PHOTOTUBE CAPACITANCE MEASUREMENT WITH THE TYPE 650-A IMPEDANCE BRIDGE

● SINCE INTERELECTRODE capacitance has a marked effect upon the frequency characteristics of a phototube, it is important in many applications that the capacitance be accurately known.

The Type 650-A Impedance Bridge has been found quite satisfactory for this measurement when an external Type 602 Decade-Resistance Box is used to give the required precision of balance.

The necessary connections are shown in Figure 2. The bridge controls are set for capacitance measurement. Since for this connection, 1 ohm is equivalent to 0.1 $\mu\mu$f,

$$C = \frac{\Delta R}{10}$$

where ΔR is the change in setting of the resistance box when the phototube is connected.

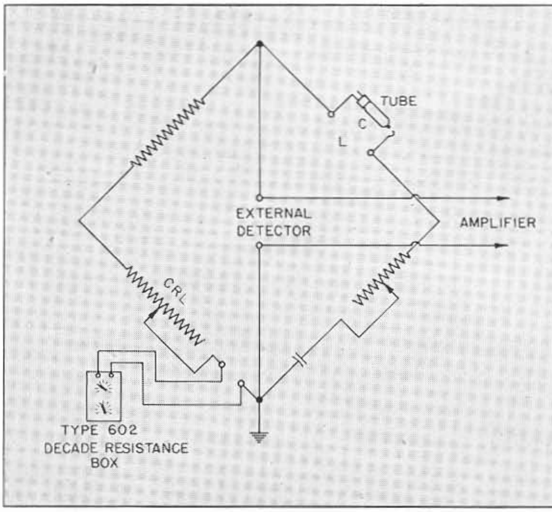
To connect the external decade-resistance box, it is necessary to break the connection between the arm of the CRL potentiometer and ground. This can be done by removing the connecting wire from the potentiometer terminal and bringing out a new lead from the terminal. An equally satisfactory and more convenient method is to insert a slip of paper between the potentiometer arm and the winding. The decade box can then be connected between the J terminal of the bridge and ground.

For measurements over a range of 0.6 to 3.0 $\mu\mu$f, balance to 0.1 $\mu\mu$f could be obtained with a decade box providing unit steps in resistance. A tenth-ohm decade gives increments of 0.01 $\mu\mu$f, and with an amplifier as indicated in Figure 2 the bridge is sufficiently sensitive so that balance to 0.01 ohm or 0.001 $\mu\mu$f is easily obtained. Since hundredth-ohm decades are not generally available, it would be necessary to use a slide wire to obtain this degree of precision.

When a wire from the CRL potentiometer is brought out to the decade, the zero capacitance of the bridge, which amounts to approximately 10 $\mu\mu$f, can be balanced out by means of an initial setting of the CRL dial. If the CRL potentiometer is disconnected by insulating the contact arm from the winding, the decade box must be large enough to balance this zero capacitance, and a four-dial box consisting of hundred-, ten-, one-, and tenth-ohm decades should be used.

In order to keep the conductance component small, the phototube should be shielded from light during the meas-

Figure 1. Panel view of the Type 650-A Impedance Bridge.



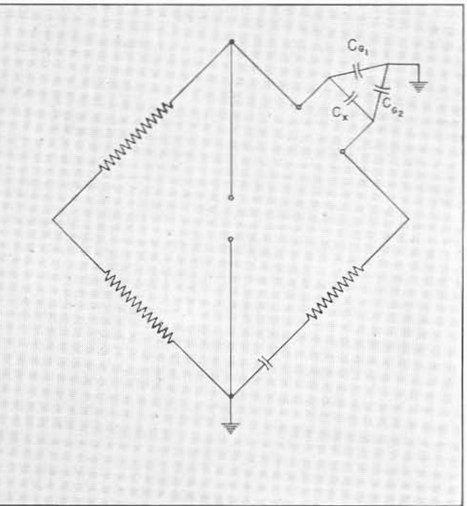


FIGURE 2 (*left*). Circuit diagram of the bridge, showing the decade resistance box connected in series with the CRL dial.

Figure 3 (*right*). By tying the terminal capacitances C_{G1} and C_{G2} to ground, as shown here, the direct capacitance C_x can be measured.

urement. If the tube is exposed to light, an additional decade resistance across the standard condenser is needed for balancing the parallel conductance, in order to avoid a serious sliding balance.

The accuracy obtainable with the TYPE 650-A in the measurement of capacitance of this magnitude is limited largely by the unavoidable connection errors. Since connection errors of the order of 0.1 $\mu\mu$f are difficult to eliminate,* these errors will usually determine the absolute accuracy of the measurement.

It should be noted that this method measures direct capacitance rather than total capacitance and hence is applicable to a number of other problems where small values of capacitance must be measured. It can be seen from Figure 3 that capacitance to ground from the low unknown terminal is in parallel with the detector, while that associated with the high terminal is across the standard arm of the bridge and, when not small enough to be considered negligible, can be corrected for. For measurements of capacitance increments where connection errors do not exist, as, for instance, with plug-in elements, highly accurate measurements can be made.

One possible application is in the measurement of the interelectrode capacitances of vacuum tubes, where the socket is connected to the bridge, and the capacitance increment resulting from plugging in the tube is measured. For these measurements, all unused electrodes should be grounded, so that only the direct capacitance between the two significant electrodes is measured. For accurate measurements of the smaller capacitances such as the grid-to-plate capacitances of screen grid tubes, shielded sockets are necessary to avoid connection errors larger than the capacitance being measured.

— L. E. PACKARD

*R. F. Field, "Connection Errors in Capacitance Measurement," *General Radio Experimenter*, XII, 8 January 1938.