Electronic Flash Tube Construction

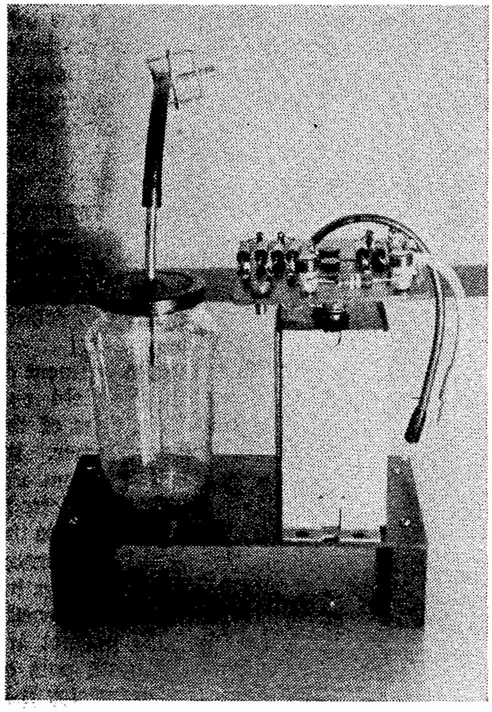
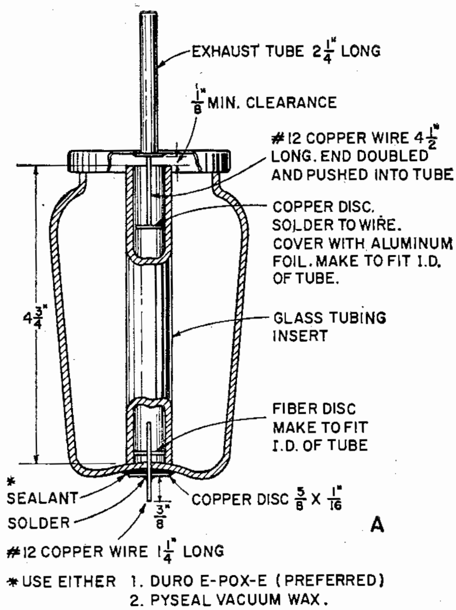
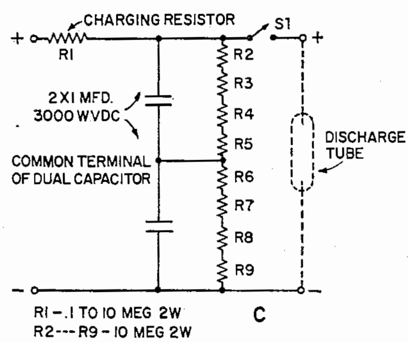
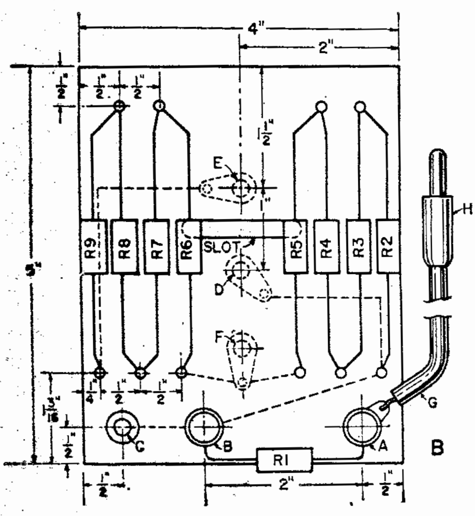


FIG. 12. Demonstration electronic flash tube and R-C assembly. Plugs connect in box.







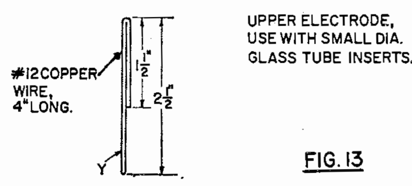


FIG. 13

☐ Intense flashes of light of brief duration are produced by the demonstration electronic flash tube assembly shown in Fig. 12 and detailed in Fig. 13. In operation, a capacitor in parallel with the tube is charged up to a high voltage through a charging resistor.

At a sufficiently high voltage, the gas within the tube ionizes and becomes highly conductive. The capacitor then discharges through the tube in a very short interval resulting in a brilliant flash of light. The basic principle demonstrated is used in photographic electronic flash guns, in high speed photography for "freezing" the motion of rapidly moving parts, and in timing lights and stroboscopic lamps.

Begin construction by making the jar as detailed in Fig. 13A, using construction procedures as detailed for the De La Rive tube. As before, the lower terminal of the tube is cemented to the jar using E-Pox-E cement. Make several glass insert tubes ranging in diameter from 5 to 15 millimeters. A minimum of ⅛-in. clearance is necessary between the jar cap and the insert tube because the cap collapses slightly when the jar is evacuated.

Large diameter insert tubes are centered by suitable fiber discs at the lower end. The upper end is centered by means of a copper disc attached to upper electrode X as shown. For the small diameter insert tubes, use the plain wire electrode Y (Fig. 13). The inserts confine the discharge in specific volumes of gas at all but very low tube pressures.

Next, make the R-C assembly (Fig. 12) as detailed in Figs. 13B and 13C. This assembly is housed in the shield box to permit short connecting leads to the tube. Series connection of the capacitor sections of a dual 1 mfd. 3 KV oil capacitor provides .5 mfd. at 6 KV for operation of the tube. Capacitors of higher value may be used but they must be operated within their voltage ratings.

Make the resistor board as detailed in Fig. 13B but modified as required to mount on the terminals of the capacitor used. Either staked lugs or lug strips may be mounted on the board for support of bleeder resistors R2 through R9. Mount binding posts A and B and the red HV banana jack C as shown.

Holes D and E admit the screw terminals of the capacitor. Common terminal F of the capacitor used is underneath the board because it was shorter than the other terminals. When using a single section capacitor, the connection from the midpoint of the bleeder string and common terminal F is, of course, eliminated.

At the solder lug under binding post A, connect an 8-in. length of red HV test prod wire G and attach a red banana jack H to the end. Do likewise at capacitor terminal E except using black wire and banana jack. R1 is supported by the binding posts to allow substitution of other values of resistance.

Electronic Flash Operation

☐ For the first experiments, omit the glass tube inserts and use plain upper electrode Y (Fig. 13A). Install the tube and the R-C assembly in the shield box placing R1, a one megohm resistor, toward the front. Insert the black banana plug connected to capacitor terminal E into the banana jack on the negative stand-off insulator (left). Insert the red banana plug connected to binding post A into the banana jack on the positive stand-off insulator (right).

Plug the red 20-in. lead into the jack on the resistor board and attach the copper clip on the other end to the lower terminal of the tube. Clip the black lead on the negative stand-off insulator onto the copper exhaust tube. Connect the exhaust tube to the vacuum system.

Plug the 3-ft. red and black power supply leads into the jacks of corresponding color on the rear panel of the box. Plug the black lead into the negative terminal of the power supply (jack J1a) and the red lead into the positive terminal (jack J3a). Ground the negative terminal of the power supply.

Evacuate the tube to about 15mm. hg. pressure (about 29.5 inches vacuum). Gradually increase the voltage applied to the tube (by advancing variable transformer T3) until the tube flashes over. The discharge will appear as a pencil of intense white light and will be accompanied by a noisy report. The tube will continue to flash periodically at a repetition rate depending on the power supply impedance, on R1, on the setting of T3, and on the pressure and electrode spacings.

Electrode spacing is 5 in. with an adjusted tube current of about .3 ma filtered DC. Tube pressures are respectively about 2, 1.5, and .5 mm. hg. from top to bottom.

Displays at low pressures exhibit a soft green glow of the glass tube in the region between the cathode and the luminous node of the positive column. In addition, a prominent thread-like streamer extending from the cathode is visible. Using a magnet, deflect this streamer so that it strikes the sides of the glass tube. Note the bright green glow of the glass at the point where the streamer strikes the glass tube. Electrons in the streamer, upon striking the glass, produce the green or green-blue fluorescence of the glass.

Next, evacuate the tube to about 1 mm. hg. pressure. At this pressure, the discharge is quite diffuse filling out most of the space in the tube. The tube now flashes over at a much lower voltage, produces less light, and flashes at more frequent intervals. The discharge is predominantly pink or red in the middle portion and white near the electrodes. Repeat these experiments using the glass tube inserts which confine the discharge in definite volumes of gas.

At times, you may hear the noise produced by the discharge but fail to see the flash although you are looking directly at the tube. The explanation is that you happened to blink your eyes at the instant of discharge. The discharge takes place in a very short interval, much shorter than the time it takes to blink your eyes.

If an oscilloscope and a selenium photocell are available, you can obtain an estimate of the duration of the flash as follows. Connect the photo-cell to the oscilloscope using a shielded cable. Connect a 100-ohm ½ watt resistor directly across the cell terminals. Tape or otherwise support the cell, facing the tube, on the glass panel outside of the shield box.

Set the oscilloscope sweep circuit to 500 sweeps per second (1/500 sec. per sweep). After observing scope traces of several flashes, the shape and approximate duration of the flash can be determined. The waveform appears as a sharply rising wavefront followed by an essentially exponential decay taking place in less than one-fifth the length of the sweep line. This is less than 1/2500 second in duration! The brightest portion of the flash takes in even less time, probably within 1/25000 second. This experiment demonstrates why photographic electronic flash units are able to "freeze" the motion of rapidly moving objects.

For single shot, manually controlled flash discharges, install single pole single throw porcelain knife switch S1 (Fig. 13C) within the shield box near the top. Arrange a long plastic plunger or lever for operation of the switch from the exterior of the box. Connect this switch in series with the red lead wire normally plugged into jack C on the resistor board. With the switch open, allow time for the capacitor to charge up to its rated voltage. To flash the tube, quickly close the switch.

Commercial photoflash tubes include a triggering electrode and are filled with the gas xenon. They are rated in watt-secs, typically from 100 to 500 watt-secs. The watt-secs rating refers to the energy delivered by the capacitor to the tube. The energy stored in a capacitor is given by $E=\frac{1}{2}CV^2$. E is the energy in joules (watts-secs.), C is the capacitance in farads and V is capacitor voltage.

When operating this tube at a 5KV flash point and using the .5-mfd. capacitor, the energy delivered to the tube is 6.5 watt-secs. Photoflash capacitors of higher capacitance can deliver much more energy to a flash tube. When using a capacitor having a working voltage less than the maximum available from the adjustable DC power supply, use a vacuum tube voltmeter with HV DC probe to measure the power supply output voltage. Otherwise, the capacitor may break down with excessive applied voltage. Observe normal precautions when working with the power supply and charged capacitors.