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ELECTRIC DISCHARGE DEVICE

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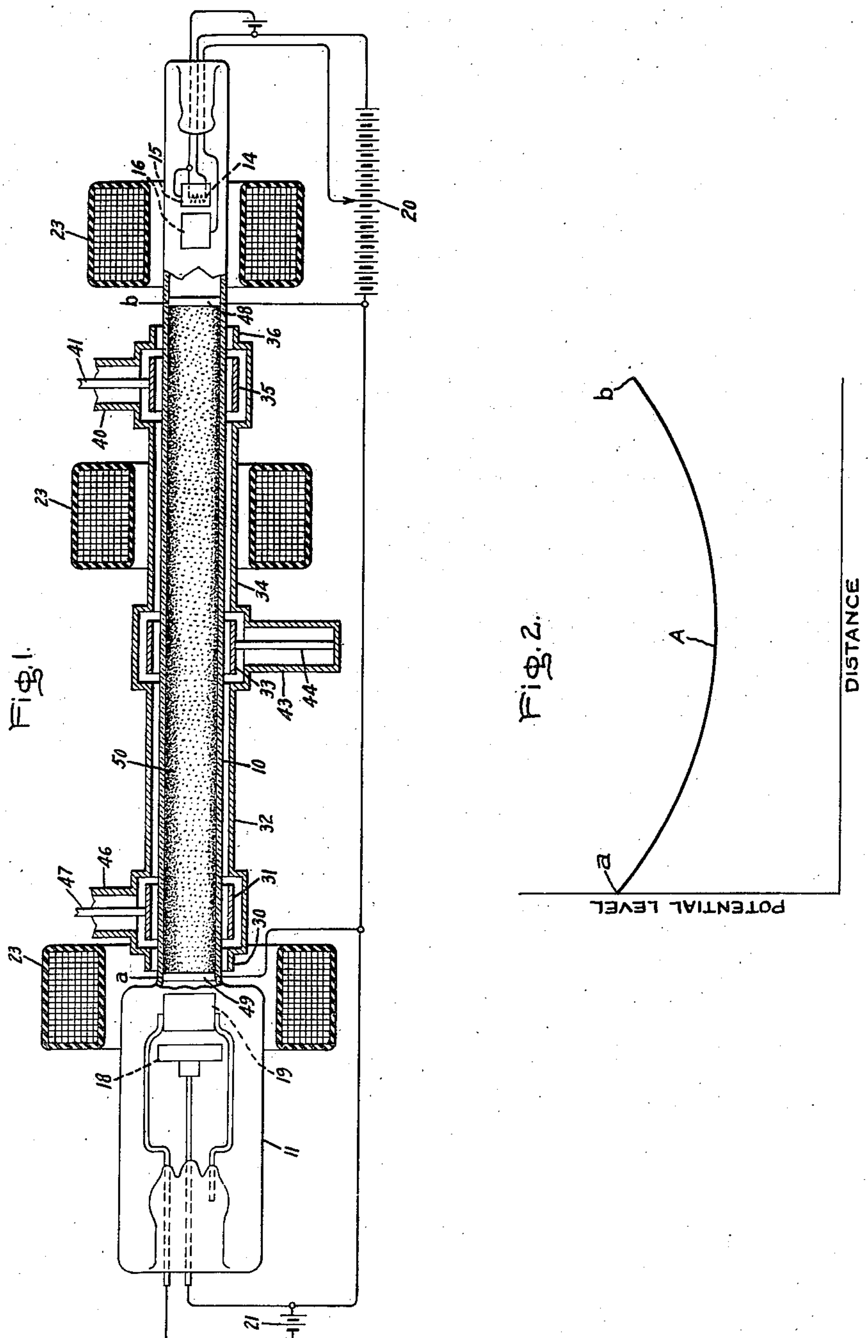

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ELECTRIC DISCHARGE DEVICE

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3 Claims. (Cl. 250—141)

The present invention relates to electric discharge devices and more particularly to cathode ray tubes and similar devices in which an electron beam is required to be projected through an elongated tubular envelope of glass or a similar insulating material.

In the operation of devices of the character referred to difficulty is frequently encountered due to the occurrence of wall-charging; that is to say, the accumulation of static charges on various portions of the envelope wall surface. Such charges tend to modify the potential distribution along the discharge path and may cause it to depart materially from the distribution normally maintained by the electrode elements of the device. An aspect of this phenomenon which is especially troublesome in the operation of beam tubes used as high frequency oscillators and the like lies in the occurrence of sporadic and unpredictable variations from time to time in the amount of wall-charging, so that unstable and uncertain operation results.

The difficulties stated in the foregoing may be overcome to a certain extent by arranging conductive electrode elements at the points at which objectionable wall-charging tends to occur. In many cases, however, this expedient is inconvenient in that the presence of the electrode elements and their lead-in connections interferes with the intended operation of the device as a whole.

It is an object of my present invention to provide means for avoiding the objectionable consequences of wall-charging by the use of non-conductive agencies. According to the invention this object is served by applying to the wall surface in question a finely divided insulating substance of a class which is typified by magnesium oxide, and the generic scope of which is indicated in the following.

The features which I desire to protect herein are pointed out with particularity in the appended claims. The invention, itself, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 shows in partial section a discharge device suitably embodying the invention and Fig. 2 is a graphical representation useful in explaining the invention.

Referring particularly to Fig. 1, I have chosen to illustrate my invention in connection with a discharge device adapted to be used as an amplifier for ultra high frequencies. The amplifier itself, apart from the particular improvement to be described herein, is the invention of W. C. Hahn and is fully disclosed and claimed by him in his application, S. N. 211,124 filed June 1, 1938 and assigned to the same assignee as the present invention.

The arrangement shown comprises an electron beam tube of the cathode ray type which includes an evacuated envelope having an elongated tubular portion 10. This portion, which is of uniform diameter along its length, connects at one end with an enlarged electrode-containing portion 11. The envelope is constituted of a low-loss insulating material such as glass or quartz, the latter substances being herein generically designated as "vitreous materials."

The tubular envelope portion 10 is provided at one end with means, such as a known type of electron gun, for producing an electron beam. The combination shown comprises a cathode 14, which is indicated in dotted outline, and a focusing cylinder 15 for confining the electrons emitted from the cathode to a concentrated beam. The cylinder may either be connected directly to the cathode as shown, or maintained a few volts negative or positive with respect to it. In order to accelerate the electrons to a desired extent there is provided an accelerating electrode 16 which is spaced from the cathode and which may be biased to a suitable positive potential, say, several hundred volts.

At the other end of the envelope there is provided an anode 18, which serves to collect the electron beam after it has traversed the tubular envelope portion 10. A ring-like electrode 19 in the nature of a suppressor grid serves to prevent secondary electrons emitted by the anode 18 from returning to the discharge space.

In the operation of the device the anode should be maintained at a potential one to several thousand volts above the cathode and the suppressor grid 19 should be biased fifty to several hundred volts negative with respect to the anode. These potential relationships may be established by means of suitable voltage sources conventionally represented as batteries 20 and 21. In order to maintain the beam in focus during its passage along the axis of the envelope one may employ a series of magnetic focusing coils such as are indicated by the numeral 23.

The combination of elements so far described comprises means for producing a unidirectional beam of electrons. Outside the envelope there is provided an electrode system for modulating the beam at high frequency and for abstracting power from the modulated beam.

The electrodes which make up the high frequency system include a series of sequentially arranged tubular conductive elements which concentrically surround the envelope and which are respectively numbered **30** to **36**. The tubular elements which have even numbers are solidly connected together and may thus be held at a common potential by connection to the positive terminal of battery **20**. The elements **31**, **33** and **35** on the other hand, constitute independent electrodes which are capable of varying in potential with respect to the fixed potential elements **30**, **32**, **34** and **36**. As is fully explained in the Hahn application S. N. 211,124 above referred to, the longitudinal dimensions of all the tubular elements are, by design, accurately correlated to the velocity of the electron beam traversing the envelope **10** and to the particular frequency at which the device is desired to operate.

In the use of the apparatus as an amplifier, high frequency potential is supplied to the electrode **35** through a concentric conductor transmission line comprising the conductive elements **40** and **41**. Due to the resultant potential gradients established at the gaps adjacent the electrode extremities, longitudinal modulation of the electron beam is produced. This modulation is intensified by the action of electrode **33** and an associated resonant circuit comprising concentric conductors **43** and **44**. It is finally reproduced in amplified form by the reaction of the modulated beam on the electrode **31**. From this electrode the resultant amplified voltage may be applied to output conductors **46** and **47**.

In the design of a system such as that described above it is ordinarily convenient to start with an intended beam velocity. The dimensions of the electrode parts and their spacings are then determined in such fashion as to be correlated to the assumed velocity. It is apparent, therefore, that in order that the intended operation of the device shall obtain, it is necessary that the beam velocity shall remain at all times at the assumed value.

To some extent the condition specified in the preceding paragraph can be realized by positioning conductive members **48** and **49** at the boundaries of the high frequency electrode system and by connecting such electrodes to a voltage which corresponds to the desired beam velocity. It is found, however, that without additional precautions, the occurrence of charging of the wall surfaces of the envelope tends to produce considerable variation of the potential distribution between the conducting members and thus to cause a departure of the average beam velocity from the desired value. The nature of this phenomenon is indicated graphically in Fig. 2, in which the curve A shows the variation of potential which may occur between the regions *a* and *b* (Fig. 1), where the potential level is definitely fixed by the presence of the conductive members **48** and **49**. Even more important than the mere existence of a potential variation due to wall-charging is the fact that the amount of such variation is not constant with time but tends to change in a sporadic and unpredictable manner. Consequently, the operation of the tube **10** as a high frequency device may become objectionably unstable. In some cases the magnitude and frequency of variation of the wall-charging may even be such as to cause a spurious modulation of the signal output of the device, such modulation corresponding to a noise component.

While it is theoretically possible to remedy this situation by providing additional internal electrodes at various points, along the axis of the envelope, it is frequently inexpedient to do this in connection with an electrode system of the type illustrated in Fig. 1. The difficulty referred to arises from the fact that it is objectionable to have bodies of conductive material arranged within the envelope at points where high frequency fields exist—lest the high frequency losses be increased to an insupportably high value. Moreover, in view of the presence of the high frequency electrode system, it is difficult to arrange lead-in connections for maintaining the intermediate electrode elements at a desired potential level.

In accordance with my present invention the more objectionable consequences of wall-charging are substantially eliminated in another way by coating the insulating surfaces where such charging is apt to occur with a finely divided non-conductor such as magnesium oxide. Thus, in the present connection, a coating of this kind may be applied as indicated by the stippled area **50** of Fig. 1. It has been especially observed that the application of such a coating to a surface of glass or quartz very markedly lessens the occurrence of instability traceable to wall-charging.

On the basis of the data now available and the known fact that wall-charging is mainly a secondary emission phenomenon, it is considered that the stabilizing effect just referred to may be due to the circumstance that magnesium oxide and related substances differ quite materially from glass and quartz in their secondary emission properties. More particularly, it is thought that the higher ratio of secondary emission to primary electron current exhibited by these substances tends to increase their potential stability in the presence of a high velocity electron stream.

In addition to magnesium oxide, other insulating substances of high secondary emissivity, including beryllium oxide and aluminum oxide may be alternatively employed. The substance utilized need not be a metallic oxide provided it is of insulating character and possesses secondary emission characteristics comparable to those of the materials named.

I prefer to use and have particularly referred to magnesium oxide, because of its great ease of application. In this connection it has proven convenient to develop the oxide by burning magnesium in air or some other oxygenous atmosphere and to project the resultant "smoke" (aerosol) into the vicinity of the glass or quartz surface desired to be coated. By this procedure the magnesium oxide particles may be deposited on and caused to adhere to the glass or quartz in the form of an extremely thin film.

A particular virtue of the potential stabilizing coatings described in the foregoing lies in the fact that their use does not involve the introduction of conductive masses within the discharge envelope. This is a material advantage in a device such as that shown in Fig. 1, for example, for the reason that the presence of conductive elements within the region bounded by the high frequency electrode system and especially in the vicinity of the electrode gaps would tend to produce an objectionable increase in the R. F. losses of the system. It is also advantageous that the coatings of my invention obviate the necessity for lead-in connections to be provided at inconvenient points as would be required if potential-fixing electrodes were to be employed.

It will be understood, of course, that the use of the invention is by no means limited to devices of the particular character shown in Fig. 1. On the contrary, it may be advantageously employed in any kind of beam tube operated at a sufficiently high voltage so that instability or other effects due to wall-charging are apt to occur. Therefore, while I have described a particular embodiment of the invention, I aim to cover in the appended claims all such equivalent applications as come within the true scope of the preceding disclosure.

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

1. A discharge device including means for projecting an electron beam along a path of substantial length, a non-conductive structure surrounding the beam path and constituted of vitreous material subject to wall-charging, conductive elements positioned in proximity to the interior surfaces of said non-conductive structure at spaced points along the beam path, means connecting with said conductive elements for fixing the potential of the said points at a level appropriate to the desired functioning of the device, and a superficial layer of a highly insulating substance covering interior surfaces of said non-conductive structure which are spaced from said conductive elements and at which wall-charging tends to occur, said substance being constituted of oxide of the group which includes the oxides of magnesium, beryllium and aluminum and serving the function of stabilizing the potential of the surfaces to which it is applied.

2. A discharge device comprising an elongated tubular envelope of vitreous material subject to wall-charging, means for projecting an electron stream through the envelope, conductive elements positioned in proximity to the interior surfaces of said envelope at spaced points along the envelope axis, means connecting with said conductive elements for fixing their potentials at a level appropriate to the desired functioning of the device, and a coating of a finely divided insulating substance applied to the interior surface of the envelope at regions displaced from said conductive elements, said substance being constituted of oxide of the group which includes the oxides of magnesium, beryllium and aluminum and serving to minimize the objectionable effects of wall-charging.

3. A discharge device comprising an elongated tubular envelope of vitreous material subject to wall-charging, means for projecting an electron stream through the envelope, means including electrode elements located at spaced points along the axis of the envelope for fixing the potential level at such points, and a coating of magnesium oxide applied to the interior wall surface of the envelope for minimizing the objectionable effects of wall-charging at regions displaced from said electrode elements.

VICTOR H. FRAENCKEL.