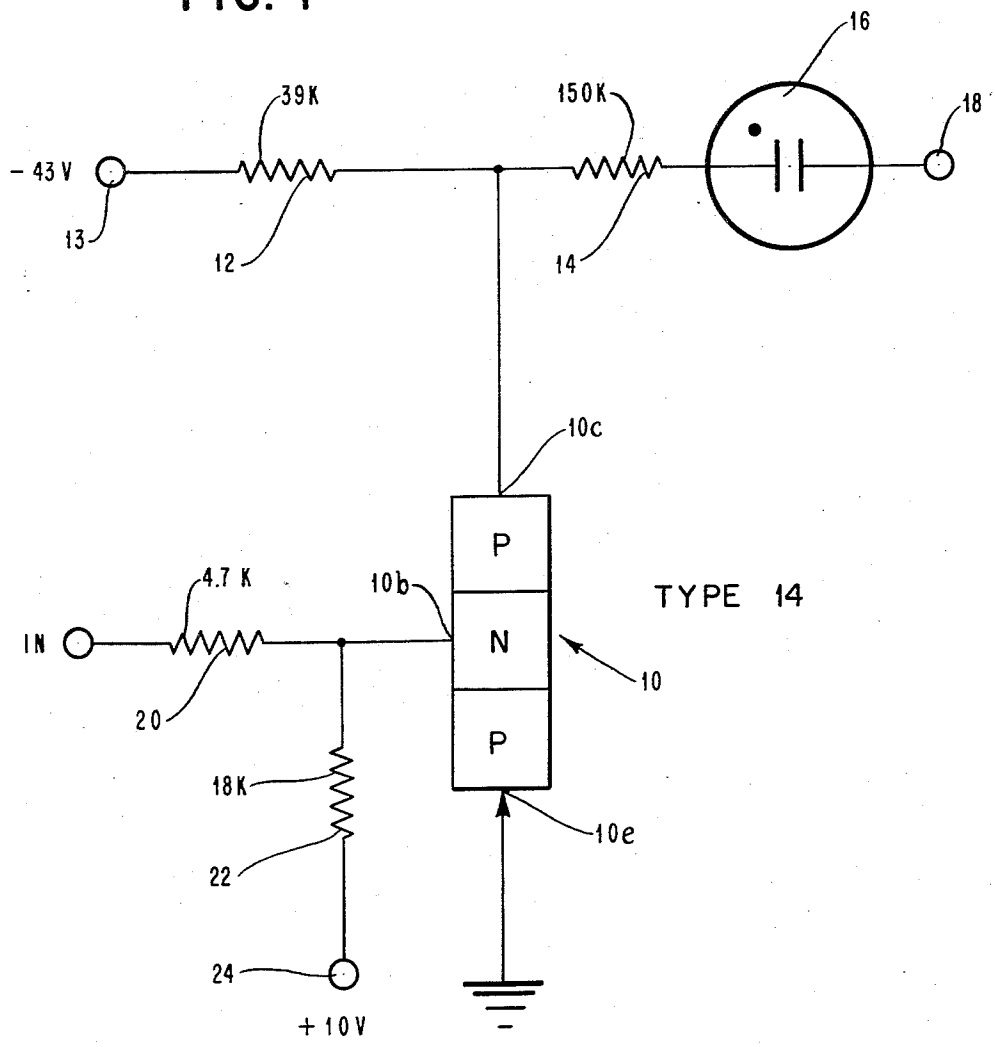
March 1, 1960 R. B. HENNIS 2,927,247

TRANSISTOR NEON DRIVER

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FIG. 1



INVENTOR
ROBERT B. HENNIS

BY Murray Rosen
ATTORNEY

March 1, 1960 R. B. HENNIS 2,927,247

TRANSISTOR NEON DRIVER

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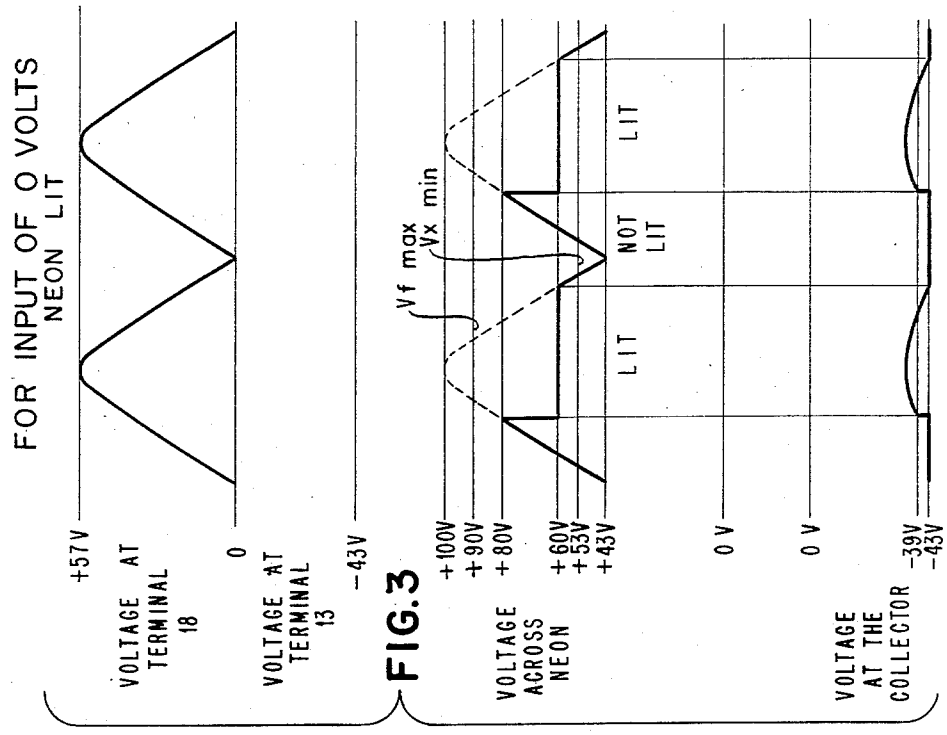


FIG. 3

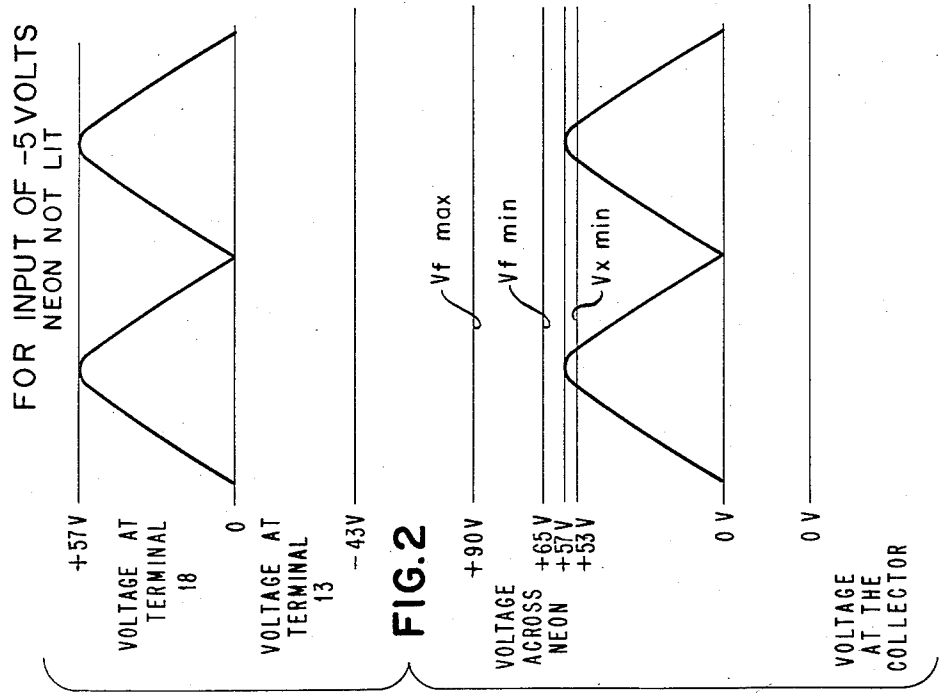


FIG. 2

United States Patent Office 2,927,247 Patented Mar. 1, 1960

2,927,247

TRANSISTOR NEON DRIVER

Robert B. Hennis, Poughkeepsie, N.Y., assignor to International Business Machines Corporation, New York, N.Y., a corporation of New York

Application June 27, 1958, Serial No. 744,978

5 Claims. (Cl. 315—135)

This invention relates to indicator circuits and more specifically to improved transistor circuits for controlling or driving visual signal devices or neon indicators to indicate electrical conditions in other circuits.

In the transistor circuits which are replacing vacuum tube circuits in modern day electronic equipment, the operating potentials are at a relatively low level. The potentials needed to operate commercially available neon indicator lamps are at a higher level. The use in a conventional transistor circuit of a potential high enough to operate a neon indicator lamp, might subject the transistor to a potential high enough to cause punch-through. When punch-through occurs, the transistor no longer functions to produce normal transistor action.

Another difficulty encountered in the design of a transistor circuit for operating a neon indicator is the fact that commercially available neon lamps have a wide range of firing and extinguishing potentials.

The invention makes use of a pulsating D.C. or A.C. voltage on one terminal of a neon for varying the potential at the terminal by an amount greater than the difference between the minimum extinguishing voltage and the maximum firing voltage of neons. The other terminal can then be placed at either of two D.C. levels, one of which does not allow the varying D.C. potential across the terminals of the neon to reach the minimum firing voltage, so as to maintain the neon in its off condition, and the other of which shifts the reference of this varying D.C. potential so that the latter scans from below the minimum extinguishing voltage to above the maximum firing voltage of commercial neons and the neon flickers to appear lit to the eye.

It is an object of this invention to provide an improved transistor circuit for reliably operating a neon indicator lamp.

Another object of the invention is to provide a transistor circuit for reliably operating a neon glow lamp without subjecting the transistor to unduly high potentials.

Still another object of the invention is to provide a transistor circuit which can operate reliably to fire a neon lamp for the full range of firing and extinguishing voltages of commercially available neon lamps.

A further object of the invention is to provide a scanning voltage which varies an amount greater than the difference between the minimum extinguishing voltage and the maximum firing voltage of neons.

A still further object of the invention is to provide a means for effectively shifting the reference level of the varying potential across a neon lamp from a position where the voltage peak does not reach the minimum firing potential of the neon to a position where the peak voltage is greater than the maximum firing voltage and the minimum potential is lower than the minimum extinguishing point of commercially available neon lamps.

Another object of the invention is to provide a transistor operated neon lamp indicator wherein the voltages are high enough to operate in the full range of commercially available neon lamps, and yet never apply greater than the punch-through voltage to the transistor.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which discloses, by way of example, the principles of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a circuit diagram of the preferred embodiment of the invention.

Fig. 2 illustrates the voltage conditions in the circuit of Fig. 1 when the neon is not firing.

Fig. 3 illustrates the voltage conditions in the circuit of Fig. 1 when the neon is firing.

Before describing the invention it is necessary to understand some of the operating characteristics of present day commercially available transistors and neon lamps.

It is well known in the art that a neon lamp will not fire to light up until the firing voltage of the neon lamp is reached. Once the neon fires, it operates as a constant voltage device and will continue to remain lit until the extinguishing voltage, which is substantially lower than the firing voltage, is reached. Different neon lamps manufactured under the same type designation may have different firing and extinguishing voltages. For any particular type designation of neon, there is a fairly well defined range of firing and extinguishing voltages. For example, in the NE–75 type neon, which is utilized in the preferred embodiment of the invention, the firing voltage for the different neons may vary from a minimum of 65 volts to a maximum of 90 volts. The extinguishing voltage may vary from a minimum of 53 volts to a maximum somewhere below the firing point of the particular neon. The average firing voltage for an NE–75 is approximately 80 volts and the average extinguishing voltage is 60 volts.

In the commercially available junction transistors, which are best suited for the operation of the preferred embodiment of the invention, the operating voltage usually placed at the collector of the transistor ranges between 5 and 20 volts. While there is no reason for going higher in a normal circuit design, these transistors are generally capable of operating with a collector voltage of 45 volts. This voltage is too low to operate the neon lamps. If voltages of greater than 45 volts are used, the problem of punch-through arises.

If the collector voltage of a transistor is increased sufficiently to cause the depletion region of the collector to move entirely through the base region and at some point contact the emitter region, a relatively low resistance path between the emitter and collector is established. This phenomenon is known as "punch-through" breakdown, and is more fully described in the "Handbook of Semiconductor Electronics" by L. P. Hunter, published in 1956 by McGraw Hill. When punch-through occurs, transistor action is lost.

A transistor indicator circuit is shown in the patent to J. C. Logue et al., in Patent 2,772,410, issued November 27, 1956. The present invention, which is an improvement on that patent, has a circuit which is operative for the full range of commercially available neons rather than for hand picked neon lamps.

One of the problems which is encountered in the circuit of the type shown in the Logue et al. patent is the reverse current which flows between the base and the collector through the collector resistor during cut off time. This current, known as I_{CO} effectively operates to produce a voltage drop across the collector resistor. This condition acts to make a lower voltage available for operating the neon as will be more fully described hereinafter. It is to be understood that this I_{CO} varies substantially with changes in temperature and from transistor to transistor in commercially available transistors, and so it is neces-

sary to take into account the worst conditions. That is, if there is a low I_{CO}, there is a larger voltage applied at the collector which will operate the neon but which may cause punch-through of the transistor. However, if I_{CO} is high, the punch-through may be avoided, but there will be less voltage available to fire the neon. The invention solves these problems by using a varying voltage across the neon in a manner which will be better understood after the description of the operation of the preferred embodiment.

There is shown in Fig. 1 a neon-indicator-driving transistor circuit including an IBM type 14 PNP junction transistor **10** having an emitter electrode **10***e*, a base electrode **10***b* and a collector electrode **10***c*. The collector electrode is connected through a 39K ohm resistor **12** to a source of −43 volts D.C. **13**, and the collector electrode **10***c* is also connected through a 150K ohm resistor **14** and a neon glow discharge lamp **16** to a terminal **18**, which is connected to a pulsating source of D.C. The waveform for the pulsating source is shown in Figs. 2 and 3, and varies from 0 volts to +57 volts D.C. This may be a well known type of waveform generated in a full wave rectifier which has no filter at its output. The base **10***b* is connected through a 4.7K ohm resistor **20** to an input terminal IN, and also through a 18K ohm resistor **22** to a source of +10 volts D.C. **24**.

The indicator circuit of the invention is ordinarily utilized to indicate the state of other transistor circuits as described in Logue et al. patent. The voltage levels found in the output of transistors, especially trigger circuits, well known in the art varies from 0 to −5 volts. The neon lamp of the invention will glow to indicate when the output of the transistor circuit to which it is connected is at 0 volts, and will not glow when the output of the transistor circuit is at −5 volts.

When the input signal from a previous transistor stage goes to −5 volts, the voltage at the base **10***b* of the driving transistor **10** starts to go negative, and the transistor **10** conducts current from the emitter **10***c* to the collector **10***c*. When the driving transistor **10** conducts current, the collector **10***c* goes to approximately 0 volts. With 0 volts on the collector **10***c*, the neon **16** is effectively in a circuit from the collector **10***c* through the 150K ohm resistor and the neon **16** to the terminal **18**.

It can be seen from Figs. 1 and 2 that there will be no current flowing through the neon, assuming first that there is 0 volts on the terminal **18** and 0 volts at the collector **10***c*, terminal **18** varies from 0 to +57 volts and thus, the voltage across the neon varies from a minimum of 0 volts to a maximum of 57 volts. Since this maximum voltage is not enough to fire a NE–75, even one at the lowest end of the range with a firing voltage $V_{f\,min}$ of 65 volts, the neons will definitely not be fired.

When 0 volts are applied at input terminal IN, the resistors **20** and **22** act as a voltage divider and approximately +2 volts are applied to the base **10***b* of the driving transistor **10**. This positive voltage on the base of a PNP transistor will cut it off. With no current flowing from the emitter to the collector of the driving transistor **10**, the neon **16** is effectively in a circuit from the terminal **13** through the 39K resistor, the 150K ohm resistor and the neon **16** to the terminal **18**.

Fig. 3 illustrates the pulsating voltage on terminal **18** and there is a constant source of −43 volts at terminal **13**. Taking the average firing voltage of 80 volts as the firing voltage, Fig. 3 indicates that when the voltage across the neon is 80 volts, the neon will fire. The voltage across the neon almost immediately drops to a voltage just above the extinguishing voltage, in the example, approximately 60 volts. Even though the voltage at terminal **13** continues to rise, the neon has a constant drop of approximately 60 volts across it. When however, the voltage at terminal **18** goes below +17 volts (assuming an average extinguishing voltage of 60 volts), the neon is extinguished and the voltage across it immediately drops to 0. The neon will remain in this unlit condition until terminal **18** again goes above +37 volts so that there is 80 volts across the neon and it again fires. The operation then continues in the same manner as previously described. The preferred source used for the pulsating D.C. voltage, which is applied to terminal **18** is a 60 cycle input, which after being put through a full wave rectifier, becomes a 120 cycle wave. Thus, the neon would go on once for each cycle of the 120 cycle wave. It thus flickers on and off at a 120 cycle rate which is fast enough so that it appears to be lit to the normal eye.

The importance of a pulsating D.C. voltage or varying voltage on terminal **18** may be understood if an analysis is made of a circuit which does not use the pulsating D.C. current. As has been hereinbefore described, the voltage at terminal **13** is limited to about 45 volts because of the possibility of transistor punch-through. The voltage on terminal **18**, if it is to be D.C., is limited because it must be low enough to provide an extinguishing voltage when the collector of the transistor **10** is at 0 volts. In addition, since the neon must be fired when the transistor **10** is cut off, the factor caused by I_{CO} must be taken into account. I_{CO} flows through resistor **12** and produces a voltage drop which may be as high as 10 volts. This further limits the potential available to the neon because it produces a more positive point at the collector than −43 volts. The voltage across the neon available for firing is the sum of the potential at terminals **18** and **13** minus the voltage drop due to I_{CO}.

By using the pulsating D.C. voltage at terminal **18**, the voltage can be made to rise high enough to produce firing and low enough to provide extinguishing. The amount of D.C. voltage necessary at terminal **13** then becomes an amount which is high enough to shift the pulsating D.C. voltage at terminal **18** from just below the extinguishing point to just above the firing point. Therefore, this D.C. voltage does not have to be made so high, as to cause punch-through of the transistor. The pulsating D.C. voltage must vary so that the difference between its minimum point and its maximum point is slightly more than the difference between the minimum extinguishing voltage and maximum firing voltage. It may be understood that this pulsating D.C. voltage may be an A.C. voltage superimposed on a D.C. voltage in a well known manner. It can be understood that with this circuit, if a neon burns out, it can be replaced from commercially available stock without worrying about readjusting circuit values.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention therefore, to be limited only as indicated by the scope of the following claims:

What is claimed is:

1. Visual signal apparatus comprising in combination, a glow discharge lamp having a firing potential and an extinguishing potential within a predetermined range of values, a source of potential connected to one terminal of said glow lamp which varies periodically by an amount greater than said predetermined range, and means for applying a unidirectional potential to the other terminal of said glow lamp, said means including means to vary the potential at said other terminal between two fixed potential levels.

2. Visual signal apparatus comprising in combination, a glow discharge lamp having a firing potential and an extinguishing potential within a predetermined range of values, a source of potential connected to one terminal of said glow lamp which varies periodically an amount greater than the difference between the minimum extin-

guishing potential and the maximum firing potential, and means for applying a unidirectional potential to the other terminal of said glow lamp, said means including means to vary the potential at said other terminal between a first fixed potential level which provides a maximum difference of potential at the terminals of the glow lamp of less than the minimum firing potential and a second fixed potential level which provides a difference of potential at the terminals of the glow lamp which varies from a value greater than the maximum firing potential to less than the minimum extinguishing potential.

3. Visual signal apparatus comprising in combination, a transistor having an output electrode, load circuit means connected to said output electrode including a load resistor and a first source of unidirectional electrical energy in series, means for indicating an electrical condition in said load circuit means comprising a glow discharge lamp having a firing potential and an extinguishing potential within a predetermined range of values, and an energizing circuit for said lamp including, in series, said load resistor, said lamp and a source of periodically varying electrical energy having a polarity opposite to that of the potential drop across said resistor produced by the current flowing through said output electrode and varying an amount greater than the difference between the minimum extinguishing potential and the maximum firing potential of said predetermined range.

4. Visual signal apparatus comprising in combination, a glow discharge lamp having a firing potential and an extinguishing potential within a predetermined range of values, a first source of unidirectional potential connected to one terminal of said glow lamp, the potential of said first source varying periodically an amount greater than the difference between the minimum extinguishing potential and the maximum firing potential of said predetermined range, an energizing circuit for said lamp including in series, a second source of unidirectional potential, a

load resistor, and a transistor, said load resistor and the output electrode of said transistor being connected to the other terminal of said lamp, and means for selectively operating said transistor to produce current flow through said load resistor, said operation of said transistor providing at the output electrode two fixed levels of potential, a first fixed level when current is flowing which provides a maximum difference of potential across the glow lamp of less than the minimum firing potential and a second fixed level when no current is flowing which provides a difference of potential at the terminals of the glow lamp which varies from a value greater than the maximum firing potential to less than the minimum firing potential.

5. Visual signal apparatus comprising a glow discharge lamp having a firing potential and an extinguishing potential within a predetermined range of values, an energizing circuit for said lamp including a resistor and a source of periodically varying electrical energy in series, said source having a potential which varies an amount greater than the difference between the minimum extinguishing potential and the maximum firing potential of said predetermined range, and means for controlling the potential across the lamp including circuit means for conducting a current through said resistor to produce a potential drop thereacross of a polarity and magnitude effective to reduce the maximum potential available at the lamp below the potential required to fire the lamp, and means for selectively stopping the current conduction through said circuit means to shift the potential available at the lamp so that it varies between the minimum extinguishing voltage and maximum firing voltage of said predetermined range.

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