

[54] **DISPLAY DEVICE**

[76] Inventor: **Walter Rosenzweig**, 238 St. Cloud Avenue, West Orange, N.J. 07052
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[51] Int. Cl. **G08b 5/36**
[58] Field of Search **340/343, 336; 315/179**

[56] **References Cited**

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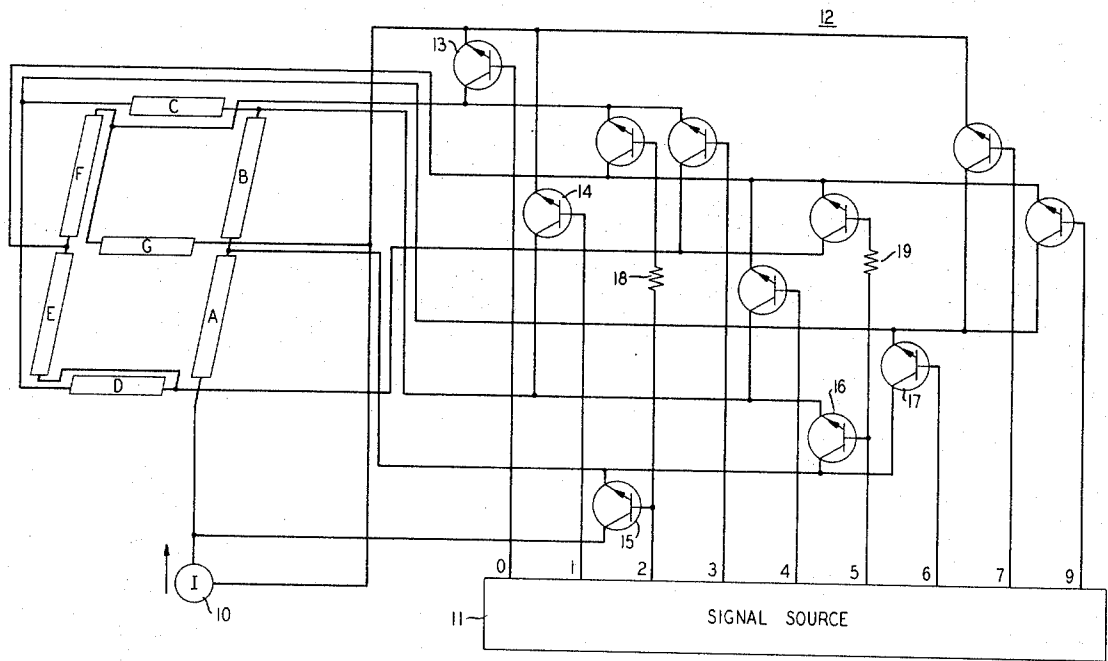
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Primary Examiner—David L. Trafton
Attorney—R. J. Guenther et al.

[57] **ABSTRACT**

A device utilizing a minimum number of switches which will convert a signal from one of a plurality of inputs to a visual display. Light emitting elements are connected in series to a current source such that all elements are normally energized until a figure is selected for display. Figures are displayed in response to a signal from one of the input conductors by means of switches arranged to shunt unwanted elements. This arrangement allows several contiguous elements to be shut off by a single switch.

6 Claims, 2 Drawing Figures



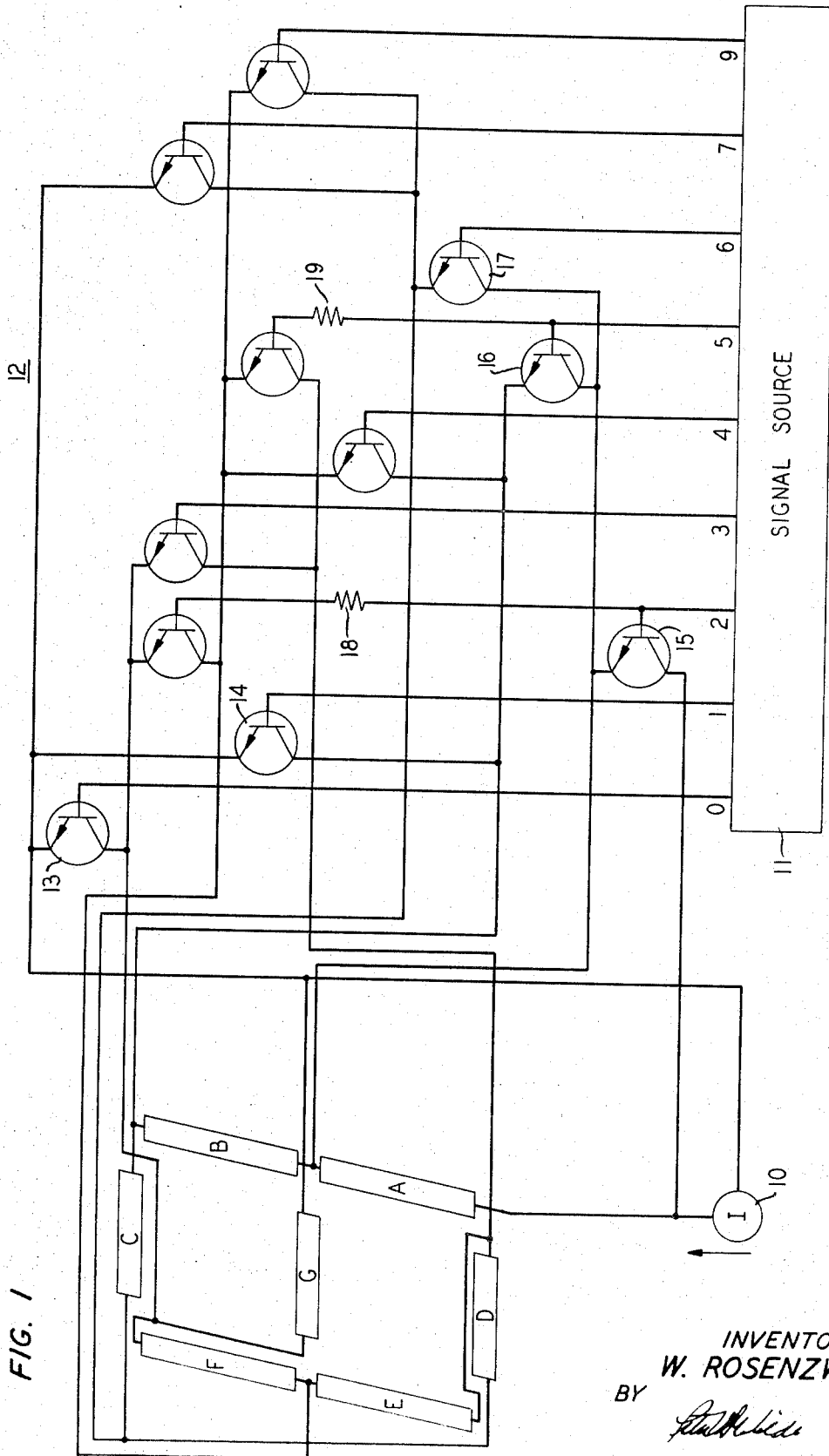
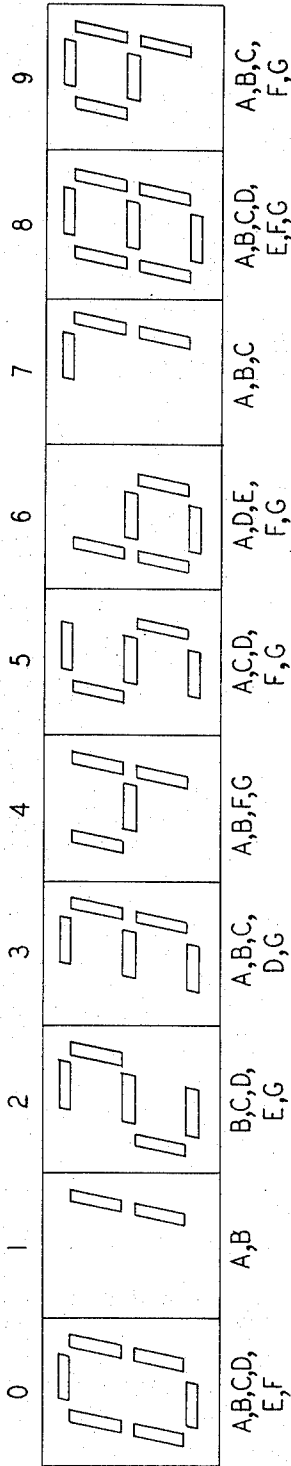


FIG. 1

INVENTOR
W. ROSENZWEIG
BY *[Signature]*
ATTORNEY

FIG. 2



DISPLAY DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a device which will convert a signal from a plurality of inputs to a visual display of a plurality of figures by means of a minimum number of switching elements. In the context of this application, it should be noted that the term "figure" is used in its generic sense as the representation of a particular form and includes numerals, mathematical symbols and other forms.

Information from computers, data handling equipment and other types of data processing systems is often represented by a series of voltage signals from one of a number of conductors. It is desirable to provide a visual display of this information in the form of a group of light emitting elements. For the display of numerals, for example, the light emitting elements often comprise seven bar-shaped elements arranged in the form of a figure "8." These elements are energized or de-energized in response to a signal at one of the input conductors through a switching network to display the desired number.

Several schemes have been proposed to perform this switching function. Each of the light emitting elements is usually connected in parallel to a voltage source through a series of switches which are activated by the signal produced at the input conductors. Thus, in one form of prior art display device, the switches associated with each element are normally open. When a signal appears at one of the input conductors, the switches connected thereto will close to energize the display elements which will form the numeral represented by that signal. (See, for example, U.S. Pat. No. 3,399,402.) Such an arrangement, however, requires a minimum of 47 switches. In addition, if elements fail by open-circuiting, which is the normal failure mode for filament lamps and electroluminescent diodes, invalid numbers will be displayed. In another form of prior art device, a subtraction method is used. As before, each element is connected in parallel through a series of switches. Here, however, each element is normally energized and a desired numeral is displayed by de-energizing a specific combination of elements. Thus, the switches will open in response to a signal from one of the input conductors. This sort of arrangement requires a minimum of 23 switches and will also display invalid numbers in the event of open-circuiting.

It is therefore desirable to produce a more economical display device by reducing the number of switches required in the switching network and to eliminate the display of invalid numbers caused by open-circuiting.

SUMMARY OF THE INVENTION

In accordance with the present invention, a display device is provided in which the light emitting elements are connected in series to a constant current source. Switches are arranged to close in response to a signal from one of a plurality of input conductors and thereby shunt unwanted elements to display the figure represented by the input signal. This configuration allows any contiguous elements for a desired figure to be turned off by a single switch. By connecting the elements so as to maximize the number of contiguous elements for all figures, the number of switches needed is minimized. For a seven-segment numerical display, 11

switches are required. Furthermore, the problem of open-circuiting causing invalid number is eliminated.

BRIEF DESCRIPTION OF THE DRAWING

These and other features of the invention are delineated in detail in the description to follow and in the drawing in which:

FIG. 1 is a schematic circuit diagram of one embodiment of the present invention; and

FIG. 2 is an illustration showing the combination of display elements of FIG. 1 which must remain energized to display each numeral according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 depicts one embodiment of the invention designed to convert a nine-line input to a seven-segment numerical display. The nine lines represent a decimal code in which a signal appears on one line at a time representing the integers 0, 1, ..., 7, 9 and no signal is present for the integer 8. It should be understood that the principles of the present invention may be applied to the display of any group of figures, including mathematical and other symbols, which may be represented by a signal to one of a plurality of inputs.

Referring to FIG. 1, the bar-shaped display elements A, B, C, D, E and F are arranged so as to form a figure "8." These elements may take many forms as is well known in the art. For example, each element may comprise an electroluminescent diode such as GaP, and a bar-shaped reflector serving as the character segment which is illuminated when the diode is energized. It is to be understood then that the term "display element" is meant to include a light emitting element and an appropriate housing or aperture so that each display element will be illuminated in the proper shape to form one segment of the combination of figures desired. To improve readability of the numerals, the vertical elements are slightly slanted as shown. While a seven-element display is described, it should be noted that two more vertical elements may be provided for greater definition of the numeral "1." (See, for example, U.S. Pat. No. 3,081,450.)

Each display element is connected in series to a constant current source, 10. In operation, all elements are energized in the absence of a signal, displaying the figure "8." Any of the other nine numerals can be displayed by turning off a predetermined combination of elements in response to an electrical signal from the signal source, 11, appearing at one of nine input conductors. A switching network, 12, is provided to accomplish this. The combination of display elements which must remain energized to display each numeral is shown in FIG. 2.

Referring again to FIG. 1, the switching network is composed of a series of normally open switches in the form of transistors such as 13, 14, 15, 16 and 17, each coupled to one of the input conductors so as to close when a signal appears at the conductor. Each conductor is numbered in the figure to indicate the numeral to be displayed when a signal appears there. The switches coupled to a particular conductor are connected in parallel to the elements which must be de-energized in order to display the desired numeral. Thus, for example, when a signal is applied to the first conductor

(labeled 0), switch 13 will close and shut off element G to display the figure "0." Similarly, when a pulse is applied to the second conductor (labeled 1), switch 14 will close to shut off elements C-G and the figure "1" is displayed. The same operation is performed when a signal is applied to each of the remaining conductors. Of course, since the number "8" will be displayed when no element is de-energized, no signal appears at the source for this integer.

The main advantage associated with this arrangement of connecting the display elements in series and the switching elements in parallel thereto is the fact that any contiguous display elements associated with a desired numeral may be de-energized by a single switch. As described above, for example, switch 14 operates to turn off five display elements to produce the figure "1." In the prior art, parallel, display element configuration, a separate switch would be needed to turn off each element. By connecting the elements in the order shown, the maximum number of contiguous elements is achieved so that a minimum number of eleven switches shown can be employed.

Another advantage of this device is that invalid numbers will not be displayed when one of the light emitting elements fails by open-circuiting. Since the elements are coupled by series, open-circuiting in one element will cause a blank when the selected number includes that element. Valid numbers will still be shown. A further advantage accrues when the light emitting elements are electroluminescent diodes since the diodes are most controllably driven from a constant current source. In prior art devices coupling the diodes in parallel, a current limiter was required for each element to meet this requirement.

The devices such as 13, 14, 15, 16 and 17 utilized to perform the switching function have been depicted as transistors. It should be clear that the switching elements may be any of a number of devices known in the art which exhibit low and high impedance states. Transistors are employed by connecting the collector and emitter regions across the display element and coupling the base region to one of the input conductors. A signal from the conductor will forward bias the transistor and thereby close the switch. Current limiting into the transistor bases is accomplished through load resistors which are part of the signal source and therefore not shown. Additional load resistors 18 and 19 must be provided, however, where there are more than one transistor on a line to prevent all of the current from flowing into the base of the transistor at lower electrical potential.

If GaP electroluminescent diodes constitute the light emitting elements, a minimum of 14 volts must be supplied by the current source 10 to energize all seven elements. This requires that the transistor switch 15 have a minimum collector-base breakdown voltage of 14 volts. This is easily obtainable. The minimum base-emitter breakdown voltage of switch 15 must be 12 volts. This is not easily achieved in high gain transistors where a value of perhaps 6 volts is possible. Thus it would be necessary to protect each of the three switches, 15, 16 and 17 whose emitters may be held at 12V, 10V and 8V respectively with a diode (not shown) in series with each base lead. The voltage produced by the signal source, 11, must be at least 12.7

volts in this device to insure that all switches will close. Such voltages may be supplied by TTL (Transistor Transistor Logic) and DTL (Diode Transistor Logic) circuits with open collector outputs and by other logic circuits well known in the art.

Latching thyristors may be utilized as the switching elements if it is desired to maintain the display of a numeral after the input signal has been removed. In this case it would be necessary to provide another switch in the series circuit (not shown) to allow the thyristors to drop out before the next numeral is displayed.

Various additional modifications and extensions of this invention will become apparent to those skilled in the art. All such variations and deviations which basically rely on the teachings through which this invention has advanced the art are properly considered within the spirit and scope of this invention.

What is claimed is:

1. A device for displaying figures in response to a signal at one of a plurality of input conductors comprising:

a plurality of display elements coupled in series to a current source, said elements being illuminated when energized by said current source and physically arranged so as to display a desired figure when a predetermined combination of said elements is de-energized;

a plurality of input conductors for selecting a predetermined combination of said elements;

and means for de-energizing predetermined combinations of said elements each comprising switching means coupled to one of said input conductors and coupled in parallel to said combination of elements, individual switching means being coupled in parallel to a plurality of elements of said combination which are contiguous in said series circuit, such that when a signal is applied to said input conductor the switching means will shunt the predetermined combination of elements to display the figure represented by the signal to said input conductor.

2. The device according to claim 1 wherein the display elements each comprise a light emitting diode associated with a reflector.

3. The device according to claim 1 wherein the switching means comprise transistors.

4. A device for displaying numerals in response to a signal at one of a plurality of input conductors comprising:

seven display elements coupled in series to a current source, said elements being illuminated when energized by said current source and physically arranged so as to display the number "8" when all elements are energized and other numerals when a predetermined combination of said elements is de-energized;

nine input conductors for selecting a predetermined combination of said elements;

and means for de-energizing predetermined combinations of said elements each comprising switching means coupled to one of said input conductors and coupled in parallel to said combination of elements, individual switching means being coupled in parallel to a plurality of elements of said combination which are contiguous in said se-

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ries circuit, such that when a signal is applied to said input conductor the switching means will shunt the predetermined combination of elements to display the number represented by the signal to said input conductor.

5. The device according to claim 4 wherein the dis-

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play elements each comprise a light emitting diode associated with a reflector.

6. The device according to claim 4 wherein the switching means comprise transistors.

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