information needed for most ordinary purposes may be obtained by much simpler methods than those used in the preceding sections, particularly if we assume that the loop is rectangular. A summary of this information is presented in Fig. 10.12.

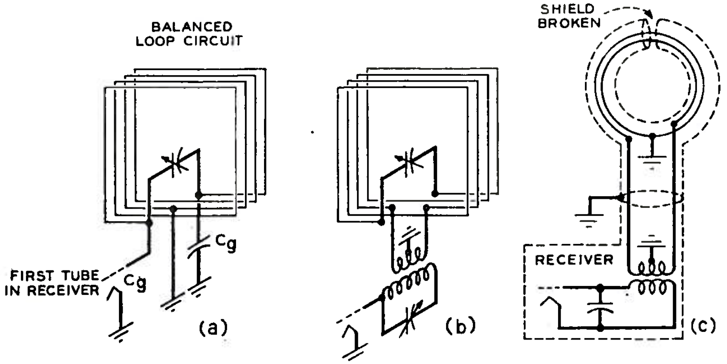

Fig. 10.13 Balanced methods of feeding loop antennas to eliminate the dipole type of radiation from unbalanced currents.

The loop antenna is generally used for direction finding at broadcast and longer waves. This use depends on its figure 8 radiation pattern which has a null along the perpendicular to the plane of the loop. Hence, as we rotate the loop round its vertical axis, we receive a signal until the perpendicular points in the direction of the source of incoming waves.

The figure 8 pattern shown in Fig. 10.12 is obtained only if the loop circuit is balanced to ground;* an unbalance causes the loop to act also as a dipole antenna. Consequently, the nulls are obscured and their directions may be changed. This effect has frequently been called the "antenna effect"; but this is no longer considered good usage. Figures 10.13*a* and *b* show typical balanced loop circuits. A better balance is obtained by enclosing the loop in an electrostatic shield (Fig. 10.13*c*).† Such a shield insures that all parts of the loop will have the same capacitance to ground, irrespective of the loop orientation or of the proximity of various objects.‡ Single-turn balanced shielded loops are discussed by L. L. Libby.§

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* It is a good example of the effects one must look for in the presence of the earth.

† J. E. Browder, Design values for loop-antenna input circuits, Fig. 1, *IRE Proc.*, 35, May 1947, pp. 519–525.

‡ Frederick E. Terman, *Radio Engineering*, Third Edition, McGraw-Hill, New York, p. 821.

§ Special aspects of balanced shielded loops, *IRE Proc.*, **34**, September 1946, pp. 641–646.

10.14 Magnetically and dielectrically loaded antennas

For a given current in the winding, a loop wound on a magnetic core (Fig. 10.14*a*) produces a stronger field than the loop alone. The current in the loop magnetizes the core, and the core becomes a magnetic doublet whose field is superimposed in phase on the field of the current. If the loop and its core are small, the directive pattern is still of the figure 8 shape; hence, the directivity of the loop is not affected by the core. Since for the given current the field and, hence, the radiated power are increased by the core, the radiation resistance must become larger. Thus, let H_1 and H_2 be the distant magnetic intensities of the loop alone and of the loop with the magnetic core; then,

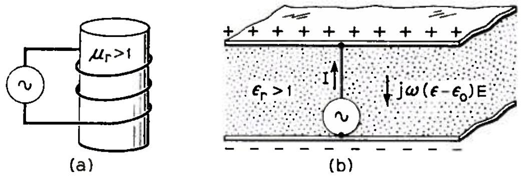

Fig. 10.14 Magnetically and dielectrically loaded antennas.

$$H_1 = AI, \qquad H_2 = kAI, \qquad k > 1, \tag{88}$$

where A and k are proportionality factors. The radiation intensity is proportional to the square of the magnetic intensity, and, *for the same shape of the radiation pattern*, the radiated power is proportional to the radiation intensity; therefore,

$$P_2 = k^2 P_1. \tag{89}$$

If R_1 and R_2 are, respectively, the radiation resistance of the loop alone and of the loop with the magnetic core, then,

$$P_1 = \tfrac{1}{2} R_1 I^2, \qquad P_2 = \tfrac{1}{2} R_2 I^2. \tag{90}$$

Consequently,

$$R_2 = k^2 R_1. \tag{91}$$

The heat loss in the loop is unaffected by the presence of the core. Hence, if the heat loss in the core is kept negligible, the radiation efficiency and the power gain of the loop are increased.

In the case of a dipole antenna or a capacitor antenna (Fig. 10.14*b*), loaded with a dielectric, the effect is the opposite. The density $j\omega(\varepsilon - \varepsilon_0)E$ of the polarization current* in the dielectric is in the direc-

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* Polarization current is the excess of displacement current in a given medium over the displacement current in vacuum (for equal electric intensities).