between both said main electrodes eventuates in a disruptive discharge across said spark gap and in a consequent reversal of the potential upon said starting electrode, thereby initiating the main discharge of said tube, whereby the ceasing of said disruptive discharge allows said starting electrode to substantially instantaneously take on the original non-firing potential thereof.

2. A system for igniting a vapor discharge tube of the type employing an ignition electrode, including a resistor connected from said ignition electrode to the adjacent main electrode, and a disruptive gaseous discharge gap connected from said ignition electrode to a point carrying a potential opposite from said main electrode, said potential being derived from the main feed circuit of said tube, whereby a disruptive gaseous discharge occurs across said gap at a predetermined instant, reverses the instantaneous potential of said ignition electrode by creating a voltage drop across said resistor, and thereby fires said tube, and whereby current flow through said resistor promptly restores said ignition electrode to a non-firing potential when said disruptive discharge ceases.

3. A mercury vapor discharge tube system, including a double ended tube, having a mercury pool and main discharge electrodes located at the respective ends thereof, a starting ring located around each of said pools, a resistor connected from each starting ring to the adjacent main tube electrode, and a spark gap connected between both said rings, whereby a predetermined difference of potential between said main electrodes causes a spark discharge across said gap and consequently causes a substantially instantaneous reversal of the potential normally imparted to each starting ring via the respective resistor connected thereto, thereby firing said tube.

4. A system according to claim 3, in which said spark gap is subdivided into a plurality of sections, thereby increasing the closeness with which the disruptive potential may be adjusted.

5. A system, according to claim 3, including a

fuse connected in series with said spark gap, whereby the accidental establishment of an arc thereacross will blow said fuse and prevent the firing of said tube.

6. A frequency conversion system, including a tube of the double ignitron type, a source of low frequency alternating current connected to the main tube electrodes, a high frequency resonant circuit including a storage condenser, connected also to said main electrodes, a resistor connected from each ignition electrode to the adjacent main electrode, and a spark gap connected between said ignition electrodes, whereby said storage condenser receives a charge of rising potential until said spark gap ionizes, and thereby triggers off the main tube discharge, thus exciting said resonant circuit.

7. A system, according to claim 6, including a reactive element connected between said low frequency source and said tube, whereby triggering of said main tube discharge lowers the potential of said source sufficiently to extinguish said main discharge, thereby permitting a plurality of discharges for each cycle of said low frequency current.

8. A system, according to claim 6, including a series resistor and a safety spark gap connected directly across the main electrodes of said tube, whereby undue potentials due to failure of ignition are dissipated.

9. A system, according to claim 6, in which said high frequency circuit comprises a relatively low current resonant circuit directly connected to said tube, and a relatively high current tank circuit capacitatively coupled to said low current circuit.

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