Sept. 25, 1951 E. DONATH 2,569,154

ELECTRONIC DISCHARGE DEVICE

Filed July 24, 1948

Fig. 2

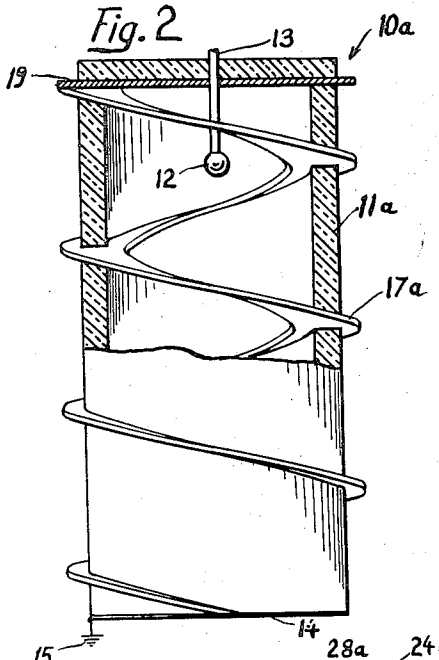
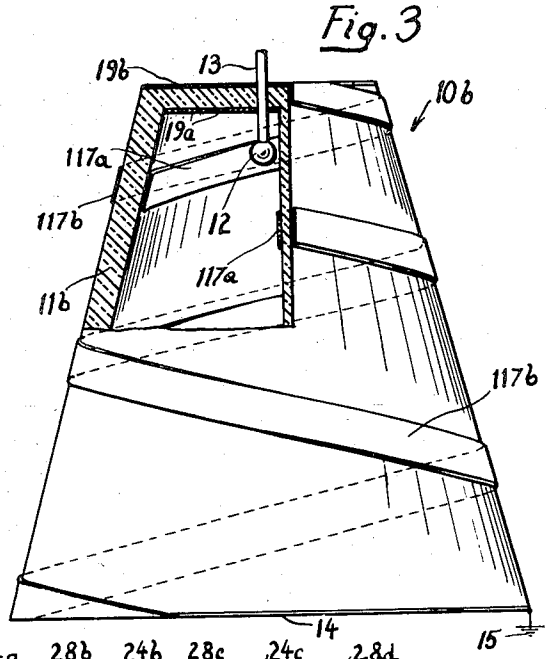


Fig. 3



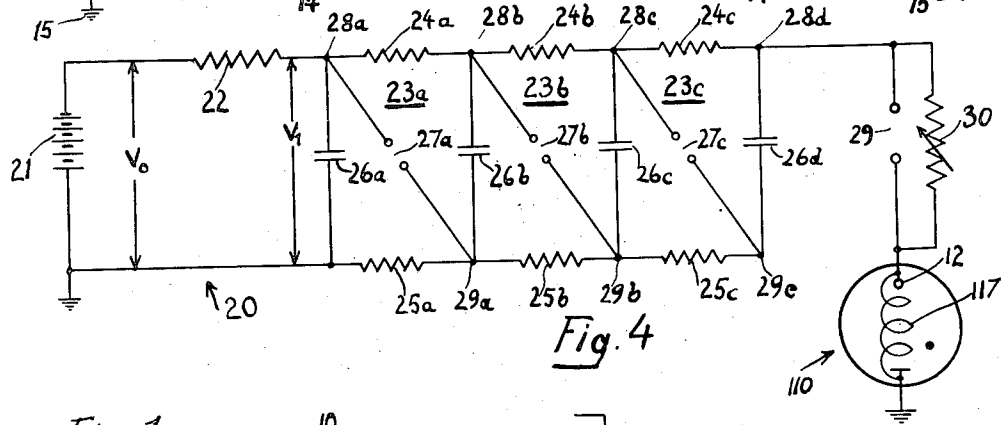


Fig. 4

Fig. 1

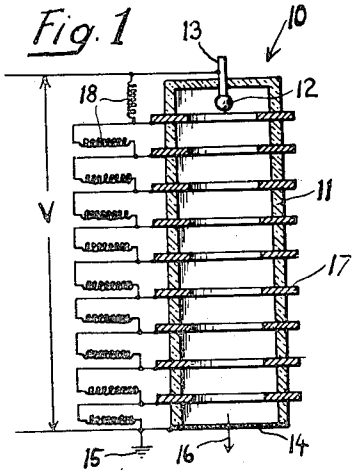
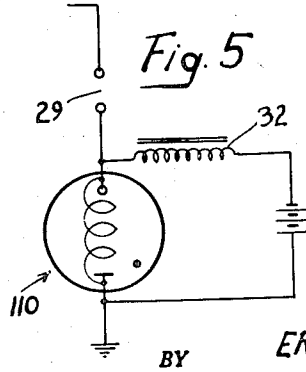


Fig. 5



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ELECTRONIC DISCHARGE DEVICE

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9 Claims. (Cl. 313—325)

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The present invention relates to electronic discharge devices and, more particularly, to electronic discharge devices or tubes of the type comprising a spark gap within an envelope which latter is provided with a "window" (generally a thin metal foil) through which electrons set in motion by the voltage difference across the spark gap may be discharged into the atmosphere. Tubes of this description are well known and are used for the purpose of sterilizing or otherwise treating matter by electron bombardment.

In tubes of the type set forth above, each discharge is preceded by a very high surge voltage (e. g. of the order of several million volts) built up across the spark gap which voltage must be sustained by the insulating material supporting the electrodes of the gap in spaced-apart relationship; these electrodes are generally a grounded metal foil, representing the aforesaid "window," and a cathode, both supported directly from the tube envelope. It has been found that in such tubes special precautions must be taken lest, even where the dielectric strength of the envelope material is theoretically sufficient to withstand the voltages employed, breakdown occur as the result of parasitic charges and non-uniform field distribution. None of the tubes heretofore designed has proved fully satisfactory in this respect, as far as I am aware.

It is, therefore, an object of the present invention to provide an improved electronic discharge device of the character described.

It is another object of my invention to provide, in an electronic discharge device comprising a preferably tubular envelope of insulating material and a pair of electrodes supported by said envelope in spaced-apart relationship, means for insuring a substantially uniform field distribution along the envelope and for dissipating parasitic charges collected thereon, whereby the life span of the device will be increased.

A further object of this invention is to provide, in an electronic discharge tube having a spark gap suitable for electron bombardment of matter preferably located outside the tube envelope, means for directing the electrons upon a predetermined path while substantially preventing them from reaching any part of the envelope intermediate the electrodes of the gap.

Still another object of the invention is to provide a method of making a tube envelope in such manner that the preceding objects will be realized.

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The above and other objects of the invention will become apparent from the following description, reference being had to the accompanying drawing in which:

Fig. 1 is a longitudinal cross section of a well known electron tube of the character described, this figure also illustrating schematically the improvement proposed in accordance with the present invention;

Figs. 2 and 3 are elevations, partly in section, of two embodiments of tubes in accordance with the invention;

Fig. 4 is a complete circuit diagram of an arrangement for producing large and intermittent electronic discharges, utilizing a tube according to the invention; and

Fig. 5 shows a fragmentary modification of the circuit of Fig. 4.

Fig. 1 shows an electron discharge device 10 comprising a tubular envelope 11, e. g. of ceramic material, from the top of which a cathode 12 is suspended by a conductor 13. The other electrode of the spark gap is formed by a metal foil 14 inserted in the bottom of the envelope 11. The foil 14 is grounded as shown at 15, and a voltage V is intermittently applied across the electrodes 12, 14, resulting in a violent discharge of electrons from the cathode 12 which penetrate the window 14 as indicated by the arrow 16. Since the cathode 12 is unheated, the electrons necessary for the discharge are obtained through ionization within the tube which contains air or gas at low pressure.

It has been believed for some time that the reason for the failure of a tube of the type shown in Fig. 1, if subjected to high voltages, lies in the fact that the distribution of voltages along the internal and the external surfaces of the envelope 11 is not uniform, thus giving rise to voltage differences across the walls of the tube which exceed the breakdown strength of the dielectric material, resulting in the destruction of the envelope. Accordingly, such tubes have been provided with spaced conducting members 17, of annular form, which traverse the envelope 11 and are designed to equalize the potentials outside and inside the tube. This arrangement, however, has several serious drawbacks among which are the following:

The set of conductive rings 17 acts as a capacitive voltage divider inserted between the cathode 12 and ground. This would be very desirable, were it not for the fact that each ring during discharges will act as an auxiliary anode, thereby attracting electrons which will alter the potential of the ring as determined by its position

within the capacitive voltage divider; this is especially true for the lower rings whose capacity to ground is large. Accordingly, a non-uniform field will again exist and will again place undue stresses upon the dielectric material of the envelope.

Furthermore, the drain upon the electron stream caused by the rings 17 will materially reduce the output of electrons passing through the window 14 whereby the efficiency of the tube will be impaired. Finally, the composition of the tube 10 of annular portions of insulating material alternating with the rings 17 entails a mechanical weakening of the structure as compared with a tube wherein the envelope consists of a unitary piece of insulating material.

As will be subsequently apparent from the description of Fig. 4, the voltage across the electrodes 12, 14 remains substantially zero during the major part of the interval between discharges, then rises steeply to its peak, and immediately thereafter drops to substantially zero as the tube discharges.

According to the present invention, I propose to overcome the first of the above-mentioned drawbacks by galvanically interconnecting the electrodes 12, 14 over an inductive circuit which includes the auxiliary conductors 17, and which, in a simple form of the invention, may include a set of series-connected induction coils or chokes 18 as shown in Fig. 1, each auxiliary conductor or ring 17 being connected to the junction of two coils 18. The coils 18 present a substantially infinite impedance to the steep flanks of the voltage pulses preceding the discharges, yet in the interval between discharges facilitate the dissipation of stray charges built up on the rings as well as on the dielectric adjacent thereto. During each voltage peak, therefore, the rings 17 will act as a capacitive voltage divider producing an essentially uniform electric field inside and outside the tube envelope, and undue electric stresses upon the dielectric material will be avoided.

Even more advantageous is the tube 10*a* of Fig. 2. Here the annular members 17 have been replaced by an auxiliary conductor 17*a* of helical configuration which penetrates the tube envelope 11*a*. It will be appreciated that the inductivity of auxiliary conductor 17*a* will be of the same order as the combined inductivity of the serially connected coils 18 in Fig. 1. The helical conductor 17*a* terminates at the top in a disk-like member 19, establishing conductive contact with the cathode 12, and galvanically contacts at the bottom the foil 14. The foil 14 is again grounded as schematically indicated at 15.

The helical member 17*a* becomes the source of a magnetic field, on being subjected to the surge voltages, which field extends in the axial direction of the tube. Such a magnetic field will have a focusing effect upon the electrons emitted from the cathode 12, that is to say it will tend to prevent any electron from reaching the conductor 17*a*. Thus, with suitable dimensioning of this conductor in relation to the wave form of the surge voltage, it will be possible to direct most if not all electrons upon the "window" or foil 14, either concentrating them upon a predetermined spot thereof (such as the center) or, as will be preferable in some instances, sufficiently defocusing them to have them emerge at widely spaced points of the foil.

The focusing effect of a magnetic field upon an electron having a velocity component transverse to the field, as is well known, consists in the tendency of the field to force the electron into a helical path whose axis extends in the direction of the field and whose diameter is determined by the magnetic field strength and by the magnitude of the said component. If we assume that the electron undergoes constant radial acceleration as the result of the existence of an auxiliary conductor such as 17 or 17*a*, the path of the electron will still be helical but the helix will lie on the periphery of a cone rather than a cylinder. Accordingly, Fig. 3 shows a further tube according to the invention, indicated at 10*b*, which is of frusto-conical configuration; thereby the likelihood of any electron impinging upon the auxiliary conductor or conductors will be still further reduced.

From Fig. 2 it will be seen that the envelope 11*a* of tube 10*a* no longer consists of discrete portions of insulating material as is true of tube 10 in Fig. 1, but is made in a single piece of dielectric material of helical configuration, which may be directly moulded or cast between the threads of the conductive member 17*a*. Fig. 3 shows how even greater mechanical strength may be obtained without sacrificing any of the advantages of the invention. According to Fig. 3, the envelope 11*b* is a single, generally tubular (in the present case frusto-conical) piece of insulating material carrying a helical conductive strip 117*a* on the inside and a similar conductive strip 117*b* on the outside. The two strips extend opposite one another along the inner and outer surface, respectively, of the envelope 11*b* and are conductively connected to the cathode 12 by means of an inner and an outer layer 19*a*, 19*b* of conductor material; they are also in contact with the foil 14. Strips 117*a*, 117*b* may be thin layers of metal applied to the envelope 11*b* in any suitable manner, as by spraying.

According to still another feature of the invention, the auxiliary conductor such as 17*a* or 117*a*, 117*b* may be utilized as a carrier for a magnetic biasing current which may serve for the focusing or defocusing of the electrons in the manner previously set forth. Referring to Fig. 4, there is shown a surge voltage generator 20 of a type well known per se, which may be advantageously used in combination with a tube according to the invention and indicated schematically at 110. Tube 110 may be of the type illustrated, for example, in Fig. 2 or 3. The generator 20 comprises a source of direct current shown here schematically as a battery 21, connected by way of a current-limiting resistor 22 across a series of networks 23*a*, 23*b*, 23*c* each comprising two resistive series arms 24*a*, 24*b*, 24*c* and 25*a*, 25*b*, 25*c*, a capacitive shunt arm 26*a*, 26*b*, 26*c*, 26*d*, and a diagonally arranged spark gap 27*a*, 27*b*, 27*c*, extending between respective terminals 28*a*, 29*a*; 28*b*, 29*b*; 28*c*, 29*c*. Although only three networks or voltage multiplication stages are shown, any suitable number thereof may be used. The high voltage terminal 28*d* of the last network 23*c* is connected to ground over a circuit including the auxiliary spark gap 29 in series with the main gap of the tube 110.

The operation of this arrangement is as follows:

Battery 21, having a voltage V_0, charges capacitors 26*a*, 26*b*, 26*c* and 26*d* through resistor 22 until a voltage V_1 exists across these capacitors. The spark gap 27*a* is arranged to break down at this voltage, thereby virtually short-circuiting the terminals 28*a* and 29*a* and

adding the voltage existing across condenser 26*a* to that existing across condenser 26*b*, the impedance of the series arms 24*a*, 25*a* being at this instant large relative to that of the discharged path 26*a*, 27*a*, etc. Now a voltage of approximately 2 V_1 exists across the gap 27*b* which in turn breaks down, applying a voltage of 3 V_1 to gap 27*c*. The latter voltage, as will be apparent, is now applied across gap 29 and tube 10 in series, gap 29 having been provided for the purpose of preventing a breakdown of the main gap at the initial voltage V_1 before multiplication sets in. It will be noted that the potential of cathode 12 is caused to rise sharply to a value of n V_1 wherein n is the number of networks such as 23*a*.

By shunting the auxiliary gap 29 by a high resistance 30, it will be possible to energize the auxiliary conductor of tube 10, indicated generally at 17, by a direct current serving to produce the desired magnetic field. Resistor 30 may be adjustable, as shown, in order to permit the focusing effect of the field to be varied.

In Fig. 5, wherein the resistance 30 has been omitted, the biasing current is derived from an auxiliary source of current shown as a battery 31, the latter being connected in series with a protective choke 32 serving to prevent the passage of surge current through the battery 31. Although the invention has been described with reference to certain preferred embodiments it is to be understood that the same is not limited to the form specifically disclosed herein and that various modifications and adaptations may be made without departing from the spirit or exceeding the scope of the invention. In addition to electronic bombardment tubes as hereinabove referred to, the invention may be employed in connection with any electronic discharge device wherein a voltage of steep wave form results in an electronic discharge. Such voltages may, of course, be derived from suitable generators such as relaxation oscillators other than the generator shown in Fig. 4, which has been shown merely by way of example and is not claimed per se.

Furthermore, while there have been shown in Figs. 2 and 3 two exemplary embodiments of the invention, it is to be understood that the conductor arrangement of Fig. 3 may also be applied to the cylindrical tube form of Fig. 2, or the conductor arrangement of Fig. 2 may be used in combination with a flared or frusto-conical tube as shown in Fig. 3; many other changes will likewise be obvious to those skilled in the art without inventively distinguishing from the present disclosure.

The invention also contemplates a method of making a tube of the general character shown in Fig. 2. This method consists in winding an insulated conductor, which may be ordinary wire, into a coil having closely adjacent turns, fusing together the insulation of the adjacent turns, whereby a tube will be formed, and removing sufficient insulation from the inner and the outer surfaces of said tube to bare the helically wound wire.

What I claim as novel and desire to secure by Letters Patent is:

1. An electronic discharge device comprising an envelope of insulated material, a pair of electrodes forming a spark gap within said envelope, and auxiliary conductor means substantially coextensively disposed along the inner and outer surfaces of said envelope, said conductor means representing a highly inductive path which galvanically interconnects said two electrodes.

2. An electronic discharge device according to claim 1 wherein said auxiliary conductor means comprise a plurality of substantially parallel rings extending through said envelope and a plurality of serially connected inductances inserted between adjacent ones of said rings and between each of said electrodes and a respective ring adjacent thereto.

3. An electronic discharge device according to claim 1 wherein said envelope is of tubular configuration, said auxiliary conductor means comprising at least one helical conductor connected between said two electrodes and extending coaxially with said envelope.

4. An electronic discharge device comprising a generally tubular envelope of insulating material, a pair of electrodes supported from said envelope in spaced-apart relationship so as to form a spark gap within said envelope, and an auxiliary conductor of helical configuration extending coaxially with and contiguous to the said envelope, said conductor galvanically interconnecting said two electrodes.

5. An electronic discharge device comprising a generally tubular envelope of insulating material, a cathode extending into said envelope and supported from one end thereof, a foil-like anode inserted into the other end of said envelope so as to permit the passage of electrons from said cathode into the atmosphere, and helical conductor means galvanically interconnecting said anode and said cathode, said conductor means being contiguous with the inner and outer surfaces of said envelope at points opposite one another across the wall of the envelope.

6. An electronic discharge device according to claim 5 wherein said envelope is flared outwardly towards said anode.

7. An electronic discharge device according to claim 5 wherein said conductor means comprises a single helical conductor extending through the wall of said envelope.

8. An electronic discharge device according to claim 5 wherein said conductor means comprise first and second helical conductors extending along the inner and outer surfaces of said envelope, respectively.

9. An electronic discharge device according to claim 5, further comprising a magnetic biasing circuit including said helical conductor means, said biasing circuit also including a source of direct current connected across said anode and cathode.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,005,021	Brasch et al.	June 18, 1935
2,048,556	McArthur	July 21, 1936
2,145,727	Lloyd, Jr.	Jan. 31, 1939
2,206,558	Bennett	July 2, 1940
2,375,830	Spencer	May 15, 1945
2,386,820	Spencer	Oct. 16, 1945
2,414,622	Watrous, Jr.	Jan. 21, 1947