Harvey Pierce WØOPA
5372 E. Bald Eagle Blvd.
White Bear Lake, Minn.

The Feedline Argument

One of the perennial arguments on the air is the one of "coax versus parallel line." Perhaps a little history and a few facts about the feeding of antennas might add some fuel and some intelligence to the discussions. Everything said about transmitters except power applies to receivers as well.

First, antennas were erected solely with the idea that the more wire and the higher the wire, the better. No thought was given to feed line because the antenna was grounded and a part of the transmitter circuit anyway; however, with the coming of the "short" waves, it became apparent that the best antenna was a half-wave as high as possible. Of course, the grounded vertical was and still is used, but the half-wire horizontal antenna had to have a feedline. Height had some influence, but was not deemed important.

Right away, it seemed, an argument began:

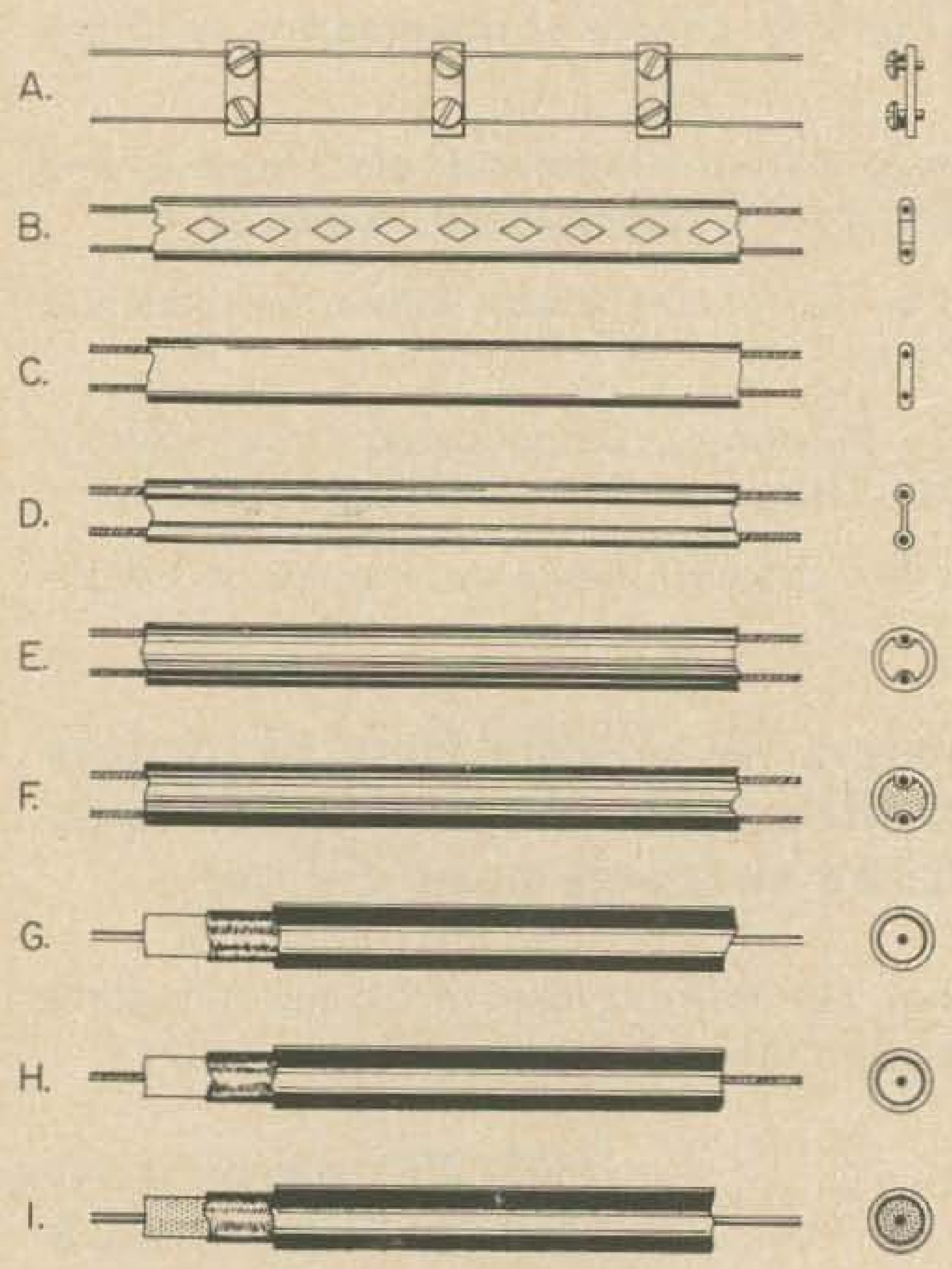

Fig. 1. Common types of feedline.

Which was better—end feed or center feed? Also, what was the proper "impedance" of the line? The impedance didn't really matter to amateurs, but the feed point did. If you fed at the end, you needed only two supports for the wire, one at either end; but if you fed in the middle, *three* supports were usually needed, one in the middle to hold up the feedline. The feedline was the same for both.

It was the so-called "ladder line" (**Fig. 1a**) of two wires held apart by spacers. The impedance was often given as "600 ohms," but nobody cared very much. "Standing waves," if thought of at all, were expected and even encouraged. Everyone had an antenna tuner with variable coupling to the transmitter.

The "center feed" side had the best of the argument, it seemed. No matter what frequency was put out, the feedline was always "balanced"; the voltage and current in one wire always canceled out the voltage and current in the other wire. Result—no feedline radiation. This was not true of end-feed where feedline radiation occurred whenever the antenna itself was not exactly a half-wave or multiple of a half-wave long. You rarely hear of an end-fed half-wave these days.

Just before WW-2, somebody discovered that a half-wave horizontal wire (dipole) could be fed with ordinary twisted lamp cord. It was lousy when wet, but was easier than building a feedline. It wouldn't handle a kilowatt either. The manufacturers brought out EO-1 cable, which wasn't very good, but was much better than the lamp cord it replaced; it was the first generally available low-cost, low-impedance feedline.

Then came the War and polyethylene. It and the war-surplus made low-cost feedlines available to everybody, and the arguments started, growing with each new development in feedlines. Today we have lots of lines available, thanks to polyethylene and to TV. See **Fig 1**. We have.

a. Ladder-line, two wires held separated by spacers.
b. "Punched" line, a ribbon type with a

portion of the polyethylene removed.
c. Ribbon line, of solid polyethylene.
d. "Dumbbell" line, with the insulation thinned to make it cheaper.
e. Tubular line, to reduce the effect of rain.
f. "Foamed" line, lower losses than the tubular.
g. Solid inner conductor coax.
h. Stranded inner conductor coax.
i. "Foamed" coax with less insulation than standard.

The ribbon types we owe to TV and is nearly always 300 ohms. The coax is either about 75 ohm or 50 ohm impedance.

All insulation has dielectric losses, and while polyethylene is good, some kinds have losses that are higher. With air as 1, solid polyethylene (as in the coax type) has a figure of about 2.6 and the nitrogen foamed variety about 1.7. In contrast, the ladder type line has a figure of 1.01 or better. Air is the ideal.

The losses in db per 100 feet increase with the frequency and the amount of insulation. For the lower bands, as 75 meters, it will make very little difference *what* kind of line is used, but on 2 meters it will pay to study the loss figures very carefully. It is very easy to lose three-fourths of your power in the feedline on two meters!

Power-handling capability varies greatly with the type of line in use. It has nothing to do with db loss, but increases with the size of the conductors and the impedance of the line. Always remember that a given line will handle less and less power as the SWR goes up because it is the SWR that determines the maximum current on your line, and the line will handle no more current than the smallest of the conductors can handle without melting or distorting the insulation. A line may be "good" for 500 watts only with a 1:1 SWR.

The SWR on a line increases losses in db, but it is only of importance if the db loss of the line is already high or if it exceeds the wattage rating of the line; otherwise, the SWR on the feedline is of little, if any, importance. If the antenna takes the power, it will radiate it no matter *what* the SWR is.

Nor is the impedance of a line of very great importance except it should match the antenna. These days it is possible in some way to match an antenna to almost any line available. Of course, nearly all manufactured and kit-form transmitters are built to "match" 50 ohm coax. This is the cause of the argument.

A "balanced" antenna—dipole, yagi, quad, rhombic, etc.—requires a balanced line, as ladder line or ribbon. An unbalanced antenna —grounded vertical, groundplane, coaxial skirt

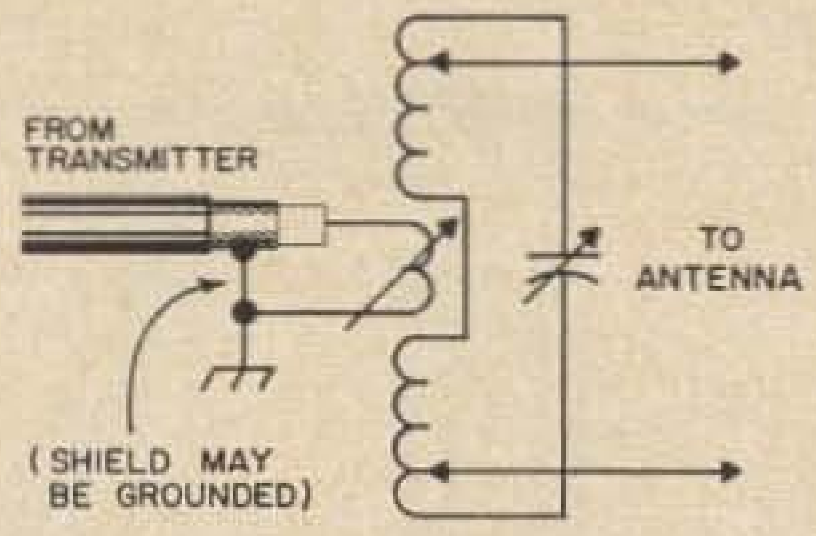

Fig. 2. Antenna matcher.

—requires a coax line. Transmitters nearly all require coax.

What is the best type of line? The "ladder" type. With proper type separators, it has negligible loss, is practically unaffected by the weather, standing waves do not bother it, and, being air-cooled, can handle much higher power for a given wire gauge. There are a few drawbacks. The impedance is high, usually 300 ohms or more, and commercial varieties often have plastic separators that become very brittle when exposed to light of the sun. With all types of balanced line, it is necessary to keep the wires of equal length and spacing, several inches at least, away from all conducting objects, and make all turns gradual.

Next to the ladder type line in desirability is the round nitrogen foamed line, then the round tubular line. Both are relatively unaffected by wet weather, with the foam type giving the lowest loss. As with all polyethylene insulated lines, the power and/or standing waves must be kept down to keep from melting the insulation. The flat, or ribbon, lines are the worst (and cheapest) types, very much affected by rain. If you must use polyethylene, be very sure you get the type with an ultraviolet inhibitor that prevents the development of brittleness when exposed to sunlight.

For coax line, be sure it has virgin polyethylene insulation, white or clear, not brown. It needs no additives against ultraviolet or sunshine, being covered. Stranded wire is best for the center conductor in the interest of flexibility. The shield braid should be tight, covering 95% of the polyethylene. The neoprene coating should be of the best, with no plasticizers that will "bleed" into the center insulation in hot weather. Lastly, the nitrogen foamed line is much the best. If you can, inspect a sample. If the different layers stick together, it is old and of poor quality. The impedance, of couse, should be of the proper value.

The big question is, of couse, "How do you connect a balanced dipole to an unbalanced transmitter?" The answer is, "You must use some sort of matching device." The common-

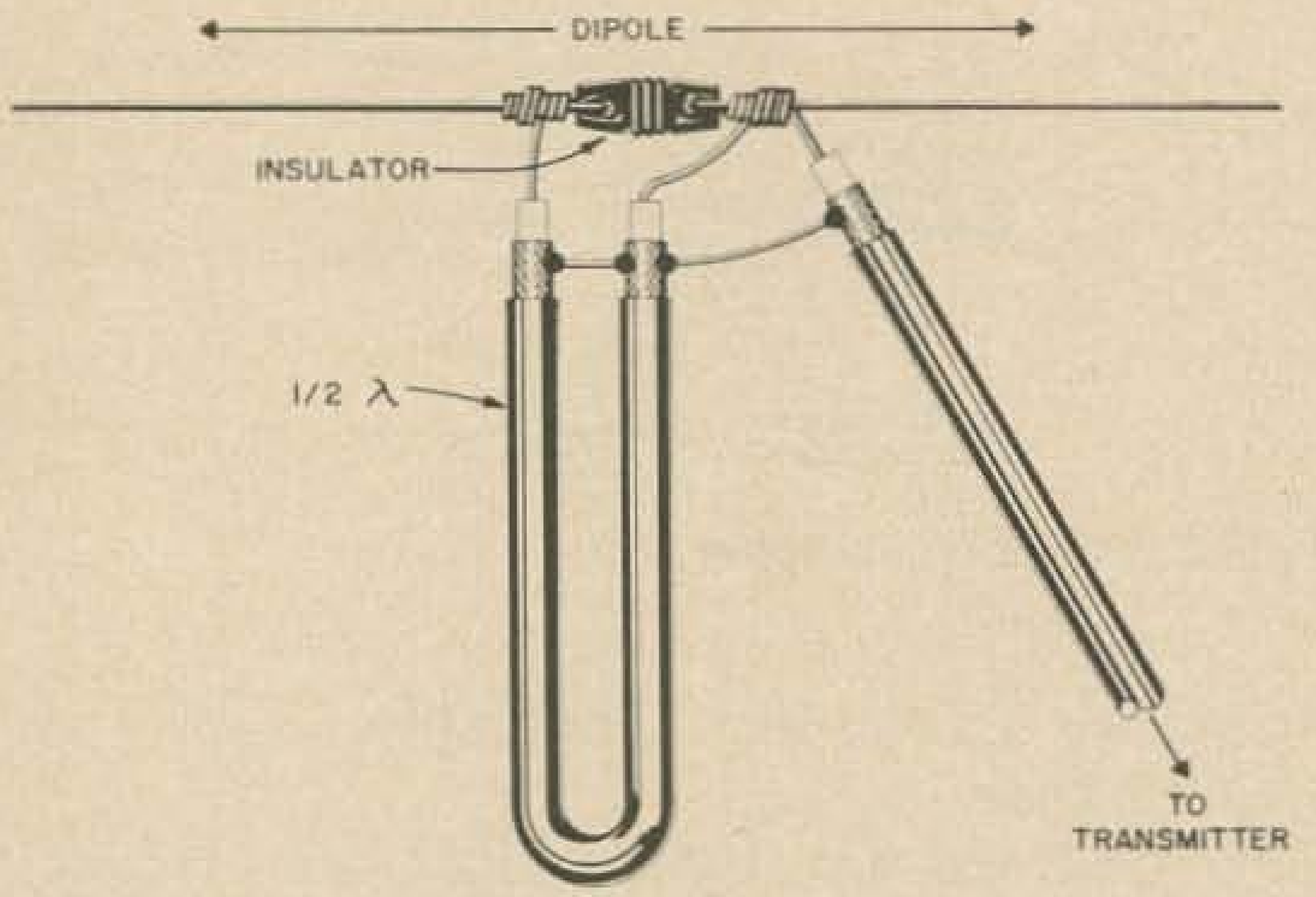

Fig. 3. Coax balun for matching coax to a dipole.

est is either an antenna tuner or a balun. **Fig. 2** shows the circuit of a typical antenna tuner. If you do *not* use a matching circuit, regardless of the impedance, the shield of your coax will pick up a voltage equal to the center. The center cannot radiate, but the shield can and does. This is the reason coax cannot be recommended for balanced type antennas. The radiation can, and sometimes does, "back-up" on the transmitter chassis and the AC line to cause feedback and TVI.

Parallel wire line will radiate whenever the voltage and current in one wire is not exactly equal and opposite to the voltage and current in the other wire. This can come about through unbalanced feed from the antenna ("Windom" antenna, etc.) where the feedline wires are not the same length, or when one wire runs closer to a conductor than the other. When one wire is grounded at the transmitter (a common case), the balanced feed will put rf on the chassis unless the transmitter ground is a true rf ground, which is almost impossible. The result is a likelihood of feedback at the microphone and/or radiation (and TVI) from the power line. Of course, troubles from radiation increase with frequency.

TV producers long ago found out about coax. For years now all TV beams have been of the balanced line type (300), with a wide-band balum transformer to line-type feed to the unbalanced input of the receiver. (Incidentally, these balums will handle low power very well for 2 and 6 meters.)

The antenna turner has the advantage of responding only to one frequency, effectively reducing harmonics. It is unaffected by SWR and feedline impedance, and it will reduce the SWR on the coax to 1:1. (If it does not, the excessive SWR is the harmonic content of the transmitter.) It has its drawbacks, though. It adds two or more controls to the transmitter. It is essentially, even with plug-in coils, a one-band device. (But so is a good antenna.) It really cannot do anything about antenna mismatch and SWR on the feedline.

Coax, such as RG 8/U, can be run anywhere that the insulation will stand, such as inside walls, through pipe, under ground, etc. It will match nearly every transmitter. It is what nearly all SWR meters are built for. With a proper balun it will couple to most antennas. And it will handle a fair amount of power. But it has a pretty high loss at high frequencies and if not balanced, will radiate from the shield.

A ½ wave feedline balun (see **Fig. 3**) is a good device, but only good close to one frequency. It has a 4 to 1 ratio, matching a 300 ohm antenna to an unbalanced 50 ohm feedline. The popular "Gamma" match is good for matching an unbalanced line to a dipole only when the antenna's "neutral point" is thoroughly grounded for rf; otherwise, the shield of the feedline will radiate. Other types of match, such as delta, tee, stub, etc. will radiate from the shild, particularly on harmonics.

On the lower bands, losses in feedlines do not matter so much, but harmonic radiation does. An antenna tuner is the answer. On the high frequencies, a ladder line and tuner can give you three db or more signal. It seems a cheap way of doubling your power.

If you bought your antenna ready made and it calls for coax feedline, obey your instructions. Maybe it was built to use that line and that impedance. If you feel adventuresome or like to build your own, consider the ladder-type line and an antenna tuner. It will practically eliminate harmonics, laugh at any SWR, and reduce losses. Just be sure the wires are of identical length, have no sharp bends, and are evenly and closely spaced. The nitrogen foamed parallel line is almost as good, but has more loss and will not handle the power.

Coax line should be used with some sort of a balun. The ½ wave balun of **Fig. 3** discriminates somewhat again harmonics as well as balancing the feedline output. There is little to be gained by cutting a coax to a certain length for better feed. If it works, the SWR is too high anyway. Coax is a good type of feedline within its limits—short lengths, or low frequencies, with some balancing system to keep the shield "cold", and low SWR—and it matches nearly all transmitters.

I hope the statements in this article will, perhaps, put a few more watts on the air and reduce a few SWR's *and* add fuel to the FEEDLINE ARGUMENT. . . . WØOPA