United States Patent [19]

Standler

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[54] **PASSIVE OVERVOLTAGE PROTECTION DEVICES, ESPECIALLY FOR PROTECTION OF COMPUTER EQUIPMENT CONNECTED TO DATA LINES**

[75] Inventor: **Ronald B. Standler**, Albuquerque, N. Mex.

[73] Assignee: **RIT Research Corp.**, Rochester, N.Y.

[21] Appl. No.: **560,710**

[22] Filed: **Dec. 12, 1983**

[51] **Int. Cl.**[4] **H02H 9/04**; H02H 9/06

[52] **U.S. Cl.** **361/91**; 361/56; 361/119

[58] **Field of Search** 361/54, 55, 56, 91, 361/110, 111, 119, 402, 406; 336/232

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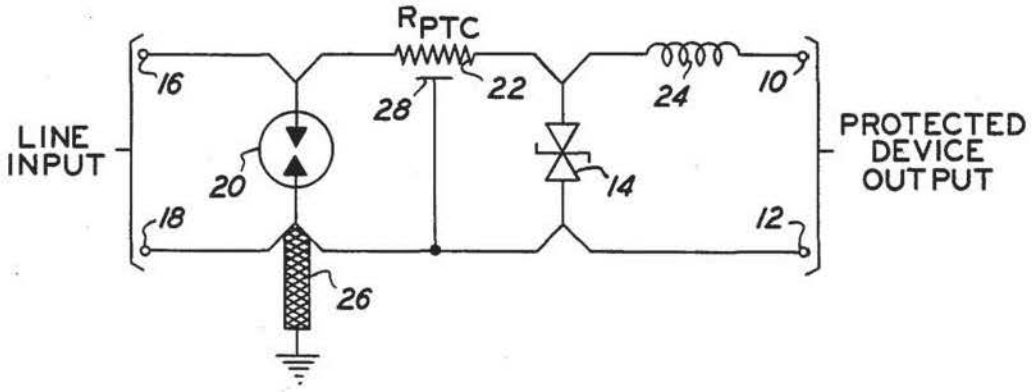
Primary Examiner—Harry E. Moose, Jr.

Attorney, Agent, or Firm—M. Lukacher

[57] **ABSTRACT**

Overvoltage protection devices operative to prevent damage to electrical equipment in response to overvoltages in the form of fast transients and also to continuous overvoltages utilizes clamping or discharge elements which conduct in response to overvoltages or current surges. A high voltage responsive element, suitably a spark gap, is connected to the input of the device which goes to the line, while a lower voltage responsive element, suitably an avalanche diode or diodes or a zener diode or diodes, is connected to the output of the device which goes to the equipment to be protected. A resistor is connected between the spark gap and the avalanche device in series with one side of the line on the circuit to be protected. This resistor is preferably a positive temperature coefficient resistor which changes resistance rapidly to a high resistance state when the avalanche device conducts so as to protect the avalanche device while allowing the development of overvoltages sufficient to cause breakdown and conduction in the spark gap. Fast overvoltage transients are protected against by inductance between the avalanche device and the output that is greater than the inductance in the shunt path provided by the avalanche device.

25 Claims, 8 Drawing Figures



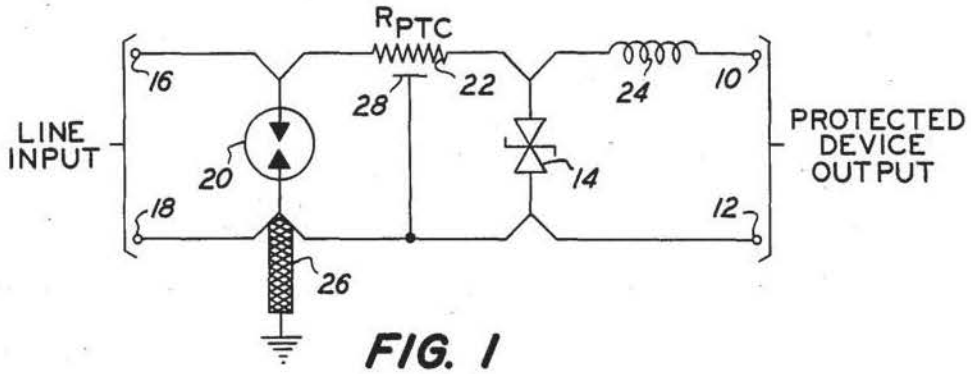


FIG. 1

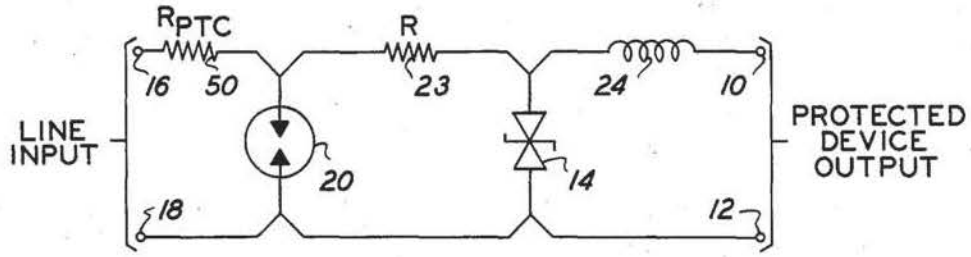


FIG. 5

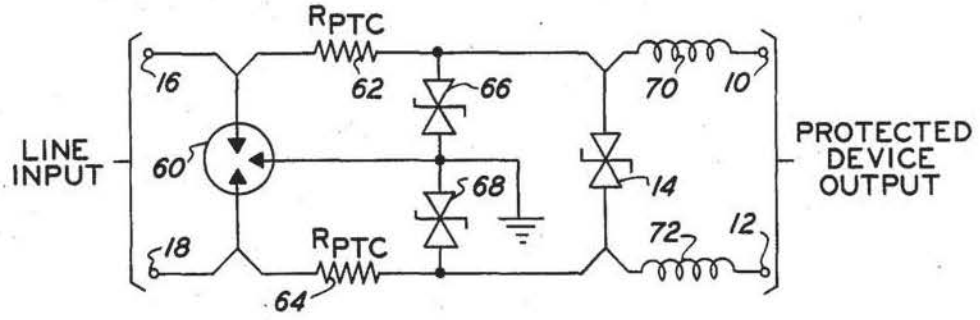


FIG. 6

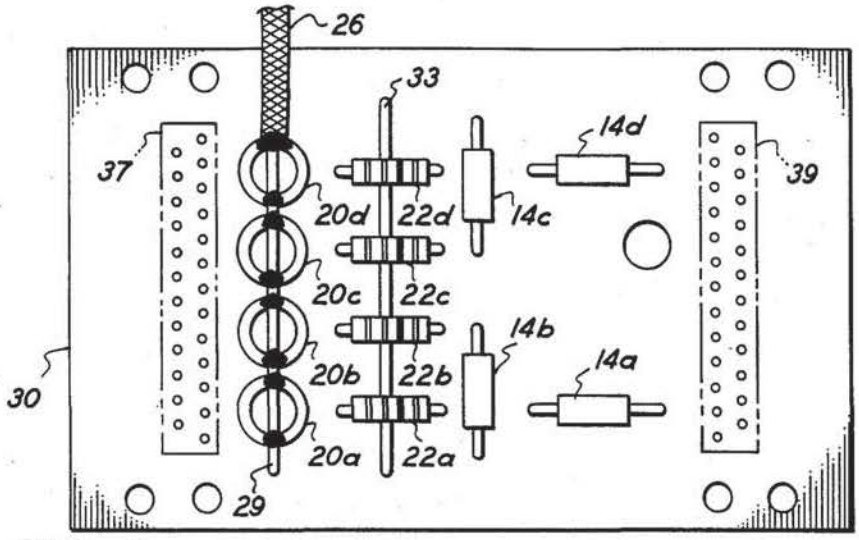


FIG. 2

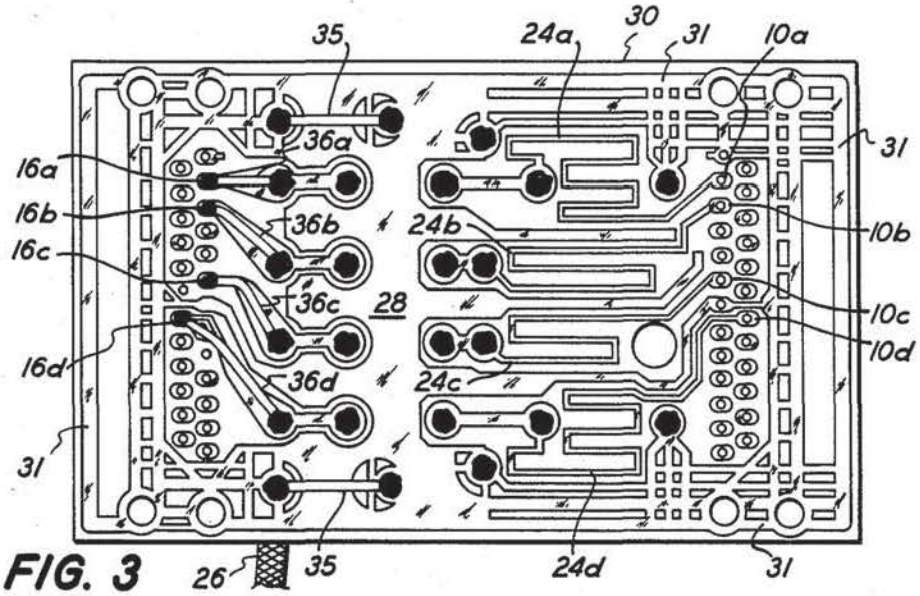


FIG. 3

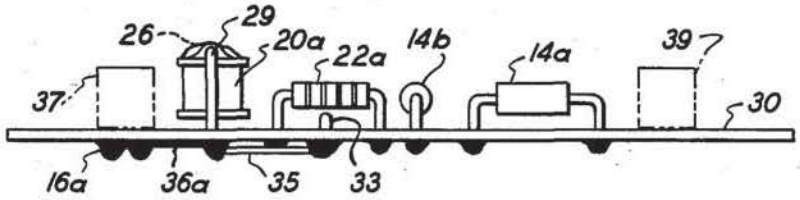


FIG. 4a

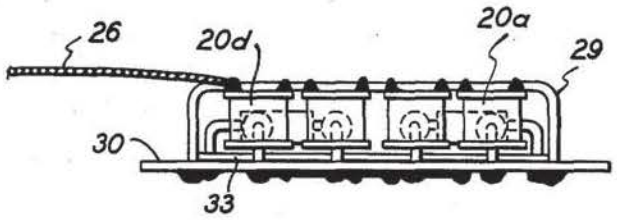


FIG. 4b

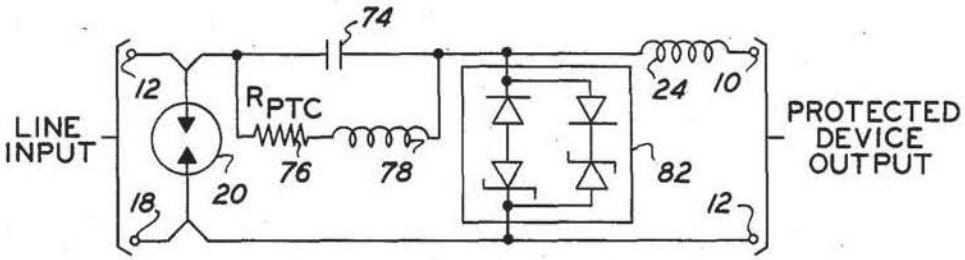


FIG. 7

PASSIVE OVERVOLTAGE PROTECTION DEVICES, ESPECIALLY FOR PROTECTION OF COMPUTER EQUIPMENT CONNECTED TO DATA LINES

DESCRIPTION

The present invention relates to overvoltage protection devices, and particularly to an overvoltage protection device which is purely passive and which protects against both fast transients, as well as continuous overvoltages.

The invention is especially suitable for protecting computer equipment, particularly computer interfaces or terminals which are interconnected by long connecting cables or transmission lines and which operate in accordance with standard protocols such as the RS-232 for serial unbalanced lines and interfaces and the RS-422 for serial balanced data lines and interfaces.

When computer terminals are located a long distance from the computer, transient voltages can enter the connecting cables and damage the interface hardware. Such transient overvoltages are commonly caused by lightning but they may, however, be due to electrostatic discharge or electromagnetic pulses and be very fast, having rise times of nanoseconds to microseconds. In addition, overvoltages may be sustained over long periods of time. For example, cloud to ground lightning can have long continuous currents of the order of 100 amperes for the duration between 0.04 and 0.5 seconds. Overhead power lines may sag or fall and touch the lines on which the data is transmitted. This will inject sustained overvoltages which may, unless protected against, enter the computer directly or through a modem. Overvoltages may also result from accidental connections, for example, of telephone lines to computer data lines. There is also the possibility of malicious damage or sabotage by the connection of a high voltage or current source (e.g. the 120 V power lines) to a computer data line.

The problem therefore presents itself to protect equipment, and particularly sensitive computer hardware, from overvoltages across the gamut from extremely fast transients to sustained overvoltages.

An approach which has been taken for overvoltage protection is to use different elements which conduct at different voltages. Typically, an avalanche or a zener diode is selected to conduct before the voltage across the protected equipment exceeds the rating of that equipment. An element which conducts at a higher voltage, typically a spark gap, protects the diode from high currents which could destroy that diode. Such devices are described in U.S. Pat. No. 2,789,254 issued Apr. 16, 1957 and U.S. Pat. No. 3,934,175 issued Jan. 20, 1976. The device of the latter patent utilizes a delay circuit including an inductor and a resistor in series between the spark gap and the zener diode to allow them to respond independently and conduct at their respective higher and lower voltages. It has also been suggested to use positive temperature coefficient resistors for overcurrent protection in a protected circuit (see an article by Frank A. Doljack, IEEE Transactions on Components, Hybrids and Manufacturing Technology, vol. CHMT-4, No. 4, December, 1981, p. 372, and particularly p. 377). For fast transients, however, overvoltages may appear at the output of the circuit to be protected before either the avalanche device or the spark gap conducts. The failure of the elements to conduct promptly has been attributed to their inherent inductance which blocks the flow of transient currents. To that end, special avalanche devices in a special package having low shunt inductance have been suggested (see U.S. Pat. No. 4,325,097, issued Apr. 13, 1982).

It is desirable to use conventional elements such as spark gaps and avalanche diodes as protection elements, while, at the same time, accommodating overvoltages which run the gamut from continuous to very fast transients. The protection device must be kept small in size to be compatible with the computer equipment with which it is used. Desirably the protection device is used directly ahead of the interface. With many standard computer interfaces very little space is available, for example, the available space may be only a few inches long, a few inches wide, and less than an inch in height. The space limitations exacerbate the problem owing to the possibly large amount of energy to be dissipated.

It is an object of the present invention to provide a protective device which may be connected to the ends of lines and cables which interface with the electronic equipment for protecting the equipment from overvoltages appearing on the lines, whether fast transients or sustained overvoltages, whether with little energy or extremely large energy and high current, which is small in size so as to be compatible with the space available and the connectors used in standard interfaces, such as RS-232, and which utilizes standard circuit components.

A protection device provided in accordance with a feature of the invention utilizes inductance, in the path between an element which conducts in response to an overvoltage and the protected circuit, which presents higher inductance in series with the circuit than is presented in shunt by the protecting elements, such that fast transient overvoltages cause the protecting element to become conductive before an overvoltage reaches the protected circuit.

In accordance with another feature of the invention, the protection device utilizes a positive temperature coefficient resistor to protect a low power element, such as an avalanche device in shunt with the output of the device, which goes to the protected circuit to protect the avalanche device from sustained large currents while providing a low resistance during normal operation (no overvoltage condition).

A protection device provided in accordance with another feature of the invention utilizes a printed circuit card on one side of which the components are mounted and on the other side of which there are traces or printed conductors, which provide the protective inductance between the output and the element (e.g. the avalanche device) which conducts at lower voltage, by having a number of bends in and a length of the trace greater than the bends and the length of the bends in the shunt path provided by the conductive element.

A protection device provided in accordance with still further features of the invention utilizes the traces on the printed circuit card as well as bus bars to minimize inductance which might prevent operation of the elements of the circuit in their protective modes on fast transients.

Briefly described, an overvoltage protection device embodying the invention, for transient overvoltages which appear on a line connected to the input of the protection device, the line transmitting signals with respect to an electrical circuit connected to an output of

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