How's Your Antenna?

BY JOHN E. MAGNUSSON*, WØAGD

The effectiveness of an antenna is often questionable. WØAGD makes some suggestions on how to check and improve the efficiency of many antenna installations.

With the present trend toward fixed output impedance equipment, in both the low power as well as the high power level, it becomes necessary to make an evaluation of the antenna system. We will then assure ourselves, that the equipment will operate and load properly, and that we have given it an even chance to deliver maximum performance. The trend is also to multiband antennas which serve very adequately. And since the average amateur does not have the real estate or the wherewithall to have an elaborate antenna farm with separate antennas for each band of operation, he has to get the most out of a simple antenna system. The trend is also to feed all antennas with an unbalanced line so that it can be connected through the accessory equipment, such as low pass filters, TR-switches, directional couplers and indicators, into the unbalanced output of the pi-network. There are also excellent balanced fed antennas that require the use of balun coils, antenna tuners or the commercially available Matchboxes to provide all band operation, and to make the transformation from the single ended output of the pi-network to the balanced feed requirements of the antenna. Connecting a folded dipole or a Windom antenna directly to the coax fitting of any transmitter is a practice that should be avoided.

Impedance Matching To The Antenna

One of the biggest problems in matching the transmitter equipment to the antenna system is the transformation effect that takes place in the transmission line between the antenna and the transmitter. Too often the main concern has been the loss through the transmission line because of the s.w.r. It is equally as important to take into consideration the transformaion of impedance through a section of transmission line. In fig. 1, we have represented the s.w.r. on a 50 ohm transmission line. (For the sake of brevity, we will call all 51½ and 52 ohm coaxial cables 50 ohms.) You will notice that a 2 to 1 mismatch can be either 100 ohms or 25 ohms. A 3 to 1 mismatch may be 150 ohms or 16 ohms, and 4 to 1 can be either 200 or 12½ ohms. Let's take a hypothetical case where an individual has just installed a new three band beam and he measures the s.w.r. as being 2 to 1, but is unable to load the transmitter properly. If the length of the antenna lead-in is harmonically related to the frequency of operation, or is an odd multiple of quarter wave lengths thereof, a transformation effect takes place in the transmission line. In this case, if the impedance is 2 to 1 (or 100 ohms) at the antenna end of the coax, the impedance would be 25 ohms (which is still 2 to 1) at the transmitter. A pi-network will not match an impedance lower than 30 ohms, thus making it very difficult for the individual to load the transmitter adequately, although he has what appears to be an acceptable s.w.r. This explains the difficulty in loading the transmitter because of the low impedance presented to the pi-network. The clue to this condition is a broad tuning indication with a very shallow plate current dip. Let's not kid ourselves, there are hundreds of amateurs who don't know what their s.w.r. actually is and would be surprised to learn it is probably 4, 6 or sometimes greater than 8 to 1. They have never been too excited about finding out what it actually is, or do not own the equipment it takes to indicate the s.w.r. This is unfortunate, because there is a good selection of s.w.r. bridges, directional couplers and indicators, power or wattmeters for transmission lines available and the costs are very reasonable. In the same hypothetical case we can actually lengthen the coax by five

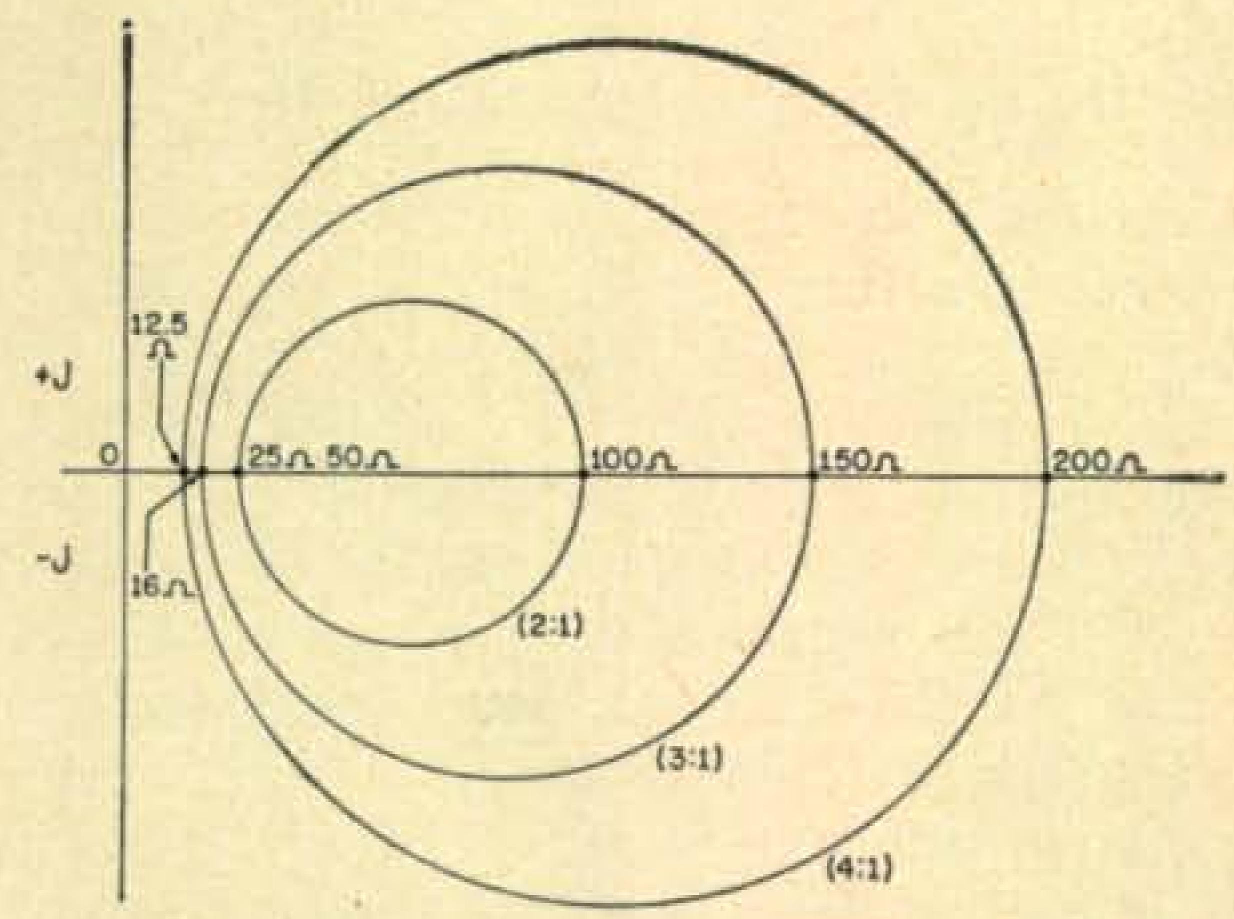


Fig. 1—Graphic presentation of s.w.r. based upon a 50 ohm transmission line.

*Customer Service Supervisor, E. F. Johnson Co.

feet and the loading of the transmitter will improve considerably. This would cause us to lose sight of the fact that we still experience a given loss through this transmission line as long as this 2 to 1 mismatch prevails. The antenna should be readjusted to present an impedance closer to 50 ohms in order to have the maximum transfer of energy to the antenna in the first place, and secondly, to avoid this transformation effect. Being realistic, the advantages of reducing the s.w.r. below 1.5 to 1 is usually academic. When calculating the electrical length of the coax it is important to consider the velocity factor, (RG-8-U has a velocity factor of 0.66).

Using Transformation Effect

This same transformation effect that we have experienced in this hypothetical case with the three band beam, can also be used to our advantage in a mobile installation. The 75 meter mobile antenna usually presents an impedance between 5 and 15 ohms. This low impedance is beyond the range of any pi-network, even marginal in the case of some pi-L sections. We can take a given length of coaxial cable, and taking advantage of the transformation effect, have an impedance at the transmitter end of the coax that will be well within the range of the pi-network. For instance, a quarter wave length in free space at 3.9 mc is approximately 60 feet. The velocity factor of RG-8-U is 0.66. Multiplying 0.66 times 60, we find that the physical length of the section of the transmission line should be approximately 39 feet long. It may be a little inconvenient to accommodate 39 feet of coax in the trunk of a car, or between the trunk and the dash, so we could divide this by two and still experience enough transformation effect, plus reducing the loss through this section of line. Here is a case where we have to take the loss in order to have the correct impedance match.

Reflected Power

Reviewing the losses and reflected power should be of primary concern to everyone. Assuming a transmitter with 100 watts input to the final and a final tube dissipation of 50 watts, we can easily see the disadvantage of s.w.r. We know that the final will be between 65 and 70 percent efficient, so that 30 to 35 watts are dissipated in the plate of the tube and the associated wiring. Now we know that we have between 65 and 70 watts of output to couple into the antenna. If we connect this transmitter to an antenna system that has a s.w.r. of more than 2 to 1, the reflected power will be somewhere between 10 to greater than 40 percent of the output power the transmitter is trying to deliver into the transmission line. We soon see that this causes a pronounced reduction of the effective radiated power from the antenna system.

Radial System

Installing a radial ground system is time well spent, and can be done easily with a hunting knife and screw driver. The hunting knife is used to cut a slot in the sod so the copper wires can be forced down below the roots of the sod using the screw driver. The roots of the sod will hold the radials in place so they do not become a hazard when mowing the lawn, or when the family is using the lawn for their daily pleasure. By placing the copper radials below the surface of the sod, you know where the true ground is and it is easy to determine the theoretical impedance of the antenna. As most amateurs find it impractical to raise an 80 meter antenna a quarter wave length above ground, they usually install the antenna at the 35 to 40 foot level. Therefore, the antenna is closer to 50 ohms than it is to 72 ohms, and the 80 meter dipole can be fed with 50 ohm coax. There is little reason for concern about using unbalanced feedline. This is an ideal arrangement as the 50 ohm coax matches the 50 ohm low pass filter, and the 50 ohm coax fitting on the back of the transmitter.

The effectiveness of a low pass filter can be greatly reduced by the s.w.r. and line impedance.

The higher the standing wave ratio the greater will be the voltages across the filter components until the filter may be destroyed by arc-overs or component breakdown. The lengths of an antenna, as given in any manual, are theoretical and will have to be changed with each installation in order to bring the s.w.r. down to a tolerable level. This is due to the proximity effects of other objects in the immediate area as well as the end effect of the antenna itself. A perfectly adjusted beam antenna may vary as much as 20% in the drive point impedance, when it is rotated through 360°, by the proximity effect of nearby objects.

Antenna Bandwidth

An antenna is a series resonant circuit and will have a reactance curve similar to the one shown as a dotted line in fig. 2. You will notice

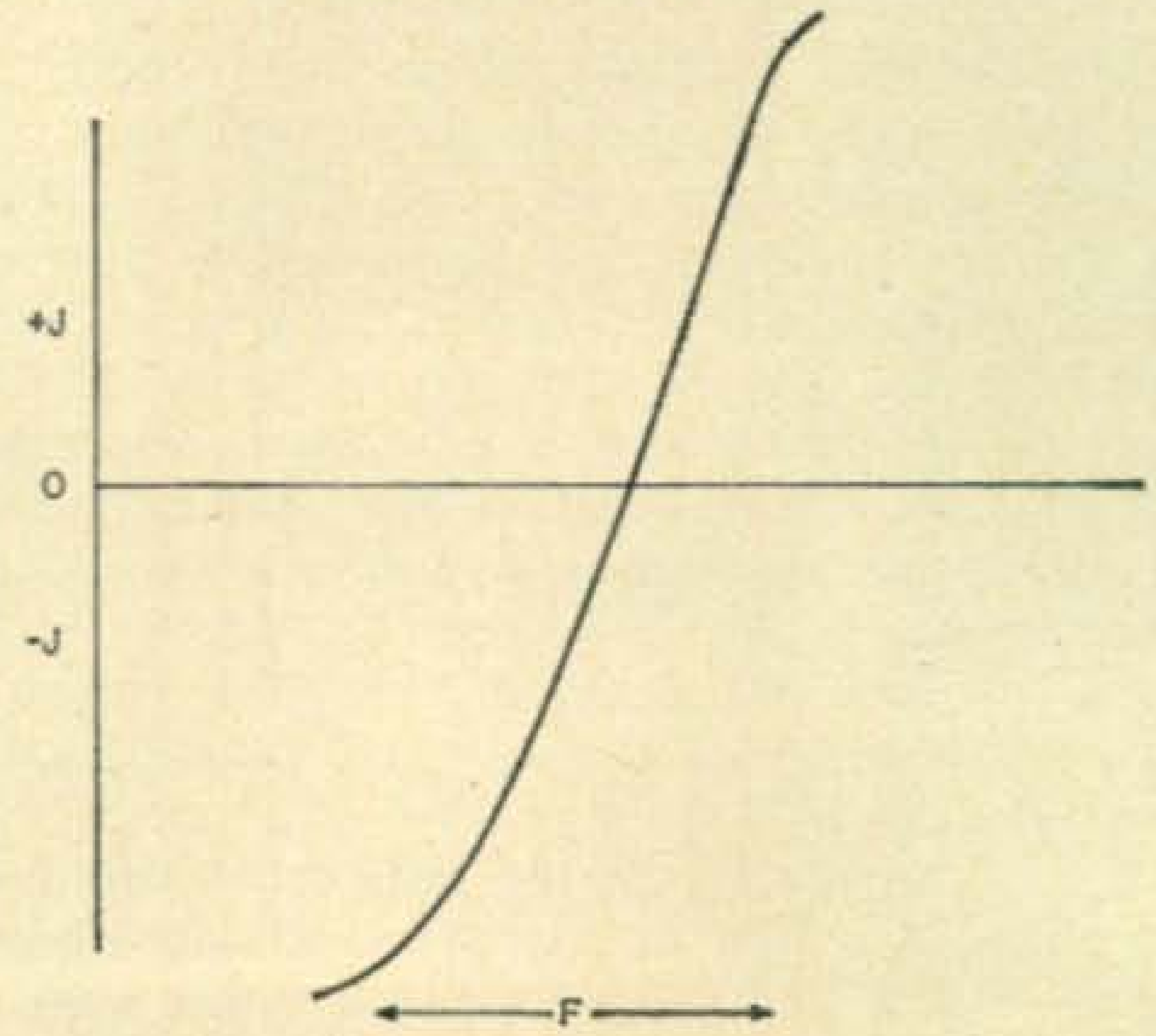
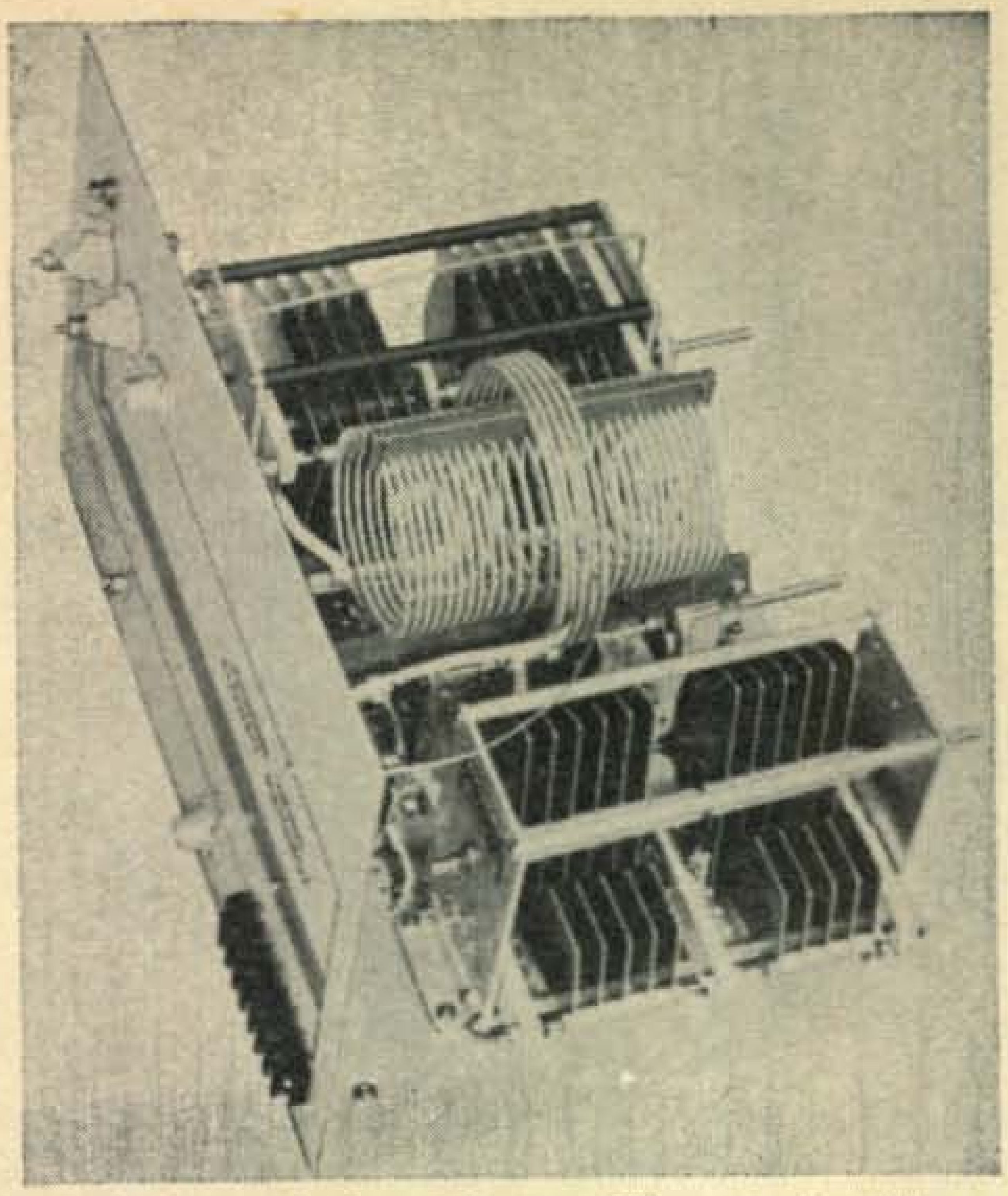


Fig. 2—Curve illustrating the reactance of a series resonant circuit such as an antenna.



Internal view of the Johnson Kilowatt Matchbox. It will match balanced antennas from 50 to 1500 ohms and unbalanced antennas from 50 to 2000 ohms. It also measures s.w.r.

that the point where you have a pure resistance is the point where the reactance curve intersects the line. This point is a function of the spacing of the elements, the length and diameter of the elements, and the height above ground for a beam antenna as well as a dipole. The resistance can be made to be exactly 50 ohms by these factors.

The more familiar Viking Matchboxes provide an excellent solution to all band operation with one antenna. This is made possible by the length of the antenna, feedline impedance and length, transformation effect and the range of the Matchbox. The impedance of the antenna, at its feedpoint, varies greatly over a wide frequency range; from just a few ohms to several thousand ohms. It is the same whether the antenna is center fed, or end fed. This impedance is transformed by the feedline into a representative range at the Matchbox terminals to allow all band operation. Only if it falls within the range provided, (usually 25 ohms to 3000 ohms.) As we learned in elementary electronics, the impedance across a parallel tuned circuit is infinite, and we can tap down to any level we need within reason in order to match the feedline. The tuning controls tune the parallel tuned circuit to resonance and the matching controls provide a capacity divider across this tuned circuit in order that we may select a wide range of impedances. This is more convenient than the old antenna tuner method of tapping the turns on the coil. The limitations are controlled by the earlier mentioned factors of length and feedline impedance.

Arc-overs would indicate that the impedance is extremely high and that the antenna, or the frequency, is beyond reasonable limits. When the impedance is at the lower limit, the controls will run to the end of their range and the broad tuning characteristic outlined earlier will be experienced. The high impedance open wire feedline is important because of the lower losses. Too often, the temptation seems to arise to blame the s.w.r. on the transmitter, matchbox, or the feedline. Nothing could be more absurd, as the transmitter has no influence on the s.w.r. And it is more practical to adjust the antenna to better match the feedline, than to try to make compromises in the feedline to offset the improper adjustment of the antenna.

Often the question is asked, "How far should I be able to move my transmitter, frequency wise, on the 80 meter band?" Simple arithmetic shows us that the reactance of the antenna is going to determine how large a frequency excursion the antenna will allow us to make. Let's be realistic; moving 50 kc on the 80 meter band represents the same percentage of frequency change as moving 200 kc on the 20 meter band, or 800 kc on the 10 meter band. The reactive element makes it difficult to have an antenna that would be absolutely flat across any band of operation, more specifically across the 80 meter band. On 80 meters, a small change in frequency represents a greater percentage of the operating frequency than on the higher bands. A wide range pi-network output in the transmitter will give considerably more freedom, than is the case with a fixed output impedance in the transmitter.

Radiation Angle

The height of the antenna not only controls the impedance, but also the radiation angle. At the lower frequencies the antennas are usually placed closer to the ground to take advantage of the higher angle of radiation for local coverage. An 80 meter antenna can be as close to the ground as 12 or 15 feet if you really want local coverage. (That is within the immediate area up to 100 to 150 miles.) If you want to work DX, the antenna has to be raised to take advantage of a lower angle of radiation and the resultant skip that this will provide. The vertical antenna with a low angle of radiation in the order of 15 degrees, is usually poor for local area coverage, but excellent for "DX." The angle of radiation of a beam antenna is also controlled by height above ground as indicated in fig. 3. With the

[*Continued on page 90*]

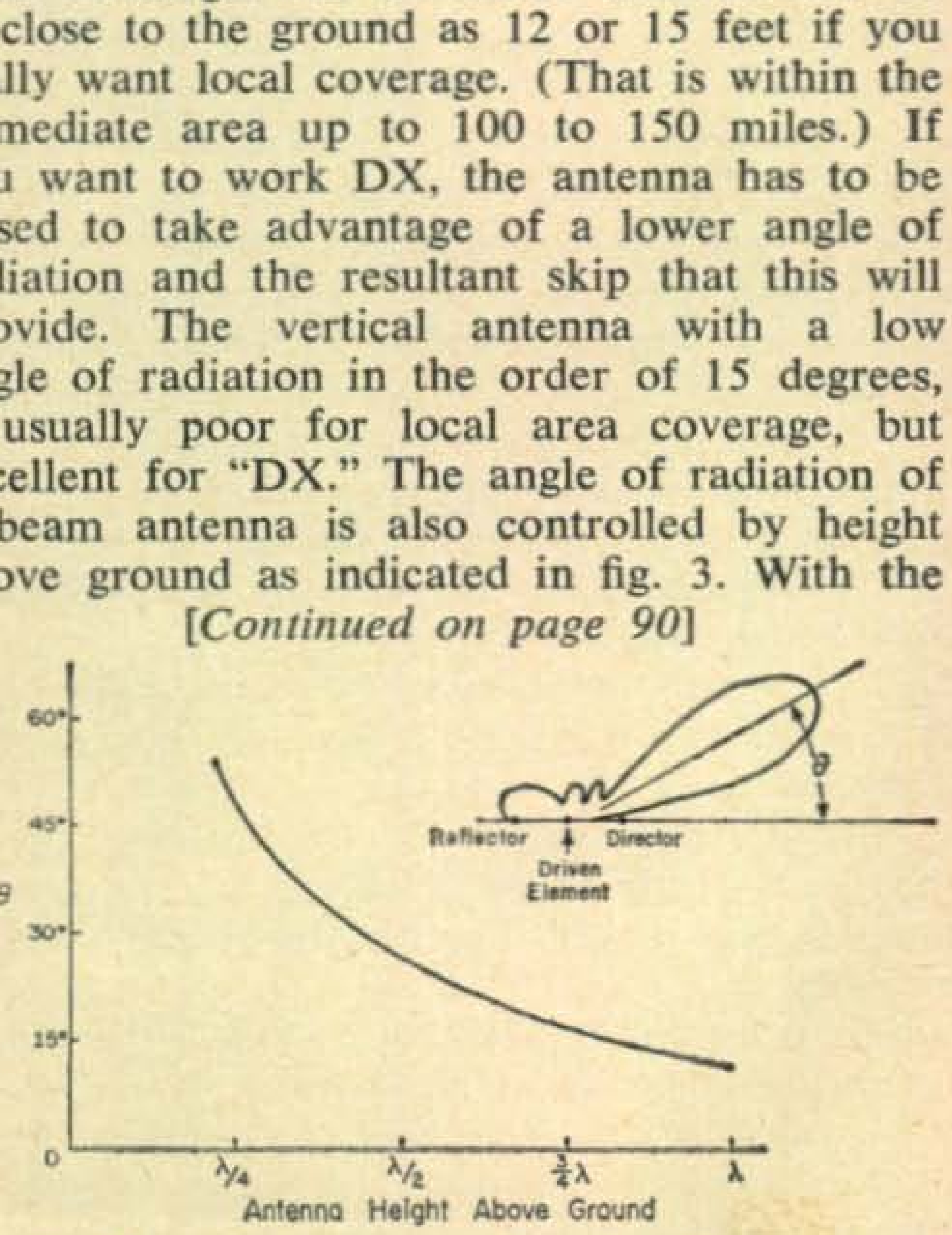


Fig. 3—Chart depicting angle of radiation versus antenna height above ground.

eager to renew old friendships. He inquired particularly after Bill, W5CAC, and his lovely XYL, Alice, so you Websters, please get back on 20 and give your many friends a treat . . . Rundy, OD5CT, and Ray, W6MLZ, were guest speakers at the SSBARA's November meeting in New York. It took place after our deadline for this column but we'll bring you up to date on the doings next month.

Our fervent wishes for a Happy, Healthy, and Peaceful New Year go out to one and all.

73, Irv and Dorothy

Contest Calendar [*from page 64*]

2. For W/VE/VO contacts made with other W/VE/VO stations . . . 2 points per QSO. For W/VE/VO contacts to any other part of the world . . . 10 points per QSO.

3. For all other countries . . . 2 points per QSO to stations within the same country; 5 points per QSO to stations in other countries except W/VE/VO QSOs which shall count 10 points per QSO.

4. KH6 is a "state" but QSO points count as a "foreign country". However, as a multiplier it counts only as either a state or country but not both. QSOs to District of Columbia count the same as Maryland.

5. A multiplier of 1 for each State, Canadian province and foreign country worked.

6. Final score: Total points multiplied by total multiplier.

7. Sample logging—W2EQS 589001 NJ

8. Awards: A most attractive certificate to the top station in each State, Canadian province and foreign country.

Your logs should be postmarked no later than March 15 and go to: *CQ*, Attention 160 Contest, 300 West 43d Street, New York 36, N. Y.

Ed. Note

It's no news that conditions for the Phone week-end were pretty miserable for the U.S.A. and surrounding areas, and except for the last few hours of the contest, they were way below the normally low expected conditions. A big disappointment was the 40 meter band which just did not come up to expectations. Even so, a certain select few got through consistently and some surprising good scores have been submitted, as indicated in the following claimed scores.

Now don't get perturbed if yours is not listed. These are only a few of the higher scores from logs received as of November 15th.

Scores

A couple of real pile-ups were created by HV1CN and XT2Z, especially the latter. And some top scores are expected from CX2CO, HC1AGI, VP5BL and VQ4RF.

Now if George Jacobs doesn't come up with a better forecast for the c.w. week-end he had better leave the country. Sorry George.

Trust your Christmas was a merry and pleasant one and that the New Year will be peaceful and prosperous for all of us.

73 for now, Frank, W1WY

Results of the 1961 Helvetia 22 Contest

U.S.A.	
W1ADM	1560
WA2DIG	776
W1FZ	588
W8MUR	468
W1WY	216
KØIKL	126
W5WZQ	90
W3MGP	12
W5ARJ	12
W5KC	3
Other Countries	
OD5LX	765
OA4FM	750
PY4AYO	360
VE3BWY	360
VE1AE	330
VQ4KRL	192
ZS4MG	27
VE3JZ	3
European	
OH2LX	10164
G3EYN	9675
YU3CDE	9480
DL1CF	9009
PAØVO	7560
DJ4SB	7250
OH2AA	7030
SM5AJU	6840
PAØADP	6588
PAØVB	6528
OK3KAG	5600
SM5TW	5202
DM2ATL	5130
OH5SG	4830
OK2KJU	4700
IT1TAI	4653
DJ2IV	4410
OM1VA	4386
G3HZL	3580
OH1QP	3510
SP9ADV	3393
SP8HR	3256
DJ3XK	3204
OZ4H	3180
DL7FU	3150
PAØHG	3108
OH2DW	2772
OH2PO	2646
SP8MJ	2550
OH8QA	2520
DM2AGH	2418
OH7NW	2347
OY7ML	2205
OH3PY	2181
OH3NS	2109
SM3BEI	1995
HB1DX/FL	1980
UQ2AS	1965
SM3CNN	1620
SM5AEV	1620
OH9PF	1530
OH2PT	1512
OK1KRS	1458
DJ4VO	1445
SM5KV	1377
YO8RL	1370
LA5UF	1326
OH3WH	1296
OK1AAA	1242
OK1IK	1242
LA5QC	1224
SM6CWP	1224
OH3TY	1152
OZ6RL	1140
DJ6LV	1125
SP2CO	1080
OK3PA	1071
DJ1UE	900
OH6RC	900
OH5NB	885
SM5BPJ	864
SM5CZK	840
OK2LN	810
UR2KAE	792
OH3SO	765
TF3AB	756
SM3BCZ	756
OK1ACF	675
DJ2XP	594
OH3PJ	528
LA5HE	468
SM6CJK	450
DM2AQL	441
OH2RW	429
YU3SF	396
DL1YA	396
YO6EX	390
OK2BCJ	363
SM3CJD	363
YU3IH	324
ON4CE	264
DL6BP	240
G3JUL	240
OK2OU	216
PAØHGT	216
I1FMC	210
OK2KU	176
OK2BBJ	168
SM5CCE	168
OZ4RT	168
SP5AIM	126
OH2FS	126
SP5AHW	75
LZ1CW	63
OK1AMS	57
SM6BZT	48
I1ER	48
HA5FQ	48
OK3WX	48
SM3ATG	45
SM5CHA	27
HA5AM	12
OK2ABU	12
OK2BCB	12
OK1OO	12

How's Your Antenna [*from page 29*]

three band beam antenna it becomes necessary to select a compromise between the three bands as to which angle of radiation you will settle for on each of the three bands with one antenna height. The ideal situation would allow provisions to raise or lower the antenna. This expensive solution makes the compromise of one height more realistic.

The Multiband antennas have only one drawback, they do not add to the harmonic suppression of the pi-network. A well designed pi-network will provide 35 to 40 db of harmonic suppression. With this in mind you will agree that if you are 40 to 60 db over S-9 across town on 20 meters, you would be S-9 to 20 db over S-9 across town on 10 meters. This is the best you can expect from the pi-network and would be a problem in the more heavily populated areas. A single band antenna gives additional relief as it would present a very high impedance to the second harmonic, and wouldn't readily accept and radiate this second harmonic component as the case with a multiband antenna. Here again, the Matchboxes will be of additional value as they provide another tuned circuit between the pi-network and the antenna, and will add another 15 db to the harmonic attenuation. This is a worthwhile consideration in the areas where the activity on all bands is great since one should be considerate of others.

The effort one expends in thoroughly checking his antenna system can be very rewarding. You may be very pleasantly surprised to learn that you can double your power, effectively, by spending a half day or more on your antenna system without the outlay of a single cent. The old dipole you stretched between the house and the tree three years ago may be four feet longer than the last time you measured it. How do you know you aren't down to one strand in the center conductor of the coax at the antenna? The other six may have work-hardened and snapped off months ago. A partially defective antenna system, as well as a questionable ground system can be a never ending source of transmitter troubles, TVI, and the reason you don't raise all those calls you hear around the country.

Ground Lead

It goes without saying that a good ground system is important in order to have an effective antenna system. If you are unfortunate enough to have your "Ham shack" above the first floor level, you may find it desirable to tune the ground lead to a half wave length, or multiple thereof, in order to obtain better results. This can be done very easily by installing a roller coil or a variable capacitor in series. There is a world of difference between a good d.c. ground and a good r.f. ground. You actually need both, and the waterpipe is a good d.c. ground in all cases. It can also be a good r.f. ground if you consider how far it is from the transmitter to the waterpipe.

At this point I am sure you will agree, that an antenna will not necessarily transmit as well as it appears to receive, and it is entirely possible that your antenna system can be improved. Good luck in your efforts to increase your effective radiated power, and doubling your number of contacts as well as your pleasure in being an amateur. ■

DXing is Different [*from page 41*]

meaningless bother. The moon, we have found, is a better place just to locate the beam. Of course tnere is some loss in the feed line.

That's why there is so much space activity in California. The dream of every DX ham here is to go the orbiting TV camera one better, to put a TV *station* in space, to scan the DX areas and report who's on the air, and particularly the frequency he's on. The old saw "if you can't hear 'em, you can't work 'em" is passé here. Our motto is "If you can't see them, you can't tell whether or not they're bootleggers."

But back to the California receiver. Less known than the California transmitter, it represents advancement of the art unequaled anywhere else. For example, there's the California S-meter, which guarantees that all DX stations will get at least an honest S-9 report. This is made possible by installing The California Face, whose numbers *begin* at S-9. This enhances the possibility of a QSL from a flattered rare one using peanut power and the XYL's clothesline.