Matching Stubs

Blackwell B. Evans, Jr. WA5STM
5514 Sutton Place
New Orleans, Louisiana 70114

This article will show you how to match any feedline to an antenna and get an SWR of less than 2 to 1. There is no restriction on antenna type or feeder length. All that is required is an SWR meter; however, knowing the approximate antenna impedance will do.

First, I'll tell you how I came across this idea. I had just moved and no longer had any good trees for stringing up antennas. I looked through some old *73's* and came up with a bi-square antenna. It looks like a single element from a Quad, except that it is a half-wavelength long on each side. The article (73, August 1961) was by David Bell W8GUE/6. Many thanks to David for an excellent antenna.

There was only one small problem. My version was for 15 meters with each side about 22-feet long. This made it more than 30-feet tall when suspended from the peak. In the article it was matched through a quarter-wave stub of open wire line hanging from the end. This was another 11 feet added to the end. My only tree was not tall enough to accomodate this too. The bottom three feet of the stub were left on the ground. In addition, I was going to have to tune the thing by the trial and error method after I got it up. I figured there had to be an easier way to match all this junk up so it would radiate properly.

A few hours spent flipping through the pages of the ARRL *Antenna Handbook* and other books were very profitable.

When a line is hooked up to an antenna and the impedance of the line is different from that of the antenna, then there is a reactive component present on the line. The SWR is high and losses increase. A great deal of power may be lost without putting much of a signal on the air. To rectify this you need only put in an equal amount of reactance, but of the opposite kind. This will reduce the SWR and power losses.

A length of transmission line which is a quarter-wavelength long behaves like a resonant circuit. If it is shorted at one end, it appears as a parallel resonant circuit with high resistance; if open-ended, a series resonant circuit with low resistance. Lines

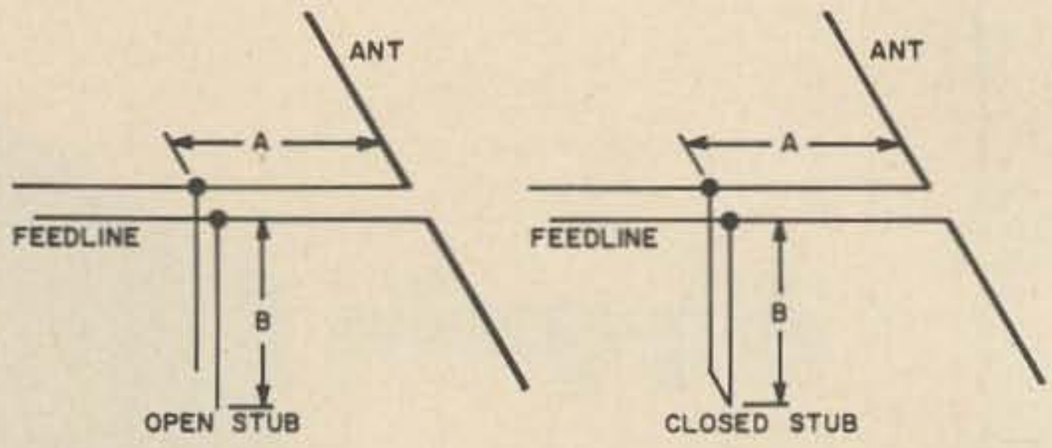

Fig. 1. How reactance is inserted. A shows the distance from the antenna for inserting the stub and B is the length of the stub.

shorter than a quarter-wavelength will exhibit reactance as well as resistance. An open end line will have capacitive reactance. A closed end line will have inductive reactance. A line less than a quarter-wavelength long may therefore be used to match antenna and line impedances for low SWR.

Fig. 1 shows how the reactance is inserted. *A* is the distance from the antenna at which the stub is inserted. *B* is the length of the stub itself. **Fig. 2** shows another arrangement which performs the same way, but looks a little different.

If either the standing wave ratio or the impedance of the antenna is known, then lengths *A* and *B* can be computed easily. There are only two requirements. One, the stub and the feedline must have the same impedance, and two, the antenna must be resonant at the intended frequency of operation. These are easy requirements to fulfill.

The first decision to make is whether to use an open-end stub or a closed stub. This will depend on the ratio of antenna to line impedance. When the antenna impedance is

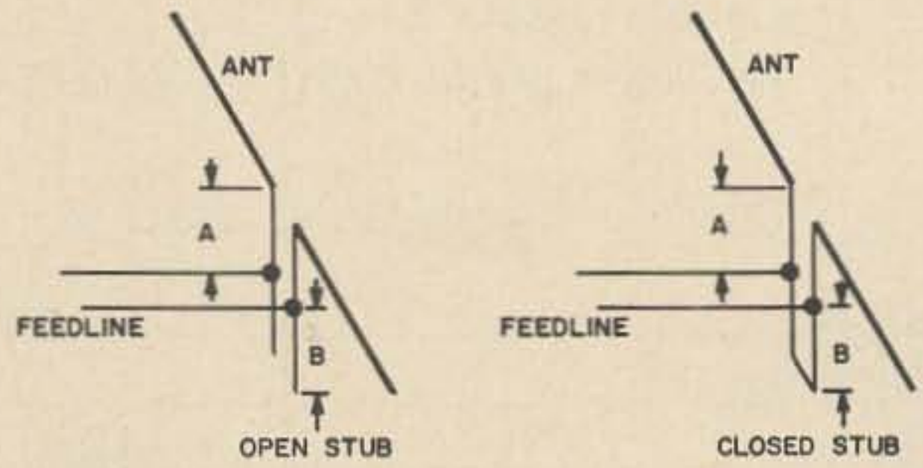

Fig. 2. This arrangement gives the same performance as Fig. 1 but is different in appearance.

less than the line impedance, a capacitive or open end stub is used. If the antenna impedance is greater than the characteristic line impedance, an inductive or closed end stub is needed. If you are using 150, 300, 450, or 600 ohm twinlead or ladderline and the antenna is current-fed, then you will probably need an open stub. If the antenna is voltage-fed, then a closed stub will probably be needed. There are exceptions.

Fig. 3 shows the current and voltage distribution along a half-wavelength of antenna. If the feedline intersects the antenna at a current loop (maximum) and a voltage node (minimum) then the antenna is current-fed. The old standby, the half-wave dipole, is current-fed. If the antenna is fed at a voltage loop and current node, then it is voltage-fed. Note that these terms do not correspond to the terms end feed or center feed.

Having decided what type of stub to use, the next step is to measure the standing wave ratio. Hook the feedline directly to the antenna and tune up. CAUTION: do not load to maximum. When these manufacturers say that their super-duper trans-

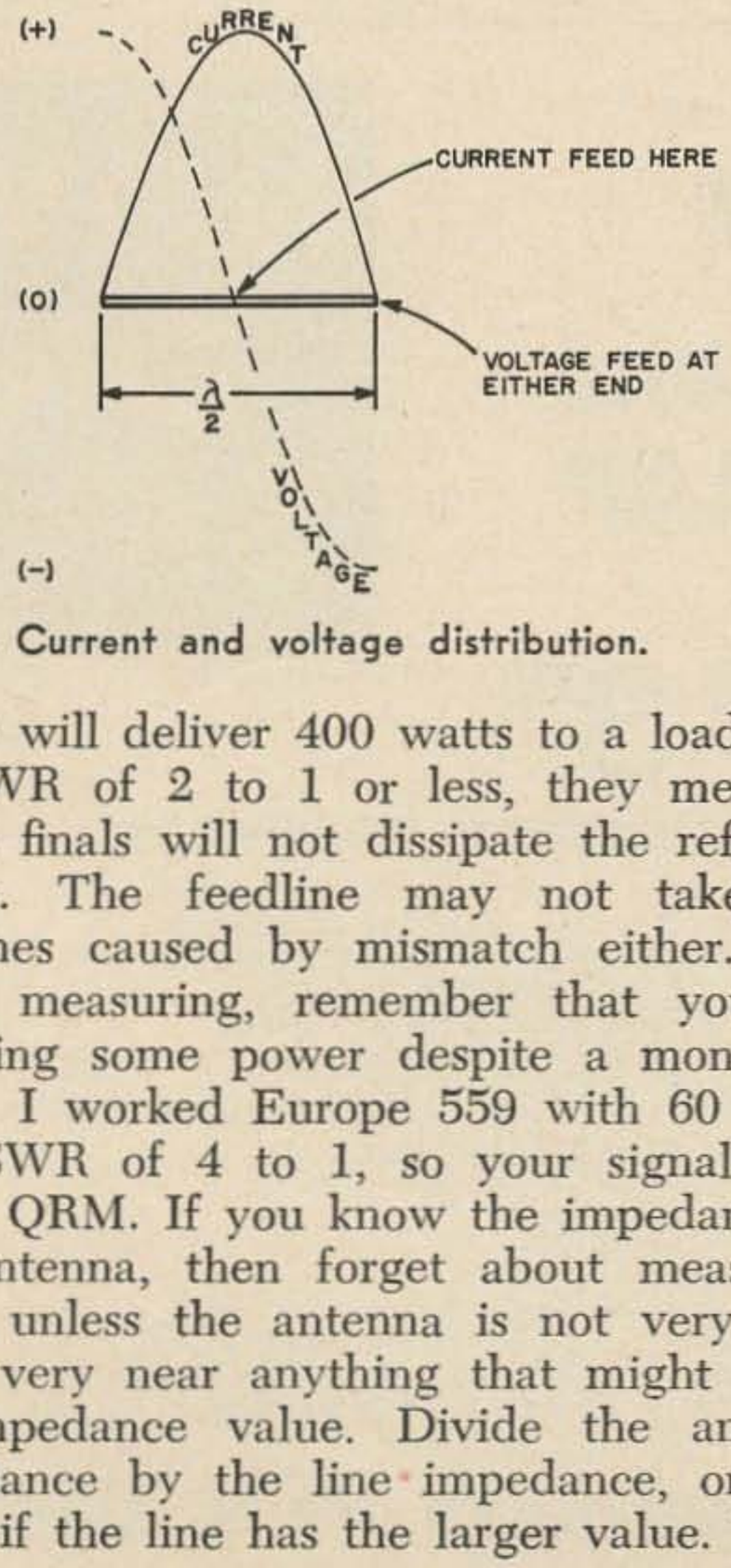

Fig. 3. Current and voltage distribution.

ceiver will deliver 400 watts to a load with an SWR of 2 to 1 or less, they mean it. These finals will not dissipate the reflected power. The feedline may not take the extremes caused by mismatch either. And while measuring, remember that you are radiating some power despite a monstrous SWR. I worked Europe 559 with 60 watts and SWR of 4 to 1, so your signal does cause QRM. If you know the impedance of the antenna, then forget about measuring SWR unless the antenna is not very high or is very near anything that might affect its impedance value. Divide the antenna impedance by the line impedance, or vice versa if the line has the larger value. Using this or the SWR reading (they should be about the same).

Chart 4. For Open-End Stubs

SWR	Wavelengths A	Wavelengths B
1.5	.109	.062
2	.096	.099
3	.083	.138
4	.074	.156
5	.067	.167
6	.062	.178
7	.058	.184
8	.054	.189
9	.051	.193
10	.049	.196
12.5	.044	.202
15	.040	.207
17.5	.038	.210
20	.035	.213

Chart 5. For Closed-End Stubs

SWR	Wavelengths A	Wavelengths B
1.5	.141	.188
2	.152	.151
3	.167	.113
4	.177	.093
5	.184	.081
6	.188	.072
7	.192	.066
8	.196	.061
9	.199	.057
10	.202	.054
12.5	.206	.047
15	.210	.043
17.5	.213	.039
20	.215	.037

Chart 6

Feedline Type	Velocity Factor
Coax (solid dielectric)	.66
Twinlead	
75 ohm	.70
150 ohm	.77
300 ohm	.82
Open-wire line	.98

Due to the different dielectrics used, radio waves travel along transmission lines at different speeds, always less than the speed of radio waves in free space. Assuming you now have the wavelength required and the frequency and the velocity

factor, you are now ready to compute the exact lengths needed. Use the following equation:

$$\text{length in feet} = \frac{985}{\text{frequency}} \text{ X velocity factor X length in wavelengths.}$$

You will need to use it twice; once for A, and again for B.

Now that you have the lengths required, merely break into the line at the appropriate point and connect the stub. If you use the arrangement in **Fig. 2**, just connect a stub equal in length to A plus B and hook the feedline onto it at a distance from the antenna equal to A.

Just to make sure you've got the idea, I'll work out an example. Let's assume that I have just put up a two half-waves-in-phase collinear for ten meters. This looks like a dipole except each side is a half-wave-length long. This makes it voltage-fed. Therefore I will use a closed stub. I hook up the 300 ohm twinlead and measure the SWR. I get a reading of about 15 to 1. Next I take a look at chart 5. From this I get a value of .21 wavelengths for A and .04 for B. Using the velocity factor of .82 for twinlead and an operating frequency of 28.1, I get the following equations:

for A

$$\frac{985}{28.1} \times .82 \times .21 = \text{approximately 6.05 feet}$$

for B

$$\frac{985}{28.1} \times .82 \times .04 = \text{approximately 1.15 feet}$$

Which means that a distance of six feet and one-half inch from the antenna I should insert a stub one foot two inches long, shorted at the end.

It's hard to say just how broadband this type of thing will be. On fifteen meters, by designing around a frequency of 21.050 MHz, I get a standing wave ratio of 1.1 to 1 at 21.0 MHz, and 1.5 to 1 at 21.350 MHz on my bisquare. Being a CW man, I have never been higher than this.

There is no reason why you cannot make the stubs out of coax if you want to. You can use a T-connector or splice it and seal the joint with tape.

This method should eliminate a lot of unnecessary work in tuning the feed system of any antenna that uses stub matching. No

more will you have to make an endless string of hit-or-miss adjustments and oftentimes end up settling for less than the best match. For those who want a more theoretical and detailed explanation, I recommend the ARRL Antenna Handbook. Also, strangely enough, many of the older radio handbooks (pre 1950) give excellent information on this aspect of antennas. I have always found that when it comes to putting up a new antenna, it is always the cost of the feedline that stops me. From now on though, I can feed a new antenna with whatever I can get my hands on. . . . WA5STM

UFO NET

(*Continued from page 2*)

tigation project of the Air Force and mutual cooperation has been assured. Nicap (National Investigations Committee on Aerial Phenomenon) is also interested in our project and has promised cooperation. The cover photograph on the April issue and the photograph at the head of this article were both provided by NICAP. Both photographs are considered authentic and have been exhaustively investigated. The net is also tied in with the 24-hour a day reporting system set up by Franklin Pierce College in Rindge, New Hampshire.

Are UFO's Space Ships?

In spite of the thousands upon thousands of eyeball reports on UFO's by dependable observers, there is still a serious question in many minds about their actual existance. Their existence has yet to be fully proven . . . and so has their lack of existence. The mere possibility that the UFO's do really exist and are space ships is, I am sure, motive enough to warrant the use of every means at our command to investigate the question.

The reports in newspapers of UFO sightings frequently follow very definite patterns across the country. It does appear that if communications were established throughout the country, communities along the projected path of these UFO's might be able to spot them and even get set up to take pictures. If this works out it would not be long before teams could start getting ready for more sophisticated examinations of the UFO's as they pass by.

If we set up our network so that we get immediate reports from every possible source in our communities, we will have made a major contribution to our country. And this sensitive detection system would work two ways. It would report anything spotted to the amateur radio network . . . and the network would report to the "eyes" of the community when anything was heading in that direction, alerting hundreds or even thousands of people to be on the watch.

On the UFO Net

During the establishment of the net it might be of interest to those gathered to review some of the books and magazine articles on UFOs. While some of them are rather obviously far out, others make every attempt to report only carefully checked facts.

It is interesting that many of the governments of the world take the UFO problem quite seriously. I believe that our own government is almost alone today in poo-poohing UFO reports. Those of you who subscribe to Soviet Life or read it in your local library were undoubtedly fascinated by the article in the February issue on UFO reports in Russia and the establishment of a serious program to investigate them. They have mobilized their observatories, weather stations, and all other functions which could help in the quest for answers to the UFO's. Their pilots are taken seriously when they give detailed reports of sightings, unlike the ridicule that American pilots get when they try to give UFO contact reports. Is it likely that the thousands of UFO reports in Russia are just imaginary?

I would like to hear from operators interested in acting as net control for the UFO Net. I will call in whenever I can, but I pretty much work the clock around here at 73 and my air time is sadly scanty. With the backing of 73 I hope that we can get enough operators interested so that we will have a good solid network going. I will be glad to publish reports in 73 of the progress of the net and its accomplishments.

Remember, if the UFO's are not real our network will certainly make this obvious. If they *are real*, then amateur radio may be on the verge of doing the most important piece of PICON in its history. How about you? Are you going to be a part of this? We need every community in the country in this net.

. . . W2NSD