effective line capacitance. This, in turn, affects the *velocity of propagation* (VP). An electrical quarter wavelength for various types of lines may be calculated from:

$$\text{Length in feet} = \frac{246 \times K}{\text{Frequency (mc.)}}$$

wherein K is a constant which depends upon the type of transmission line. It is the factor expressing the ratio of the actual velocity of the energy on the line to the velocity of light. For various lines, K is as follows:

Parallel open wire line	0.975
Coaxial line, polyethylene insulation	0.659
Coaxial line, teflon insulation	0.695
Transmitting twin-lead, 300 ohms	0.840
Transmitting twin-lead, 75 ohms	0.710
Receiving twin-lead, 300 ohms	0.820
Receiving twin-lead, 150 ohms	0.770
Receiving twin-lead, 75 ohms	0.680

It may be observed from the above formula that the electrical length and the physical length of any section of transmission line differ by the factor K. The electrical length is always shorter than the physical length. For example, one quarter wavelength in space at 14-Mc. is 17′ 7″. One quarter wavelength of RG-8/U coaxial line (VP of 0.659) at the same frequency is about 11′ 7″. It is imperative that the velocity factor (K) be employed when the length of a Q-section is being determined, or when any transmission line is being cut to a specific number of wavelengths.

The Broad Band Balun

A form of 1-to-1 coaxial balun capable of covering several octaves is a useful device for feeding a multiband beam antenna having a split driven element. Described in this section is a simple and inexpensive balun that will transform an unbalanced 52 ohm coaxial line to a balanced 52 ohm termination over the range of 7 to 30 megacycles. The device is small enough to be mounted directly on the boom of the antenna at the driven element.

A balun of this type is illustrated in Figure 16A and consists of nine turns of RG-8A/U coaxial cable, wound into a coil having an inside diameter of six and three-quarters inches. The balun may be thought of as an auto-transformer tuned to resonance near 14 megacycles by the distributed capacitance of the cable in the top portion of the coil. The Q of the resonant circuit is quite high (about 200) and when loaded with a 52 ohm balanced load the selectivity of the tuned circuit is broadened out to encompass a passband of over 23 megacycles. The unbalanced 52 ohm coaxial transmission line is coupled to the top half of the balun coil and the balanced 52 ohm load is placed across the taps at the center of the coil. Each portion of the balun coil "feeds" one side of the balanced load and the bottom coil section is coupled to the top section with near unity coupling. An equivalent circuit of this broad band balun is shown in Figure 16B.

Construction details of the cable assembly are shown in Figure 17. A length of RG-8A/U (52 ohm) coaxial cable sixteen feet, six inches long is wound into a nine turn coil, leaving an inch or so at the ends for connections.

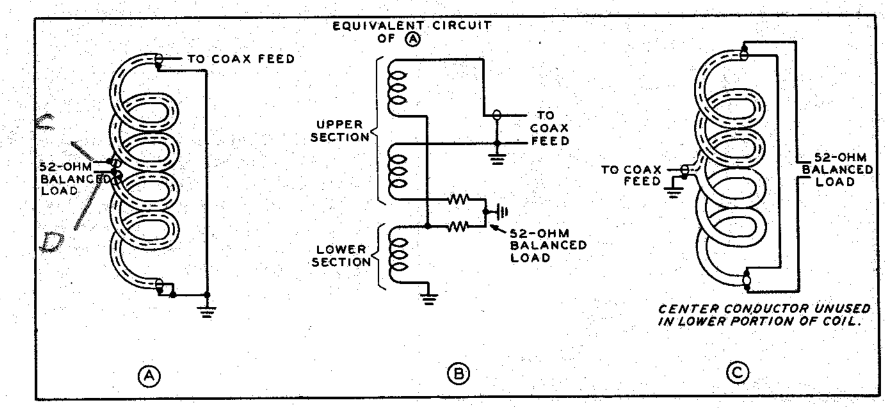

Fig. 16 (A) Simple 1:1 balun may be made of coil of coaxial line tapped at the center. (B) Electrical equivalent of balun shown at (A). (C) Coaxial balun may be fed at center by unbalanced system, with balanced load at ends.

Before winding the coil, mark the mid-point of the cable with a piece of tape. Manipulate and flex the coil so that the ends of the cable fall opposite the center mark. If necessary, trim an inch or so equally from the ends so that they fall within a half-inch of the correct points. Now, once the approximate configuration of the coil has been ascertained, unwind it and prepare the ends and center point for the terminations. The inner conductor is shorted to the outer shield at the ground end and a length of #12 wire connects this point to the outer shield of the coil at the input end of the balun.

The center termination is now prepared. Using a sharp knife, slit the outer dielectric of the cable for one inch each side of the center mark. Next, run the knife around the circumference at each end of the slit and remove a two inch length of the vinyl jacket, being careful not to damage the fragile copper wires of the outer braid. Cut the braid in two at the center mark, pushing the ends back to expose the center dielectric of the cable. A ½-inch slug of the dielectric is cut away to expose the center conductor of the cable and a short length of #12 wire is soldered to the conductor. The outer braid of the lower portion of the balun cable is now slid back into place and soldered to the center conductor adjácent to the #12 wire.

The last step is to trim back the outer braid of the upper section of the balun so it cannot short to the center conductor and to solder a length of #12 wire to the braid. Use a hot iron and make your joints quickly so that you will not overheat the center dielectric of the cable. When the joint is completed it should be wrapped securely with vinyl electrical tape to prevent moisture from entering. The coaxial cable is finally wound back on the form, the ground lead is cut short and soldered to the input shield and the whole assembly taped with vinyl tape at several points. The coil form may be an eight inch length of gray *Polyvinyl Chloride* (P.V.C.) plastic pipe, available from a plumbing supply house. Alternatively, the coil may be "air wound" and taped. Using this simple construction technique, several coaxial baluns have been built having a SWR of less than 1.1/1 over the range of 7 to 30 megacycles when terminated with a noninductive 52 ohm load.