June 28, 1966 R. B. POWER 3,258,629

COLD CATHODE DISPLAY DEVICE WITH FLUORESCENT INDICIA ANODES

Filed Jan. 29, 1962

Fig. 1.

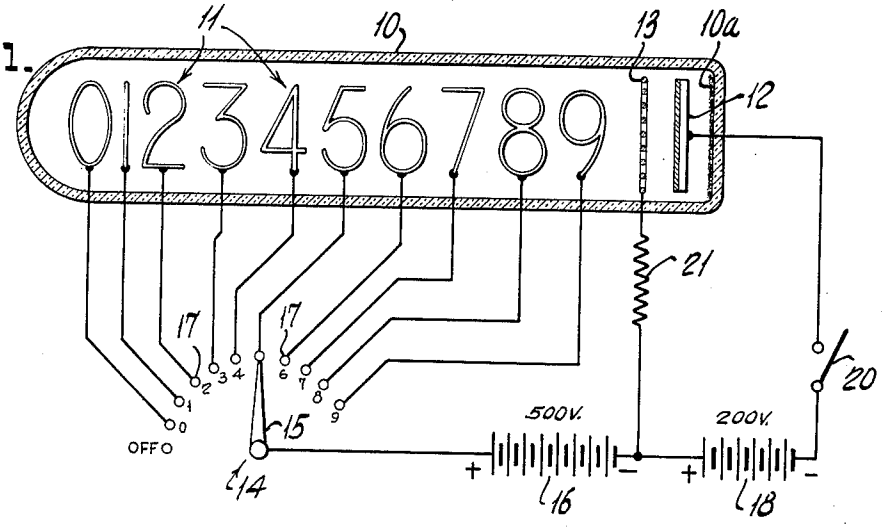


Fig. 2.

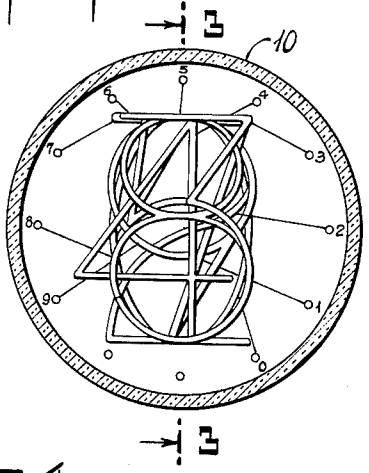


Fig. 3.

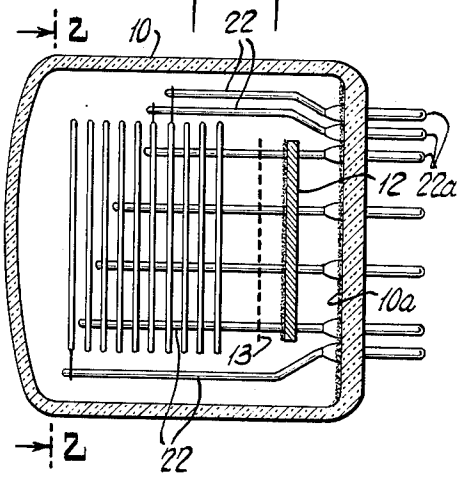
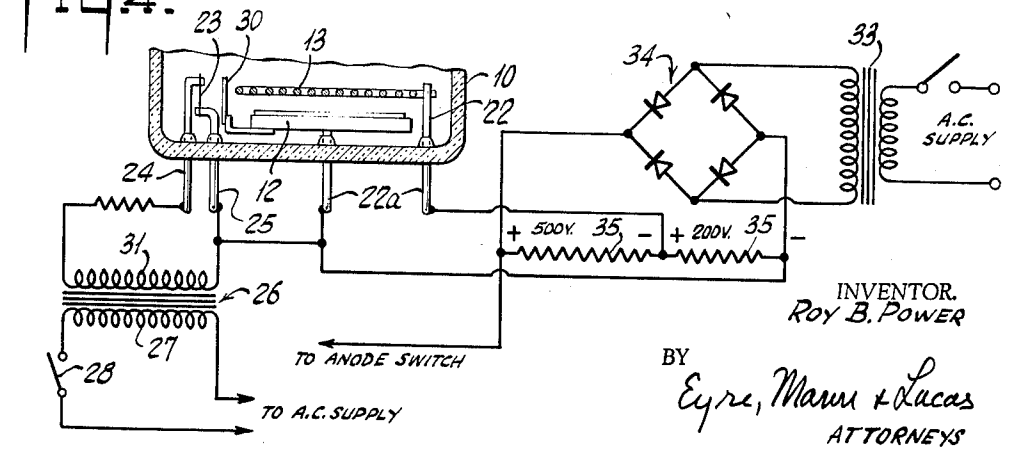


Fig. 4.



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United States Patent Office 3,258,629 Patented June 28, 1966

3,258,629

COLD CATHODE DISPLAY DEVICE WITH FLUORESCENT INDICIA ANODES

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Filed Jan. 29, 1962, Ser. No. 169,487
7 Claims. (Cl. 313—108)

This invention relates to a display device having a cold cathode which requires no heater power and produces electrons whenever an adjacent anode is supplied with high voltage. The invention has specific relationship to a display discharge device which includes a plurality of anodes formed in a distinct symbolic shape for visually indicating a circuit condition. The display may be formed in the shape of numbers, letters, or any other symbolic design.

Indicator tubes having display devices therein are old in the art and have been employed in various types of circuits for indicating circuit conditions. The types most generally used include a common anode and a plurality of cathodes formed with distinctive shapes to indicate digital values or letter symbols. These tubes have generally been filled with gas at a reduced pressure and have a short life due to the sputtering action of the material sputtered from the anodes. Applicant's tube, hereinafter described, employs a high vacuum and a cold cathode emitting surface which produces only electrons. All the displays are anodes and are covered with a fluorescent material which produces light when bombarded by a stream of electrons. Because of the electrode arrangement and the voltages employed, there is no sputtering action and hence no darkening of the tube. A sustaining electrode is employed to maintain the cathode in its electron emitting state.

One of the objects of this invention is to provide an improved display device which avoids one or more of the disadvantages and limitations of prior art arrangements.

Another object of the invention is to provide a digital display device which is efficient and which uses only a small standby current.

Another object of the invention is to lower the operating temperature of the device by eliminating the power consumed by a conventional cathode.

Another object of the invention is to increase the operating light of display devices by using only a stream of electrons as the light producing means and eliminating all gas discharge effects.

Another object of the invention is to eliminate darkening of the tube envelope by eliminating gas sputtering of the electrodes.

Another object of the invention is to provide a display device which can be designed to show characters in many different colors.

The invention includes an evacuated transparent envelope containing a plurality of anodes, a cold cathode, and a sustaining electrode. The anodes in this device are each formed in a distinctive symbolic shape, each including a conductor surrounded by a fluorescent coating which produces light when bombarded by an electron stream. The cathode in this device includes a supporting conductor covered with a layer of an oxide of a metal selected from the group which consists of aluminum, beryllium, and magnesium. The sustaining electrode is a grid generally formed with a wire mesh and spaced from the cathode surface.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

FIG. 1 is a schematic diagram of connections showing the display device with separated digit displays, an anode switch, a cold cathode, and electrical power supply means for operating the device.

FIG. 2 is a cross sectional view of the display device shown in FIG. 3 and is taken along line 2—2 of that figure. This view shows the display anodes and their respective lead-in conductors.

FIG. 3 is a cross sectional view of the display device taken along line 3—3 of FIG. 2 and shows how the anodes are mounted within the envelope in relationship to the cold cathode and the sustaining electrode.

FIG. 4 is a schematic diagram of connections indicating one means for starting the cold cathode.

Referring now to FIGS. 1, 2, and 3, the display device includes a transparent envelope **10**, a plurality of display anodes **11**, a cold cathode **12**, and a sustaining electrode **13**. The anodes are each connected to a lead-in conductor which in turn is connected to a control switch **14** or other circuit control device which can be employed to switch an anode source of potential to any one of the display anodes. In FIG. 1 the switching device includes a single rotatable arm **15** which is connected to an anode source of potential **16** which may be a direct current battery. Switch **14** also includes a plurality of contact points **17** which are connected to the display anodes inside the tube.

In this tube the electrons are furnished by a cold cathode **12** and its cooperating sustaining electrode **13**. The cold cathode **12** includes a supporting conductor on which is coated a thin layer of magnesium oxide or other oxide of an active metal selected from the alkaline earth metals. In order to initiate and sustain the electron emission from cathode **12** an additional source of potential **18** is connected between the cathode and the sustaining electrode in series with a starting switch **20** and limiting resistor **21**. The source of potential **18** may be a direct current battery having a terminal potential of approximately 200 volts. When this power source is connected between the cathode **12** and the sustaining electrode **13**, an electric field is set up between the two electrodes which is sufficient to draw electrons from the oxide coating and project some of them beyond the sustaining electrode into the anode space.

As shown in FIGS. 2 and 3, the display anodes **11** are supported by conductors **22** which are extensions of lead-in conductors **22*a*** extending beyond the lower surface of the envelope. Conductors **22*a*** are arranged for convenient connection to a socket and an external operating circuit. This means of support has been found to be sufficient for the display anodes enclosed in small envelopes. For larger envelopes and larger anodes it may be necessary to add additional supporting means such as glass insulator rods similar to those used as the supporting means for electron guns in cathode ray picture tubes. An additional support forms a means for securing the cold cathode **12** while another support is connected directly to sustaining electrode **13**.

It has been found that the illuminated portions of the anode can be made more readily visible and distinctive by applying a black insulating coating to the inside surface of the base. This coating, indicated at **10*a*** in FIGS. 1 and 3, may be spread on the base or it may be incorporated in the glass itself.

The anode wires **11** are conductive and can be made of copper or nickel or any other suitable substance. The wires are coated with a fluorescent material similar to the type used in picture screens of cathode ray receiving tubes. It is obvious that a wide range of colors is available to the tube designer and also different colors may be used in the same tube. For example, all the digit

figures from 1 to 9 may have a coating which produces a white light when connected in the circuit while the 0 character may show red when it is connected. Other combination of colors, depending upon the practical application desired, may be used.

FIG. 2 shows all the digits from 0 to 9, inclusive, stacked one on top of the other as they appear when not illuminated. When one of the anodes is connected in the circuit, the light it produces is sufficiently intense to shine through the unlighted display wires positioned between the lighted anode and the upper end of the tube so that the intervening wires can not be seen if the viewing distance is greater than one foot.

The cold cathode shown in FIGS. 1 and 3 requires a starting operation before it will emit electrons. There are several means of starting the electron flow, one of which is shown in FIG. 4. In this figure the cathode **12** is spaced from the sustaining electrode **13** and a filament of tungsten **23** is positioned between two lead-in conductors **24** and **25** so that a voltage applied to these terminals can be used to heat the filament and raise it to a temperature where it emits electrons. The power means for supplying current to the filament may comprise a transformer **26** having a primary winding **27** in series with a starting switch **28** which is connected to alternating current source. It has been found by experiment that an incandescent filament not only gives off electrons but also sputters off some molecular impurities and, because of this, a mask **30** is mounted between the filament **23** and the top surface of the cathode **12**.

When switch **28** is closed, current flows through the primary winding **27** and the secondary winding **31** heats filament **23** to cause it to give off electrons. The electrons travel around mask **30** and activate the magnesium oxide coating on the cathode, thereby starting electron emission between the cathode and the sustaining electrode. As soon as cathode **12** starts to emit electrons, filament **23** and its power supply may be disconnected. In FIG. 4 the potentials for the anodes and the sustaining electrode are derived from an alternating current supply. This supply is coupled through a transformer **33** to a bridge rectifier **34** and this direct current is applied to a voltage divider **35** which supplies both the anodes and the sustaining electrode with operating voltages.

A single cathode is generally sufficient to supply all the anodes with activating electrons but if the display is large and if there are a large number of characters within the transparent envelope, it may be necessary to mount additional cathodes along the sides of the tube in parallel alignment with the tube axis. Each of these cold cathodes must be supplied with its own sustaining electrode but all cathodes and all sustaining electrodes can be connected respectively to their own lead-in conductors.

The foregoing disclosure and drawings are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense. The only limitations are to be determined from the scope of the appended claims.

I claim:

1. A high vacuum display device comprising: an evacuated transparent envelope containing a plurality of anodes, a cold cathode, and a sustaining electrode; said anodes each formed in a distinctive symbolic shape and each including a conductor surrounded by a fluorescent coating which produces light when bombarded by electrons; said cathode including a supporting conductor covered with a layer of an oxide of a metal selected from the group consisting of aluminum, beryllium, and magnesium; said sustaining electrode comprising a mesh of conducting wires spaced from said cathode surface.

2. A high vacuum display device comprising: an evacuated transparent envelope containing a plurality of anodes, a cold cathode, and a sustaining electrode; said anodes each formed in a distinctive symbolic shape and each including a conductor surrounded by a fluorescent coating which produces light when bombarded by electrons; said cathode including a supporting conductor covered with a layer of magnesium oxide; said sustaining electrode comprising a mesh of conducting wires spaced from said cathode between the anodes and the cathode and substantially parallel therewith.

3. A high vacuum display device as claimed in claim **2** wherein each anode is respectively supported by an extension of the conductor thereof.

4. A high vacuum display device as claimed in claim **2** wherein the inner surface of a portion of said envelope is coated with a non-reflecting film.

5. A high vacuum display device as claimed in claim **2** wherein said layer of magnesium oxide is a porous coating.

6. A high vacuum display device as claimed in claim **2** wherein said cathode is supplemented by a starter electrode comprising a filament connected to two lead-in conductors, said filament positioned to one side of the cathode and arranged for injecting electrons into the cathode-sustaining electrode space when the filament is heated to an electron emitting temperature.

7. A high vacuum display device as claimed in claim **6** wherein a mask is positioned adjacent to said filament for preventing ions and molecular impurities given off by the filament from being deposited on the cathode surface.

References Cited by the Examiner

UNITED STATES PATENTS

2,842,706	7/1958	Dobischek et al.	313—108 X
2,957,098	10/1960	Bernstein	313—108
2,964,672	12/1960	Nixon	313—73 X
3,136,911	6/1964	Crawford et al.	313—109.5 X
3,201,634	8/1965	Weidel et al.	313—109.5

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