

[54] **LOW VOLTAGE COLD CATHODE
DISCHARGE TYPE DISPLAY DEVICES
WITH METAL OXIDE CATHODE AND
PHOSPHOR ANODE MATRIX**

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[51] Int. Cl. **H05b 37/00**

[58] Field of Search 340/166 R, 166 EL, 324 R,
340/324 M; 313/108 A, 108 B, 108 R, 109,
109.5; 315/169 TV

[56] **References Cited**

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[57]

ABSTRACT

A plurality of anode electrodes coated with a phosphor and cathode electrodes coated with an electron emissive substance are disposed at right angles on both sides of an insulative spacer having a plurality of perforations which are arranged in a matrix between a pair of substrates, at least one of them being transparent. Each anode electrode is arranged to face one column of the matrix and each cathode electrode is arranged to face one row of the matrix. The peripheries of the pair of substrates are sealed to form an envelope and the envelope is filled with an inert gas. Switching means is provided for applying an operating voltage across selected anode and cathode electrodes thereby causing the phosphor to luminescence at the cross-point between the selected anode and cathode electrodes.

5 Claims, 5 Drawing Figures

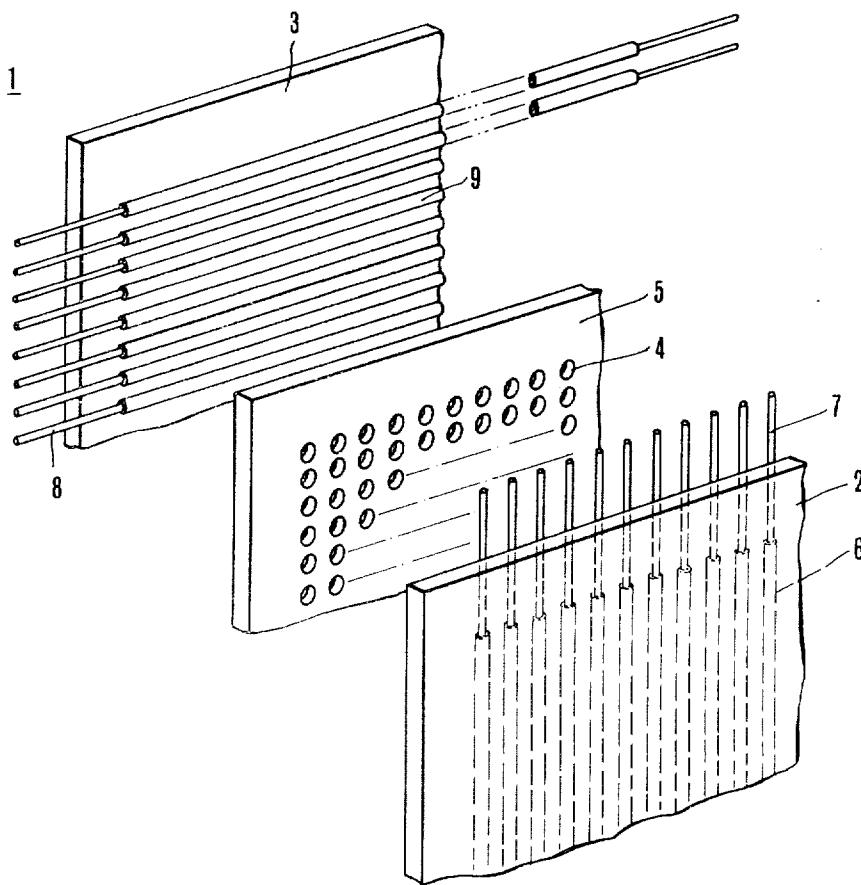


FIG. 1

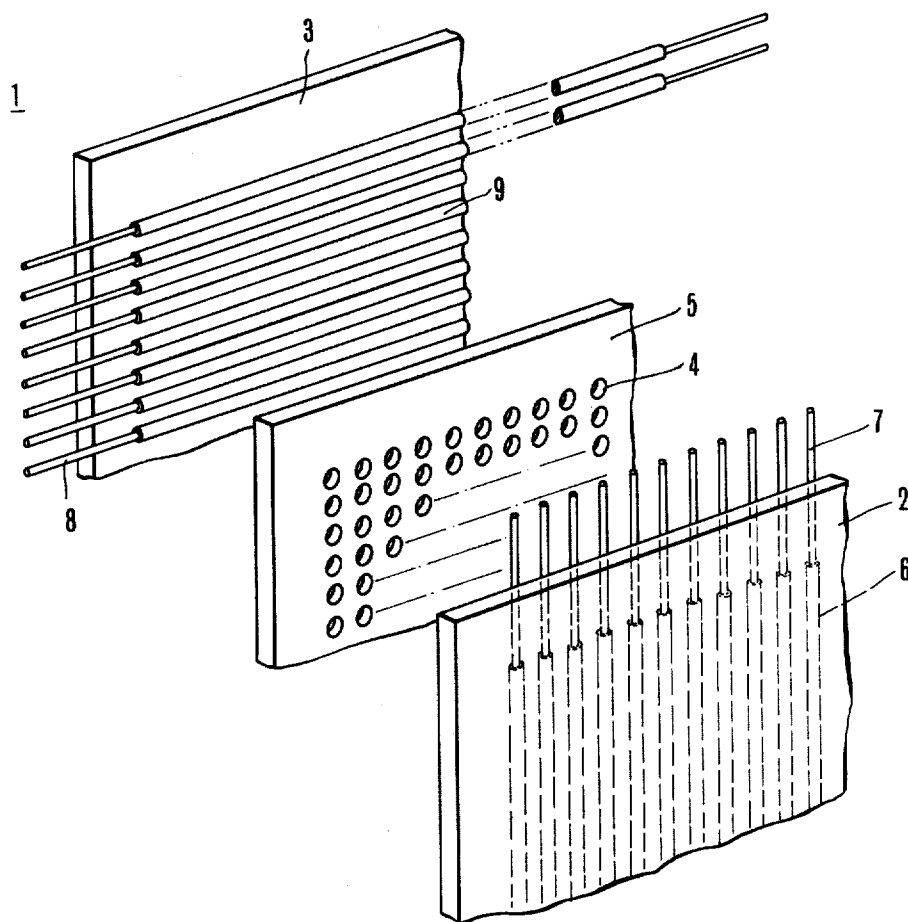


FIG. 2

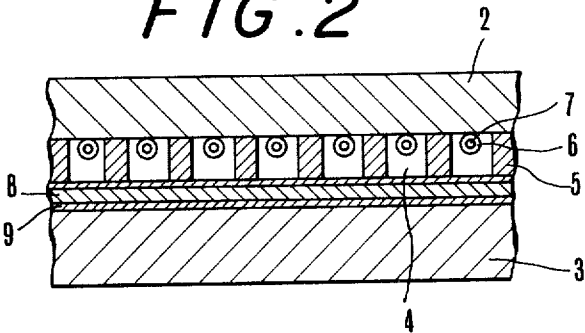
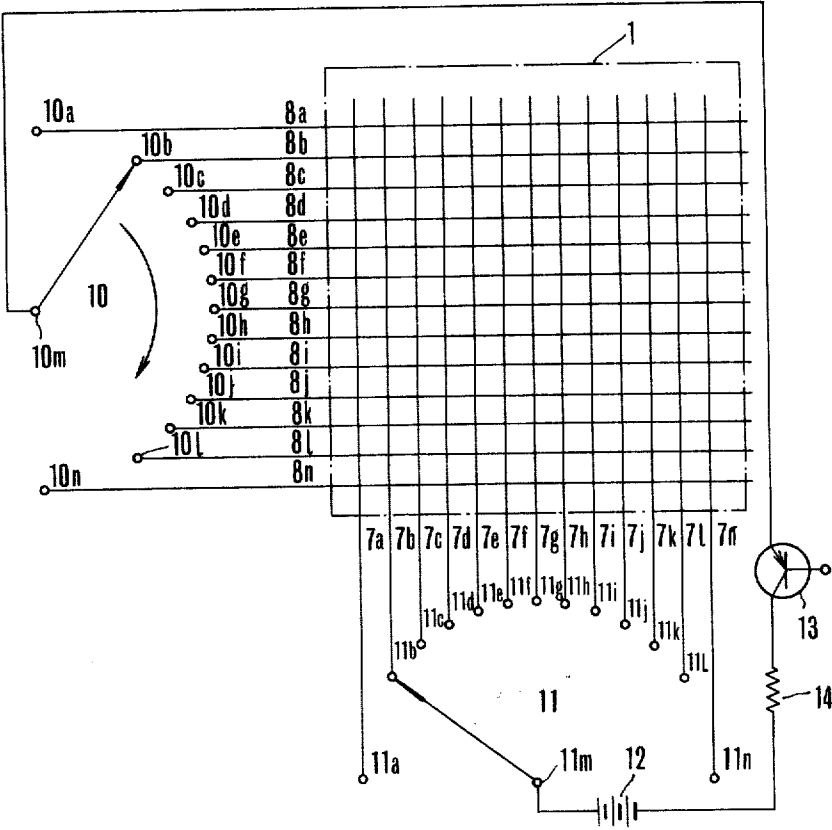


FIG. 3



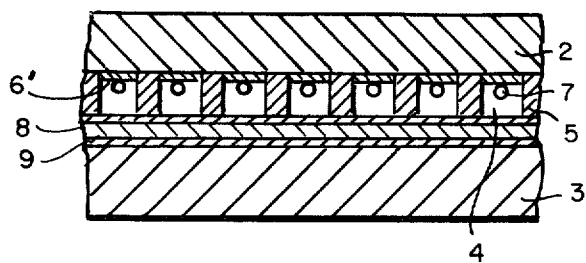


FIG.2A

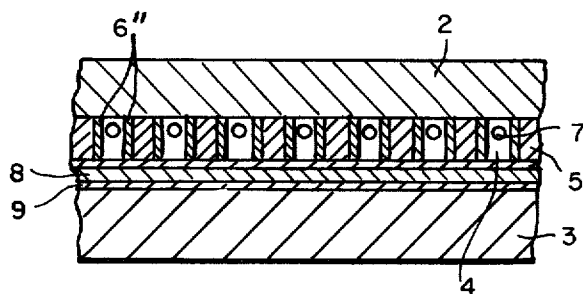


FIG.2B

LOW VOLTAGE COLD CATHODE DISCHARGE TYPE DISPLAY DEVICES WITH METAL OXIDE CATHODE AND PHOSPHOR ANODE MATRIX

BACKGROUND OF THE INVENTION

This invention relates to a cold cathode discharge type display device wherein a plurality of spaced apart cold cathode electrodes and a plurality of spaced apart anode electrodes are arranged in a matrix and selected cross-points between the electrodes are caused to discharge to display a desired pattern.

However, as the breakdown voltage or the discharge initiating voltage of the prior art cold cathode discharge display device is high, it is necessary to use a drive source of high potential of the order of 180 volts, for example, and it has been impossible to drive the display device directly by a transistor. Moreover, since in this type of the display device, display is made by the light of discharge, it has been impossible to obtain a variety of colours.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved cold cathode discharge type display device which can be driven by a low voltage and can produce a variety of discharge colours of high brightness.

In accordance with this invention, there is provided a cold cathode discharge type display device comprising a pair of substrates, at least one of them being transparent, an insulative spacer disposed between the pair of substrates and provided with a plurality of perforations which are arranged in a matrix, a plurality of cold cathode electrodes disposed between one substrate and the insulative spacer with each cold cathode electrode opposed to one row of the matrix, and electron emissive substance coated on respective cold cathode electrodes, a plurality of anode electrodes disposed between the other insulative substrate and the insulative spacer with each anode electrode opposed to one column of the matrix, means for hermetically sealing the peripheries of the pair of substrates thereby forming a sealed envelope, an inert gas sealed in the envelope, and means for applying an operating voltage across selected anode and cathode electrodes so as to establish electric discharge at the cross-point between the selected anode and cathode electrodes. A phosphor for emanating a selected colour is applied on respective anode electrodes, or on the inner surface of respective perforations or on the inner surface of the transparent substrate at portions thereof facing to the anode electrodes. The use of phosphor decreases the breakdown voltage of the display device and emanates a desired colour at a high brightness.

DESCRIPTION OF THE DRAWINGS

The invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective exploded view of certain essential elements of the cold cathode discharge type display device embodying the invention;

FIG. 2 is a cross-sectional view of a portion of the cold cathode discharge type display device shown in FIG. 1;

FIGS. 2A and 2B show modifications; and

FIG. 3 shows a connection diagram of the driving circuit utilized to operate the novel display device.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to FIG. 1 of the accompanying drawing, the cold cathode discharge type display device 1 shown therein comprises a pair of opposing insulative substrates 2 and 3, at least one of them being transparent, and an insulative spacer 5 disposed between the substrates and is provided with a plurality of perforations 4 arranged in a matrix. A plurality of anode electrodes 7 respectively coated with phosphor films 6 are arranged in parallel with each other between the upper substrate 2 and spacer 5 with each anode electrode opposed to a column of the perforations 4. The phosphor film 6 is a mixture, for example, of silicon oxide zinc and manganese ($\text{Zn}_2\text{SiO}_4 : \text{Mn}$), sulphate zinc and silver ($\text{ZnS} : \text{Ag}$), or sulphate cadmium zinc and silver ($\text{ZnCdS} : \text{Ag}$).

Similarly, a plurality of cold cathode electrodes 8 are disposed between the lower substrate 3 and spacer 5 with each cathode electrode opposed to a row of the perforations 4. As shown, cold cathode electrodes 8 and anode electrodes 7 intersect with each other at right angles. The cold cathode electrodes 8 are made of nickel wires or 42-6 alloy wires for the purpose of improving the bond with glass when the cathode electrodes are sealed with glass as will be described later. Further, to improve electron emission each cathode electrode is coated with a film of barium carbonate BaCO_3 , calcium carbonate CaCO_3 , strontium carbonate SrCO_3 or the like and these carbonates are converted into a film of oxide 9 of barium, calcium or strontium as will be described later.

After laminating these elements as shown in FIG. 2, the periphery of the assembly is sealed with a binder such as frit glass to form an envelope. Thereafter, the interior of the envelope is evacuated through a suitable exhaust pipe, not shown, and a voltage of about 8 volts, is impressed across respective cathode electrodes to cause them to generate heat. By this heating the barium carbonate, calcium carbonate or strontium carbonate is converted into a stable oxide 9. Then, an inert gas such as xenon, argon or mercury is introduced into the evacuated envelope thus completing the cold cathode discharge type display device 1.

When a voltage of 10 to 20 volts is impressed across selected ones of the anode and cathode electrodes 7 and 8, electric discharge will occur at the cross-points between the selected electrodes through a perforation 4 corresponding to the cross-point. The discharge excites the phosphor 6 on the anode electrode 7 at a portion corresponding to the particular cross-point thereby causing the phosphor to luminescence. The phosphor of a mixture of silicon oxide zinc and manganese ($\text{Zn}_2\text{SiO}_4 : \text{Mn}$), sulphate zinc and silver ($\text{ZnS} : \text{Ag}$), and sulphate cadmium zinc and silver ($\text{ZnCdS} : \text{Ag}$) luminescence in green, blue and red, respectively. Thus, it can be noted that perforations 4 in the spacer 5 act as discharge cells.

FIG. 3 shows a connection diagram of the driving circuit for the novel cold cathode discharge type display device. There is provided a first rotary switch 10 having a plurality of stationary contacts $10a$ through $10n$ which are connected to cold cathode electrodes $8a$ through $8n$, respectively, and a second rotary switch 11 having a plurality of stationary contacts $11a$ through $11n$ which are connected to anode electrodes $7a$

through $7n$, respectively, of the cold cathode discharge type display device 1. An electric source 12 is provided with its positive pole connected to the movable contact $11m$ of the second rotary switch 11 and its negative pole connected to the movable contact $10m$ of the first rotary switch 10 through a current limiting resistor 14 and a transistor 13. The first and second rotary switches are synchronized to operate stepwisely.

In operation, when a negative input signal is impressed on the base electrode of transistor 13, the transistor is rendered conductive to apply the voltage of the source 12 across one of the cathode electrodes $8a$ through $8n$ selected by the first rotary switch and one of the anode electrodes $11a$ through $11n$ selected by the second rotary switch 11 whereby the oxide 9 on the selected cathode electrode emits electrons. These electrons excite the inert gas in a corresponding discharge cell thus initiating discharge between the selected anode and cathode electrodes. Consequently, the phosphor 6 at the selected cross-point luminescences. When the rotary switch 10 is rotated while transistor 13 is conductive, the cross-points on respective rows are caused to luminescence successively.

In this manner, by applying to the base electrode of transistor 13 a signal which is synchronized with the operation of the second rotary switch 11 and corresponding to a desired pattern, respective cross-points are caused to selectively luminescence. If such selection is performed at such a high speed that can prevent flicker, it would be possible to display the desired pattern.

By changing the type of the phosphor 6 coated on the anode electrodes it is possible to display the pattern with different colours. Moreover, when compared with the prior art display device of the type wherein the light per se of the discharge is used to display a pattern it is possible to drive the display device with a lower voltage and yet to produce luminescence of higher brightness.

Instead of applying the coating of the phosphor on respective anode electrodes, the phosphor can also be applied to one substrate 2 as shown at $6'$ in FIG. 2A, or on the inner surfaces $6''$ of the perforations 4 as shown in FIG. 2B.

As above described, the invention provides an improved cold cathode discharge type display device having a low break-down voltage hence can operate with a low driving voltage of the order of 10 to 20 volts. Fur-

ther, in accordance with the invention as a phosphor is caused to luminescence by electrons emitted from cold cathode, it is not only possible to operate the display device at a lower voltage than the prior art display device but also to increase brightness.

What is claimed is:

1. A cold cathode discharge type display device comprising a pair of insulative substrates, at least one of the substrates being transparent, an insulative spacer disposed between said pair of substrates, said spacer being provided with a plurality of perforations which are arranged in a matrix, a plurality of cold cathode electrodes disposed between one substrate and said insulative spacer with each cold cathode electrode opposed to one row of the matrix, an electron emissive metal oxide coated on respective cold cathode electrodes, a plurality of anode electrodes disposed between the other insulative substrate and said insulative spacer with each anode electrode opposed to one column of the matrix, means for hermetically sealing the peripheries of said pair of substrates thereby forming a sealed envelope, an inert gas sealed in said envelope, and means for applying an operating voltage across a selected one of the anode electrodes and a selected one of the cathode electrodes so as to establish electric discharge at the cross-point between said selected anode and cathode electrodes thereby displaying a desired pattern.

2. The display device according to claim 1 wherein a phosphor is coated on respective anode electrodes.

3. The display device according to claim 1 wherein a phosphor is applied on the inner surface of the transparent substrate at least the portions thereof facing to said anode electrodes.

4. The display device according to claim 1 wherein a phosphor is coated on the inner surfaces of said perforations.

5. The display device according to claim 1 wherein said means for applying said operating voltage comprises a first rotary switch having a plurality of stationary contacts connected to respective cathode electrodes, a second rotary switch having a plurality of stationary contacts connected to respective anode electrodes, and a source of supply and a transistor which are connected in series across the movable contacts of said first and second rotary switches.

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