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A simple voltage sensor and switch

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An inexpensive, easily constructed, device for protecting electrodes or cells under test is described.

1. Introduction

When long-term, constant current, tests are being conducted on new electrode materials it is usual to connect together several cells electrically in series. The factor limiting the number that may be connected together is usually the voltage output of the power supply. As an electrode becomes less active the voltage required to maintain the current increases and, if allowed to go unchecked, will continue to rise until the total voltage required by the circuit is higher than that available from the power supply. When this occurs the power supply is unable to control the current which consequently decreases. This problem may be overcome by use of the simple apparatus described below.

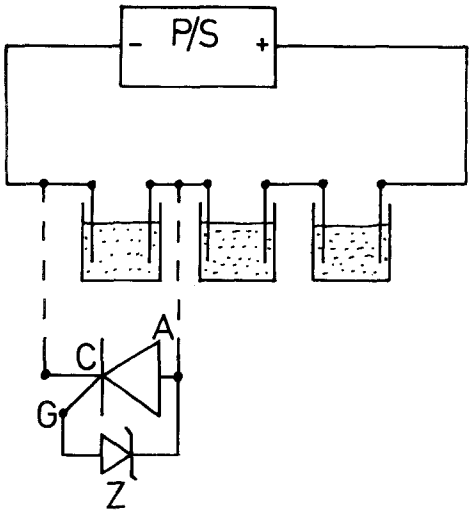

Fig. 1. The basic sensing circuit.

2. Circuit description

The basic circuit is shown in Fig. 1. A thyristor is connected across the cell to be protected with the anode (A) of the device being connected to the positive electrode, and the cathode (C) to the negative electrode, of the cell. No current will flow through the thyristor until the gate (G) of the device reaches a certain positive voltage with respect to the cathode. The gate is connected to the anode via a reverse-biased zener diode (Z).

When reverse-biased the zener diode has a very high resistance below a certain value of applied voltage and a very low resistance above it. The voltage at which this change occurs is called the zener voltage. Thus as the voltage across the cell rises, the thyristor does not conduct and only a very small current flows through the zener diode. However, when the voltage across the diode reaches the zener voltage, the diode conducts and connects the gate to the anode, thereby switching on the thyristor. Once it is conducting, the thyristor can only be switched off by disconnecting it from the voltage supply. Most thyristors require about 1 V across the anode and cathode and will pass several amps although, if high currents are required, it is advisable to mount the device on a heat sink. Thus, since the voltage across the thyristor is about 1 V, so is the voltage across the cell, thereby effectively shorting it out of the circuit.

Several refinements to this simple circuit are suggested below.

(a) *Fig. 2.* The variable resistor in series with the zener diode permits the 'switching' voltage to be varied over a wide range with one zener diode

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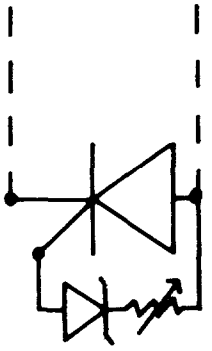

Fig. 2. Use of a variable resistor to vary the switching voltage.

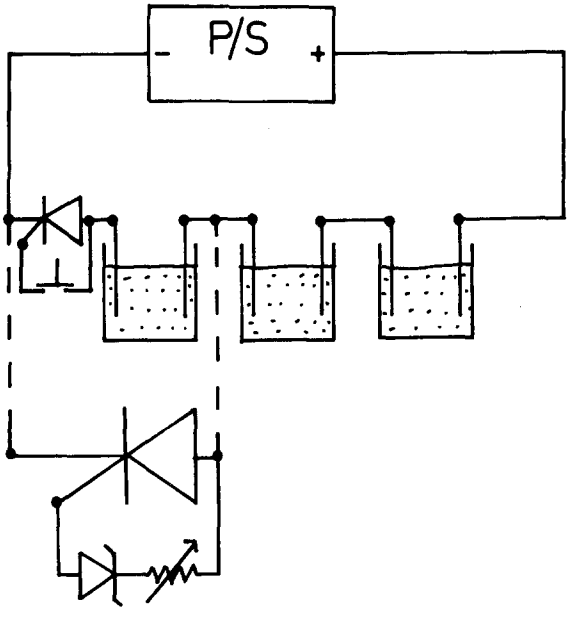

Fig. 3. Circuit for switching the faulty cell to open-circuit.

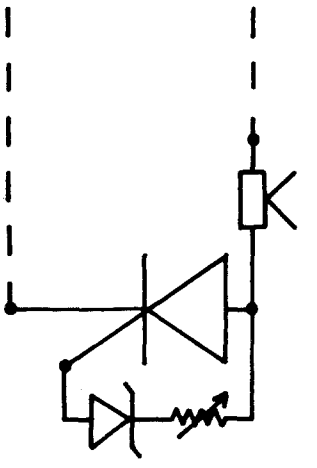

Fig. 4. Audible warning that the preset voltage has been exceeded.

and, since a wide range of zener voltages is available, this unit can be used to detect almost any voltage.

(b) *Fig. 3.* This circuit results in the faulty cell being open-circuited when the sensor switches. This is because the current through the cell becomes too low and the thyristor ceases to conduct. To make the thyristor conduct at the beginning of the experiment it is necessary to momentarily connect the gate to the anode. It will then continue to conduct until the current flowing through it falls below the minimum threshold current of that particular device, usually less than about 50 mA.

(c) *Fig. 4.* This circuit used an 'audible warning device' (RS Components) to indicate electrode or cell failure. It should be noted that the electrode is not protected and the full current (less that taken by the warning device) continues to pass through it.