$$R_x = \frac{193}{0.984} = 196 \text{ ohms}$$

$$X_x = \frac{-137 - \dfrac{193^2}{-16{,}400} - \dfrac{(-137)^2}{-16{,}400}}{0.984} = -136 \text{ ohms}$$

5.4 MEASUREMENT OF A 50-OHM LINE TERMINATED IN ITS CHARACTERISTIC IMPEDANCE AT 50 MC. At very high frequencies, lead corrections are very important. It is also desirable, if possible, to bring up the outer conductor of the coaxial line over the panel and make contact either with the panel directly or with a clamp placed under one of the panel screws. (One of the black panel screws supplied must be replaced with an unpainted 10-32 screw for this application.) (See Figure 9.)

a. Connect the generator and detector, and check for leakage as outlined in paragraph 3.5. At high frequencies, reliable measurements cannot be made unless both the generator and detector are fitted with coaxial connectors.

b. As indicated in paragraph 3.7, either the short clip lead or a short length of No. 20 bus wire can be used for connection to the unknown. Assume that the short clip lead is used for this measurement. Screw the lead into the ungrounded bridge terminal and clip it to ground directly at the end of the coaxial line under test. (See Figure 4b.) The reactance of any ground connection used is therefore included in the initial balance and is not measured as part of the unknown.

c. Since the line is terminated in its characteristic impedance, the measured reactance will be low. Therefore, the REACTANCE dial should initially be set in the lower part of its range, say at 500 ohms, with the switch at LOW. Establish initial balance using the INITIAL BALANCE controls.

d. Transfer the connecting-lead clip to the center conductor of the coaxial line and rebalance with the RESISTANCE and REACTANCE controls. Suppose the readings are 40.5 ohms and 350 ohms, respectively. Before corrections, the indicated resistance R_m and reactance X_m are:

$$R_m = 40.5 \text{ ohms}$$

$$X_m = \frac{350 - 500}{50} = -3.0 \text{ ohms}$$

For a slightly more precise reactance reading, repeat the measurement, with the REACTANCE dial initially set closer to zero.

e. To correct for inductance in the resistance capacitor, determine from Figure 7 the correction for a dial reading of 40.5 ohms at 50 Mc. It is 1.23. The corrected value of resistance then becomes:

$$R_m{}' = 40.5 \cdot 1.23 = 49.8 \text{ ohms}$$

f. To correct for the capacitance to ground of the connecting lead, determine from Figure 6 the corresponding reactance (X_a) of the short clip lead at 50 Mc. It is -838 ohms. Applying equations (1) and (2) to determine the actual line input impedance, Z_x,

$$A = \left(1 - \frac{-3}{-838}\right)^2 + \left(\frac{49.8}{-838}\right)^2 = 0.996$$

$$R_x = \frac{49.8}{0.996} = 50.0 \text{ ohms}$$

$$X_x = \frac{-3.0 - \dfrac{49.8^2}{-838} - \dfrac{(-3)^2}{-838}}{0.996} = 0 \text{ ohms}$$

g. This example is cited as an extreme case, in which failure to correct for the inductance of the resistance capacitor leads to an error in resistance measurement in the order of 20 percent.

5.5 MEASUREMENT OF BALANCED CIRCUITS. The Type 1606-A R-F Bridge will not measure balanced circuits directly. However, the measurement can be made by an indirect method. In the balanced circuit shown in Figure 8a, the following three impedance measurements are required:

Z_1 = impedance between A and ground, B grounded,
Z_2 = impedance between B and ground, A grounded,
Z_3 = impedance between A and B connected together and ground.

The effective components of the balanced network can be calculated from the following equations:

$$Z_{AB} = \frac{2Z_1}{1 + \dfrac{Z_1}{Z_2} - \dfrac{Z_1}{Z_3}}$$

$$Z_{BC} = \frac{2Z_2}{1 + \dfrac{Z_2}{Z_3} - \dfrac{Z_2}{Z_1}}$$

$$Z_{AC} = \frac{2Z_3}{1 + \dfrac{Z_3}{Z_1} - \dfrac{Z_3}{Z_2}}$$

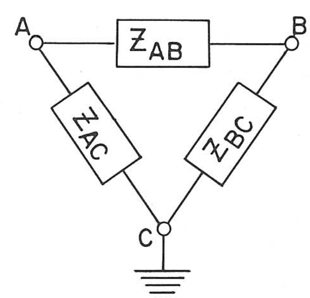

Figure 8a.

If the line is exactly balanced, $Z_{AC} = Z_{BC}$ and $Z_1 = Z_2$.

An auxiliary network to permit direct measurements can be constructed. Details are given in the General Radio Experimenter of September, 1942.

Section 6

CHECKS AND ADJUSTMENTS

6.1 RESISTANCE CALIBRATION. If the RESISTANCE dial calibration changes slightly with time or rough usage, trimmer capacitors C5 and C6, mounted under snap buttons on the panel, can be used to restore calibration. Capacitor C5, under the lower snap button, adjusts the RESISTANCE dial span with the switch at LOW. Capacitor C6, under the upper snap button, adjusts the RESISTANCE dial span with the switch at HIGH. To check calibration, measure the resistance of a good r-f resistor, preferably the carbon-film type, at 1 Mc, with the switch first set at LOW and then at HIGH. The measured resistances at both switch settings should match the d-c value within one percent. If they do not, adjust C5 and C6. Turning these capacitors clockwise decreases the dial reading for a given resistance, and vice versa. Be sure to readjust the initial balance after each adjustment, as the capacitors affect the initial balance as well as the RESISTANCE dial.

6.2 CORRECTION FOR INDUCTANCE IN RESISTANCE CAPACITOR. The change in effective capacitance of the resistance capacitor (refer to paragraph 4.5) is subject to some variation between instruments. Therefore, direct use of the average correction curves of Figures 7 and 8 may lead to error in the resistance measurement. This error is a constant fraction of the correction percentage, and amounts to maximum of ±0.2. That is, if the average correction factor is, say 1.15 (correction percentage = 15%) as determined from Figure 7 or 8, the correction for any individual instrument may be from 1.12 to 1.18. For small corrections, such departures from the average are usually negligible. At the highest frequencies, however, they may be large enough to warrant an individual check on the correction curves.

a. To check the curves of Figure 8, measure a good high-frequency resistor, such as a carbon-composition or carbon-film resistor, whose resistance is known to be 50 ohms, a Type 874-WM 50-ohm Termination, or a Type 874-W100 100-ohm Coaxial Standard, at a frequency of 50 Mc with the switch at LOW. Connect the resistor directly across the bridge terminals or use a very short No. 20 bus wire lead. Suppose the measured resistance and reactance of a 50-ohm resistor are:

$$R_m = 37.7 \text{ ohms}$$

$$X_m = \frac{-600}{50} = -12.0 \text{ ohms}$$

b. The actual resistance "seen" by the bridge is the effective series resistance of the parallel combination of the standard resistor and the connecting-lead capacitance. The effective resistance R_e is:

$$R_e \cong \frac{R_x}{1+\left(\frac{R_x}{X_a}\right)^2} = \frac{50}{1+\left(\frac{50}{-838}\right)^2} = 49.8 \text{ ohms}$$

(This is an approximation because the effective reactance of the resistor is assumed to have a negligible effect. For accurate results, the resistance value should not exceed 2500 f ohms, where f is the frequency in megacycles.)

The correction factor is equal to the ratio:

$$K = \frac{R_e}{R_m} = \frac{49.8}{37.7} = 1.32 \tag{3}$$

c. The correction factor for this particular instrument can be obtained for any resistance setting from this one measurement through the relation:

$$\frac{R_m'}{R_m} = K = 1 + A(R_m + 560)f^2$$

where f is the frequency in megacycles, R_m' is the effective resistance of the unknown across the bridge terminals (that is, the effective series resistance of the parallel combination of the unknown impedance and the capacitance of the bridge leads and terminal, and R_m is the resistance read from the RESISTANCE dial. Therefore: