A WIDE-RANGE, CONSTANT-CURRENT SHOCK STIMULATOR[1]

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The circuit to be described in this note provides an output with about 16% drop in current from zero load to 500,000 ohms when set at 2 milliamperes and about 3% drop when set at 1 milliampere. The necessary high potential is provided by a 1000-volt transformer hooked into a voltage-doubler circuit (rectifiers and capacitors in Fig. 1). The output current is controlled by the

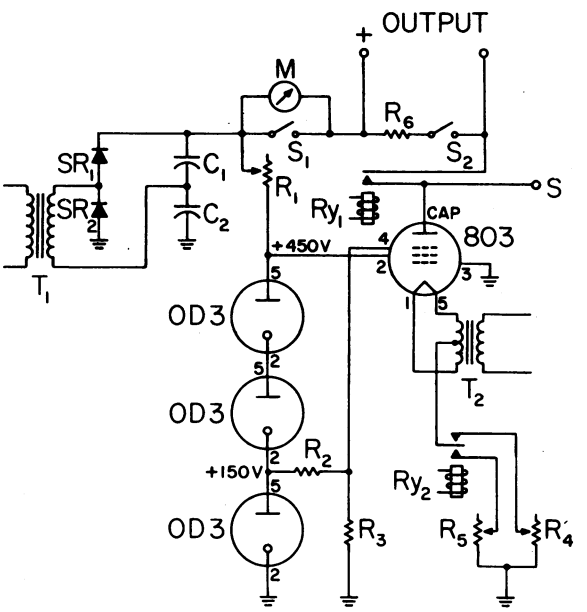

Fig. 1. Schematic diagram.

803 transmitting tube, which is rated for a plate voltage of 2000. Conduction through the plate circuit of this tube is regulated by the voltage relation between the control grid (Pin 3) and the filament; since Pin 3 is grounded, the grid bias corresponds to the voltage drop across R_4 or R_5, whichever is currently in the circuit. The result is that as the resistance of the load (experimental subject) increases, its share of the total voltage drop in the circuit likewise increases, leaving a smaller drop across R_4 or R_5; the corresponding reduction in the (negative) grid bias reduces the resistance of the tube sufficiently to compensate for the increase in the resistance of the load. The same level of current continues to flow through the circuit.

The function of the three voltage-regulator tubes (0D3/VR150) is to provide a stable potential of about 450 volts for the collector grid (Pin 2) and, with the voltage-divider network of R_2 and R_3, a potential of about 40 volts for the suppressor grid (Pin 4). The resistor R_1 should be set in the neighborhood of 80,000 ohms, to limit the current through the voltage-regulator tubes to an appropriate level.

Two relays are built in to provide for the programming of the stimulator from external circuitry. Relay 1 turns the output on and off, and Relay 2 selects between the levels of current set at Potentiometers R_4 and R_5. The operate studs for these relays, plus monitor lights if desired, may be mounted on the front panel. Vacuum-switch relays will probably remain reliable for a longer time than those with metal contacts.

Resistor R_6 is a dummy load that can be substituted for the subject for calibration purposes. The panel meter can be inserted into the circuit by opening the switch that normally bypasses it. The use of separate switches is recommended for the resistor and the meter; these switches and the potentiometers might well be mounted on insulating plates rather than directly on the metal panel.

A neon shunt (Dinsmoor, 1960) is a desirable adjunct for suppressing high-voltage arcs between subject and grid, even if vacuum switches are used for internal programming of the stimulating current. This shunt should be connected from the terminal marked S on the diagram to the positive output terminal; separate posts will be convenient.

The circuit ground indicated in the schematic diagram is a floating ground and is not connected to the chassis.

The builder should be prepared for some components, such as R_1, the 803 tube, the capacitors, and the relays, to be considerably larger than comparable components with lower voltage ratings. Appropriate relays and rectifiers are at present relatively expensive, but the 803 tube can be secured from surplus outlets. Rectifying tubes may be substituted, if desired, for the silicon rectifiers, but appropriate filament transformers with high-voltage insulation must then be provided.

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REFERENCE

Dinsmoor, J. A. Arc suppression in shock circuits. *J. exp. Anal. Behav.*, 1960, **3**, 15–16.

Table 1

Output of Stimulator: Current in Milliamperes as a Function of Load in Ohms.

Load	Zero Load Setting				
	0.50	1.00	2.00	3.00	4.00
20,000	0.50	1.00	2.00	3.00	4.00
50,000	0.50	1.00	2.00	3.00	4.00
100,000	0.50	1.00	2.00	3.00	4.00
200,000	0.50	1.00	2.00	3.00	3.91
500,000	0.50	0.97	1.84	2.56	3.06
1,000,000	0.49	0.97	1.69	2.21	2.27

PARTS LIST

C_1, C_2 1-microfarad capacitors, 3000-volt rating

M 0–3 or 0–5 DC milliammeter

R_1 100,000-ohm, 200-watt adjustable resistor

R_2 22,000 ohms (not critical)

R_3 8000 ohms (or same ratio to R_2)

R_4, R_5 for low currents, 1-megohm potentiometer, preferably with reverse log taper; for high currents, 50,000 ohms (greater sensitivity, range cut off at lower end); mount on plate of insulating material

R_6 100,000 ohms (not critical)

Ry_1, Ry_2 relays with coils rated at programming-circuit voltage, with vacuum contacts for high voltage and auxiliary contacts for monitor lights on panel

S_1, S_2 toggle switches; mount on insulating plates

SR_1, SR_2 International Rectifier Corp. high-voltage silicon cartridge rectifiers, JETEC Type 1N1139, International Type DF1C18 or equivalent ratings; mount in Littelfuse 127002 clips on insulating plate

T_1 1000-volt power transformer

T_2 10-volt, 5-ampere filament transformer with high-voltage insulation

803 transmitting tube, with Millen 36011 plate cap (9/16 inch) and Johnson 122-275-1 giant 5-pin socket

3 0D3/VR150 tubes, with Millen 33008 octal sockets

Chassis, at least 10 by 17 by 3 inches

Panel for rack mounting, at least 12.25-inch height unless panel space is to be allowed for neon shunt

2 Nuway studs for operate inputs to relays

Jack for programming-voltage input

3 monitor light assemblies

Buss HKP fuse retainer for input, HJM for output

1 pair chassis-mounting brackets (*e.g.*, Par SB-710)

4 Millen Type 37001 high-voltage terminals

Control knobs and dials for potentiometers

2 grommets

AC power plug

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