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2,553,263

TRAVELING WAVE VAPOR-ELECTRIC CURRENT GENERATOR

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FIG. 1

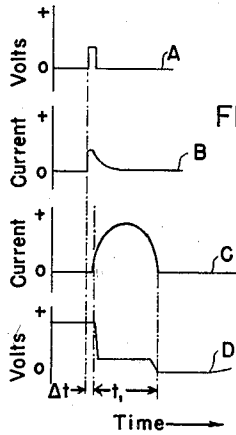
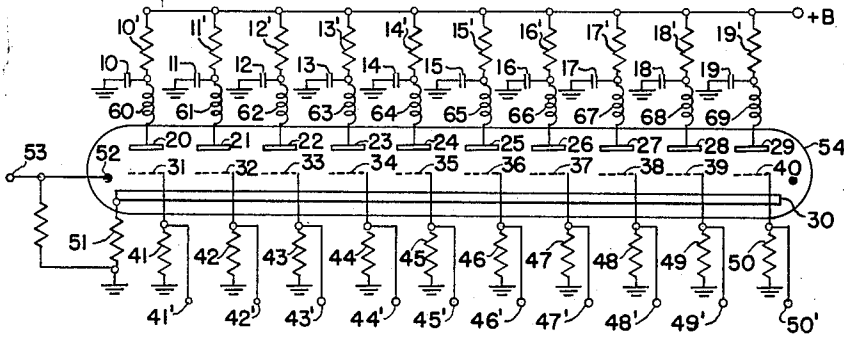


FIG. 2

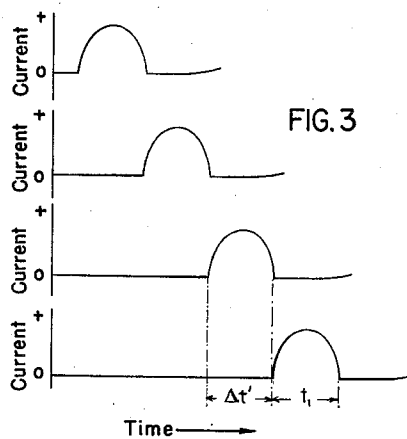


FIG. 3

FIG. 4

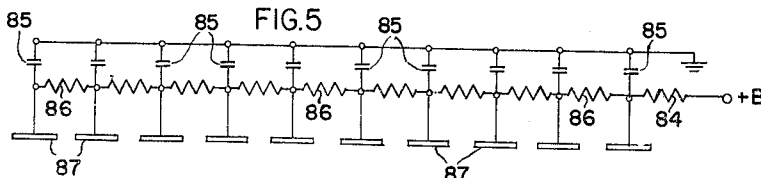
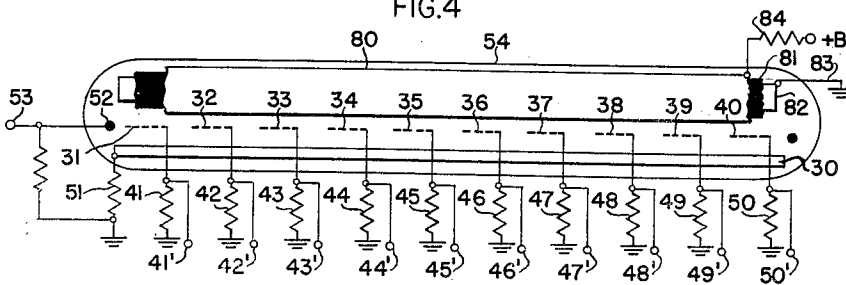


FIG. 5

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# UNITED STATES PATENT OFFICE

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## TRAVELING WAVE VAPOR-ELECTRIC CURRENT GENERATOR

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9 Claims. (Cl. 250—27.5)

1

This invention is directed to arrangements for generating a traveling wave of vapor-electric discharge current. The expression "vapor-electric discharge current," as used throughout this specification, is intended to define the type of current produced in a vapor-electric or gaseous-discharge tube during operating intervals in which such a tube is broken down or rendered conductive. In the most familiar gaseous-discharge circuits, the gas of the tube produces a visible discharge which is conveniently referred to as a glow discharge. The arrangements to be described hereinafter will usually have this characteristic.

A generator of the type under consideration may be employed in a variety of installations. For example, its use as a scanning device in applicant's novel television receiving system is disclosed in detail in application Serial No. 120,405, filed October 8, 1949, as a continuation of application Serial No. 701,188, filed concurrently herewith but now abandoned. The generator is likewise especially suited for application to commutating systems and will be particularly described in that connection.

Commutators, as such, have long been known to the art and may take any of a variety of forms. One familiar type features a rotating element to commutate between cooperating elements spaced about its axis of rotation. While that device is satisfactory for certain services, there is a practical limit to the maximum commutating frequency and this limitation may be undesirable in some cases. Electronic commutators, including a series of cascaded vacuum or gas tubes, have also been proposed, but they usually involve fairly complex circuit connections which may sometimes be objectionable.

It is an object of the present invention, therefore, to provide a traveling-wave current generator which may be employed as a commutating device and which avoids one or more of the aforementioned limitations of the prior devices referred to hereinbefore.

It is another object of the invention to provide an improved and novel arrangement for generating a traveling wave of vapor-electric discharge current.

It is the specific object of the invention to provide a novel arrangement of simplified and inexpensive construction for generating a traveling wave of vapor-electric discharge current.

In accordance with the present invention, an arrangement for generating a traveling wave of vapor-electric discharge current comprises en-

2

ergy-storage means having a plurality of energy-storage portions to be charged from a potential source. The arrangement also includes vapor-electric discharge means for discharging the aforesaid portions and including anode means comprising a corresponding plurality of anode portions spaced along a predetermined route and including cathode means providing a like plurality of cathode portions spaced from and defining with those anode portions a like plurality of spaced electrode systems constituting vapor-discharge paths extending across the aforesaid route. The arrangement further includes means for initiating a vapor-electric discharge in one of the electrode systems to discharge the associated one of the energy-storage portions and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of the aforesaid one energy-storage portion. The spacing of the electrode systems along the route mentioned above is selected with reference to the capacitance of the energy-storage portions and the characteristics of each path so that the discharge of any of the energy-storage portions through its path ionizes the discharging path for the next succeeding energy-storage portion, thereby to produce a similar localized component of vapor-electric discharge current, and propagate a traveling wave of current along the aforesaid route.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the drawing, Fig. 1 is a schematic representation of a traveling-wave current generator embodying the invention; Figs. 2 and 3 include graphs utilized in explaining the operation of the embodiment of Fig. 1; Fig. 4 represents a generator of the type of Fig. 1 having a modified construction, while Fig. 5 is a schematic circuit diagram which is the approximate electrical equivalent of one component of the generator of Fig. 4.

Referring now more particularly to the drawing, there is represented in Fig. 1 an arrangement embodying the invention for generating a traveling wave of vapor-electric discharge current. The arrangement comprises energy-storage means, including a plurality of energy-storage devices, the successive discharge of which gives rise to a traveling wave of vapor-

3

electric or glow-discharge current. These storage devices are shown as a series of discrete but similar condensers designated 10-19, inclusive. One electrode of each condenser is grounded while the opposite electrode thereof is coupled through one of a similar series of resistors denoted 10'-19', inclusive, to a common source of unidirectional potential indicated +B. It will be understood that the low-potential terminal of this source is likewise grounded.

The generating arrangement has vapor-electric discharge means for successively discharging the series of storage devices, this means being in the form of a single glow-discharge tube. The tube includes an anode structure comprising a plurality of anode elements 20-29, inclusive, corresponding in number to the number of condensers and closely spaced along a predetermined route. In the embodiment under consideration wherein the tube is a straight structure, these anode elements are spaced along a linear path. A single elongated cathode structure 30 is included in the tube, being spaced from and providing with the several anode elements, a like plurality of spaced vapor- or glow-discharge paths. A plurality of intermediate or sampling electrodes 31-40, inclusive, are arranged with one such electrode in each of the several discharge paths provided by the spaced anode elements and the common cathode, these intermediate electrodes constituting means responsive to a traveling wave in the tube for deriving a control effect. Each such electrode is grounded through one of resistors 41-50, thereby to be included in circuit with the common cathode which is likewise grounded by way of a cathode impedance 51. Output terminals 41'-50', inclusive, are connected to the high potential terminals of the correspondingly designated resistors in order to couple a utilizing circuit to the tube to be controlled by the control effects developed in a manner to be made clear hereinafter.

The several series of electrodes 20-29, inclusive, 31-40, inclusive, as well as the unitary cathode 30 are enclosed within a single glass envelope 54. An ionizable gas, such as xenon or argon, is also housed within the envelope so that the electrode system is in a gaseous atmosphere of any suitable composition and at a conventional pressure. A series of inductors 60-69, inclusive, is arranged with one inductor serially connecting one of the condensers 10-19, inclusive, to a corresponding one of the several anode elements 20-29, inclusive, so that a resonant discharge circuit is associated with each condenser.

An igniter electrode 52 positioned adjacent the leading glow-discharge path, namely, that including anode element 20 and the common cathode 30, constitutes triggering means for initiating a discharge between this anode element 20 and the cathode structure to discharge the associated condenser 10. The igniter 52 may be rendered effective by way of triggering pulses or signals of positive polarity applied to a synchronizing terminal 53.

In considering the operation of the described arrangement, it will be assumed initially that no discharge is taking place within the gas tube 54. In this quiescent condition, the series of condensers 10-19, inclusive, charge simultaneously from the common potential source +B, the charging current of each condenser being limited by its series-arranged charging resistor. At the end of the charging interval, all of the condensers are charged to a positive potential. The

4

value of the source +B is chosen so that the potential of any condenser in this charged condition is insufficient to initiate a glow discharge anywhere along the tube 54. The potential source is also selected of a sufficiently high value that the condensers are capable of maintaining a discharge within the tube, once the discharge is initiated, until the condensers become discharged.

Let it be assumed, now, that the condensers have all received a full charge and that a triggering pulse, represented by curve A of Fig. 2, is applied to synchronizing terminal 53. The triggering pulse is of positive polarity and provokes a discharge between the igniter electrode 52 and the common cathode structure 30. This discharge ionizes the gaseous atmosphere in the immediate vicinity of the igniter and produces ionization within the discharge path between anode element 20 and the common cathode. This latter ionization enables the discharge to spread to anode element 20 in the manner of conventional gas tubes utilizing an igniter electrode. The variation of igniter current, as the discharge is taken over by anode 20, is indicated by curve B. The occurrence of a discharge between this anode element and the common cathode completes the resonant discharge path for condenser 10 through the inductor 60 and produces a component of vapor-electric or glow-discharge current having a duration corresponding to the discharge time of the condenser.

Neglecting for the moment the effect of the discharge of condenser 10 on the neighboring anode elements of tube 54, its discharge current is represented by curve C. The corresponding voltage variation experienced by anode element 20 is shown by curve D. Thus, it is apparent that after a time delay  $\Delta t$  following the application of the triggering pulse of curve A, condenser 10 starts to discharge. The time delay  $\Delta t$  represents the delay in the transfer of the initial glow discharge from igniter electrode 52 to the anode element 20. The discharge time of the condenser is designated by the time interval  $t_1$ . It is approximately equal to one-half the period of the series-resonant discharge circuit comprising this condenser, its discharge inductor 60, and the resistor 51 because at the end of that time, the potential of anode element 20 is reduced to an insufficient value to sustain ionization. During the conductive interval  $t_1$ , a low impedance path is established between the intermediate electrode 31 and the cathode 30, bringing the potential of resistor 41 to that of the cathode. In this manner, a control potential is presented at the output terminal 41' for the duration of the discharge time  $t_1$  of condenser 10 and this potential may be utilized to perform the first step of the commutating process controlled by the arrangement under consideration.

The complete commutating process may be understood when the effect of the aforescribed discharge of condenser 10 upon its neighboring discharge paths is taken into account. The discharge of this condenser produces an appreciable ionization in the immediate neighborhood of anode element 20. The degree of ionization is determined, among other factors, by the characteristics of the discharge path, such as: (1) the duration of the condenser discharge time  $t_1$ ; (2) the magnitude of the discharge current; and (3) the composition and pressure of the gas included within tube 54. The duration of the discharge, as mentioned in the preceding para-

5

graphs, may be controlled by appropriately selecting the series-resonant frequency of the condenser discharge circuit and the magnitude of the discharge current is dependent upon the impedance of the discharge path as well as the initial potential of the condenser 10. The spacing of the several discharge paths along the tube is selected with reference to the capacity of the condensers and the characteristics of each path so that the discharge of any one condenser through its path ionizes the discharge path for the next succeeding condenser. In other words, the spacing of the anodes 20-29, inclusive, is selected so that the discharge of condenser 10 ionizes the discharge path for condenser 11 which, in turn, discharges and ionizes the discharge path for condenser 12 etc. In this fashion, the effect of a triggering pulse applied to terminal 53 is to initiate a traveling wave of current that starts with the discharge of the first condenser 10 and is propagated along the tube by the successive discharging of the remaining condensers. This phenomenon is represented by the curves of Fig. 3 which indicate the time relation of the discharge current for four of the condensers. Each has the same discharge time  $t_1$  and there is a delay  $\Delta t'$  corresponding to the time required for the discharge of any one condenser to ionize and complete a discharge path for the next succeeding one. The discharge of any condenser produces a control potential at the associated output terminal so that for the arrangement illustrated and described the terminals 41'-50', inclusive, successively present control potentials capable of effecting a commutation.

As already mentioned, the complete discharge of any of the condensers 10-19, inclusive, extinguishes the glow discharge from the particular anode element associated therewith. While some ionization continues to be associated with a given anode element following the extinction of the glow discharge thereto, the charging resistors 10'-19', inclusive, are selected of large values so that the recharging of any condenser is at a slow rate. This permits deionization to be accomplished within the tube 54 to restore the arrangement to its quiescent condition. After the first condenser 10 has been discharged and has received its subsequent charge from the source +B, a second triggering signal may be applied to terminal 53 to repeat the commutating cycle just described. Of course, where the tube is exceedingly long, the leading condenser 10 may well have been completely recharged before the last condenser 19 has been discharged. In such a case, the control potential developed at resistor 50 may be employed to trigger the tube again, thereby to maintain continuous operation. Also, with a long tube several waves of discharge current may traverse the tube simultaneously and independently.

The arrangement of Fig. 1 constitutes a flexible commutating system. Since the glow discharge advances in step-by-step fashion along the tube, spreading from first one electrode to its neighbor on the right, a combination of output terminals may be selected to provide a convenient commutating program. All output terminals may be used to give a succession of commutating steps with approximately equal time separations or some may be omitted to vary this commutating sequence. It will also be apparent that only one output terminal may be employed where it is desired to effect the timing of some operation

6

with a predetermined delay with respect to a triggering signal applied to terminal 53. Additionally, the igniter 52 shown at the leading edge of the anode structure may be variously positioned within the tube. Where it is located centrally of the tube, the glow discharge current may advance in two opposed paths effectively producing two traveling waves of current.

It is not necessary that the glow-discharge tube have discrete, spaced anode elements. It may be convenient in some applications of the invention to utilize the modification of Fig. 4 wherein the energy-storage device and the anode structure constitute one structural member. As represented, this member is circular in cross section and has an outer conductor surface 80 of resistive material, an intermediate layer 81 of a suitable dielectric, and an inner or nested conductive element 82. The dielectric material 81 insulates but electrically couples conductive surfaces 80 and 82 to one another throughout their lengths so that the structure 80-81-82 may be considered as an elongated condenser. The inner element 82 is grounded at one or more points in the manner shown by the connection 83. The source of unidirectional potential +B is connected through a common charging resistor 84 to the outer conductive surface 80. This outer surface also serves as the anode structure of the gaseous discharge tube. The remaining electrode elements of this tube as well as the circuit connections to the intermediate electrodes, the common cathode, and the igniter are the same as those of Fig. 1 and are designated by similar reference characters.

Fig. 5 is a schematic representation of the electrical equivalent of the unitary structure 80-81-82 serving both as the energy-storage means and the anode structure. It is represented as effectively having a plurality of elemental condensers 85, 85 corresponding to the distributed capacitance between the conductive surfaces. One electrode of each condenser is connected to a common ground and the other electrode is connected with the charging surface +B through the resistor 84 as well as a series of resistors 86, 86. The latter designate the distributed resistance along conductive surface 80. This same surface 80 simulates a like plurality of elemental anodes 87, 87, where each elemental anode is considered to be the portion of conductive surface 80 represented by the high potential electrode of each elemental condenser 85, 85. The operation of a generator of the type represented in Fig. 4 in producing a traveling wave of glow-discharge current is generally similar to that described in connection with the embodiment of Fig. 1. Resonant discharging of the condensers 85, 85 may be obtained by using the inherent distributed inductance of the condenser discharge circuits. It will be understood that the construction of Fig. 4 featuring distributed capacitance is not limited to the use of a structure 80-81-82 of circular cross section. It is only necessary that this component effectively provide the distributed capacitance as well as the anode surface and its cross section may take any of a variety of forms. Further, the condensers 10-19 of Fig. 1 and condensers 85, 85 of Fig. 4 may, if desired, be arranged to return to the cathode 30 instead of to ground as illustrated.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modi-

fications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: energy-storage means having a plurality of energy-storage portions to be charged from a potential source; vapor-electric discharge means for discharging said portions and including anode means comprising a corresponding plurality of anode portions spaced along a predetermined route and including cathode means providing a like plurality of cathode portions spaced from and defining with said anode portions a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; and means for initiating a vapor-electric discharge in one of said electrode systems to discharge the associated one of said energy-storage portions and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one energy-storage portion; the spacing of said electrode systems along said route being selected with reference to the capacitance of said energy-storage portions and the characteristics of each path so that the discharge of any of said energy-storage portions through its path ionizes the discharging path for the next succeeding energy-storage portion, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route.

2. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: a plurality of energy-storage devices to be charged from a potential source; vapor-electric discharge means for discharging said storage devices including an anode structure, effectively comprising a corresponding plurality of elemental anodes spaced along a predetermined route, and including a cathode structure effectively providing a like plurality of cathode elements spaced from and defining with said anodes a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; and means for initiating a vapor-electric discharge in one of said electrode systems to discharge the associated one of said storage devices and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one storage device; the spacing of said electrode systems along said route being selected with reference to the capacity of said storage devices and the characteristics of each path so that the discharge of any of said devices through its path ionizes the discharge path for the next succeeding storage device, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route.

3. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: energy-storage means including a plurality of elemental energy-storage devices to be charged from a potential source; vapor-electric discharge means for discharging said storage devices including a corresponding plurality of anodes spaced along a predetermined route, and including a cathode structure effectively pro-

viding a like plurality of cathode elements spaced from and defining with said anodes a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; and means for initiating a vapor-electric discharge in one of said electrode systems to discharge the associated one of said storage devices and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one storage device; the spacing of said electrode systems along said route being selected with reference to the capacity of said storage devices and the characteristics of each path so that the discharge of any of said devices through its path ionizes the discharge path for the next succeeding storage device, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route.

4. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: energy-storage means effectively including a plurality of elemental energy-storage devices to be charged from a potential source; vapor-electric discharge means for discharging said storage devices including an anode structure, effectively comprising a corresponding plurality of elemental anodes spaced along a predetermined route, and including a single elongated cathode structure spaced from and providing with said anodes a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; and means for initiating a vapor-electric discharge in one of said electrode systems to discharge the associated one of said storage devices and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one storage device; the spacing of said electrode systems along said route being selected with reference to the capacity of said storage devices and the characteristics of each path so that the discharge of any of said devices through its path ionizes the discharge path for the next succeeding storage device, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route.

5. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: energy-storage means effectively including a plurality of elemental energy-storage devices to be charged from a potential source; vapor-electric discharge means for discharging said storage devices including an anode structure, effectively comprising a corresponding plurality of elemental anodes spaced along a linear route, and including a single elongated cathode structure spaced from and providing with said anodes a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; and triggering means for initiating a vapor-electric discharge in an end one of said electrode systems to discharge the associated one of said storage devices and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one storage device; the spacing of said electrode systems along said route being selected with reference to the capacity of said storage devices and the characteristics of each path so that the discharge of any of said devices through its path ionizes

the discharge path for the next succeeding storage device, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route.

6. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: energy-storage means effectively including a plurality of elemental energy-storage devices to be charged from a potential source; vapor-electric discharge means for discharging said storage devices including an anode structure, effectively comprising a corresponding plurality of elemental anodes spaced along a predetermined route, and including a cathode structure effectively providing a like plurality of cathode elements spaced from and defining with said anodes a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; means for initiating a vapor-electric discharge in one of said electrode systems to discharge the associated one of said storage devices and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one storage device; the spacing of said electrode systems along said route being selected with reference to the capacity of said storage devices and the characteristics of each path so that the discharge of any of said devices through its path ionizes the discharge path for the next succeeding storage device, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route; and means, comprising a sampling electrode positioned in the space between one of said elemental anodes and said cathode structure, responsive to said traveling wave for deriving a control effect for utilization.

7. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: energy-storage means effectively including a plurality of elemental energy-storage devices to be charged from a potential source; vapor-electric discharge means for discharging said storage devices including an anode structure, effectively comprising a corresponding plurality of elemental anodes spaced along a predetermined route, and including a cathode structure effectively providing a like plurality of cathode elements spaced from and defining with said anodes a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; a plurality of sampling electrodes arranged with one in each of said electrode systems; means for initiating a vapor-electric discharge in one of said electrode systems to discharge the associated one of said storage devices and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one storage device; the spacing of said electrode systems along said route being selected with reference to the capacity of said storage devices and the characteristics of each path so that the discharge of any of said devices through its path ionizes the discharge path for the next succeeding storage device, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route; and a plurality of output terminals individually coupled to said sampling electrodes and individually effective to present a control potential during

any operating interval in which the sampling electrode associated therewith is within a vapor-electric discharge.

8. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: energy-storage means effectively including a plurality of elemental energy-storage devices to be charged from a potential source; vapor-electric discharge means for discharging said storage devices including an anode structure, effectively comprising a corresponding plurality of elemental anodes spaced along a predetermined route, and including a cathode structure effectively providing a like plurality of cathode elements spaced from and defining with said anodes a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; a plurality of inductors serially connected with said storage devices in said discharge paths so that a resonant discharge circuit is associated with each of said storage devices; and means for initiating a vapor-electric discharge in one of said electrode systems to discharge the associated one of said storage devices and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one storage device; the spacing of said electrode systems along said route being selected with reference to the capacity of said storage devices and the characteristics of each path so that the discharge of any of said devices through its path ionizes the discharge path for the next succeeding storage device, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route.

9. An arrangement for generating a traveling wave of vapor-electric discharge current comprising: energy-storage means including a pair of nested and insulated elongated conductive elements having distributed capacitance therebetween effectively to comprise a plurality of elemental energy-storage devices to be charged from a potential source; vapor-electric discharge means for discharging said storage devices including the outer one of said conductive surfaces as an anode structure, simulating a corresponding plurality of elemental anodes spaced along a predetermined route, and including a single elongated cathode structure spaced from and providing with said anodes a like plurality of spaced electrode systems constituting vapor-discharge paths extending across said route; and means for initiating a vapor-electric discharge in one of said electrode systems to discharge the associated one of said storage devices and produce a localized component of vapor-electric discharge current having a duration corresponding to the discharge time of said one storage device; the spacing of said electrode systems along said route being selected with reference to the capacity of said storage devices and the characteristics of each path so that the discharge of any of said devices through its path ionizes the discharge path for the next succeeding storage device, thereby to produce a similar localized component of vapor-electric discharge current and propagate a traveling wave of current along said route.

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