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[54] **ALTERNATING CURRENT DRIVEN LOAD CIRCUIT**
4 Claims, 2 Drawing Figs.

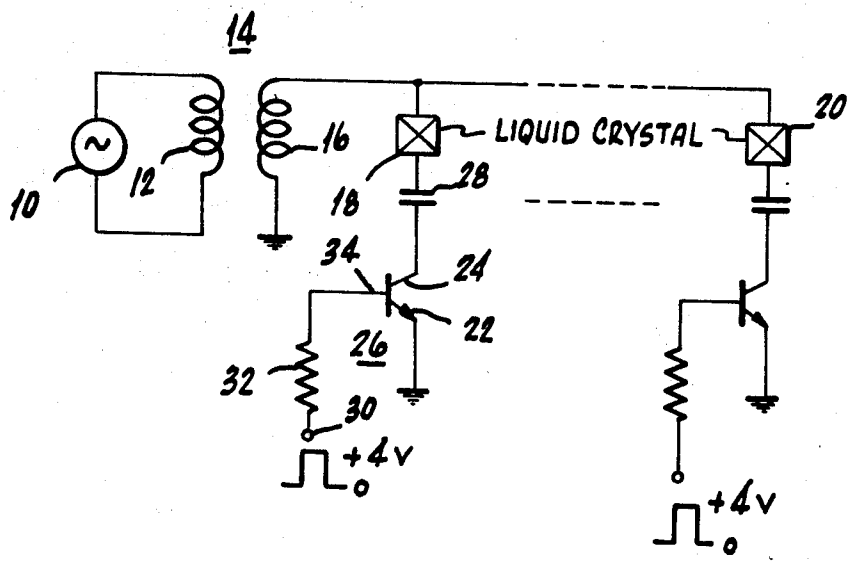
[52] **U.S. Cl.** **307/38;** 350/160; 315/149
[51] **Int. Cl.** **H02j 3/14**
[50] **Field of Search** ..... 350/150, 160 (Inquired); 307/253 (Inquired), 311, 38, 39, 41 340/324.1 (Inquired); 315/149

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ABSTRACT: A simple switch for an alternating current driven liquid crystal element. The switch comprises the emitter-to-collector path of a bipolar transistor in series with a capacitor. A liquid crystal display employs one switch per display element and this provides sufficient isolation among the elements that a single alternating current source may be employed for the entire display.



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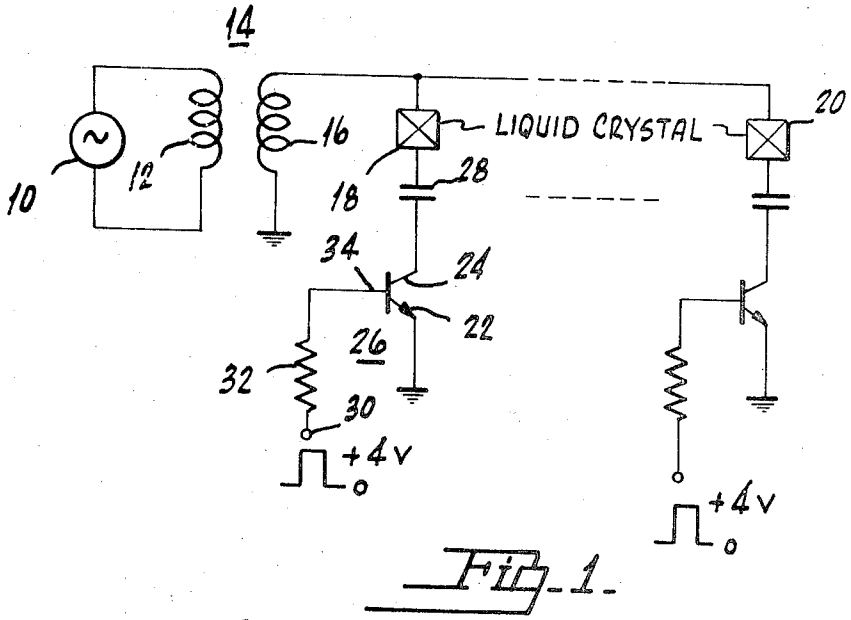


Fig. 1.

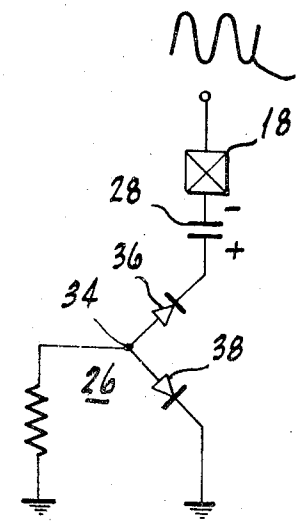


Fig. 2.

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ALTERNATING CURRENT DRIVEN LOAD CIRCUIT

BACKGROUND OF THE INVENTION

Liquid crystals such as those of the nematic type which operate on the principle of dynamic scattering have optical properties which make them suitable for alpha-numeric, television and other types of displays, light shutters and so on. Such crystals, when in an unexcited state, appear to be relatively transparent and, when in an excited state, reflect the major portion of the light reaching the crystal. It has been found that when a direct voltage is employed to produce the electrical field necessary to excite the crystal, electrochemical reactions occur which degrade the performance of the liquid crystal. In particular, the life of the crystal is very much shortened.

The object of the present invention is to provide an improved switch circuit for permitting alternating voltage operation of liquid crystals.

BRIEF SUMMARY OF THE INVENTION

The circuit of the invention includes two terminals for an alternating current power supply and a series circuit connected between these terminals comprising the emitter-to-collector path of a transistor, a capacitor and a load which may be liquid crystal element. The circuit also includes means for placing the transistor in conducting and nonconducting conditions comprising means for applying a signal to the base of the transistor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a preferred form of the present invention; and

FIG. **2** is an equivalent circuit of the circuit of FIG. **1**.

DETAILED DESCRIPTION

The circuit of FIG. **1** includes a common, alternating voltage power supply **10** such as a 60-cycle source connected to the primary winding **12** of a power transformer **14**. The secondary winding **16** of the transformer is connected to all of the liquid crystal elements of a display, such as an alpha-numeric display. For purposes of the present discussion, only two of the elements **18** and **20** are illustrated.

As the switch circuit for each liquid crystal element is identical, only one such circuit is described. It includes the emitter **22** to collector **24** path of a transistor **26** in series with a capacitor **28**. A source of turn-on voltage is connected via terminal **30** and resistor **32** to the base **34** of the transistor **26**. The transistor may be of the NPN type, as shown, in which case the turn-on voltage required is relatively positive. For example, the turn-on voltage may be a pulse starting at 0 volts which reaches an amplitude of +4 volts.

The operation of the circuit of FIG. **1** may be better understood by referring to FIG. **2**. Here, the transistor **26** is shown in equivalent circuit form as two diodes **36** and **38** connected anode to anode. Diode **38** is the emitter-to-base diode and diode **36** is the base-to-collector diode. When the transistor **26** is turned on, it is forward biased sufficiently that the transistor operates in saturation. Current therefore flows from the secondary winding **16** of the transformer through the liquid crystal cell and the emitter-to-collector path of the transistor during both the positive and negative portions of the sine wave **40** driving the crystal. This current causes dynamic scattering of light to occur in the crystal.

When it is desired to turn the liquid crystal off, the base **34** is returned to ground as shown in FIG. **2**. As the emitter and base are now at the same potential, the emitter-to-base diode **38** does not conduct. However, it would appear, at first consideration, that each time the alternating voltage driving signal **40** of FIG. **2** went negative, the base-to-collector diode **36** would be driven into conduction and the liquid crystal cell **18** would, rather than being turned off, exhibit dynamic scattering.

In practice, the above actually does occur but only for a few cycles. By that time, a charge develops on the capacitor **28**, as shown, that is, the capacitor plate connected to the cathode of the base-to-collector diode **36** becomes sufficiently positive with respect to ground that diode **36** becomes reverse biased and no longer can conduct. The switch **26** therefore opens (the transistor becomes nonconducting) and the power supply voltage develops mainly across the relatively high impedance of the transistor. The voltage and electric field across the liquid crystal reduces correspondingly to a value sufficiently low that the crystal is turned off (is returned to its quiescent state in which it appears relatively transparent).

It is found, in practice, that the switch circuit described provides sufficient isolation among the liquid crystal cells of a display, such as an alpha-numeric display, that a single power supply may be employed for all liquid crystal cells and any one or more cells may be individually turned on without affecting the state of the remaining cells.

In one practical circuit, the following values of circuit elements and circuit parameters were employed. These values, of course, are intended merely to be illustrated and are not to be taken as limiting.

Resistor 32	ohms	3900
Capacitor 28	microfarads	0. 001
Transistor 26, type RCA		40, 084
The value of alternating voltage appearing across secondary winding 16, peak-to-peak	volts	70

While in the circuit given by way of example, NPN transistors are employed, it is to be appreciated, of course, that PNP transistors may be used instead provided the proper polarity of turn-on voltage is employed. Also, while the liquid crystal discussed is one of the type operating on the principle of dynamic scattering, the invention is equally applicable to other types of liquid crystals.

In the claims which follow, the expression, "series connected circuit" is employed in the strict sense as set forth in the International Dictionary of Physics and Electronics, Van Nostrand, 1956, pages 817 and 818. As explained there, network elements are said to be series connected if they carry a common current. As also stated there, two terminal elements are connected in series when they form a path between two nodes of a network such that only elements of this path and no other elements terminate at intermediate nodes along the path.

I claim:

1. In combination:
two terminals for an alternating current power supply;
a transistor having a base, an emitter and a collector, said emitter and collector defining the ends of a conduction path through the transistor, said path being connected at one end to one of said terminals;
a series connected circuit comprising a capacitor in series with a load, said series connected circuit being connected at one end to the other of said terminals and at its other end to the other end of said path; and
means for placing said transistor in conducting and nonconducting conditions comprising means for applying a signal to the base of said transistor.

2. In the combination set forth in claim **1**, said load comprising a liquid crystal cell.

3. In the combination set forth in claim **2**, said transistor being connected at its collector electrode to one terminal of said capacitor and said capacitor being connected at its other terminal to said liquid crystal cell.

4. In combination:
two terminals for an alternating current supply;
a plurality of circuits individually connected between said terminals, each said circuit comprising:
a bipolar transistor having a base, emitter, and a collector, said emitter and collector defining the ends of a

conduction path through the transistor, said path being connected at one end to one of said terminals; and

a series connected circuit comprising a capacitor in series with a liquid crystal cell of the nematic type which operates on the principle of dynamic scattering, said series connected circuit being connected at one end to

the other of said terminals and at its other end to the other end of said path; and

means for selectively placing said transistors in conducting and nonconducting condition.