Aug. 6, 1940. W. ROGOWSKI 2,210,127

COLD CATHODE TUBE

Filed Dec. 7, 1935

Fig.1

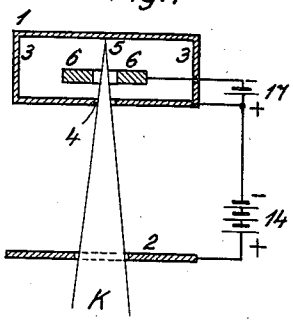


Fig.2

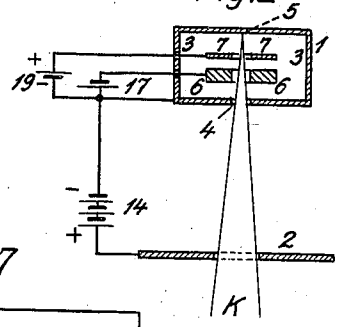


Fig.7

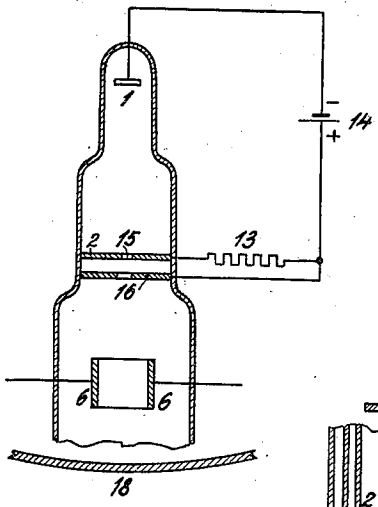


Fig.3

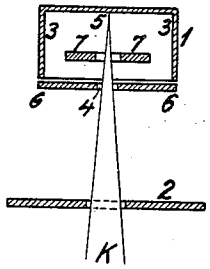


Fig.6

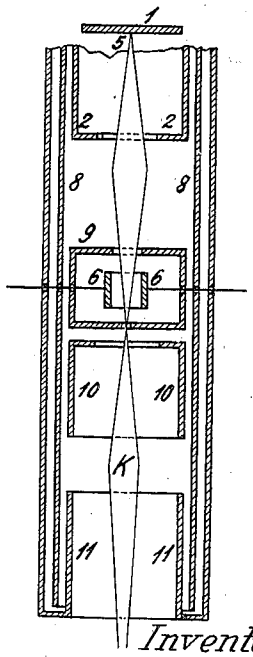


Fig.5

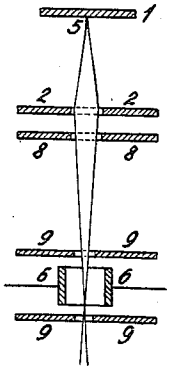
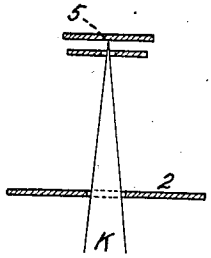


Fig.4



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Patented Aug. 6, 1940 2,210,127

UNITED STATES PATENT OFFICE

2,210,127

COLD CATHODE TUBE

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Application December 7, 1935, Serial No. 53,355

6 Claims. (Cl. 250—27)

In the operation of cold cathode tubes such as the electron or ion tubes employed in oscillographic and television or picture transmitting arrangements or in X-ray devices, for example, it is well known to deflect the electrons with respect to an annular diaphragm in order to vary the intensity of the cathode ray. In this way however not only the current density of the ray on the oposite side of the diaphragm but also the shape of the spot on the receiving screen is varied, this shape changing from a circular form to a crescentic one in the best possible case, if not as an additional result the spot is displaced. No other methods of varying the intensity of a ray of electrons have been proposed with regard to cold cathode tubes. In particular it has not been attempted in the case of cold cathode ray oscillographs or television tubes, for instance, to vary the intensity of the ray of electrons by varying the current density of the ray without altering the spot shape, as has been known with glowing cathode oscillographs for a long time.

The invention described hereafter shall enable such variations of intensity to be effected also in the case of cold cathode tubes. This is in accordance with the invention attained by varying the quantity of electrons conveyed to the space intended for deflecting the ray of electrons, such variation being accomplished by means of rotation-symmetrical energy fields acting in a field of a low velocity of the electrons. This arrangement has the advantage that the change from the maximum intensity to the minimum intensity is obtainable with the aid of voltages comparatively small and economical.

The invention will be understood from the following description and be particularly pointed out in the appended claims, reference being had to the accompanying drawing in which Figs. 1 to 7 are diagrammatic sectional views each showing an embodiment of the invention. Similar parts are denoted by the same reference numerals.

The simplest means of effecting the invention consists in making the cathode hollow so that it forms a sort of Faraday cage of a certain depth, and to dispose control electrodes in this cage which are of a rotation-symmetrical construction. These electrodes must have sufficiently large openings for the ions or electrons to pass through. Arrangements of this kind are shown in Figs. 1 to 3.

In the arrangement according to Fig. 1 the cathode 1 has a hollow 3 and towards the anode 2 an opening 4. K denotes the cathode ray. By 14, 17 two continuous voltage sources are designated. This arrangement may belong to a cold cathode ray oscillograph. The ions in consequence of the long free path they have to pass through, readily pass through the opening 4, as has been shown by the well known canal ray experiments. At the spot 5 where they hit against the inner surface of the cathode, electrons are released. The initial velocity of the electrons is low at first and in the hollow 3 remains low because the opening 4 is so narrow that the field of the anode 2 can only to a small extent penetrate through this opening. In consequence thereof a rotation-symmetrical control electrode 6 can by means of a comparatively small potential either drive back or extract the electrons released at 5, this depending on the polarity of the electrode, so that with the aid of such electrode an intensity regulation of the useful ray of electrons is possible without the spot-shape undergoing any change. Since the ions always have a comparatively high velocity they are not influenced by the small control voltages in a manner worth mentioning. The control fields are preferably electrostatic but may be also of the magnetic type.

It is desirable that the electrons arising at 5 be given a certain low velocity at first in order that the ray of electrons have an appropriate shape, that is to say, have not too large a top angle. To such end it is appropriate to employ not only a single control electrode but a number thereof and in such a manner that the electrons are in the first place given velocity and ray shape and that only after this they are given intensity fluctuations by means of a negative electrode or electrodes of a variable potential. In Fig. 2 the numeral 7 indicates the suction electrode, connected to the positive pole of a voltage source 19, while 6 again denotes the control electrode.

It may be advantageous to arrange the electrode 6 to form a wall of the Faraday cage or cathode 1. Such an arrangement is shown in Fig. 3.

As represented in Fig. 4, the cathode 1 may in the usual manner be plane or curved without being hollow. In such case it is only necessary to dispose the control electrodes in a sufficiently close proximity to the cathode 1 in order that low control voltages shall be sufficient.

Furthermore, with a cold cathode of the type shown in Fig. 4 the cathode ray may be so shaped as to be given a certain low velocity over a certain part of its length and to be readily con-

trollable therefore. To such end the electrons produced in a normal manner must pass through a rotation-symmetrical counter field. As is well known such an action also entails a concentration of the electrons. If then the electrons, concentrated and retarded in this way, pass through a rotation-symmetrical control electrode, they can here be modified in their intensity, as stated before, by means of a comparatively low voltage. Arrangements of this kind are illustrated in Figs. 5 and 6. The arrangement according to Fig. 5 is purely schematic whilst Fig. 6 in a diagrammatic representation shows a device adapted for practical purposes.

Either of these two arrangements has an electrode 8 that serves to produce the said rotation-symmetric counter field, and is provided also with annular diaphragms 9 between which the control electrodes 6 are located to which the variable control potential is conducted. The diaphragms 9 serve for limiting the control range. After the intensity regulation of the ray of electrons by means of the electrodes 6, the electrons may again be accelerated in a known manner. The diaphragms 9 shown in Fig. 6 are arranged to form a Faraday cage.

The diaphragms 9 must have a somewhat higher potential than has the cathode 1 in order to allow the electrons originating from this cathode to pass through. The electrodes 10, 11 are preferably connected to the same potential as the anode 2.

The arrangements described heretofore have still certain disadvantages which may sometimes be troublesome, which however are easy to overcome by means of the further invention.

In a number of practically important cases not only a variation of the quantity of electrons but also a variation of the output requires to be taken into consideration, that is to say a variation of the product of the number of electrons and the velocity of these. Such is the case for instance with television systems, the fluorescent screen mainly responding to this output, and is the case also with X-ray tubes. In cases of this kind the novel method of regulating the quantity of electrons can only be successful if the voltage source which is to supply the cathode-anode voltage is of such characteristic that with a variable number of electrons a sufficiently constant cathode-anode potential is produced. There are however voltage sources which when here employed tend to decrease the anode-cathode potential whenever the quantity of electrons is increasing, and to decrease this potential to such an extent that any effectual change in the said output will not occur. This drawback can be overcome, at least to a considerable extent, by connecting the tube to a voltage source that within certain limits with increasing load does not show a considerable drop of potential. In this case a resistance 13 (Fig. 7) must be interposed in the circuit comprising the anode and cathode, because otherwise the weak discharge of the tube may happen to turn into a strong discharge so as to destroy the tube (falling characteristic); but it will in general be possible to so dimension this smoothing resistance that although not the number of electrons but the said output is more or less impaired in its ability of being controlled, yet the result of controlling the output will be suitable for practical purposes.

In accordance with the further invention the output control may be improved considerably by interposing the resistance 13 between the anode 2 and the voltage source 14. Appropriately, the anode is provided with a narrow opening 15 which the ray of electrons is caused to pass through. In order to perform this, means for concentrating the ray may be used, such as the electrodes 8 shown in Figs. 5 and 6. After the anode a second annular diaphragm 16, likewise of a rotation-symmetrical construction, is disposed according to the invention. This diaphragm 16 is in direct connection with the positive pole of the voltage source 14 so that between cathode 1 and diaphragm 16 the entire voltage is active, whereas the voltage active between cathode 1 and anode 2 is smaller by the drop of potential due to resistance 13. On varying the quantity of electrons the potential difference which there is between anode 2 and diaphragm 16 acts to impart an additional velocity to the electrons so that on the receiving plate 18 not only the quantity of electrons but also the electronic output and thus the brightness is controlled to a full extent. The advantage of the arrangement is that the resistance 13 will prevent the discharge between cathode and anode from turning into a discharge richer in current. On the other hand however a discharge rich in current can likewise not arise between cathode 1 and diaphragm 16 because the narrow anode bore 15 forms a large resistance to the gas discharge.

The fundamental idea of the last described arrangement is that despite the fact that the quantity of electrons is variable and that further the anode-cathode voltage cannot be prevented from undergoing variations, an additional field is created by means of a second diaphragm 16, this field acting to compensate the variation to which the anode-cathode potential is subjected.

There are still other possibilities to carry this idea into effect. For example, the drop of potential due to resistance 13 may be used for controlling an electron tube which in its turn leads a suitably chosen voltage to the cold cathode tube by variation of the anode current, so as to care for a suitable potential difference between anode 2 and diaphragm 16. The arrangement represented in Fig. 6 however is the simpler means for neutralizing the drop of potential due to resistance 13.

As long as the anode-cathode discharge is purely self-acting the described means are not adapted to afford a large range of regulation or control. This is attributable to the fact that if the quantity of electrons is decreased by such regulation the conditions for the existence of a stable gas discharge are growing more and more unfavourable, so that finally the discharge is interrupted. As is well known all self-acting gas discharges have the property of being suddenly extinguished with a sufficiently small current. The use of smaller currents in this connection requires a very high voltage and very great resistances in series connection to be employed, whereby however the output regulation or control is rendered extremely difficult, as will be understood from the previous statements. But even then it will be seen that with a lower limit the discharge must stop, so that a new ignition must be brought about, the ignition voltages being in general much higher than the voltages of operation. This adds to the difficulties experienced under these circumstances when employing the described control or regulation method. A self-acting discharge is hence not suitable for a regulation effected within wide limits, such as deemed

necessary for instance in the case of television, picture transmission, X-ray purposes, etc.

It is well known however to operate cold cathode tubes by means of an auxiliary discharge. The further invention therefore proposes to employ such auxiliary discharge in combination with the novel method of controlling the quantity of electrons in order to enlarge the range of regulation in the case of cold cathode tubes. In this way the tube can be controlled also in the case of small current intensities and thus be used for television and similar purposes, such as picture transmission, X-ray purposes, etc.

What is claimed is:

1. A cold cathode tube comprising a cathode, means including a control electrode for producing a rotation-symmetrical field, said rotation-symmetrical field being disposed in the region of low velocity of the electrons to provide intensity control, and means in the immediate proximity of said control electrode between said electrode and said cathode for causing said electrons to pass through a common point whereby low velocity of said electrons is assured.

2. A cold cathode tube comprising a cathode having an emitting surface substantially perpendicular to the axis of said tube and extended from said surface to form a hollow cylinder, and an auxiliary control electrode within said cylinder producing axial-symmetrical fields operating substantially along the axis of said tube for controlling the intensity of the electrons emitted from said cathode.

3. A cold cathode tube arrangement comprising, a cathode means including a control electrode for producing a rotation-symmetrical field, said control electrode being disposed in the region of low velocity of the electrons for the purpose of intensity control, means in immediate proximity with said control electrode for causing said electrons to pass through a common point, a continuous voltage source adapted on variation of the current load to care for the variation of the cathode-anode voltage being small enough to enable the electronic output to be regulated, an anode operatively associated with the said cathode, and a resistance interposed between this anode and the positive pole of said voltage source.

4. A cold cathode tube arrangement comprising, a cathode means including a control electrode for producing a rotation-symmetrical field, said control electrode being disposed in the region of low velocity of the electrons for the purpose of intensity control, means in immediate proximity with said control electrode for causing said electrons to pass through a common point, a continuous voltage source adapted on variation of the current load to care for the variation of the cathode-anode voltage being small enough to enable the electronic output to be regulated, an anode operatively associated with the cathode and provided with a bore, a resistance interposed between this anode and the positive pole of said voltage source, and an annular diaphragm connected directly to this pole.

5. A cold cathode tube arrangement comprising, a cathode means including a control electrode for producing a rotation-symmetrical field, said control electrode being disposed in the region of low velocity of the electrons for the purpose of intensity control, means in immediate proximity with said control electrode for causing said electrons to pass through a common point, an anode operatively associated with said cathode, an annular diaphragm, this anode being located between this diaphragm and the cathode, a continuous voltage source, a resistance interposed between the positive pole thereof and the anode, and means for causing the drop of potential due to this resistance to generate a potential difference between said cathode and diaphragm.

6. A cold cathode tube arrangement comprising, a cathode means including a control electrode for producing a rotation-symmetrical field, said control electrode being disposed in the region of low velocity of the electrons for the purpose of intensity control, means in immediate proximity with said control electrode for causing said electrons to pass through a common point, and means for producing an auxiliary discharge in addition to the main discharge to be controlled.

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