This invention relates generally to display devices and, more particularly, to visual indicating segments of display devices and circuits therefor. Display devices may be constructed in numerous ways to present the desired information for visual observation. Commonly, each character displayed is composed of several segments which are individually actuated in response to signals that carry the information. The device segments are usually current conductive lamps or the like which emit visible radiation upon energization.

A principal difficulty with previous display devices has resided in the inability to detect easily an inoperative condition of a segment. When a segment is inoperative, erroneous displays can readily occur without detection, thereby causing incorrect information to be transmitted to the observer. Accordingly, it is a principal object of the present invention to provide a display device segment and circuit therefor wherein an inoperative condition of the segment is easily ascertainable.

In accordance with one aspect of the invention which will be more fully described hereinafter, there is provided a display device segment and circuit therefor in which indication of inoperative condition of the segment is presented regardless of whether or not the segment is energized. In part this is achieved by connection of a unilaterally conductive device and a source of forward bias in parallel with the segment in such fashion that when the segment is inoperative or non-conductive, current flows in the unilaterally conductive device circuit. When the segment is operative or conductive, no current flows in the unilaterally conductive device circuit. The presence or absence of current flow in the unilaterally conductive device circuit is used as an indication of the operativeness of the segment.

Other objects and features of the invention will be better understood from a consideration of the following detailed description when read in conjunction with the attached drawings in which the single figure is a schematic drawing of a display device segment and circuit therefor in accordance with the invention.

Referring specifically to the figure, there is shown a display device segment 21 and a circuit for energizing it in response to information-containing signals. In essence the energizing circuit comprises a bistable circuit which operates a transistor switch. Depending upon whether the transistor switch is conducting or non-conducting, current will or will not be conducted through segment 21.

As is apparent from the figure, the bistable circuit includes a pnp transistor 11, an npn transistor 13 and a resistor 23 connected in the emitter circuit of transistor 13 to a source of negative bias (no reset) voltage at terminal 25. The base of transistor 13 is connected to the collector of transistor 11 and to a source of negative bias voltage 26 through a resistor 31. The base of transistor 11 is connected as shown to the collector of transistor 13.

The emitter of transistor 11 is connected to the base of a pnp transistor 12 which serves as a transistor switch in a manner which will become more apparent later.

The bistable circuit has, of course, two states, in one of which transistors 11 and 13 are conducting and in the other of which transistors 11 and 13 are non-conducting. In the conducting state, it may be assumed that emitter-base current flows in transistor 11. Its collector current then flows through the base-emitter diode of transistor 13. The collector current of transistor 13 flows through the emitter-base diode of transistor 11, a condition which was assumed above. Consequently, the circuit remains stable in the conducting state. In the non-conducting state, the base-emitter diode of transistor 11 is reversely biased, causing its collector to be cut-off. Since only leakage current then flows in transistor 11 and the potential of source 26 is more negative than that of terminal 25, the emitter-base diode of transistor 13 is reversely biased and its collector is cut-off. Consequently, the potential at point 17 is positive with respect to ground and the circuit remains in its non-conducting state.

As has been mentioned above, when the bistable circuit is in its conducting state, emitter-base current flows in transistor 11. The emitter of transistor 12 is connected to ground, its base to the emitter of transistor 11 and its collector to a negatively poled source of current 27 through a resistor 19 and current conductive display device segment 21 which is illustrated in the figure as a hot filament lamp. When emitter-base current flows in transistor 12, current flows in the collector circuit and hence segment 21 is energized. When the bistable circuit is in its non-conducting state, the emitter-base diode of transistor 12 is reversely biased because point 17 is at positive potential at such time. This cuts off the collector of transistor 12 so that current from source 27 no longer energizes segment 21. Accordingly, it is apparent that segment 21 is energized or de-energized depending upon whether the bistable circuit is in its conducting or non-conducting state.

The circuit thus far specifically described is operative to energize segment 21 and produce a visual indication in desired fashion. However, if segment 21 were faulty and non-conductive, the bistable circuit would continue to operate and the only manner in which the defective condition could be detected would be by observance of lack of visual indication when such should occur. In some few instances this might be satisfactory but in many instances it is not, because there is no ready way to determine that a particular segment should be operative at a particular time. In accordance with the present invention, whether segment 21 is conductively operative or not is continuously determinable, regardless of whether or not transistor 12 is conducting.

Continuous indication or monitoring of the condition of segment 21 is obtained by means of the circuit including a resistor 20 connected at one end of a source of positive potential 32 and at the other to a unilaterally conductive device which is illustrated as a diode 22 having its anode connected to resistor 20 and its cathode to negatively poled source of current 24 through current responsive device 33. If segment 21 is energized by transistor 13, point 30 will be essentially at ground potential, differing only by the small voltage drop across resistor 19 and transistor 12. Since the potential of source 24 is only slightly negative with respect to ground, the potential of point 30 is negative with respect to source 24, whereby the diode is reversely biased and no current will flow there through. If transistor 12 is not conducting and segment 21 is not energized, point 30 will be even more negative than it is when segment 21 is energized. Consequently, no current will flow through the diode in such event. If, however, segment 21 is not operative and not capable of conducting current, point 30 will not be forced negative in polarity by source 27 and current will flow from the
source of positive potential 32 in forward direction through diode 22. Current responsive means 33 such as a relay or even a visual indicating device may be placed in circuit with diode 22 to indicate or otherwise respond to current flow in the diode circuit.

In the ordinary course of operation of display devices of the type which can embody the present invention, it is necessary to provide means for clearing or removing information previously obtained prior to the receipt of new signal information. This function, usually termed reset, is accomplished in the circuit of the invention for segment 21 by applying a positive potential (reset) to terminal 25. This causes the emitter-base diode of transistor 13 to be reversely biased thereby it is rendered non-conducting. In turn transistor 11 ceases conducting, and the bistable circuit is reset into its non-conducting state preparatory for the receipt of new signal information. Terminal 25 can then be returned to its normal negative potential (no reset) and the bistable circuit will remain in its non-conducting state.

After the bistable circuit has been set (or reset) into its non-conducting state, segment 21 will be energized if terminals 15 and 17 are caused to become negative. Current will then flow through resistor 16, which is connected to the base of transistor 11, and through the emitter-base diode of transistor 11, thereby causing the bistable circuit to shift to its conducting state and remain there as explained above. When the bistable circuit is in its conducting state, segment 21 is of course energized.

Since a plurality of the circuits of the invention is customarily employed to produce a desired display device, several terminals 15 will be connected together and a signal simultaneously applied thereto. In order that a bistable circuit may be selected as desired, an "enabling" circuit is provided. This comprises a resistor 18 connected to point 17 at one end and at the other to a switch 14 which can be operative to connect a source of positive potential 34 to resistor 18. When the bistable circuit is in its non-conducting state and switch 14 is closed, the potential at point 17 is positive with respect to ground and the bistable circuit will remain in its non-conducting state, regardless of whether a negative signal is applied to terminal 15. Thus if switch 14 is open the bistable circuit is "enabled" to switch its state and energize segment 21; when switch 14 is closed the bistable circuit remains in whatever state existed before the closure.

It is sometimes convenient to interrogate or determine the state of the circuit of the invention so that the information on a display device may be transferred, stored or otherwise utilized. This is accomplished by means of an interrogation circuit comprising a resistor 35 connected between the end of resistor 18 remote from point 17 and the emitter of transistor 13 and a diode 28 connected from the emitter of transistor 13 to a terminal 29. The potential of terminal 29 is such that to pass current through diode 28, switch 14 must be open and the bistable circuit must be in its non-conducting state, thus causing the cathode of diode 28 to be negative with respect to terminal 29. Switch 14 thus serves when it is open to enable current to flow through diode 28 from terminal 29 and permits utilization of a single current responsive device thereby to detect passage of interrogation current in each of a plurality of segment circuits in a display device.

As exemplary of suitable constants for components in a practical circuit constructed according with the figure, the following tabulation is given:

<table>
<thead>
<tr>
<th>Resistors:</th>
<th>16</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>23</th>
<th>31</th>
</tr>
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<tbody>
<tr>
<td>ohms</td>
<td>10,000</td>
<td>2000</td>
<td>82</td>
<td>1500</td>
<td>620</td>
<td>2000</td>
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</table>

While the invention has been described with reference to a particular embodiment thereof, it will be understood that numerous changes may be made by those skilled in the art without departing from the invention. For example, transistors 11 and 12 may be npn type and transistor 13 may be a pnp type whereby the polarities of sources 24, 27 and the source connected to resistor 20 may be reversed. We therefore aim in the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In combination: a bistable device comprising a bistable circuit, a bistable current source responsive to current flow through said bistable circuit and a bistable information detector responsive to current flow through said circuit and responsive to said bistable current source to cause said bistable device to change state.

2. A bistable as in claim 1 wherein said bistable current source comprises a transistor circuit which includes said display device segment circuit.

3. A combination as in claim 1 wherein said switch means is operably connected to a bistable circuit.

4. In combination: a first circuit comprising a first source of current, a display device segment responsive to current flow therefrom to create a visual indication, and a switch operable to open and close said circuit to stop and start current flow from said first source through said segment; a second circuit comprising a second and third sources of current, and an impedance element and a unilaterally conductive device connected between said second and third sources of current, said second source of current having polarity opposite to said third source, and said third source of current being connected to said second source of current to forward bias said unilaterally conductive device, said second and third sources of current having polarities opposite to said second source but said second source having a magnitude between that of said first and third sources; means interconnecting the ends of said unilaterally conductive device and said segment remote respectively from said first and third sources of current whereby current will flow in said second circuit if said segment becomes non-conductive; and means responsive to said current flow through said unilaterally conductive device.

5. In combination: a bistable device having an input and a current output; a first circuit comprising a first
source of current, a display device segment responsive to current flow therethrough to create a visual indication, and a current responsive switch operable to open and close said circuit to stop and start current flow from said first source through said segment, said switch being connected to the output of said bistable device so that the state of said bistable device determines whether said switch is opened or closed; a second circuit comprising second and third sources of current and an impedance element and a unilaterally conductive device connected between said second and third sources of current, said second source of current having a polarity to forward bias said unilaterally conductive device, said first and third sources of current having polarities opposite to said second source but said second source having a polarity between that of said first and third sources; means interconnecting the ends of said unilaterally conductive device and said segment remote respectively from said first and third sources of current whereby current will flow in said second circuit if said segment becomes non-conductive and means responsive to said current flow through said unilaterally conductive device.

6. A combination as in claim 5 wherein said bistable circuit is provided with means to reset it to its non-conducting state in response to a reset signal.

7. A combination as in claim 5 wherein said bistable circuit is provided with means for maintaining it in a desired state despite receipt of signals by said circuit which would otherwise cause a shift in its state.

8. In a display device having a switch and display device segment connected to a first current source, the improvement comprising means for indicating the inoperative condition of said segment which includes a second current source for supplying current, means for unilaterally conducting current coupled to said second current source, and means connecting said means for unilaterally conducting current to said display device segment so that said unilaterally conductive current means is biased in a reverse direction at all times except when said segment is inoperative.

9. In a display device having a switch and display device segment connected to a first current source of first potential and of sufficient magnitude for energizing said segment, the improvement comprising a means for indicating the nonconductive condition of said segment which includes means including second and third current sources of opposite polarity, said first and third current sources being of the same polarity, means for unilaterally conducting current connected to said segment so that said unilaterally current conductive means is reversely biased when said segment is in condition for the conduction of current therethrough, and means connecting said segment and third current sources to said unilaterally current conductive means so that said unilaterally current conductive means is forwardly biased when said segment is not in a condition for the conduction of current therethrough.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,963,692

Le Roy D. Barter et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 56, for "terminal" read -- terminal --;
line 66, for "exemplary" read -- exemplary --; column 4, line 59, strike out "a", second occurrence; column 5, line 9, after "current" insert a comma.

Signed and sealed this 24th day of October 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents
USCOMM-DC