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TECHNICAL NOTES

A TRANSISTORIZED CONSTANT CURRENT CONVERTER[1]

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Standard laboratory stimulators are usually designed to maintain constant voltage at the stimulating electrodes despite variations in electrode impedance. These impedance variations occur primarily at the electrode surface, however, and not in the undamaged tissue between electrodes; therefore this type of regulation results in severe distortion of the stimulus-current pulse and fails to maintain constancy of either voltage or current in the intact cells (Mickle 1961). By converting the frequently unreliable voltage pulses from most available stimulators into accurate, undistorted current pulses, the circuit to be described overcomes these difficulties and provides reliability of stimulus intensity dial settings. Since the converter is battery operated, it can be used with a stimulus isolation transformer without loss of isolation from ground.

The converter takes advantage of the fact that the collector current of a common base transistor is essentially independent of load resistance. The preparation is connected in series with the collector, as shown in Fig. 1, thus becoming the load resistor and receiving constant

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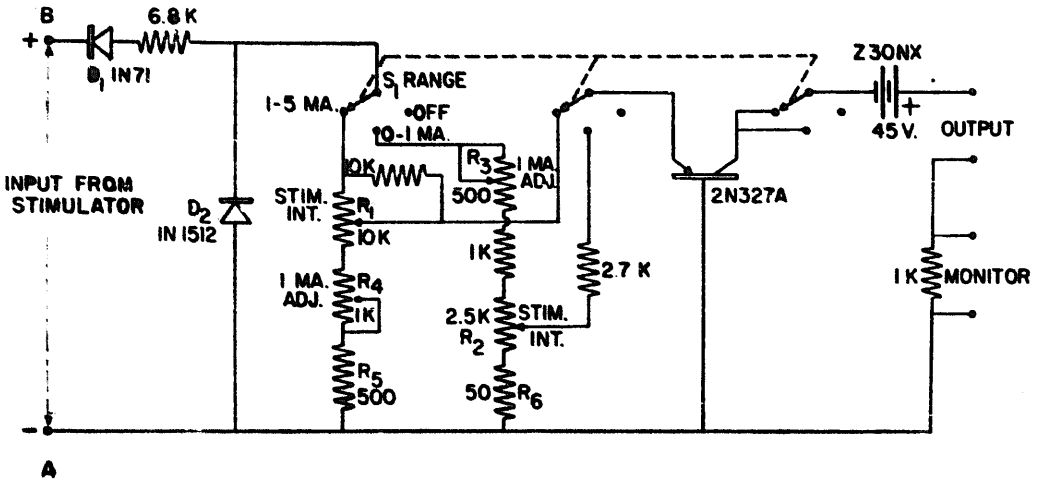

Fig. 1
Circuit of the constant current converter (see text).

current regardless of variations in electrode impedance. The desired collector current, and hence the stimulus current, is determined by the settings on the "Stimulus Intensity" dials associated with R_1 and R_2. In order to obtain precise dial calibration of stimulus-current output, the total current range of the instrument is divided into a low (0–1 mA) and high (1–5 mA) range by S_1. The "Stimulus Intensity" dials are calibrated by applying positive 100 V pulses from a stimulator or isolation transformer to A-B and monitoring the output current on an accurate oscilloscope as the controls are rotated through their range. The appropriate current readings are then inscribed on the dials. The upper limit of the 0–1 mA range is precisely determined by screwdriver adjustment of R_3, "1 mA adjust". Similarly, adjustment of R_4 determines the lower limit of the 1–5 mA range. It may be found that, for a given transistor, either of these controls may have insufficient travel to establish the 1 mA limits. In this event, substitution of slightly different resistance values for R_5 and/or R_6 will bring the "1 mA adjust" controls into range.

The 10 V Zener diode D_2, in parallel with the transistor input, makes the converter independent of drift in stimulator-pulse amplitude. The stability of the Zener diode and the silicon-transistor amplifier is such that the stimulus-current dial settings remain accurate within 2% for several years. The upper limit of current regulation is determined by Ohm's law relation between electrode resistance and supply voltage from the 45 V battery. Negligible current drain ensures extremely long battery life.

Unless the transistor cut-off current is extremely low, the preparation, being connected in series with the transistor collector, would be subjected to constant subliminal excitation between stimuli. The cut-off current of the transistor used (Raytheon 2N327A) is between 0.005 and 0.01 μA, which was judged insignificant. Transistors of the NPN type with cut-off currents on the order of 0.002 μA are now available from Raytheon.

The circuit was designed for use in chronic preparations in which, since electrical recordings were not made, the problem of stimulus artifact did not arise. Subsequent trials on acute preparations have shown the stimulus artifact from the device to be quite high, due to the necessity of using 100 V input pulses. This relatively minor limitation can be overcome by replacing the Zener diode with a clipping amplifier regulating circuit, which will accept lower amplitude input pulses.

Continuous use of these units over the past three years has established their reliability in self-stimulation, conditioning, and stimulus-threshold experiments in which both depth and surface implanted electrodes are used in various types of animals (*e.g.* Rutledge and Doty 1962).

SUMMARY

The circuit for a constant-current converter is presented. This provides a practical method for correcting the distortions of the stimulus current pulse resulting from variations in electrode impedance.

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