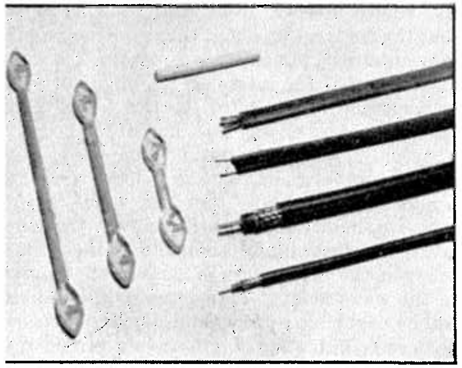

. 13-8 — Typical manufactured transmission lines spacers.

istic impedance of 300 ohms. It is sold under ious names, the most common of which is win-Lead." This type of line has the advan- ;es of light weight, close and uniform conductor cing, flexibility and neat appearance. How- r, the losses in the solid dielectric are higher n in air, and dirt or moisture on the line tends change the characteristic impedance. Moisture ects can be reduced by coating the line with cone grease. A special form of 300-ohm Twin- d for transmitting uses a polyethylene tube h the conductors molded diametrically oppo- ; the longer dielectric path in such line re- es moisture troubles.

n addition to 300-ohm line, Twin-Lead is ob- nable with a characteristic impedance of 75 ns for transmitting purposes. Light-weight 75- 1 150-ohm Twin-Lead also is available.

Characteristic Impedance

The characteristic impedance of an air-insu- ed parallel-conductor line is given by:

$$Z_0 = 276 \log \frac{b}{a} \qquad \text{(13-D)}$$

here Z_0 = Characteristic impedance
b = Center-to-center distance between conductors
a = Radius of conductor (in same units as b)

does not matter what units are used for a and b ong as they are the *same* units. Both quantities y be measured in centimeters, inches, etc. ce it is necessary to have a table of common arithms to solve practical problems, the solu- n is given in graphical form in Fig. 13-9 for a nber of common conductor sizes.

n solid-dielectric parallel-conductor lines such Twin-Lead the characteristic impedance can- be calculated readily, because part of the ctric field is in air as well as in the dielectric.

Inbalance in Parallel-Conductor Lines

exactly out of phase with each other, the electro- magnetic fields will not cancel completely and a considerable amount of power may be radiated by the line.

Maintaining good line balance requires, first of all, a balanced load at its end. For this reason the antenna should be fed, whenever possible, at a point where each conductor "sees" exactly the same thing. Usually this means that the antenna system should be fed at its electrical center. Even though the antenna appears to be symmetrical, physically, it can be unbalanced electrically if the part connected to one of the line conductors is inadvertently coupled to something (such as house wiring or a metal pole or roof) that is not duplicated on the other part of the antenna. Every effort should be made to keep the antenna as far as possible from other wiring or sizable

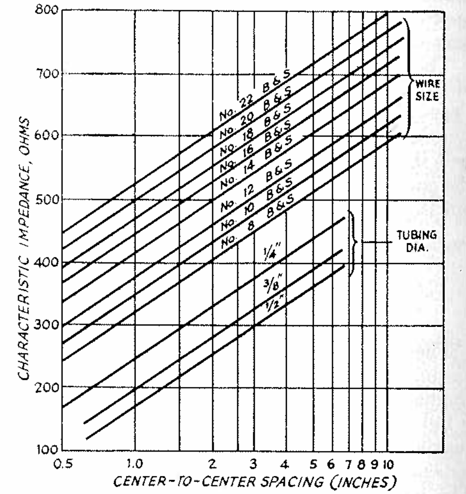

Fig. 13-9 — Chart showing the characteristic impedance of spaced-conductor parallel transmission lines with air dielectric. Tubing sizes given are for outside diameters.

metallic objects. The transmission line itself will cause some unbalance if it is not brought away from the antenna at right angles to it for a distance of at least a quarter wave length.

In installing the line conductors take care to see that they are kept away from metal. The minimum separation between either conductor and all other wiring should be at least four or five times the conductor spacing. The shunt capacitance introduced by close proximity to metallic objects can drain off enough current (to ground) to unbalance the line currents, resulting in increased radiation. A shunt capacitance of this sort also constitutes a reactive load on the line, causing an impedance "bump" that will prevent making the line actually flat.

outer conductor, and a waterproof vinyl covering is placed on top of the braid. This cable is made in a number of different diameters. It is moderately flexible, and so is convenient to install. Some different types are shown in Fig. 13-8. This solid coaxial cable is commonly available in impedances approximating 50 and 70 ohms.

Air-insulated coaxial lines have lower losses than the solid-dielectric type, but are less used in amateur work because they are expensive and difficult to install as compared with the flexible cable. The common type of air-insulated coaxial line uses a solid-wire conductor inside a copper tube, with the wire held in the center of the tube by means of insulating "beads" placed at regular intervals.

Characteristic Impedance

The characteristic impedance of an air-insulated coaxial line is given by the formula

$$Z_0 = 138 \log \frac{b}{a} \qquad \text{(13-E)}$$

where Z_0 = Characteristic impedance
b = Inside diameter of outer conductor
a = Outside diameter of inner conductor (in same units as b)

Curves for typical conductor sizes are given in Fig. 13-10.

The formula for coaxial lines is approximately correct for lines in which bead spacers are used, provided the beads are not too closely spaced. When the line is filled with a solid dielectric, the characteristic impedance as given by the chart should be multiplied by $1/\sqrt{K}$, where K is the dielectric constant of the material.

ELECTRICAL LENGTH

In the discussion of line operation earlier in this chapter it was assumed that currents traveled along the conductors at the speed of light. Actually, the velocity is somewhat less, the reason being that electromagnetic fields travel more

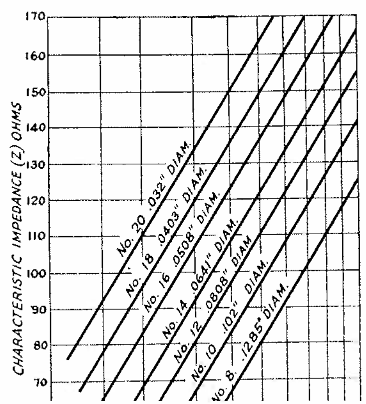

TABLE 13-I
Transmission-Line Data

Type	Description or Type Number	Characteristic Impedance	Velocity Factor	Capacitance per foot; $\mu\mu f$.
Coaxial	Air-insulated	50–100	0.85[1]	
	RG-8/U	53	0.66	29.5
	RG-58/U	53	0.66	28.5
	RG-11/U	75	0.66	20.5
	RG-59/U	73	0.66	21.0
Parallel-Conductor	Air-insulated	200–600	0.975[2]	
	214-080[3]	75	0.68	19.0
	214-023[3]	75	0.71	20.0
	214-079[3]	150	0.77	10.0
	214-056[3]	300	0.82	5.8
	214-076[3]	300	0.84	3.9
	214-022[3]	300	0.85	3.0

[1] Average figure for small-diameter lines with ceramic beads.
[2] Average figure for lines insulated with ceramic spacers at intervals of a few feet.
[3] Amphenol type numbers and data. Line similar to 214-056 is made by several manufacturers, but rated loss may differ from that given in Fig. 13-11. Types 214-023, 214-076, and 214-022 are made for transmitting applications.

slowly in material dielectrics space. In air the velocity is as in empty space, but a prac to be supported in some fash ing materials. The result is slowed down; the currents t tance in the time of one cy space, and so the wave length than the wave length would b same frequency.

Whenever reference is mad so many wave lengths (such as a "half wave length" or "quarter wave length") long, it is to be understood that the *electrical* length of the line is meant. Its actual physical length as measured by a tape always will be somewhat less. The physical length corresponding to an electrical wave length is given by

$$\textit{Length in feet} = \frac{984}{f} \cdot V \qquad \text{(13-F)}$$

where f = Frequency in megacycles
V = Velocity factor

The **velocity factor** is the ratio of the actual velocity along the line to the velocity in free space. Values of V for several common types of lines are given in Table 13-I.

Example: A 75-foot length of 300-ohm Twin-Lead is used to carry power to an antenna at a frequency of 7150 kc. From Table 13-I, V is 0.82. At this frequency (7.15 Mc.) a wave length is

$$\textit{Length (feet)} = \frac{984}{f} \cdot V = \frac{984}{7.15} \times 0.82$$