

Aug. 5, 1958

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2,846,610

INDICATOR TUBE

Filed Dec. 7, 1956

2 Sheets-Sheet 1

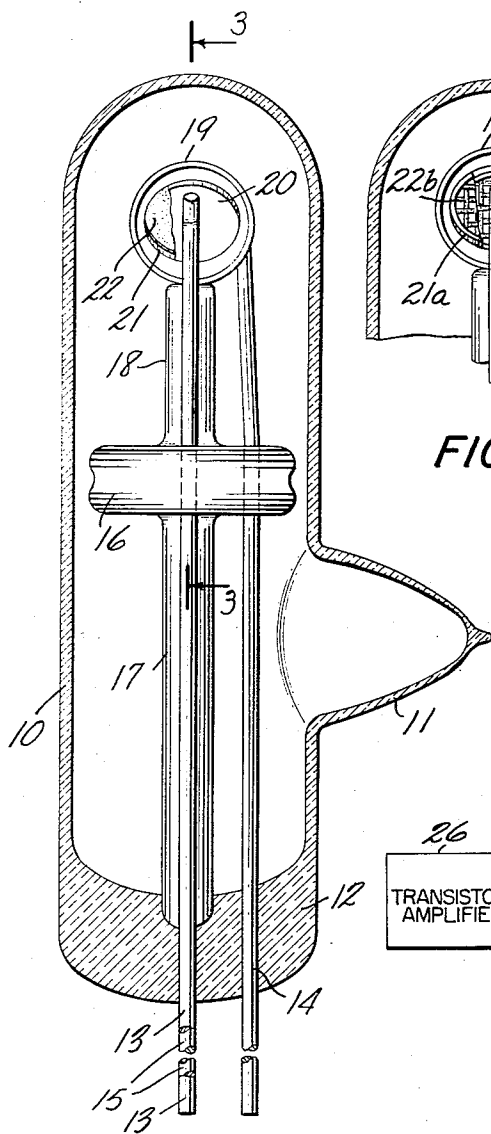


FIG. 1.

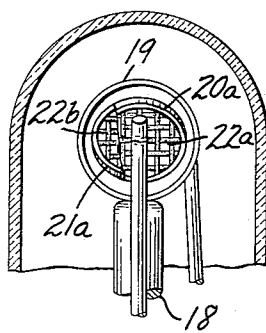


FIG. 1A.

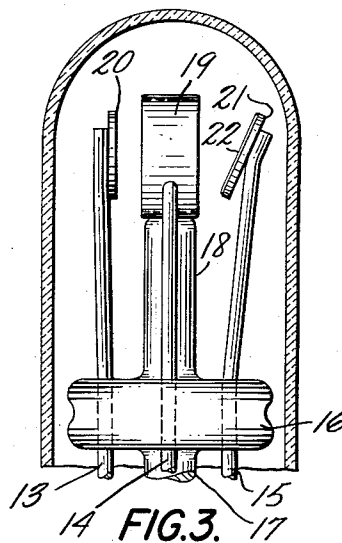


FIG. 3.

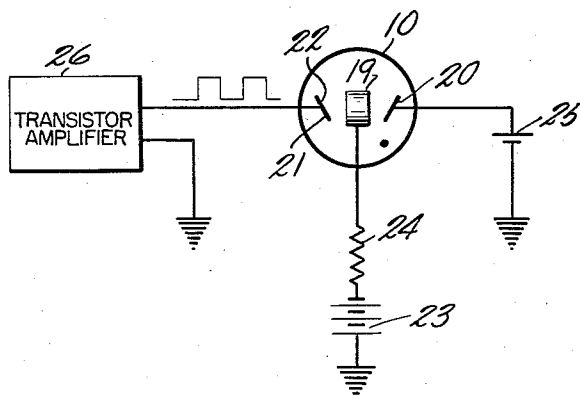


FIG. 2.

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2 Sheets-Sheet 2

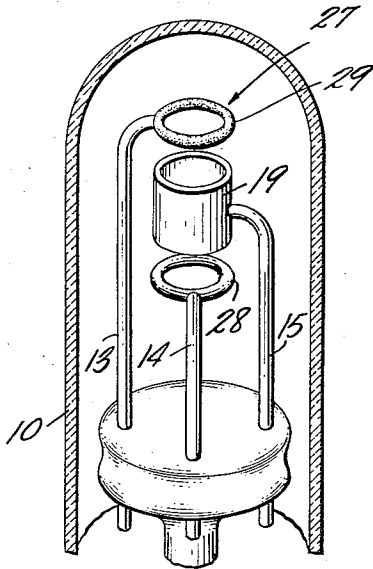


FIG. 4.

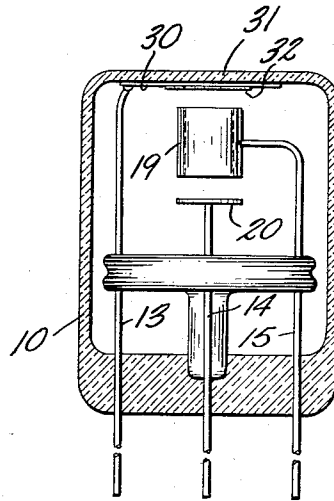


FIG. 5.

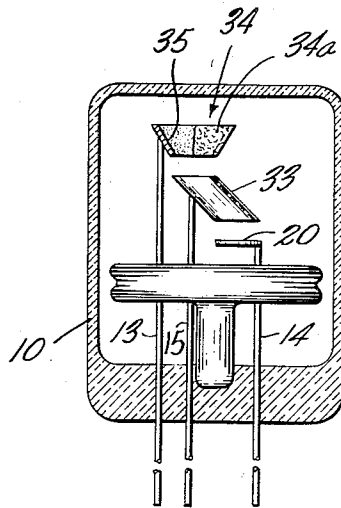


FIG. 6.

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Application December 7, 1956, Serial No. 626,988

19 Claims. (Cl. 313—108)

This invention relates to electron discharge indicator tubes.

Conventional on-off type indicator tubes requiring relatively high operating potentials cannot be used with devices such as transistors providing low voltage differentials. Accordingly, it is an object of the present invention to provide an electron discharge indicator tube operable by relatively low voltage output circuits.

It is another object of the invention to provide an indicator tube of the above character furnishing visible indications in one condition and being substantially dark in another condition.

It is a further object of the invention to provide an indicator tube having the above characteristics in which a glow discharge is selectively maintained between two of three related electrodes.

These and further objects of the invention are accomplished by disposing in an inert gas-filled envelope a hollow cylindrical cathode and two spaced anodes. A glow discharge initially maintained between the cathode and one anode may be switched to the other anode by low voltage signals, the second anode having a suitable phosphor deposited thereon to emit light when excited by an electron current flow.

In one embodiment of the invention, at least one anode may be inclined to facilitate emission of light through one end of the indicator tube. Alternatively, both anodes may be inclined and coated with different phosphors to emit light of different characteristics to indicate the tube's condition.

In other embodiments of the invention, the phosphor coated anode may take the form of a ring, a thin conductive layer on the interior of the indicator tube, or a cone shaped anode facing the end of the tube.

These and further objects and advantages of the invention will be more readily understood when the following description is read in connection with the accompanying drawings in which:

Figure 1 is an elevation, partially broken away, of an electron discharge indicator tube constructed in accordance with the principles of the present invention;

Figure 1A is a fragmentary elevation of an indicator tube similar to the tube of Figure 1 but having modified electrodes;

Figure 2 is a schematic circuit diagram illustrating one use of the tube shown in Figure 1;

Figure 3 is a fragmentary view of an electron discharge indicator tube similar to that shown in Figure 1 but with a modified arrangement of electrodes;

Figure 4 is an elevation of another electron discharge indicator tube in accordance with the principles of the present invention; and

Figures 5 and 6 illustrate further modified electron discharge indicator tubes.

Referring to an illustrative embodiment of the invention in greater detail with particular reference to Figure 1, an elongated glass envelope 10, evacuated and filled with an inert gas at a sealed opening 11, includes a thick

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lower portion 12 through which passes in sealed relation conductors 13, 14 and 15. A glass spacer 16 near the middle of the envelope 10 holds the conductors 13, 14 and 15 in a predetermined arrangement, further glass supporting columns 17 and 18 being disposed below and above the disc 16, if desired.

A hollow cylindrical or tubular cathode 19 attached by conventional means to the upper end of the conductor 14 may be formed, for example, of nickel, molybdenum, aluminum, nickel alloys or like material. A pair of disc shaped anodes 20 and 21 are spaced from the cathode 19 along its axis and inclined from a perpendicular to the axis. The spacing and angular inclination are not critical and may vary, the amount of inclination being sufficient to render the disc clearly visible over a wide angle through the tube end. The anodes 20 and 21 may be fabricated of nickel, molybdenum, aluminum, nickel alloys and similar materials in sheet or mesh form, for example.

A phosphor layer 22 deposited on the face of the anode 21 emits light when excited by a glow discharge electron current to provide a distinctive color for the indicator tube. Preferably the deposited phosphor is discontinuous to prevent it from functioning as an insulating layer.

When a common cathode and two anodes are properly spaced in a low pressure gas atmosphere and the tube fired by providing suitable potentials on the electrodes, a glow discharge will be maintained between the cathode and the anode carrying the highest positive potential. With the arrangement shown in Figure 1, it is possible to switch substantially all of the electron current from one anode to the other by driving it several volts more positive than the one anode.

For example, Figure 2 illustrates the tube 10 in a circuit which will switch the glow discharge from one anode to the other. The cathode 19 is coupled to a high negative source of potential through a current limiting resistor 24, the anode 20 being positively biased by a source 25 to a value of about one half the amplitude of signals supplied from an amplifier 26 to the anode 21. For example, the amplifier 26 may comprise a transistor circuit furnishing a five volt signal and in this instance, the source 25 may apply a positive bias of 2.5 volts to the anode 20. To complete the circuit, a 1.3 megohm resistor 24 may be used to limit current flow from the negative 350 volt source 23.

In operation, pulses from the circuit 26 will place the anode 21 at a potential 2.5 volts in excess of that found on the anode 20 causing the glow discharge to switch. As a result of such switching, the electron current will excite the phosphor layer 22 deposited on the anode 21 to indicate this condition of the tube 10. Upon cessation of a pulse from the circuit 26, the positive bias of 2.5 volts on the anode 20 results in switching of the glow discharge to its initial position.

If desired, a phosphor deposit different from that found on the anode 21 may be provided on the anode 20. With this arrangement, the tube 10 will glow with one color while it is in one state and another color while it is in its second state.

The inventive embodiment of Figure 1A incorporates this feature, as well as using anodes formed by mesh discs 20a and 21a. The mesh pattern has been somewhat enlarged for clarity. These anodes carry discontinuous deposits of different phosphors 22a and 22b, respectively, which emit light having different characteristics when excited by electron current, thereby clearly indicating the condition of the tube.

The specific phosphors deposited on the anodes 20 and 21 must emit sufficient light when excited by an electron current to provide indications clearly distinguishable one from the other. Zinc oxide phosphor provides a blue-green glow when excited by an electron current and in

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addition, this phosphor is relatively insensitive to stray electron currents which flow to it when the glow discharge is principally directed to the other anode. Willemitte phosphor also affords good results while other phosphors such as zinc silicate and other zinc compounds provide somewhat less distinguishable emitted light.

The type of inert gas in the envelope 10 and its pressure are also important factors to be considered in the indicator tube. Thus, the gas must provide a glow discharge with relatively little light emission so that it will not interfere with the indicating phosphor light. For example, neon gas is entirely unsuitable because it produces a glow discharge light of such intensity that it effectively masks the phosphor light.

The tube of Figure 1 functions most efficiently with krypton gas at 6 mm. pressure. It will be understood that this pressure can be varied over a substantial range, for example 1 to 15 mm. without rendering the tube inoperative. Furthermore, argon and xenon gas at pressures in the range of 1 to 8 mm. may also be employed in the inventive tube.

The electrode spacing in the indicator tube must also be carefully chosen to provide satisfactory switching at the low voltages encountered in transistor circuits, for example. A spacing of one sixteenth inch has been found suitable and in the particular embodiment of the invention shown in Figure 1, the anodes 20 and 21 are actually spaced .07 inch from the ends of the cathode 19 along its axis, the upper edges of the anodes being .1 inch distant and the lower edges .04 inch.

If the signal amplitude supplied to the indicator tube is adjusted to a value just large enough to cause switching action, an excellently shaped square hysteresis loop is found at frequencies as high as 2 kilocycles. Therefore, the tube may be used as a storage device with the current and signal amplitudes chosen to provide for the best square wave, switching not occurring until a predetermined threshold voltage is reached. If the tube is so used, primary transformer windings may be disposed in one or both anode circuits of Figure 2, the output pulse polarity indicating whether the tube is being switched "on" or "off."

A modified tube according to the present invention is illustrated in Figure 3. In this embodiment, the anode 20 is positioned perpendicularly to the axis of the cathode 19 to reduce to as great an extent as possible the amount of light from the glow discharge visible at the end of the envelope 10. Of course, this tube is not suited to the embodiment in which the anodes are coated with different phosphors.

Another embodiment of the invention is illustrated in Figure 4 in which elements similar to those found in Figure 1 are designated by like reference numerals. The cathode 19 is positioned between a pair of ring shaped anodes 27 and 28, the upper anode 27 being adjacent to the end of the envelope 10 and having a deposit 29 of zinc oxide phosphor thereon. These electrodes may be spaced as discussed in connection with Figure 1, the anodes being formed, for example, of a loop of .020 inch nickel wire having an inner diameter of .133 inch. It is evident that the glow discharge between the cathode 19 and the anode 28 in this tube is well shielded from the upper end of the tube through which light is emitted from the anode 27 when it receives electron current.

The indicator tube illustrated in Figure 5 includes the cathode 19 and anode 20 arranged similarly to Figure 3. However, the second anode comprises a thin conductive and transparent coating 30 on an upper flat surface 31 of the envelope 10, a phosphor layer 32 being deposited on the conductive coating. Therefore, light emitted from the phosphor layer 32 is visible through the end 31 of the envelope 10.

The indicator tube shown in Figure 6 uses an angled cathode cylinder 33 having at its lower end the anode 20, an anode 34 formed by a conical section having its

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small end facing the upper edge of the cathode. A layer of insulation 34a coats the outside of the anode 34 while its inside surface carries a deposit of phosphor 35 which, when excited, is clearly visible through the upper end of the envelope 10. Spacing of the electrodes is similar to that found in Figure 1.

It will be understood that the above-described embodiments of the invention are illustrative only and modifications thereof will occur to those skilled in the art. Therefore, the invention is not to be limited to the specific apparatus disclosed herein but is to be defined by the appended claims.

We claim:

1. An electron discharge indicator tube comprising an inert gas filled envelope enclosing a tubular cathode, a pair of anodes respectively spaced from the open ends of the cathode to support a glow discharge between one of the anodes and the cathode that may be switched to the other anode by a low potential difference between the anodes, and a phosphor deposit on one of the anodes which emits distinctive light when excited by the glow discharge electron current to indicate the condition of the tube.
2. An electron discharge tube as defined in claim 1 wherein the phosphor deposited anode comprises a disc inclined between 30 and 60 degrees from a perpendicular to the cathode axis.
3. An electron discharge tube as defined in claim 1 wherein the phosphor deposited anode comprises a ring substantially concentric with the cathode.
4. An electron discharge tube as defined in claim 1 wherein the phosphor deposited anode comprises a thin transparent conductive coating on an inner surface of the envelope.
5. An electron discharge tube as defined in claim 1 wherein the phosphor deposited anode comprises a hollow substantially conical section having its larger end facing an inner surface of the envelope and its smaller end substantially concentric with one end of the cathode, the outer surface of the anode being insulated and the inner surface carrying the phosphor deposit.
6. An electron discharge tube as defined in claim 5 wherein the cathode axis form an obtuse angle with the conical anode axis, the end of the cathode facing the conical anode being formed to be equidistant therefrom at every point on its periphery.
7. An electron discharge tube as defined in claim 1 in which different phosphors are deposited on the two anodes.
8. An electron discharge indicator tube comprising an inert gas filled envelope at a pressure between 1 and 8 mm. enclosing a tubular cathode, a pair of anodes respectively spaced from the open ends of the cathode to support a glow discharge between one of the anodes and the cathode that may be switched to the other anode by less than five volts potential difference between the anodes, and a phosphor deposit on one of the anodes which emits distinctive light when excited by the glow discharge electron current to indicate the condition of the tube.
9. An electron discharge tube as defined in claim 8 wherein the phosphor deposited anode comprises a flat disc inclined between 30 and 60 degrees from a perpendicular to the cathode axis.
10. An electron discharge tube as defined in claim 8 in which the phosphor deposited anode is formed of wire mesh.
11. An electron discharge tube as defined in claim 8 wherein the phosphor deposited anode comprises a ring substantially concentric with the cathode.
12. An electron discharge tube as defined in claim 8 wherein the phosphor deposited anode comprises a thin transparent conductive coating on an inner surface of the envelope.

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13. An electron discharge tube as defined in claim 8 wherein the phosphor deposited anode comprises a hollow substantially conical section having its large end facing an inner surface of the envelope and its smaller end substantially concentric with one end of the cathode, the outer surface of the anode being insulated and the inner surface carrying the phosphor deposit.

14. An electron discharge tube as defined in claim 8 wherein the cathode axis forms an obtuse angle with the conical anode axis, the end of the cathode facing the conical anode being formed to be equidistant therefrom at every point on its periphery.

15. An electron discharge tube as defined in claim 8 in which different phosphors are deposited on the two anodes.

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16. An electron discharge tube as defined in claim 8 in which the envelope contains krypton at a pressure between 5 and 7 mm.

17. An electron discharge tube as defined in claim 8 in which the envelope contains argon at a pressure between 3 and 5 mm.

18. An electron discharge tube as defined in claim 8 wherein the phosphor comprises zinc oxide phosphor.

19. An electron discharge tube as defined in claim 8 wherein the phosphor comprises willemite phosphor.

No references cited.