

[54] **ALPHA-NUMERIC CHARACTER DISPLAY DEVICE**

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**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 320,720, Jan. 3, 1973.

[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.**..... **340/378 R**, 313/108 D, 317/235 N, 340/336

[51] **Int. Cl.**..... **G08b 5/36**

[58] **Field of Search**..... 340/336, 378 R, 324 R; 317/235 N; 313/108 D; 178/5.4 EL, 7.3 D

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*Attorney, Agent, or Firm*—Hill, Gross, Simpson, Van Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

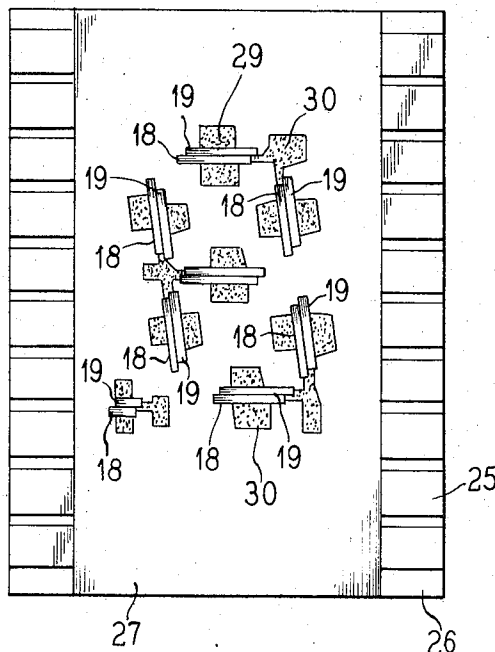
An alpha-numeric character display device which pro-

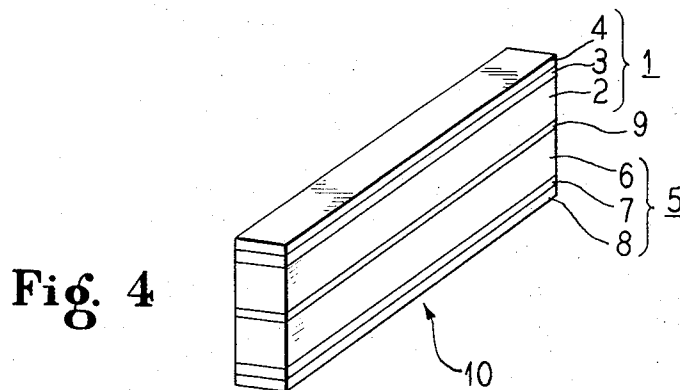
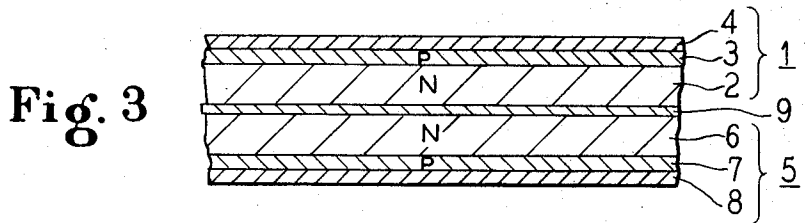
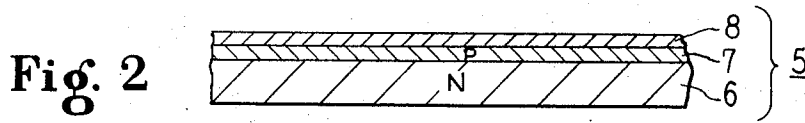
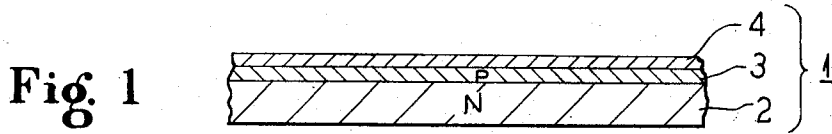
vides for the display of alpha-numeric characters in two or more colors or mixed colors. The characters are formed for example by a plurality of pairs of light emitting diodes mounted in a prearranged design on a surface of a transparent plate whose diode mounting surface side has formed thereon a plurality of conductive strips between which a layer of opaque insulating material is formed except for windows in which the diode pairs are located. Bridging strips are formed in a layer overlying the insulating layer which connect the electrodes of the diodes to their associated conductive strips for energization. Each bridging strip has associated therewith electrical contact means at one end which extends down through a window in the insulating layer adjacent an associated diode electrode into electrical contact therewith, while the other end has electrical contact means which extends down into electrical contact with its associated conductive strip.

The diodes of each pair have different color light emitting properties, such as red and green and the two diodes of a pair are sandwiched together with one single ohmic contact lying therebetween, while the other ohmic contacts of each pair are separate from each other and on opposite sides of the pair.

One convenient display array for an alpha-numeric character has light pairs of diodes arranged generally in a figure 8 pattern. The diodes may be individually selectively energized so that selected diode pairs may be made light emitting and additionally either one or the other or both diodes of each pair may be energized.

**8 Claims, 17 Drawing Figures**





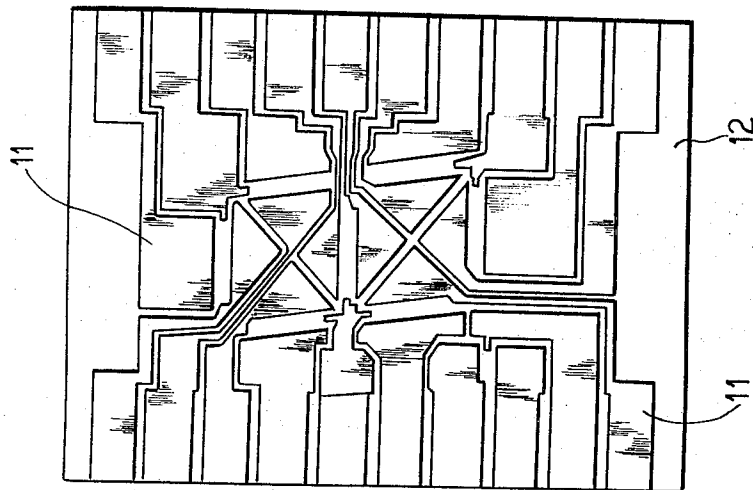


Fig. 5

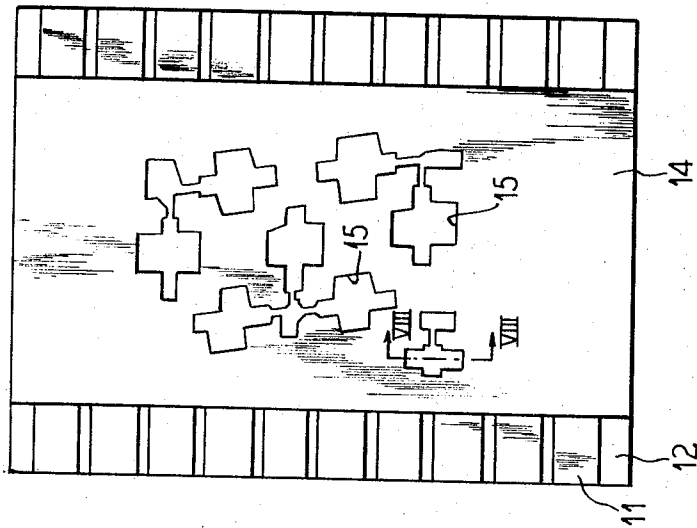


Fig. 7

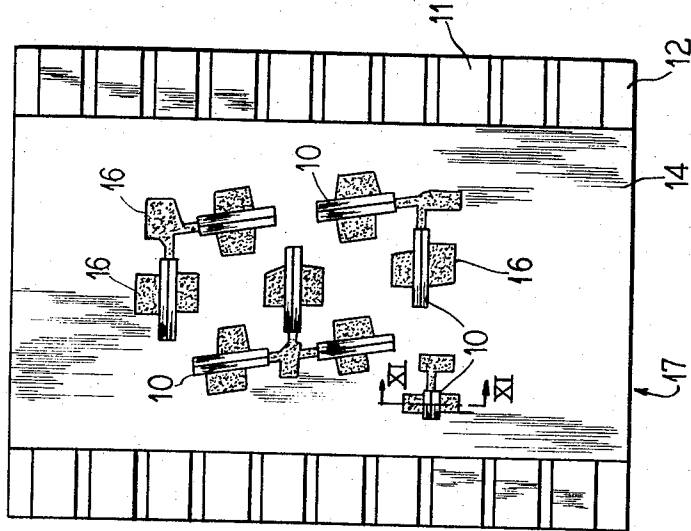


Fig. 10

Fig. 6

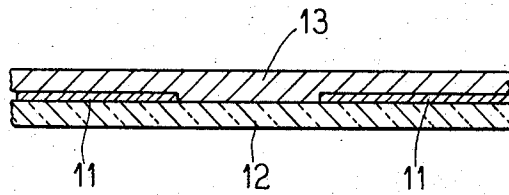


Fig. 8

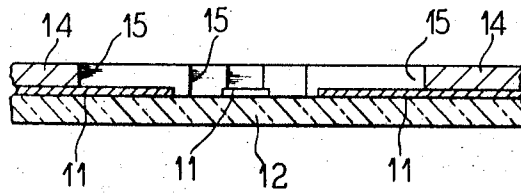


Fig. 9

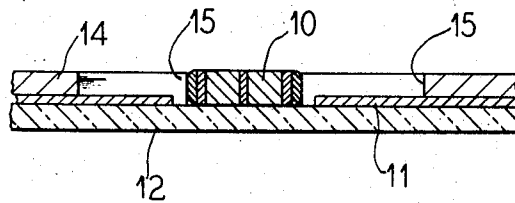


Fig. 11

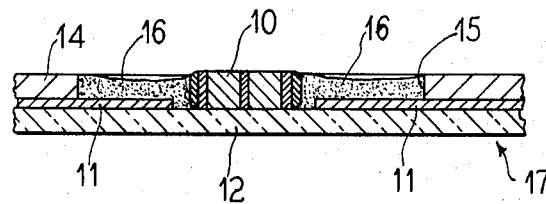


Fig. 12

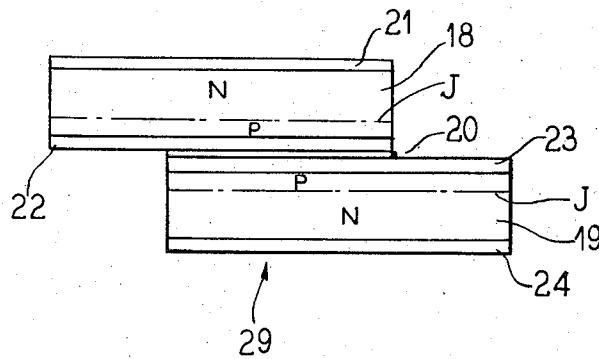




Fig. 16

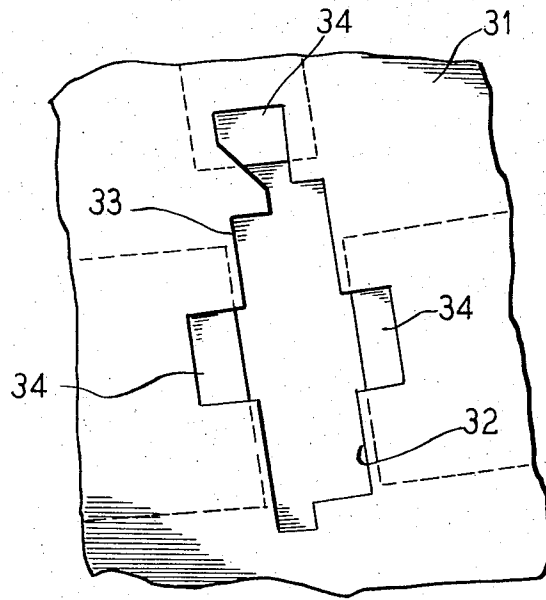
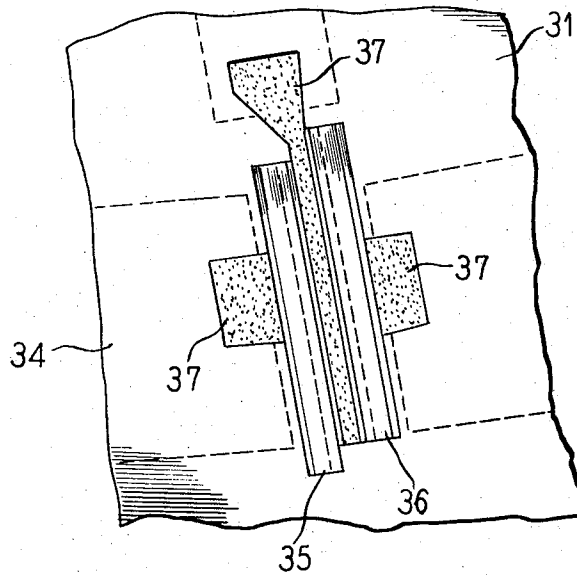


Fig. 17



## ALPHA-NUMERIC CHARACTER DISPLAY DEVICE

### CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my co-pending application, Ser. No. 320,720, filed Jan. 3, 1973, and assigned to the same assignee as the present invention.

### BACKGROUND OF THE INVENTION

Alpha-numeric character display devices have now come into rather extensive use. As the term is used, an alpha-numeric character display refers to a grouping of individual segments which form a numeral, a letter or some other sign. Typically such devices are formed in a glass envelope containing an ionizable gas with the segments formed as cathode elements and with one or more anodes associated with a group of cathodes to cause the segments to glow. One disadvantage of this type of device lies in the fact that it is difficult to get a sharp narrow line for each segment of the display.

Light emitting diodes are known. The emitted light from such a diode comes from hole-electron recombinations. In a solidstate light-emitting diode the supply of higher energy electrons is provided by forward biasing the diode, thus injecting electrons into the *n* region (and holes into the *p* region). The injected holes and electrons then recombine with the majority carriers near the junction. The recombination radiation is then emitted in all directions.

In one prior form of light emitting diode, an ohmic contact is formed on one whole surface of the diode, and another ohmic contact partially covers the opposite diode surface. In such an arrangement, the utilized light is, for the main part, obtained from light radiating from the surface of the pn junction having the smaller area ohmic contact. Such a diode is not suitable for use as an alpha-numeric character display without being encumbered by excessive bulkiness.

Light emitting diodes have been used in alpha-numeric character display devices in the past, and one such structure is disclosed in "Electronics," May 11, 1970.

In my aforesaid co-pending application, Ser. No. 320,720, a light emitting diode is disclosed in which the diode junction lies perpendicular to a transparent insulating surface such as glass. The diodes are mounted on the transparent insulating plate in such a pattern as to provide an array for an alpha-numeric character display. The diodes are selectively forwardly biased to provide the desired characters.

It is known in the past to provide light emitting diodes which will give off a red light and which will give off a green light, depending on the material of which the diode is formed.

### BRIEF SUMMARY OF THE INVENTION

The present invention provides an alpha-numeric character display which is selectively able to provide characters in either of two colors and to provide a mixture of the two colors. This is accomplished by sandwiching a pair of diodes together, one of which is able to radiate one color, and one of which is able to radiate another color and then mounting a plurality of the pairs of diodes in an array to provide different selected char-

acters from their respective pn junctions are forwardly biased. The sandwich making up each pair includes two pn junction diodes which have a conductive ohmic contact lying between them, and additional ohmic contacts on opposite outside surfaces. The semiconductor layer lying on immediately opposite sides of the intermediate ohmic contact may be the same conductivity type. Conductive leads to the ohmic contacts of the diodes are formed either directly on the transparent plate or on an opaque layer overlying one surface of the plate, there being a window provided through the opaque layer for each pair of diodes. An insulating layer covers the conductive leads. Bridge connections extend through the insulating layer to connect an ohmic contact with its associated lead. A further protective layer then preferably covers the upper surface of the assembly. Either one or the other of the diodes of a pair may be energized at one time, or both may be energized at the same time.

### DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 are fragmentary sectional views of light emitting diodes with one ohmic contact on one surface thereof;

FIG. 3 is a fragmentary sectional view showing the diodes of FIGS. 1 and 2 sandwiched together with an intermediate ohmic contact therebetween;

FIG. 4 is an isometric view of a diode pair;

FIG. 5 is a plan view of the upper surface of a transparent plate after conductive leads have been formed therein;

FIGS. 6, 8, 9 and 11 show a sequence of diagrammatic sectional views illustrating the formation of an alpha-numeric character display device embodying the preferred form of the present invention;

FIG. 7 is a plan view of the transparent plate, the conductive leads, and the insulating layer after the latter has been laid down on the former;

FIG. 10 is a plan view of a plate after eight light emitting diode pairs have been mounted thereon in a preferred form of array; and

FIGS. 12 to 17 illustrate a modified form of the present invention which provides a somewhat improved alpha-numeric character display device.

### DESCRIPTION OF A PREFERRED EMBODIMENT

The structure of the alpha-numeric character display device of the present invention will best be understood by reference to the method by which it is made. In FIG. 1 of the drawings, a light emitting diode 1 is shown having an n-type layer 2, a p-type layer 3, forming a pn junction therebetween, and an ohmic contact 4 overlying the p-type layer 3.

In FIG. 2, a second light emitting diode 5 is shown having an n-type layer 6, a p-type layer 7, forming a pn junction with said n-type layer, and having an ohmic contact 8 overlying the p-type layer 7. It is to be understood that the light emitting diode 1 of FIG. 1 emits one color light such as green, and the like emitting diode 5 of FIG. 2 emits a different color light such as red. The diode 1 is adhered to the diode 5 by a conductive resin 9 which lies between the two n-type semiconductor layers 2 and 6. This conductive resin 9 may be an epoxy resin with silver powder dispersed therein. One resin of this character available on the market is "OHMEX AG" (trade name of Pransene Co. Institute). Another

suitable conductive resin is "EPOTEK H-31" (Trade name). The conductive resin should be one which becomes hard by heating at approximately 100°C. for about 3 hours.

Thereafter, the combined wafer is cut with a diamond saw to separate it into a plurality of light emitting pairs 10 as shown in FIG. 4.

The light emitting diode pairs are now assembled into an array as illustrated in FIGS. 5 to 11. As shown in FIG. 5, a plurality of conductive layers 11 are formed in a single plane on a transparent glass plate 12 by vapor depositing aluminum, by vapor depositing copper on the aluminum layer, and then photo etching them to provide the desired pattern as illustrated in FIG. 5.

A photo sensitive resin 13 which is readily available under the trade name "SONNE KPM 1027", colored by a blue dye so as to be opaque from the light emitting diode, is then coated on the glass plate 12 shown in FIG. 6. The photo sensitive resin 13 is then selectively exposed to light through an optical mask (not shown) having a predetermined pattern and is then developed to form an insulating layer 14 as shown in FIGS. 7 and 8. The insulating layer 14 has four windows 15 for holding light emitting diode pairs and for receiving a conductive resin. Eight light emitting diode pairs 10 of the type shown in FIG. 4 are positioned in the windows 15 and secured to the glass plate 12 by an adhesive or a photo sensitive resin such as "SONNE KPM 1027" exposed from the glass plate side as shown in FIG. 9.

A conductive resin such as an epoxy resin with silver powder dispersed therein or a silver paint is poured into the windows 15 and headted to form a conductive layer 16 for electrically connecting ohmic contacts 4 and 8 and the conductive resin 9 of the diode pairs 10 to the conductive layers 11 respectively so that an alpha-numeric character display device 17 is obtained, as shown in FIGS. 10 and 11.

The device 17 may be coated with a protective resin to prevent deterioration of the diode pairs 10.

The alpha-numeric character display device 17 can display numerals or other characters in red, green and yellow colors by selectively energizing the diodes 1 and 5 of the light emitting diode pairs 10.

In the aforesaid described embodiment, a common lead of the light emitting diode pair 10 is connected to the conductive resin layer 9. Under some circumstances, this presents some difficulty, but such difficulty may be overcome by the process shown in FIGS. 12 to 17 which illustrates a second preferred embodiment of the invention. First, referring to FIG. 12, there is shown therein a light emitting diode pair 29 comprising two light emitting diodes 18 and 19 which are combined by a conductive resin 20. Diode 18 has a pair of ohmic contacts 21 and 22 and diode 19 has a pair of ohmic contacts 23 and 24. It will be observed that the two diodes making up the pair are staggered with respect to each other so that part of the ohmic contact 22 and part of the ohmic contact 23 is exposed which facilitates connection thereto by a conductive resin.

A plurality of conductive layers 25, as shown in FIG. 13, are formed on a transparent glass plate 26. The pattern of the conductive layers 25 is slightly different from that shown in the embodiment of FIG. 5, since this is necessary, due to the staggered arrangement of the diodes in each pair. An insulating layer 27 is formed on the glass plate 26, as shown in FIG. 14, which has

four windows 28 similar to those of the example shown in FIG. 7. Eight light emitting diode pairs 29, of the type shown in FIG. 12, are positioned in the windows 28. Thereafter, a conductive resin is poured into the windows 28 to form conductive layers 30 for electrically connecting the ohmic contacts 21, 24 and 22 or 23 to the conductive layers 25, respectively. In this embodiment, the light emitting diode pairs 29 are arranged as shown in FIG. 15, so that the size of a displayed character or the diodes 18 in one color is equal to that displayed by the diodes 19 in the other color. It will be appreciated that in this embodiment the distance between the pn junctions of the light emitting diodes 18 and 19 can be reduced without a short. This makes this arrangement very convenient to use for a display in mixed color, for example, yellow.

In the above embodiments, a plurality of light emitting diode pairs 10 or 29 are positioned in the windows 15 or 28, but it will be appreciated that it is also possible to position two kinds of light emitting diodes in a window and then to connect the light emitting diodes to each other by a conductive resin for connecting ohmic contacts to conductive layers. This may be accomplished as follows. An insulating layer 31 having windows 32 is formed on a glass plate 33 with a plurality of conductive layers 34 thereon, as shown in FIG. 16. Light emitting diodes 35 and 36 are positioned in the windows 32 and then a conductive resin is poured into the windows 32 and between the diodes 35 and 36 to form conductive layers 37 for combining both diodes 35 and 36 and for connecting electrically the diodes 35 and 36 to the conductive layers respectively.

It will be well understood that many variations and modifications could be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim as my invention:

1. An alpha-numeric character display device comprising a plurality of first and second light emitting diodes having two electrodes and pn junction respectively, an insulating layer having a plurality of conductive layers lying in a single plane thereon, said first and second light emitting diodes being mounted on said insulating layer with their pn junctions disposed perpendicular to the plane of said insulating layer and arranged in an array for at least two kinds of alpha-numeric displays, said first and second light emitting diodes emitting different color light respectively and being juxtaposed to each other, and means for connecting each of said electrodes of said first and second light emitting diodes to a different one of said conductive layers respectively.

2. An alpha-numeric character display device comprising a plurality of characters each made up of a plurality of segments in a pre-arranged design, each of said segments of said device being made up of a pair of side-by-side arranged light emitting diodes, each diode having outer ohmic contacts on opposite surfaces thereof, and the two diodes of each pair being sandwiched together with an electrode therebetween in electrical contact with the inner ohmic contacts of the diodes of a pair, a transparent plate upon which said diodes are mounted with their pn junctions perpendicular to said plate and a plurality of conductive strips electrically connected to said electrodes and to the outer ohmic contacts of each pair respectively, said diodes being individually selectively energizable.

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3. An alpha-numeric character display device comprising a plurality of characters each made up of a plurality of segments in a pre-arranged design, each of said segments of said device being made up of a pair of side-by-side arranged light emitting diodes each diode having one electrode which is common to both and forming a single layer sandwiched between said diodes, and having two additional electrodes one for each diode respectively which cover the outer surfaces of said diodes respectively remote from the diode junction, a transparent plate upon which said diodes are mounted with their pn-junctions perpendicular to said plate, and a plurality of conductive strips formed on said transparent plate and electrically connected to said electrodes, said diodes being individually selectively energizable.

4. A device according to claim 3, in which the diodes of each segment have different light emitting colors.

5. A device according to claim 3, in which one diode of each segment emits red light and the other diode of each segment emits green light when selectively ener-

gized.

6. A device according to claim 5, in which the size of the display characters in one color are the same as the size of the display characters in the other color.

7. A device according to claim 3, in which the diodes of each pair are partially staggered lengthwise with respect to each other but of the same length.

8. An alpha-numeric character display device comprising a transparent insulating layer having a plurality of first and second light emitting diodes mounted thereon with their pn-junctions disposed perpendicular to the plane of said layer and arranged in an array for at least two kinds of alpha-numeric character displays, said first and second light emitting diodes emitting different color light respectively, conductive strips formed on said transparent layer providing means for connection to said diodes, and means for selectively forwardly biasing different ones of said first and second light emitting diodes.

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