# United States Patent [19]

**Towne et al.**

[11] **3,918,053**

[45] **Nov. 4, 1975**


[54] **DIGITAL DISPLAY**


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[73] Assignee: **Dialight Corporation,** Brooklyn, N.Y.



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[21] Appl. No.: **385,649**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 268,717, July 3, 1972, abandoned.

[52] **U.S. Cl.** ..... **340/380;** 340/336

[51] **Int. Cl.** ..... **G09f 9/32**

[58] **Field of Search** ..... 340/336, 324 R, 324 M, 340/380, 378 R



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*Assistant Examiner*—Marshall M. Curtis
*Attorney, Agent, or Firm*—Frank R. Trifari; David R. Treacy



[57] **ABSTRACT**

A digital display device of the line segment type for displaying on a face plate illuminated characters of an alpha-numeric type. The device is generally formed of a housing having a front surface which is covered by a face plate provided with a plurality of slots forming line segments for forming the alpha-numeric display to be illuminated. The housing is formed by injection molding and is provided with a plurality of sockets for receiving light producing elements for selectively illuminating a particular arrangement of the slots on the face plate. An arrangement of light emitting diodes of the gallium phosphide or gallium arsenide phosphide types are mounted on a lamp board and assembled with one of the light emitting diodes accommodated within each of the sockets in the housing. A printed circuit board is connected to the lamp board and carries an arrangement of current limiting resistors and driving circuits which are electrically connected to the light emitting diodes for selective energization of a particular diode or combination of diodes. A lens element is carried within each of the sockets and is provided with a raised portion extending into the line segment slots on the face plate so that when the respective light emitting diode is energized the lens will produce uniform illumination of the particular slot.


**7 Claims, 11 Drawing Figures**

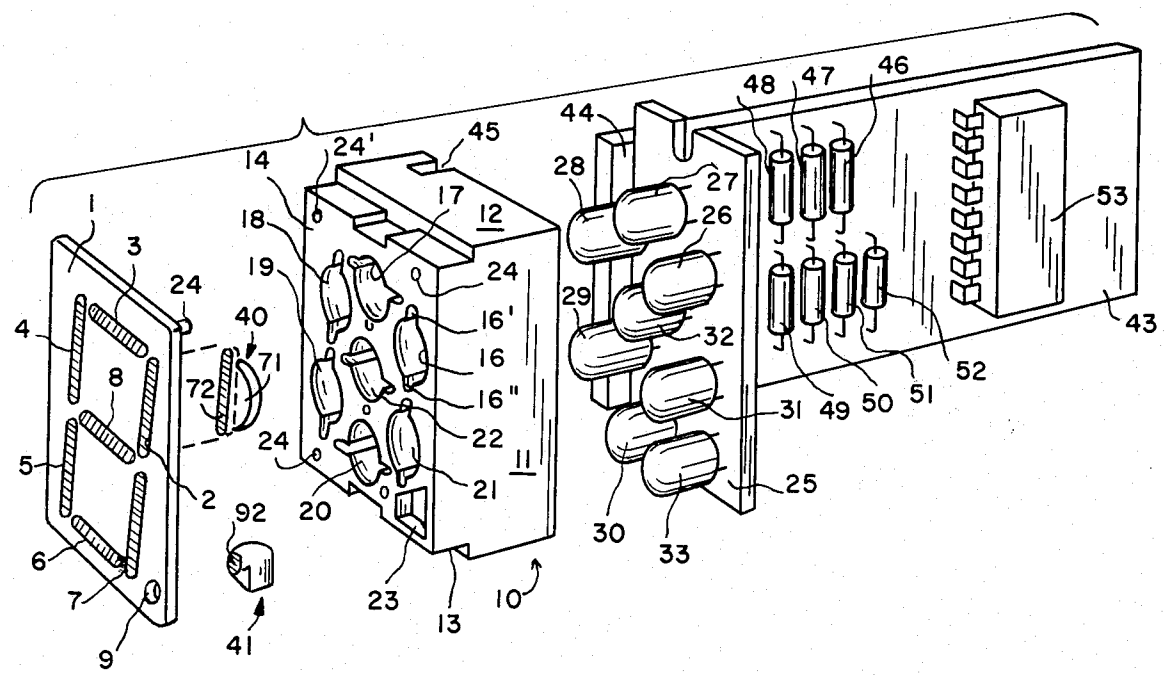


Fig. 1

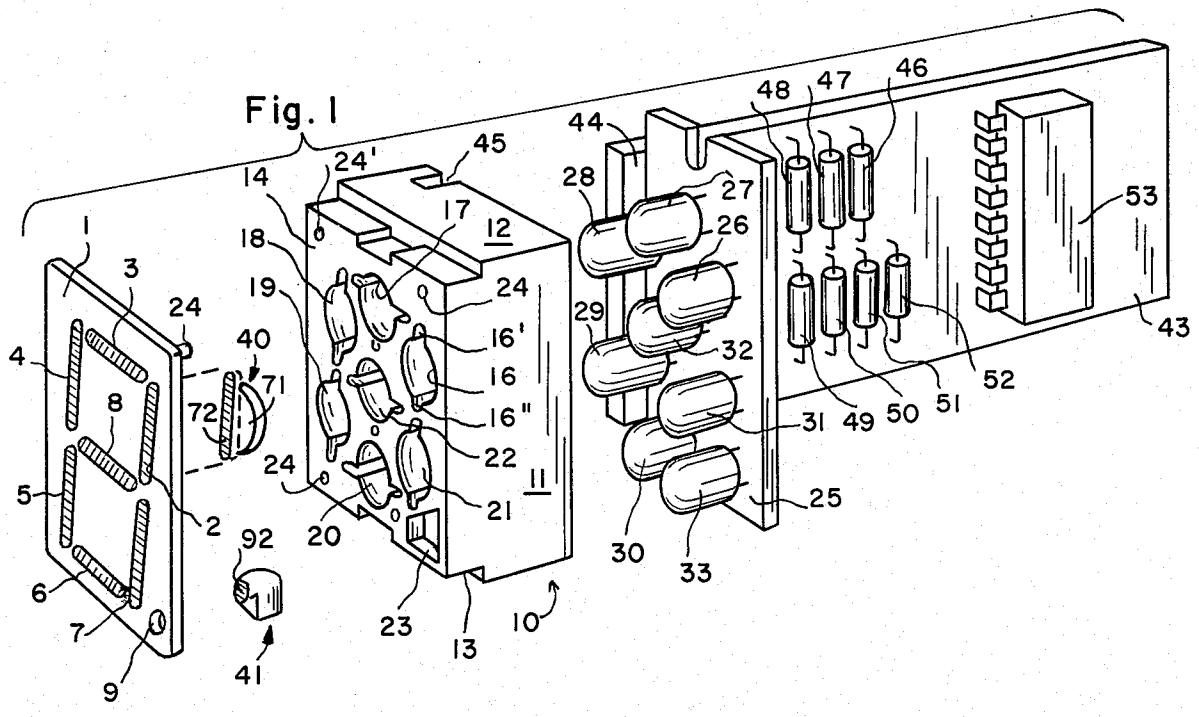
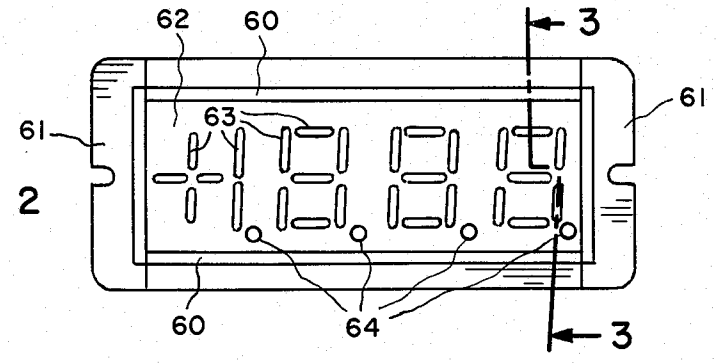



Fig. 2



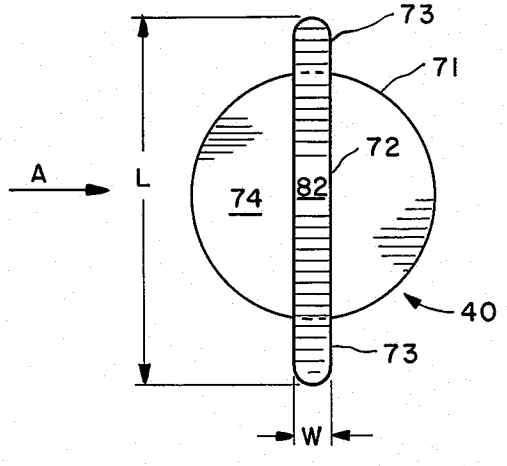




Fig. 4

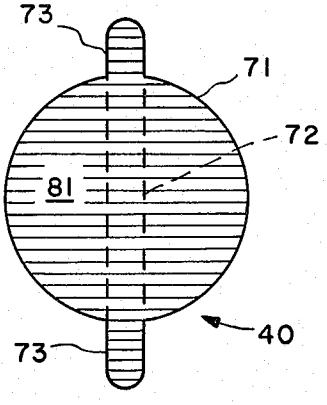



Fig. 5

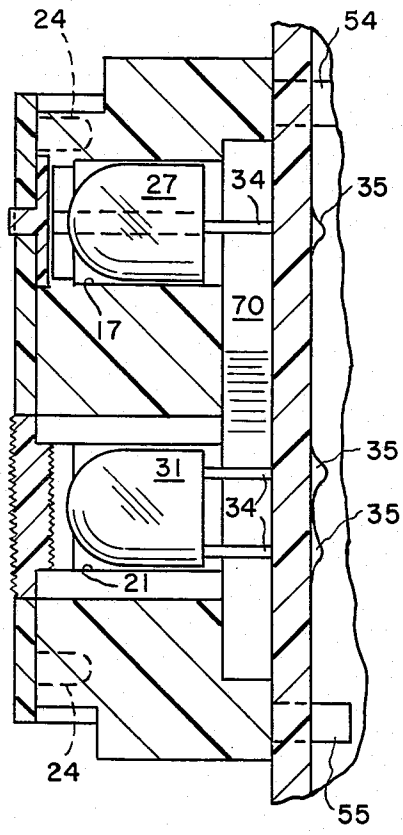



Fig. 3

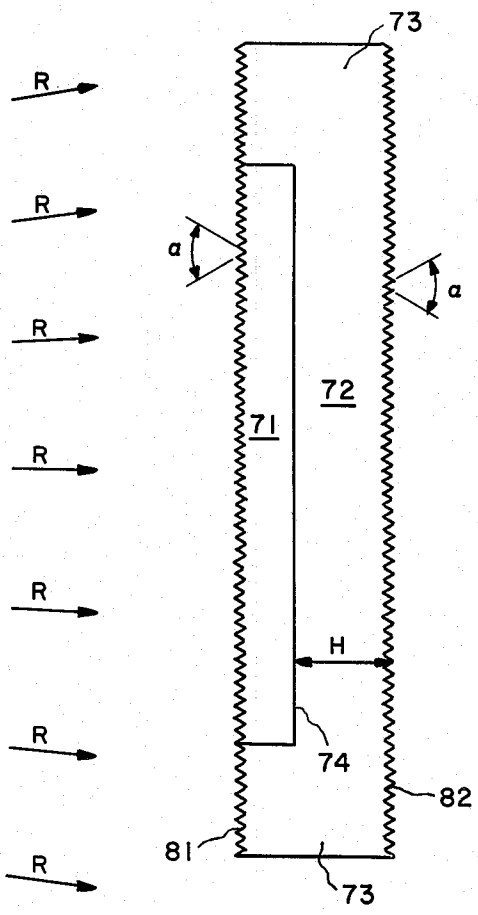



Fig. 8

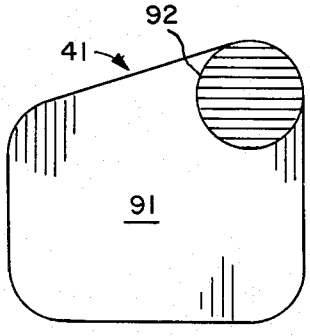



Fig. 6

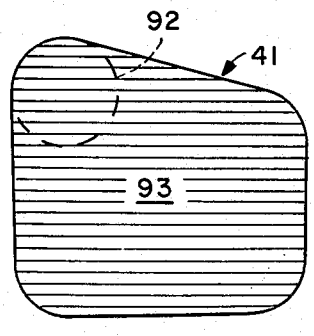



Fig. 7

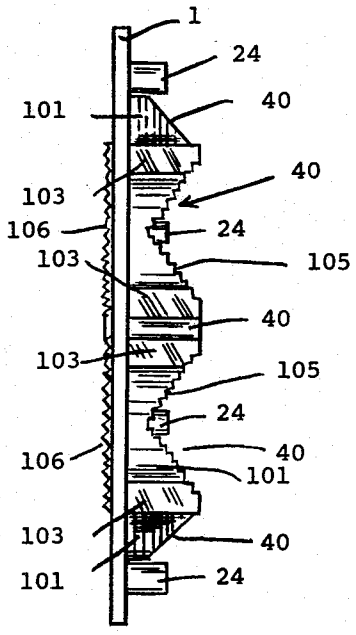



Fig. 10

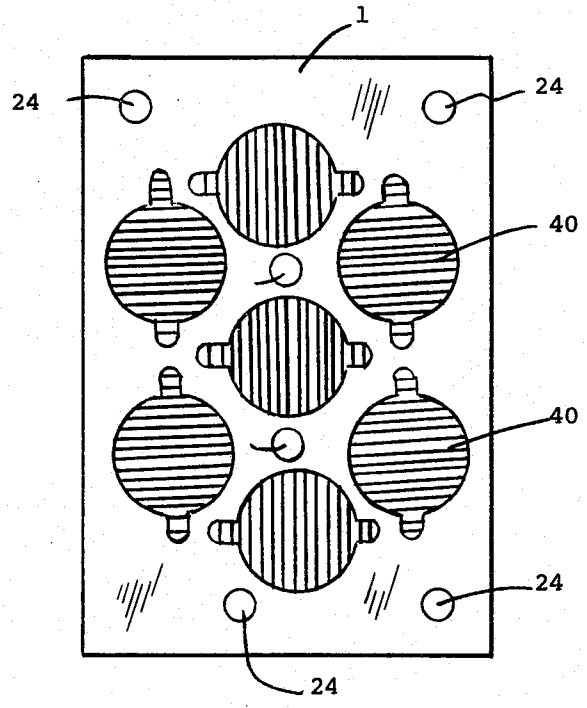



Fig. 9

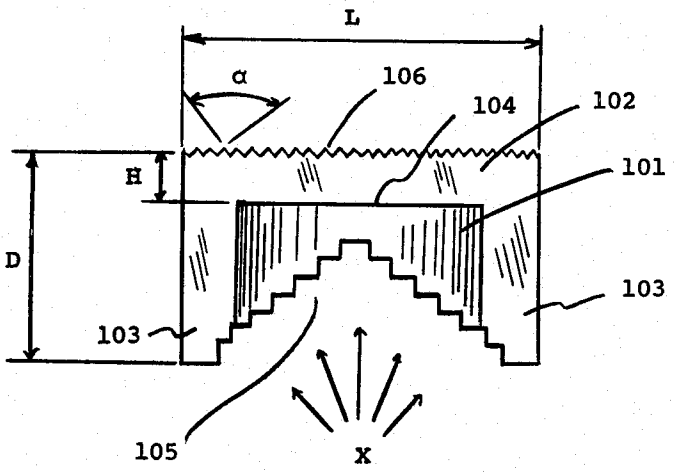



Fig. 11

# DIGITAL DISPLAY

## REFERENCE TO PRIOR APPLICATION

This is a continuation-in-part of application Ser. No. **268,717** filed July **3, 1972** and now abandoned.

## BACKGROUND OF THE INVENTION

This invention relates generally to the field of illuminated display devices and, more particularly to a digital display device adapted to display upon an opaque face plate, a visual read-out of a particular alphabetic or numeric symbol.

Digital display devices have been in use for many years in various display systems and widely used in a variety of applications. Some of the more common uses of alpha-numeric displays have been in such areas as digital volt meters, tachometers and clocks, computer consoles, stockmarket quotation displays, aircraft and spacecraft consoles in various military installations. It is desirable in most of these uses that the display devices have a simple and rugged construction, be easy to install within a console so that installation and replacement may be done quickly, have low power consumption, low cost factor and most important long life and reliability of the illuminating element. Various types of display devices have been developed in an attempt to meet these varied needs. One type of digital display device is the conventional monogram design of selectively lighted lucite rods, another type of display utilizes electro-luminescent coated characters, others are of the glow tube display type, still other read-out devices employ a front face which is entirely covered by a large number of tiny lamps selectively illuminated to outline the desired alpha-numeric character. Also known in the art is the display device utilizing individually illuminated light emitting ends of light-conducting material such as light pipes or light guides wherein the light-emitting ends are arranged so as to represent a group of segments with which the particular character may be formed. Devices utilizing neon lamps for separately illuminating an entire character formed of an individual lamp and other glow discharge devices have also been suggested. Finally, there is the more popular type of character display to which the present invention relates. This is commonly referred to as the segmental system in which the display surface typically has seven segments or lines arranged in a geometric pattern substantially defining a figure **8.** Selective illumination of the various segments can produce any desired numeric symbol from **0** – 9. Displays of this type can also include additional segments or lines for displaying any desired letter of the alphabet, digit, mathematical symbol, or other fanciful design.

It has been typical in the segmental type of display to produce illumination of each selected segment by means of an incandescent lamp placed directly behind a lamp cover forming the segment to be illuminated. Various opaque materials have been used to block the surface area surrounding the segment so that only the segmented line will appear illuminated. A typical arrangement would be to provide a plurality of incandescent lamps within a housing having light sockets for directing the light toward the particular segment to be illuminated. Devices of this type, although widely used present a number of problems. Incandescent lamps have a limited life which, when they burn out, require replacement and sometimes lead to error in the numeric display being illuminated. Prior art segmental displays have also been deficient in that the illuminations of the various segments are not as uniform as might be desired and sometimes fail to be adequately or fully illuminated in areas of bright ambient light conditions.



It is accordingly one object of the present invention to provide a luminous digital display device of the segmental type in which the line segments are contiguous with one another, which is relatively inexpensive to produce and assemble and generally overcomes the major deficiences of the prior art.

In particular, it is an object of the present invention to provide a display device of the type described which has an unlimited lifetime never requiring replacement because of failure of the light producing elements, by utilizing a solid state element as the light producing device, thereby maximizing reliability of the read-out device. It is a further object of the present invention to provide a character display device in which the line segments when illuminated are as uniform as possible and of sufficient intensity to be clearly visible even in high ambient light conditions.

A further object of the invention is to provide a character display which is relatively simple in construction requiring a minimum of assembly steps and which can easily be fabricated out of molded plastic parts.

## SUMMARY OF THE INVENTION

The foregoing objects are generally achieved by providing the device of the present invention which utilizes solid state light emitting diodes as the line segment illuminating element. The diodes are electrically and mechanically mounted on a lamp board which is connected to a printed circuit board carrying appropriate driving circuitry for selective energization of one or of a combination of diodes. The device comprises a housing formed of molded plastic and is provided with a socket for receiving and containing each diode. Each socket is covered by a lens element which has a raised portion. The front of the housing is covered by a face plate which is formed by molding with seven line segment slots arranged contiguously forming the numeral **8** when all segments are illuminated. The raised portion of the lens element covering the socket extends into the slots so that the light from an energized diode will uniformly illuminate a particular line segment.

Other objects, advantages and features of the invention will become more apparent from the following detailed description of the invention in connection with the accompanying drawings in which:

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view of the present invention showing all the constituent parts thereof;

FIG. **2** is a frontal plan view of one face plate showing a plurality of characters which may be arranged in a digital display;

FIG. **3** is a cross-sectional elevational view taken along lines **3—3** of FIG. **2**;

FIG. **4** is a front view of one embodiment of a lens element used in illuminating a line segment of the character display;

FIG. **5** is a back view of the lens element shown in FIG. **4**;

FIG. **6** is a front view of a lens element used in illuminating a decimal point character of the display;

FIG. 7 is a back view of the lens element shown in FIG. 6;

FIG. 8 is a side view of the lens element shown in FIGS. 4 and 5 along arrow A of FIG. 4;

FIG. 9 is a plan view of the rear of the face plate with lens elements;

FIG. 10 is a side elevational view of the face plate showing another embodiment of a lens element used in illuminating a line segment; and

FIG. 11 is a side view of the lens element shown in FIG. 10.

## DESCRIPTION OF THE INVENTION

In FIG. 1 of the drawing there is shown one embodiment of a numeric display device in accordance with the present invention for displaying upon an opaque face plate 1, a digital or numeric symbol. Any digit from 0, 1, 2, 3, . . . through 9 may be displayed upon the face plate 1 by selective illumination of a proper combination of the line segments formed in slots 2 through 8. The particular display illustrated in FIG. 1 also includes provision for illumination of a decimal point through aperture 9. The face plate 1 may be made of a non-reflecting plastic material and preferably dark in color to provide maximum contrast to the illuminated line segments on its surface manufactured by injection molding to form the proper combination of slots and apertures for the desired alpha-numeric display. It has in practice been found to be of advantage to use a material commercially available and known by its trade name "Lexan" as the plastic material out of which the face plate may be fabricated. The face plate 1 forms the front cover of a housing 10 which is comprised of two parallel side walls 11, a top 12, a bottom surface 13 and a front surface 14. The housing 10 is formed of an opaque plastic material (also preferably Lexan) which is easily fabricated by an injection molding process.

The face plate 1 is provided with a plurality of studs 24 arranged for cooperative engagement with partial guide bores 24' on the front surface 14 of the housing 10 so as to provide accurate means for properly aligning the face plate with the housing. A number of sockets 16, 17, 18, 19, 20, 21, 22 and 23 are formed in the housing during the molding operation of its fabrication and are designed for receiving and holding in secure position a lens element, embodiments of which will be described more fully hereinafter. FIG. 1 shows a lens element 40 arranged for engagement with slot 2 in a exploded position while the lens element 40 for each of slots 3, 4, 5, 6, 7 and 8 are shown in position within the slot, only the front surface of the lens being visible in the figure. Lens element 41 for illuminating the decimal point through aperture 9, is also shown in an exploded position. Each of the sockets are appropriately shaped so that the lens element, having one of the designs to be described, may fit complimentary therewith. Sockets 16–22 are arranged to accommodate the lens 40 for illumination of a line segment. Accordingly each of these sockets has a substantially circular cross-sectional shape with extended diametric cutouts (such as 16' and 16'') for receiving the extended end portions 73 of the lens 40. Socket 23 has a quadrangular cross-sectional shape in order to accommodate the lens element 41, shown and described more fully hereinafter in conjunction with FIGS. 6 and 7. Each socket is arranged in the housing so as to be located behind a corresponding slot or aperture in the face plate, so that the lens element will cooperatively engage with the slot on the face plate when the face plate is assembled with the front surface 14 of the housing. The face plate 1 may be permanently affixed to the front surface 14 of the housing 10 by placing the studs 24 within the appropriate partial bores 24' and ultrasonically welding the face plate to the housing with the lens elements 40 and 41 located in the appropriate socket so that the raised line segment portion of the lens 40 protrudes into the slots 2 through 8 and the raised circular portion 92 of lens element 41 protrudes into aperture 9.

Each of the line segments 2 through 8 and the decimal point 9 is to be illuminated by means of a solid state light source housed within the sockets 16 through 22. The sockets have been designed so as to form a receptacle for receiving the light-producing elements and so as to act as a light restricting cell for separately illuminating a particular line segment upon selective energization of the appropriate light producing element. The interior walls of each of the sockets must be sufficiently nonreflecting so that the light produced by the light element will travel in as much of an axial direction as is possible.

The light producing elements of the present invention are shown in FIG. 1 as being mounted on a printed circuit lamp board 25. The light producing elements 26, 27, 28, 29, 30, 31, 32 and 33 are commercially available light emitting diodes or radiators, referred to as LED;s and formed of a p-n junction diode made of gallium phosphide or gallium arsenide phosphide. It is to be noted that the radiation given off by some light emitting diodes are not necessarily in the visible range of wave lengths. However, light emitting diodes that emit visible radiation are essential for the applications of the digital display forming the present invention. The gallium phosphide and gallium arsenide phosphide type diodes are useful in this application.

Each of the LED's 26 through 33 are electrically connected to the lamp board 25 by leads 34 (see FIG. 3) being soldered thereto at 35. The lamp board with the light emitting diodes mounted thereon is assembled with the housing 10 so that the lamp board covers the rear of the housing with each of the light emitting diodes inserted within its respective socket in the housing 10.

A printed circuit board 43 is connected by angle brackets 54 and 55 (see FIG. 3) to the lamp board 25 at right angles thereto with a portion 44 of the printed circuit board extending beyond the surface of the board 25. When the lamp board 25 is assembled with the printed circuit board 43, as shown in FIG. 1, the portion 44 will be in a position to fit within a slot 45 arranged on the rear of the housing 10. The printed circuit board with the lamp board attached thereto may thus be assembled and maintained in proper position with respect to the housing.

A series of resistors 46, 47, 48, 49, 50, 51 and 52 are mounted on the printed circuit board. Each of the resistors are electrically connected in series with a light emitting diode and serve to limit the current supply thereto. A current limiting resistor of 200 ohms has been found to be appropriate. A decoder driver formed by integrated circuit element 53 is also mounted on the printed circuit board and electrically connected through the resistors to the light emitting diodes for selectively driving them.

When fully assembled the character display according to the present invention as shown in FIG. 1 will comprise the face plate mounted on the front surface 14 of the housing 10 with the various lens elements contained within the sockets 16 through 23 with the raised portions to be illuminated extending into slots 2 through 8 and aperture 9, and with the light emitting diodes located behind the lenses and contained within a respective socket, lamp board 25 acting as the back surface of the housing.

FIG. 3 shows in cross-sectional view a digital display in accordance with the present invention in a fully assembled condition. It can easily be seen from this figure that the lens elements 40 are arranged within the sockets of the housing 10 with the raised portions protruding into the slotted line segment of the face plate 62. The studs 24 are shown in dotted line within the partial bores 24'. The light emitting diodes 27 and 31, corresponding to the diodes shown in FIG. 1, are shown in place within the sockets 17 and 21 respectively. A space 70 is formed between the housing 10 and the lamp board 25 when the lamp board is in an assembled position with respect to the rear of the housing.

The character display device illustrated in FIG. 1 and described above is of the segmental type with the various line segments 2 through 8 forming the letter 8 when all segments are illuminated. It should be obvious, however, that other arrangements of line segments are possible for the display of alphabetical, arithmetical or other informational symbols or characters. Additionally, it may be and frequently is desirable to arrange a plurality of digital display devices on a console or display panel in a line so as to illuminate a multiple digit number. Such an arrangement is shown in FIG. 2 in which four digital display devices such as shown in FIG. 1 are arranged in line and framed within a single aluminum extruded housing 60 and encased by plastic end pieces 61. The face plate 62 of the display shown in FIG. 2 comprises a single plastic element molded with an appropriate number of line segment slots 63 and decimal point apertures 64. The display shown here comprises an arithmetic symbol, a digit one and three numeric displays capable of a full range of digits from 0 to 9. Each of the line segments 63 is provided with a lens element 40 such as shown in FIG. 1 or of the type shown in FIGS. 10 and 11, and each of the decimal point apertures 64 is filled by a lens element such as 41 shown in FIG. 1. Each lens is backed by and to be illuminated by a separate light emitting diode and appropriate driving circuit with current limiting resistor such as described with reference to the numeric display of FIG. 1.

It should, of course, be obvious that any arrangement of display devices can be provided in a display console with a single face plate covering the entire area of numeric characters and provided with appropriate slots or apertures for forming any combination of digits or alphabet symbols.

Referring now to FIGs. 4 and 5, one embodiment of the lens 40, which is intended for use with light emitting diodes of the gallium phosphide type is shown in enlarged view showing the front and rear surfaces of the lens element 40, shown in perspective in FIG. 1. This lens is formed integrally of two main sections molded of acrylic material and comprises a first circular section 71 and a raised section 72 having diametrically extended end portions 73 extending beyond the confines of the circumference of the circular portion 71. The width W and length L of the raised portion 72 is designed to fit within the slots on the face plate forming the line segments of the character display. The height H, see FIG. 8, of the raised portion extending from the upper surface 74 of the flat circular section of the lens is equal to the thickness of the face plate 1 so that the front surface 82 of the raised portion is flush with or slightly extended beyond the surface of the face plate 1 when inserted in the slot, and so that the upper surface 74 of the circular portion abuts flush with the rear side of the face plate. The rear surface 81 of the circular portion 71 and extended raised portion 72, which is shown in FIG. 5, will be slightly spaced from the emitting surface of the light emitting diode when assembled within the socket as shown in the sectional view of FIG. 3. Both the rear surface 81 of the circular flat portion 71 and the front surface 82 of the raised portion 72 are provided with a ridged surface as shown in detail in FIG. 8 which is a side view taken along arrow A of FIG. 4. The ridges are represented by parallel lines in FIGS. 1, 4 and 5. Light which is emitted from a typical gallium phosphide light emitting diode, represented by rays R, will strike the rear ridged surface 81 of the flat circular portion 71. Upon striking the ridged surface 81 the light rays will, through the action of reflection and refraction, pass through and exit the lens at the flat surface 74 of the circular flat portion 71 and through the ridged surface 82 of the raised portion 72. Only the raised portion will extend through the slot of the line segment so that only the light which passes through the lens exiting at the ridged surface 82 of the raised portion 72 of the lens will be visible, the flat surface 74 being blocked by the opaque face plate. The angle $\alpha$ between adjacent ridges of both the front and rear surfaces of the lens may be anywhere from 75° to 100°. However, it has been found that as a matter of convenience and efficiency in reflecting light a 90° angle would be most desirable. The ridged surfaces of the lens elements 40 produces efficient light diffusing effect of the light produced by the light emitting diode so that the illuminated line segment will appear most uniform with sufficient brightness against the dark background of the face plate. FIG. 8 shows the ridges as being enlarged and disproportionate for the sake of clarity - however, in practice the depth of the ridges will be much smaller than what is shown so that a greater number of ridges will exist on the actual surface of the lens.

FIGS. 6 and 7 are views similar to FIGS. 4 and 5 showing the front and rear surfaces of the lens element 41 used for illuminating the decimal point symbol on the character display. This lengs element is formed of a base portion 92 and a raised circular portion 92 designed to fit complimentarily with an aperture such as aperture 9 in the face plate of FIG. 1. The front surface of raised circle 92 and the rear surface 93 of the element is ridged in a manner similar to that of lens element 40 so as to obtain the most efficient light diffusing effect from the light emitting diode. The lens element 42 is designed to fit within socket 23 in housing 10 for transmitting the light from light emitting diode 33 to illuminate the aperture 9.

It should be obvious that any other convenient form of slot or aperture, such as a "comma" or other curved line segment, may be easily produced in a face plate by injection molding. A lens designed to fit such form may

also be easily produced by molding an acrylic material so that other characters may be illuminated upon the face plate of the display.

FIGS. **10** and **11** show another embodiment of the lens **40** which is particularly useful with light emitting diodes of the gallium arsenide phosphide type. This lens is also formed integrally of two main sections molded of acrylic material comprising a first circular section **101** and a raised section **102** having diametrically extended end portions **103** extending beyond the confines of the circumference of the circular portion **101.** The width W and length L of the raised portion **102** is substantially the same as the lens shown in FIGS. **4** and **5** so as to fit within the slots on the face plate forming the line segments of the character display. The height H, see FIG. **11,** of the raised portion extending from the upper surface **104** of the flat circular section of the lens is equal to the thickness of the face plate **1** so that the front surface **106** of the raised portion is flush with or slightly extended beyond the surface of the face plate **1** when inserted in the slot, and so that the upper surface **104** of the circular portion abuts flush with the rear side of the face plate. The rear surface **105** of the circular portion **101** and extended raised end portion **103** have a stepped surface so that the thickness D of the lens decreases toward the center forming a V-shaped recess on the underside of the lens forming a gap from the emitting surface of the light emitting diode when assembled within the socket. The stepped rear surface **105** of the lens shown in FIGS. **10** and **11** provides means for more evenly distributing light being emitted from a gallium arsenide phosphide light emitting diode across the front surface **106.** The light emitting surface of the typical gallium phosphide diode is significantly broader than that of the gallium arsenide phosphide diode so that the lens shown in FIGS. **4** and **5** will be adequate when gallium phosphide diodes are used as the light emitting source. When the light emitting source is gallium arsenide phosphide, its light emitting surface is much narrower and consequently the V-shaped stepped surface **105** is preferred.

Light rays X emitting from a gallium arsenide phosphide diode will strike the stepped rear surface **105** and through the action of reflection and refraction pass through the lens and exit at flat surface **104** of the circular flat portion **101** and through the ridged surface **106** of the raised portion **102.** Only the raised portion will extend through the slot of the line segment so that only the light which passes through the lens exiting at the ridged surface **106** of the raised portion **102** of the lens will be visible, the flat surface **104** being blocked by the opaque face plate. The angle $\alpha$ between adjacent ridges of the front surface of the lens is again preferably **90°.**

FIG. **9** shows the rear surface of face plate with lens **40** of either the embodiments shown in FIGS. **4** and **5** or in FIGS. **10** and **11** in place.

From the foregoing description it can be seen that a character display of the line segment type has been provided which has the facility of virtually unlimited life due to the use of the solid state light emitting diodes, and which is both simple in construction and easy to assemble so that the cost of manufacturing is kept at a minimum. The use of the lenses as described herein produces an illuminating effect which is efficient in transmitting the light from the light emitting diode and adequate even in high light ambient conditions.

While the invention has been described and illustrated with respect to a certain preferred embodiment which gives satisfactory results, it will be understood by those skilled in the art, after understanding the purposes of the invention, that various other changes and modifications may be made without departing from the spirit and scope of the invention, and it is therefore intended in the appended claims to cover all such changes and modifications.

We claim:

**1.** A character display device of the line segment type comprising a display surface having an arrangement of open segments for display of any numeric and alphabetic symbol against an opaque background upon illumination of a proper combination of segments thus forming the desired numeric symbol, a plurality of sockets arranged behind said display surface, one of said sockets being arranged substantially behind each of said open segments, a light emitting diode of the p-n junction type for producing visible light upon electrical energization thereof carried within each of said sockets for illumination of its respective open segment when said diode is caused to produce visible light, a lens element for even and uniform distribution of the visible light produced by the light emitting diodes, said lens element comprising a base section and a raised section, the base section having a rear surface and the raised section having a front surface, said base section being adapted to fit within said socket and said raised section being adapted to fit within the respective open segment, the rear surface of the base section and the front surface of the raised section of said lens being ridged, said front ridged surface of said lens element being substantially flush with the surface of said display surface when said raised section is fitted with the open segment so that upon energization of a light emitting diode its respective open segment will be illuminated by light passing through the lens element having its raised section fitted within the segment.

**2.** The character display according to claim **1** wherein said open segments are straight line slots, said slots being arranged contiguously in a figure **8** pattern so that any numeric digit may be displayed by illumination of a proper combination of slots, the raised section of said lens element for said slots being substantially elongated formed in the shape of a straight line so as to fit complimentarily within said slot.

**3.** The character display according to claim **1** wherein at least one of said open segments is a circular aperture so that upon illumination thereof a decimal point character will be displayed, the raised section of said lens element for said circular aperture being formed substantially in the shape of a circle so as to fit complimentarily within said aperture.

**4.** The character display according to claim **1** wherein said ridges have an included angle of approximately **90°.**

**5.** A character display device of the line segment type comprising a display surface having an arrangement of open segments for display of any numeric and alphabetic symbol against an opaque background upon illumination of a proper combination of segments thus forming the desired numeric symbol, a plurality of sockets arranged behind said display surface, one of said sockets being arranged substantially behind each of said open segments, a light emitting diode of the p-n junction type for producing visible light upon electrical

energization thereof carried within each of said sockets for illumination of its respective open segment when said diode is caused to produce visible light, a lens element for even and uniform distribution of the visible light produced by the light emitting diodes, said lens element comprising a base section and a raised section, the base section having a rear surface and the raised section having a front surface, said base section being adapted to fit within said socket and said raised section being adapted to fit within the respective open segment, the front surface of the raised section of said lens being ridged, said front ridged surface of said lens element being substantially flush with the surface of said display surface when said raised section is fitted with the open segment, the rear surface of the base section having a multiplicity of steps forming a concave stepped surface so that upon energization of a light emitting diode its respective open segment will be illuminated by light passing through the lens element having its raised section fitted within the segment.

**6.** The character display according to claim **5** wherein said stepped rear surface is V-shaped.

**7.** The character display according to claim **5** wherein said ridges of the front surface have an included angle of approximately **90°**.

* * * * *