United States Patent

Gartner

[15] **3,660,682**

[45] **May 2, 1972**

[54] CURRENT LIMITING CIRCUIT

[72] Inventor: **Todd H. Gartner,** Franklin Park, Ill.

[73] Assignee: **GTE Automatic Electric Laboratories Incorporated,** Northlake, Ill.

[22] Filed: **Feb. 1, 1971**

[21] Appl. No.: **111,217**

[52] **U.S. Cl.** **307/237,** 307/297

[51] **Int. Cl.** **H03k 5/08**

[58] **Field of Search** 307/296, 297, 237

[56] **References Cited**

UNITED STATES PATENTS

3,251,951 5/1966 Meewezen .....307/237 X

FOREIGN PATENTS OR APPLICATIONS

1,503,948 10/1967 France 307/237

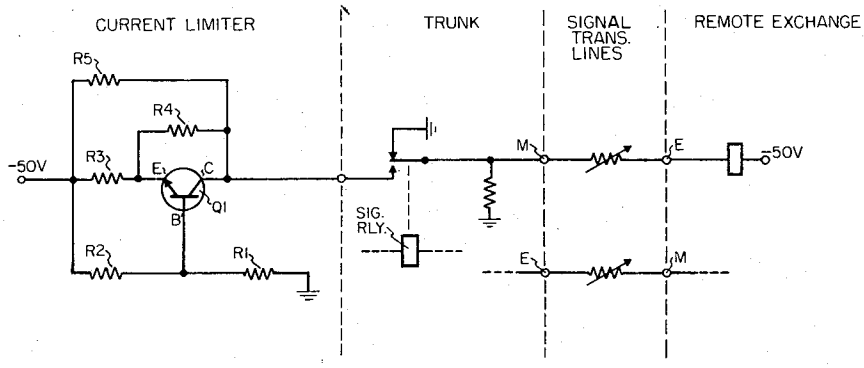
Primary Examiner—John Zazworsky

Attorney—Theodore C. Jay, Jr., K. Mullerheim and B. E. Franz

[57] **ABSTRACT**

The disclosure includes a transistor connected in the signal applying path of a telephone trunk circuit. The transistor is connected into a circuit configuration of resistors to operate as a voltage controlled "negative-resistance" shunted by the resistors which absorb the excess power during adverse line conditions. The overall voltage-current circuit characteristics very closely approximate the traditional ballast lamp.

2 Claims, 3 Drawing Figures



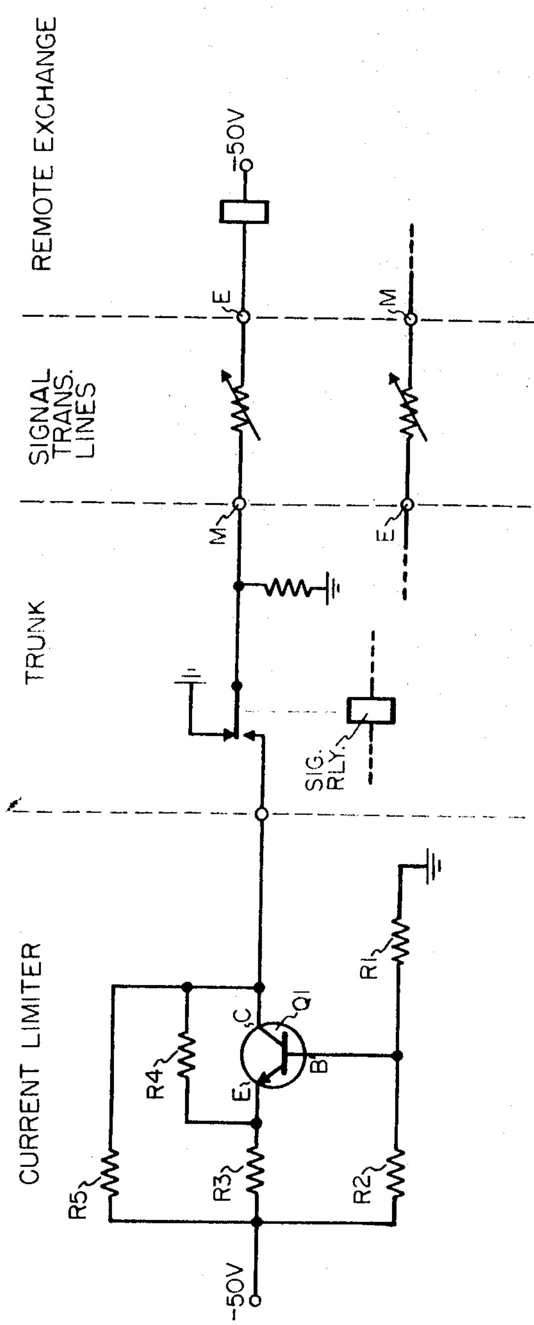


FIG. 1

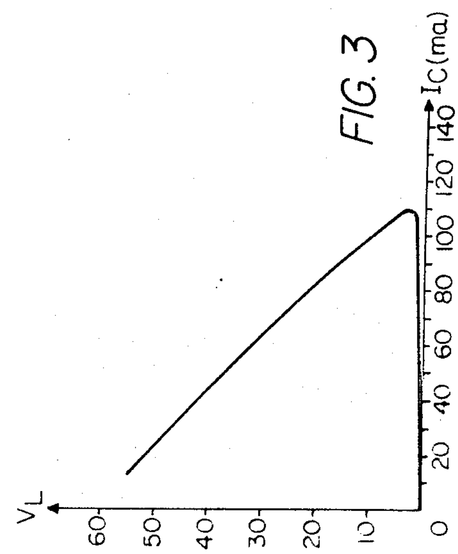


FIG. 3

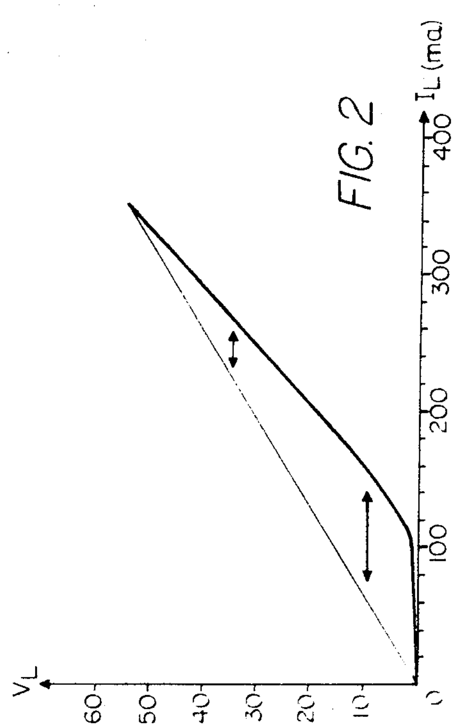


FIG. 2

INVENTOR
TODD H. GARTNER

BY Bernard E. Franz
ATTORNEY

CURRENT LIMITING CIRCUIT

BACKGROUND OF THE DISCLOSURE

1. Field of the Invention

This invention relates to a transistor circuit for limiting the current to a variable resistance load, and in particular to such a circuit which is adapted for use in telephone type trunk circuit signaling paths.

2. Description of the Prior Art

At present telephone trunk circuits of the type disclosed in U.S. Pat. No. 2,744,963 use a ballast lamp to compensate for the differences in the interconnecting cable resistances and the differences in the signaling equipment, as well as for possible signaling path faults. This type of ballast lamp operates by increasing its resistance as the current through it increases. The increased power dissipation in the lamp causes the resistance element to reach comparatively high temperatures and as a consequence a rather large bulb is used to enclose it. These latter two characteristics, while generally adequate for relay type signaling circuits, created problems of packaging. The bulb of the lamp makes it difficult to mount on conventional printed circuit cards and the heat generated by the lamp prevents it being mounted in close proximity to solid state devices.

Further, the presently available tungsten filament ballast lamp is not rugged, lacks long term reliability and exhibits a response lag that may permit injury to sensitive electronic equipment before its resistance reaches a value sufficient to limit the current through it.

Constant current transistor circuit are available that can limit the maximum current therethrough but, these constant current circuits utilize only a transistor or a group of transistors as the series limiting elements, and as a consequence, the power is dissipated in the transistor. This then requires that the transistors be large and be provided with heat sinks to dissipate heat generated by the transistors, thus defeating the space gains made possible by the use of transistors.

SUMMARY OF THE INVENTION

Accordingly a main object of the invention is to provide a current limiting device of compact form. Another object of the invention is to provide a current limiting device having the characteristics of the conventional ballast lamp. Still another object of the invention is to provide a transistorized current limiting device in which the transistor dissipates the minimum amount of power consistent with good regulations. These and other objects are carried out by providing a transistor acting as a series current limiter, shunted by a resistor network. The resistor network is arranged to absorb the power losses incident to a series regulator and also to provide the voltage environment whereby the transistor acts as a voltage controlled negative resistance element in the circuit. This provides the required overall circuit characteristics and also makes the circuit self protecting, and permits the use of a considerably smaller power rating transistor, than would otherwise be possible if the transistor were the only regulating element in the circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic circuit diagram of an illustrative embodiment of the current-limiting circuit of this invention.

FIG. 2 is a characteristic curve illustrating the voltage-current characteristics of the circuit, and

FIG. 3 is a characteristic curve illustrating the voltage-current characteristics of the transistor of the circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows the current limiting circuit connected in series from a telephone exchange signaling battery source of −50 volts through a trunk circuit signaling control to the "M" terminal of the trunk circuit. The signal path then normally extends via a signal conductor to a remote office trunk circuit

where it is terminated on a terminal designated "E." This is the path over which the remote office receives signals from the sending office. The "E" terminal is normally connected to a battery potential via a signal receiving relay. A variation of this signaling system is disclosed in U.S. Pat. No. 2,744,963 where the signaling is performed via a set of composite equipment to economize on line conductors. The functions of the "E" and "M" leads however still remain the same, the signal is forwarded via the "M" conductor and received via the "E" conductor. This patent further clearly shows the use of a ballast or resistance lamp to limit the current that may be drawn during signaling, should a fault occur of a type that might cause equipment damaging current in the signal path. The circuit of the present invention is a direct substitute for this lamp.

In this circuit the transistor Q1 operates as a voltage controlled "negative-resistance" shunted by a resistor, that is, as the voltage at the collector terminal increases (due to a shorted or grounded signal line) the collector current decreases in equal and opposite proportion to the increase in current through resistor R4. The total current to the line remains constant. In operation there is a current flow from the ground potential source through resistors R1 and R2 to the −50 volt potential. The potential at the junction of resistors R1 and R2 to the base of the transistor is such that with the emitter resistor R3 the transistor circuit is similar to a conventional constant current source. However, the position of resistor R4 across the emitter and collector terminals of the transistor Q1 causes the transistor to pass less current as the voltage at its collector terminal increases, since there is a greater voltage drop across the resistor network of R3 and R4, thus changing the positive voltage at the emitter terminal of Q1. The voltage at the base remains comparatively unchanged; however as the voltage at the emitter is increased, less current flows through the base emitter junction and thus decreases the current flow through the collector to provide a negative resistance effect. The transistor operates as a voltage controlled "negative-resistance" shunted by an effective resistance of about 154 ohms. This "negative-resistance" characteristic can be seen on FIG. 3. It can be seen that this combination yields an effective and stable circuit with a characteristic closely approximating that of the ballast lamp.

The voltage current characteristic curve of the device is shown on FIG. 2 by the curved line to the right. The line from the zero point and intersecting the line of the device characteristic is the characteristic of a linear resistor (the network of R3, R4 and R5). The horizontal distance between these two lines at any voltage level represents the increment of current that the transistor must supply beyond that of the shunt resistor.

One example of the components and values thereof which can be employed in this circuit is as follows:

Transistor,	Q1	2N4240
Resistors,	R1	6.8 kΩ
	R2	316 kΩ
	R3	10 kΩ
	R4	340 kΩ
	R5	275 kΩ

What is claimed is:

1. A transistor circuit for limiting the current to a variable resistance load connected to the output terminal of the circuit, comprising in combination: a DC voltage source comprising a negative voltage terminal and a positive voltage terminal, an output terminal, a first voltage divider including a first and a second resistor, said voltage divider connected in series between said first DC voltage source negative terminal and said output terminal, a second voltage divider including a third and a fourth resistor, said second voltage divider connected in series between said DC voltage source negative terminal and said DC voltage source positive terminal, a transistor having base, collector and emitter electrodes, said collector electrode connected to said output terminal, said emitter electrode connected to the junction of said first and second resistors of said

first voltage divider and said base electrode connected to the junction of said third and fourth resistors of said second voltage divider, and a fifth resistor, said fifth resistor connected between said DC voltage source negative terminal and said output terminal.

2. A transistor circuit as defined in claim 1, wherein said second voltage divider resistors have such values that the voltage drop across the resistors remains substantially constant, and said first voltage divider resistors have such a value that the voltage drop across the second resistor increases with increasing load current, said transistor operated by said increased voltage across said second resistor to conduct less current.

* * * * *