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Author
Fish, Val

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Val Fish, Jr.

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INTRODUCTION

Mercury relays[1] are in general use as switching elements for the generation of mμsec pulses.[2] A typical system uses a coaxial cable one-half the electrical length of the pulse desired, which is switched into a load via another coaxial line. The relay, as manufactured, represents a serious impedance mismatch discontinuity between the two transmission lines.

A simple modification capable of reducing this mismatch discontinuity to less than 1% may be accomplished for a few dollars and less than six man-hours. A modified relay, when used in a line-type pulser, will produce measured[3] pulses of 4.5×10^{-10} second into a 52-ohm cable. Pulse heights can be produced of 300 v or less to the extent of the interaction between driving coil and relay contacts (about 0.007 volt). Smaller pulse heights are obtainable from another model using a completely enclosed coaxial circuit. Wave forms as observed on a Tektronix 517 oscilloscope are shown in Fig. 1.

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[1] Western Electric Company WE-275C, WE-276D and(or) C.R. Clare and Company; Mercury-Wetted Contact Relays.

[2] J. A. Narud, "Theory of nonlinear feedback systems having a multiple number of first-order operating points and its application to millimicrosecond counting techniques," High-Energy Physics Laboratory, Stanford University, Jan. 1955.

[3] Measurements on a TW9(traveling-wave deflecting system) cathode-ray oscilloscope of Naval Research Laboratory design.

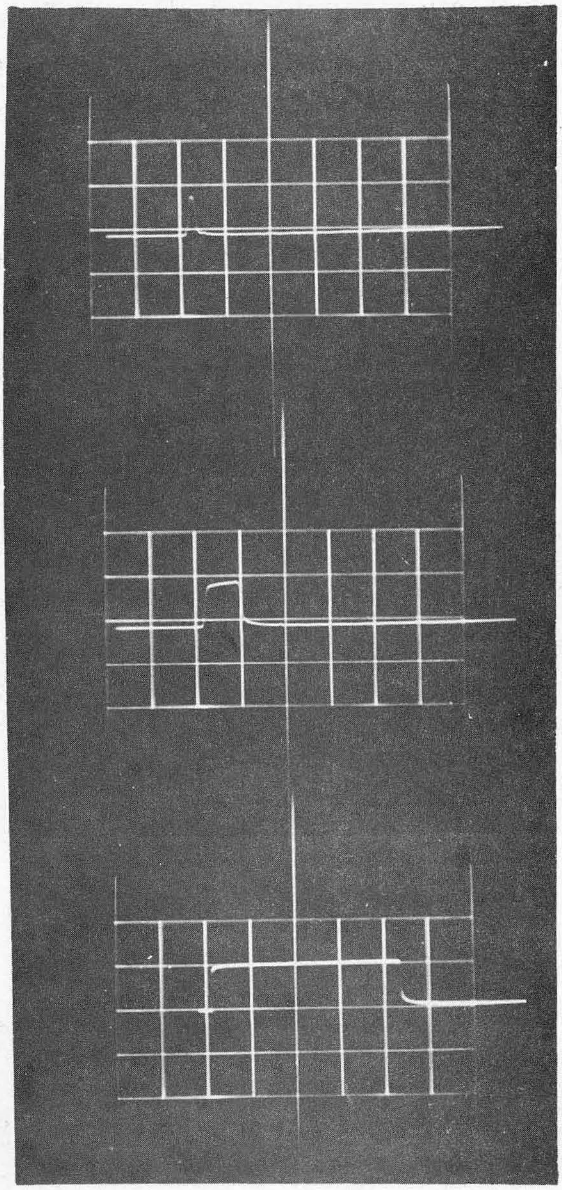

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Fig. 1. Waveforms.

Construction

The relay used for this model is a Western Electric type 275C. When purchased it is contained in a metal can with the base crimped on and has a relay coil with a mercury contact capsule inside potted in sealing wax. The first step is to bend back crimped metal on the base. The relay is placed in a pan and put into an oven set at about 140°C and heated for 45 min to melt the wax. When the wax has melted the relay may be removed from the shell.

The mercury capsule, which is inside the coil, is filled with hydrogen at high pressure to permit the contacts to be operated at high voltages. These capsules may explode if given a sudden jar by dropping or by bending the contact terminals. A face shield should be worn when the capsule is being handled after it is removed from the coil.

After the capsule has been removed from the coil, and the wiring clipped off, the excess wax should be removed from both. The coil may be reheated and the wax drained off; the capsule can be wiped off with carbon tetrachloride. The hole in the coil core must now be enlarged. The coil has two windings: A 3300-ohm winding on the outside and a 700-ohm winding on the inside. The 700-ohm winding must be removed and the opening in the terminal board enlarged to 7/16 in. This will give slightly more than 3/8 in. inside for the new core.

The shield is formed over a 3/8-in. rod from a piece of 0.002-in. copper sheet 5 in. long and wide enough to leave a 1/8-in. lip, and Scotch taped in place. Enough Scotch tape should be used so that the coil fits over the tube snugly. The ends of the copper tube are then split into 3/16-in. strips in order to be held by the coaxial fittings. A slot is cut to the edge of the coil to pass the charging and trigger resistors.

The mercury capsule is then wrapped with a strip of polystyrene tape (0.0025 by 5/8 by 10 in. and) placed between the mercury pool and the four contact wires to increase the dielectric constant of the area where the diameter ratio causes an impedance greater than 52 ohm. It may be held in place with a small piece of Scotch tape. This amount of polystyrene tape permits the capsule to fit snugly into the copper tube.

The assembly can now be installed in the frame, Fig. 2. The coaxial connectors clamp the copper strips on to the end of the tube to hold it mechanically. The terminals from the capsule are soldered to the

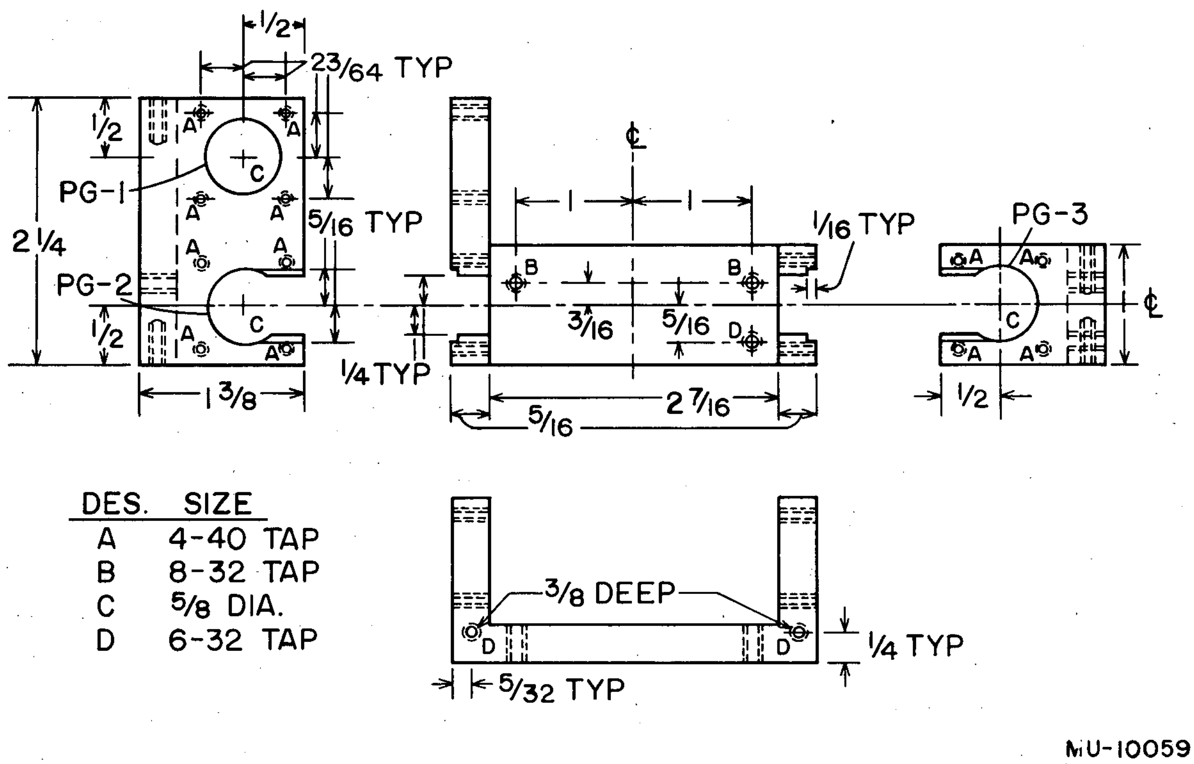

Fig. 2. Coaxial mercury relay pulser relay frame.

connectors and the resistors through the slot in the tube. Figure 3 shows the modified parts ready for assembly.

CHECKING THE RELAY

With the modification complete, the relay may be connected into the circuit of Fig. 4. This circuit provides variable-pulse voltages from 0 to 100 volts with single-pulse operation, slow repetition rate (1 pulse per second), or fast repetition rate (60 pps). This circuit may be built in a box, 6 by 6 by 6 in. and only 7 lb. The power transformer and fuse are mounted on the panel, whereas the other parts, except controls, are mounted on a bakelite board 4-7/8 x 4-7/8 in, supported by three 3-in. stand-off rods bolted to the panel. This unit is shown in Fig. 5. If a traveling-wave oscilloscope is not available, the relay may be connected to the deflection plates of a 5xp, cathode-ray tube oscilloscope, through enough delay to let the sweep start moving after receiving a signal from the trigger output, and through suitable damping resistors to prevent ringing (Fig. 6). This system will limit the rise time to about 1 mμ-sec with 20 kv acceleration voltage. A 5-mμsec pulse (using a 2.5-mμsec charging line) should be flat-topped and show little if any signal 10 mμsec after the rise. If there is any signal following the pulse, the impedance match is not perfect.

Since the mercury capsules have slight differences in construction and contain different amounts of mercury, it may be necessary to change the amount of polystyrene tape on the capsule. If the aftersignal has the same polarity as the fall of the main pulse, the relay is inductive and more polystyrene tape must be used. If the signal has the opposite polarity, a smaller amount must be used. We have found that most capsules require a strip of polystyrene tape 5/8 in. wide. However, all capsules have different characteristics such as contact resistance (as much as 15 ohms for the first few mμsec), conductor dimensions, and voltage restrictions (from 100 volts to 600 volts due to impurities in the mercury which cause varying contact resistance during operation). Conductor dimensions may be compensated for by adjusting the amount of polystyrene tape, but the other characteristics must be changed by selecting a different capsule.

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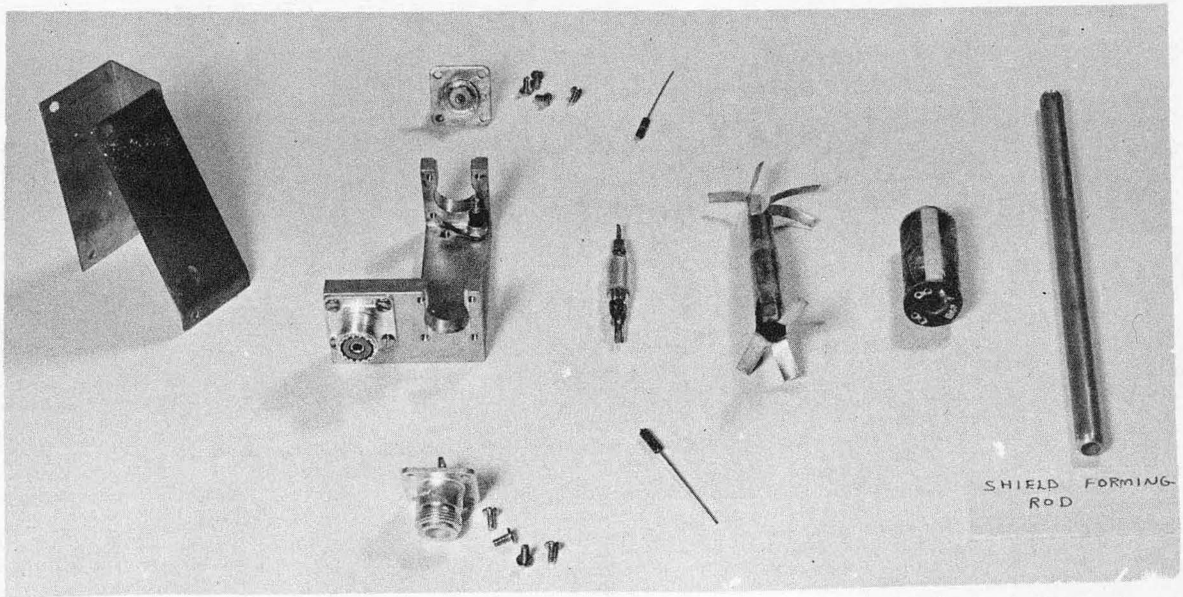

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Fig. 3. Disassembled coaxial mercury relay.

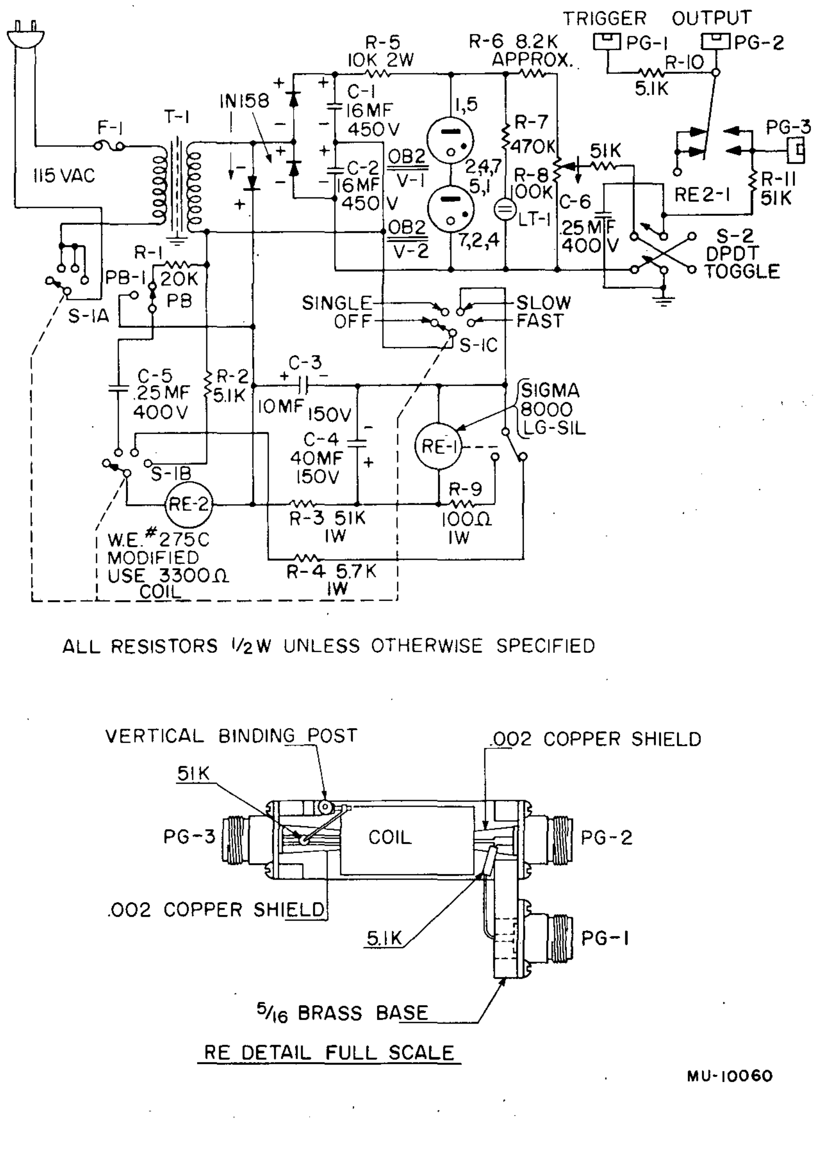

Fig. 4. Coaxial mercury relay pulser schematic.

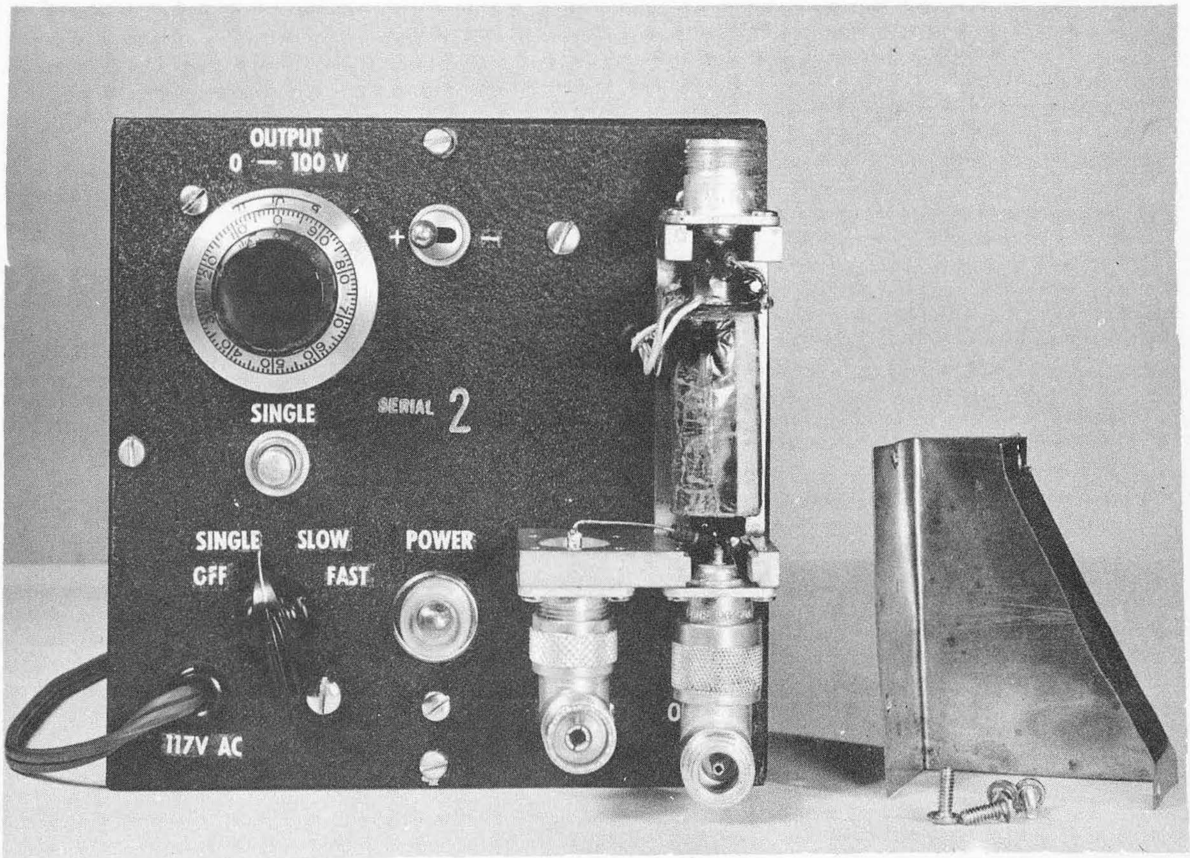

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Fig. 5. Coaxial mercury relay pulser.

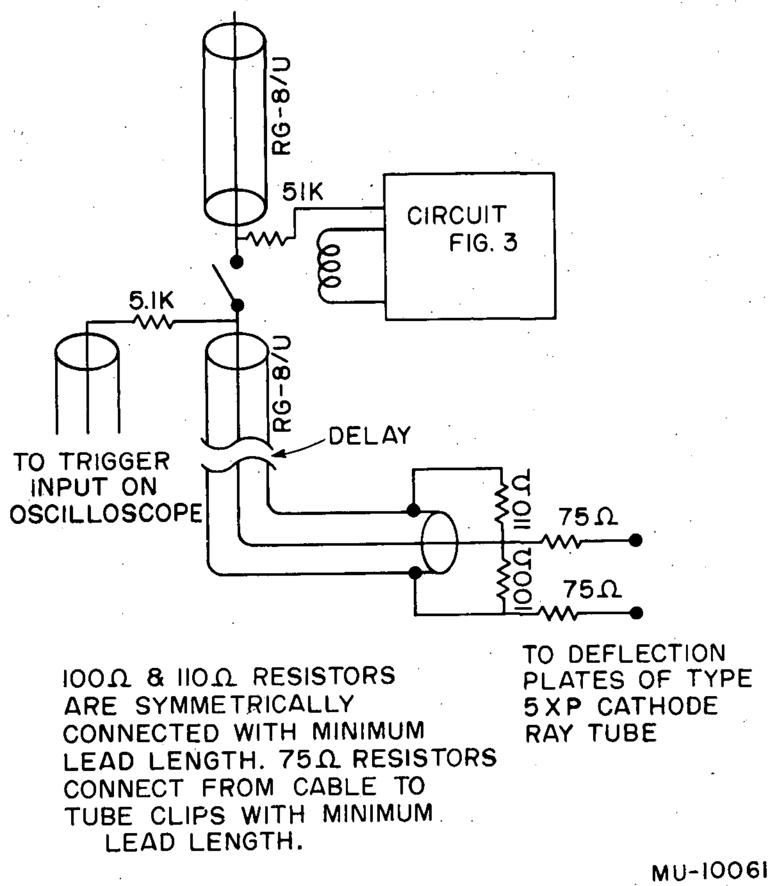

Fig. 6. Deflection plate connections for 5xp-type cathode-ray tube.