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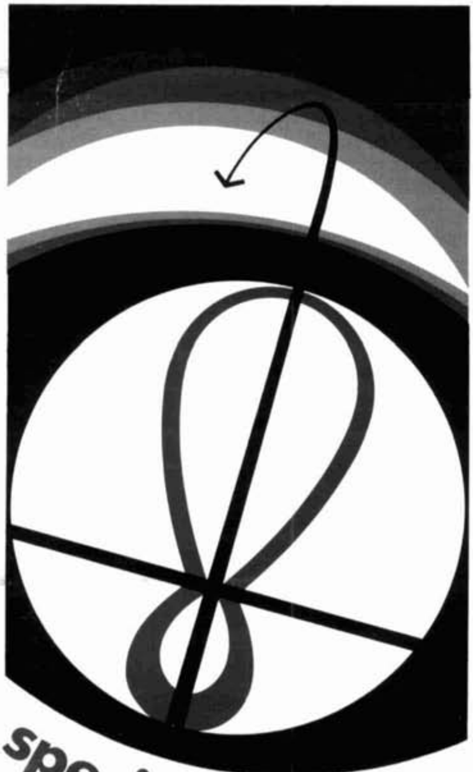

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More Details? CHECK—OFF Page 94

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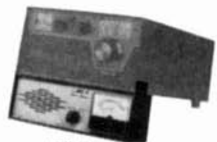

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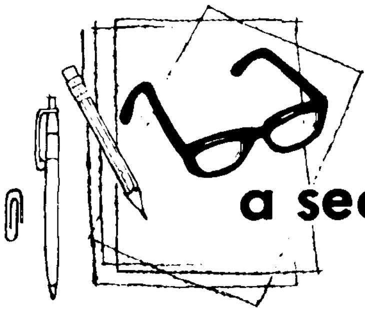


a second look by jim fisk

With the coming of late spring it is time to take a close look at your antenna system to make sure it's operating up to par. Check all the electrical connections for oxidation, inspect the feedline for damage, and if the swr is not as low as it used to be, now's a good time to tune up the system.

If you are considering a new antenna for your station you may find useful one of the designs in this, our annual antenna issue. Although there have been few important breakthroughs in amateur antenna design since the cubical quad, a great many specialized antennas have been developed for military and space communications.

One recent example is the log-periodic, first described as a microwave antenna, later as a high-frequency wire beam, and finally, for television broadcast reception. The log-periodic antenna has never become especially popular with amateurs, probably because we operate on segmented bands, and the log-periodic is a broadband device. The same might be said for other recent developments such as the backfire antenna and the phased array.

Over 100 years have elapsed since Maxwell formulated the celebrated mathematical equations that continue to provide the basis for classical radio theory. This theory was first verified by Hertz in 1887 with a center-driven wire antenna, 24 inches long, terminated at each end with a metal plate about 16 inches square. The fundamental frequency of this antenna, 53.5 MHz*, was excited by a spark gap.

Marconi's first successful wireless experiments used basically the same antenna: Two large copper plates excited by a spark gap. To increase the distance of his transmissions Marconi put up larger and larger quantities of wire. Early amateur operators did the same – the DX performance of a station was often directly proportional to the size of the station's antenna.

The first advances in gain antennas were the result of experiments by commercial radiotelephone companies which wanted to improve the reliability of their overseas service. First came the long-wire, the vee and the rhombic; then the Lazy-H, Sterba curtain and Bruce array, followed closely by the W8JK flat-top and the parasitic beam. Each new design was eagerly tried out by amateurs trying to improve the performance of their stations.

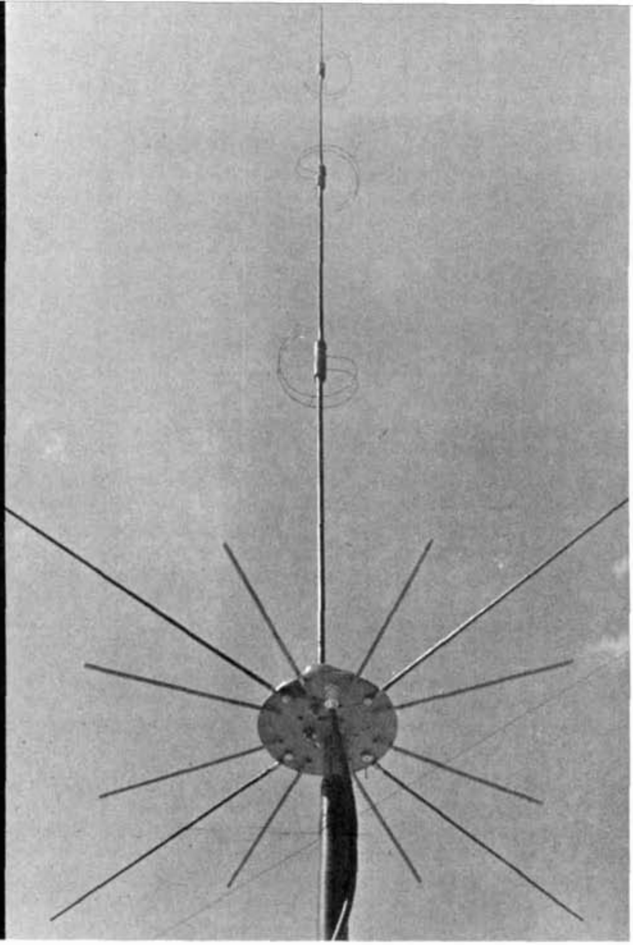
However, today it is different; the antennas are not that much different from those used a decade ago. Feed systems have been improved, impedance matching is better, and the antenna will stand up under more severe weather conditions, but the basic antenna is little changed. I wonder how much more we can improve the ubiquitous beam antenna?

expanded phone bands

The actual FCC docket for expanded phone bands is essentially the same as that discussed on this page last month. The text of Docket 19162 is printed in its entirety in the April issue of *QST*. If you don't have access to a copy of the text we will be glad to send you a copy if you will enclose a self-addressed, stamped envelope with your request.

Jim Fisk, W1DTY
editor

* R. King, "The Linear Antenna – Eighty Years of Progress," *Proceedings of the IEEE*, January, 1967, page 2.



four-element colinear array for two meters

Extended elements with phasing stubs give 14 dB gain over a ground-plane antenna

Bob Dahlquist, WB6KGF

Here is an antenna with as much gain as a medium-sized yagi beam; yet, unlike the yagi, this antenna is omnidirectional. You can easily work stations from all points of the compass without waiting for a rotator to crank the antenna around to the desired azimuth – an advantage when working in a contest, a net, or with mobile stations.

the circuit

The antenna is known as a 4-element extended colinear array. It's an improvement over the classical colinear antenna described in the literature.[1] Instead of ½-wavelength elements, the extended colinear uses 5/8-wavelength elements (except for the topmost element) to obtain gain over the conventional colinear array or the popular ¼-wave ground-plane antenna.

The topmost element is shorter than the other elements to preserve current balance in the phasing stubs. The sketches in **fig. 1** show the electrical circuits and the distribution of current and voltage.

have? I made a comparison test, starting with a simple ground-plane antenna. When the extended 4-element colinear was substituted, the radiated field strength increased by 14 dB. Some of this increase could be attributed to an increase in power input to the colinear, since the colinear was adjusted to near unity swr before it was installed.

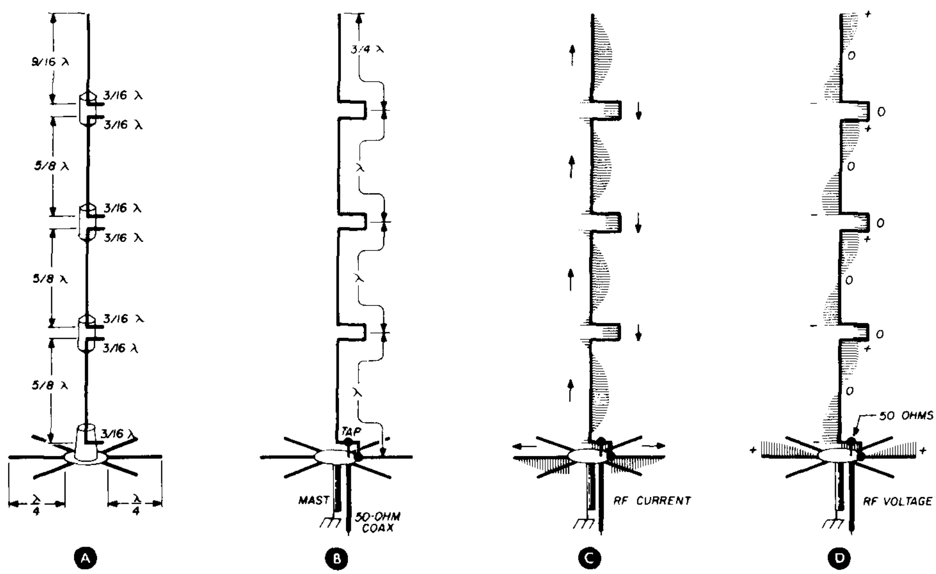


fig. 1. The extended colinear array. Sketch A shows electrical lengths of elements and tuning stubs; B gives the electrical circuit of the complete antenna. Current and voltage distribution are shown in C and D.

features

In addition to the added gain, the extended colinear has extra height compared with the ground plane. The extended colinear is self-supporting to 17 feet above its base on 2 meters. This added height puts the radio horizon several miles further away than that of a ground-plane antenna. The improvement will be more noticeable, of course, if you must roof-mount the antenna than if you can manage a 50-foot tower.

gain

Just how much gain does this antenna

theory

The extended colinear array is a bit longer than the classical 4-element colinear. The added gain results from the increased spacing between current loops, or maxima, in the radiating elements (**fig. 1**). Increasing element length beyond 5/8 wavelength actually decreases gain, because the out-of-phase currents in the element ends then become large enough to cancel some of the radiated field.

phasing

By mounting the four elements linearly and feeding them in phase, the fields radiated by the individual elements will reinforce. The sum of the four fields (total field strength) will be maximum in a plane normal to the axis of the antenna (**fig. 2**). The pattern is like the doughnut-shaped field of a vertical dipole, but much flatter. In the vertical plane, the beam-width is only about 20 degrees, with maximum radiation directed at the horizon (**fig. 3**).

Proper phasing is accomplished with stubs. Placed between each element, a stub of the proper electrical length introduces just enough delay to keep the currents in the elements phased 360 degrees apart (for our purpose, this is the same as zero degrees, or exactly in phase).

Since the elements are longer than usual, the phasing stubs must be shorter by a corresponding amount. Instead of ¼ wavelength, the stubs are 3/16 wavelength from the shorted end to the open end, or 3/8 wavelength all the way around. The length of one element, plus the length of one side of each adjacent stub, equals one wavelength (360 electrical degrees) except for the top element, where the total is ¾ wavelength; the length of the top element is 9/16 wavelength (see **fig. 1**). Lengths of all elements, tuning stubs, and radials are given in **fig. 4**.

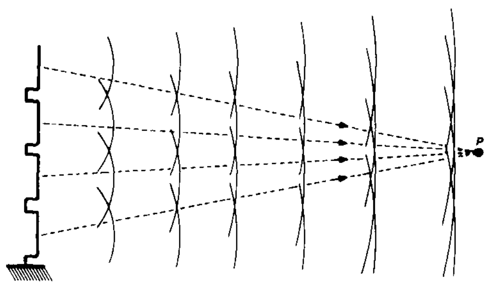


fig. 2. Relationship of waves radiated from each element as a function of range. Since the waves travel approximately equal distances to reach a distant point, P, all arrive in phase and add to produce increased field strength.

feeding and matching

The array is fed at the base through another stub, much like the phasing stubs, except that only half of this stub is constructed. (The other half is a reflection in the ground-plane disc.) Since this stub is unbalanced, coax can be connected directly without a balun. The center conductor is passed through the disc and soldered to the point on the stub where the impedance matches that of the coax, and the braid is grounded to the disc that secures the ground-plane radials. See **fig. 5**. By alternately adjusting the position where the coax is tapped, and the length of the stub, a match near 1:1 can be obtained. The radials are ¼ wavelength long. They decouple rf from the mast and the outside of the coax, thus making the array independent of actual ground. An overall view of the antenna is shown in **fig. 6**.

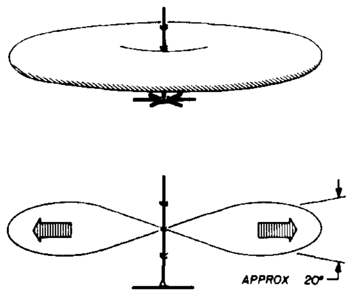


fig. 3. The "squashed doughnut" pattern of the extended colinear antenna. The angle shown is in the vertical plane.

construction

This antenna is best assembled by casting the insulators in place. This procedure is not absolutely necessary, but it does produce strong, watertight joints. The casting process is not difficult or expensive; one method is described later in the article.

radiators

Each radiating element should be

strong enough to support both the weight and the wind load of the parts above it. I used tapered elements; it would also be possible to make each element from a different-size tubing. Aluminum alloy is a good choice for material because of its high strength-to-weight ratio, although it's difficult to solder.

If each element is made with a joint of

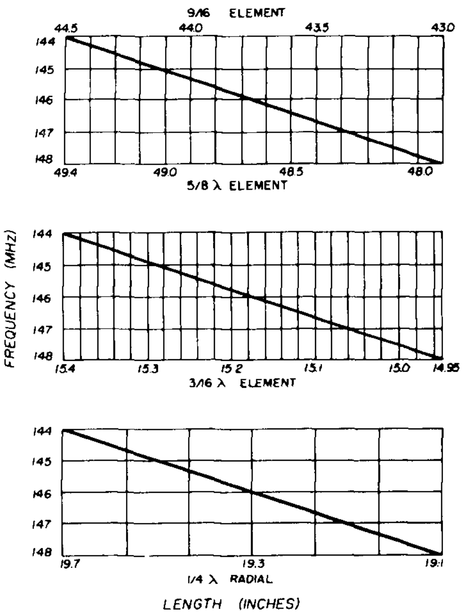


fig. 4. Lengths for elements, stubs, and radials in inches versus frequency. Data is based on 1/2 to 3/8-inch-diameter elements.

some type, the antenna can be disassembled to make transportation easier. If this isn't done, the antenna should be assembled in a place where its 17-foot length won't become a problem. My tubing had threaded joints; however, lacking these, you can use progressively smaller sizes of tubing. By splitting the end of a tube with a hacksaw, slipping the smaller tube inside and applying a hose clamp or two, you'll have a joint that will allow adjustment as well as disassembly of each element.

Each stub is made in two halves at first, to be joined later. Cut each half to length according to **fig. 4**, but allow a little extra for making the joint to the tubing. Add a little more than this for pruning; say 6 inches. It's best either to solder or weld the wire to the tubing. Make sure all joints are mechanically and electrically sound. Do *not* use acid-core solder.

casting the insulators

For casting, you'll need three basic items: a mold, resin, and a means to hold the parts steadily while the resin cures.

The mold can be made of plaster of Paris. You can make a mold for each insulator and do the casting all at once, or you can make one reusable mold and cast the insulators one at a time except, of course, the base insulator, which requires its own mold. I used the latter method; however, if I were to do it again I'd use the former method, which saves a lot of trouble and resin.

element insulators

Arrange each element with stub wires attached, and with the joints disassembled, so that each element is in its proper relative position with respect to the others. A cardboard mold, fashioned from a quart milk carton, is then used to cast a block of paraffin. When the paraffin has solidified, remove the cardboard mold and carve the paraffin into the shape of the insulator (see photo).

Using another piece of cardboard, cast a block of plaster of Paris around the wax insulator. This will form a mold for the plastic resin, which constitutes the insulator. When the plaster has set, the wax can be melted. You'll need at least one hole in the plaster to drain the melted wax, and another for pouring the resin. These holes can be made during the casting process with two greased, pointed sticks; or after casting, with a drill. Use care when melting the wax, because if it gets too hot the plaster will dry and crumble, or soldered connections on the stubs will melt.

base insulator

Forming the base insulator can be tricky, but here are some hints to make the process easier.

First, drill three holes in the ground-plane disc of the proper size to accept the bolts that will hold the antenna. Then drill another hole in the center of these three holes. (This hole will be used to pour paraffin into a mold.) Turn the ground-plane disc upside-down and place the three bolts into position, threading the nuts on the bolt ends to support the weight of the bolts as they hang (also upside-down) through the holes. See **fig. 7.**

Place the entire assembly on top of a paper cup, with the bolts hanging down inside the cup, but not touching its sides. The cup forms a mold for the paraffin, which is cast to form a pattern for the mold, as before.

After casting the paraffin, turn the base over and carefully remove the paper cup. Place a cardboard cylinder, or a can with the top and bottom removed, around the paraffin pattern to hold the plaster. Arrange a brace to hold the tubing vertically. Heat the end of the tubing, and let it melt its way into the wax pattern until the tubing reaches the proper position. (You'll probably lose some paraffin through the slot melted by the stub wire and have to retouch your pattern.)

When the pattern is ready, be sure that the base plate is absolutely level and the tubing is absolutely vertical. Then pour the plaster. Check to ensure that nothing has shifted out of alignment. When the plaster has solidified, you can melt the wax pattern, as before. It will probably be easier to do this without the radials installed.

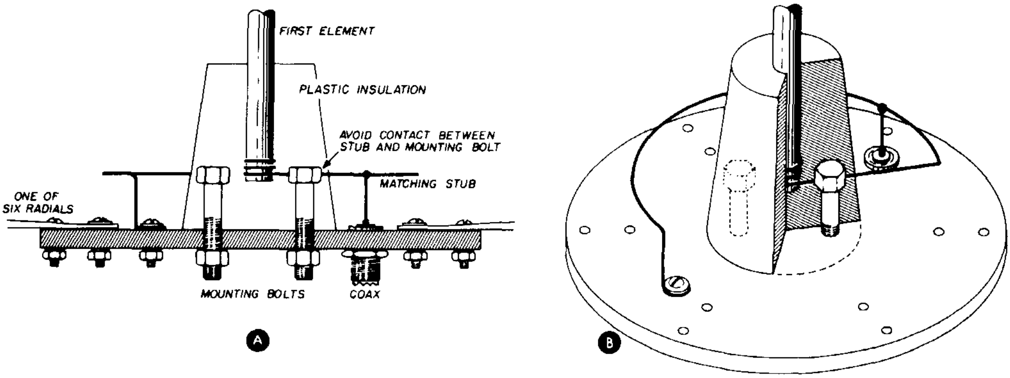


fig. 5. Detail of center insulator, bottom matching stub, and radial anchor plate, A. View B shows the assembly in perspective.

casting in resin

With the molds ready, you can cast all the insulators in plastic at the same time, using only one batch of resin. This will eliminate considerable waste of resin and acetone. Use polyester or slow-curing epoxy resin, of the type used for fiber-glass boats, for the casting. Do not, under any circumstances, use the rapid-curing type of epoxy resin, which is commonly supplied with patching kits. The heat generated by the rapid curing causes a chain reaction inside the mold, because the heat can't escape as fast as it's generated. It can get hot enough to boil, which causes bubbles; or it can even catch fire. When the reaction is over and the

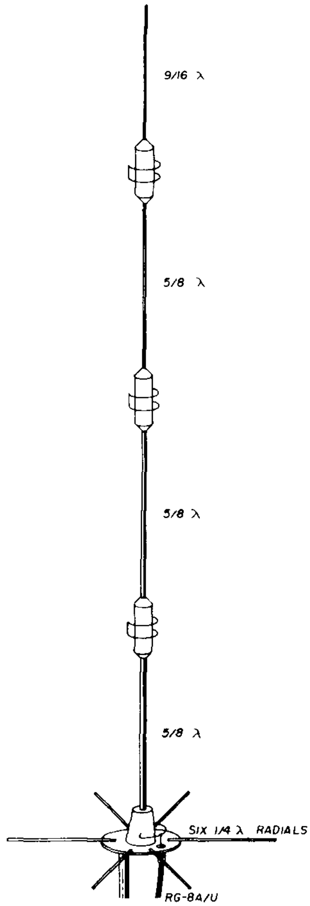


fig. 6. Overall view of the complete assembly.

stuff cools, it will crack. If polyester resin is used, apply twice the usual amount of hardener or catalyst. This will cause the mix to set up a bit faster and will also make the finished casting more flexible and less brittle.

Always measure carefully, and stir with care to avoid mixing bubbles into the plastic. Keep everything out of direct sunlight, and never mix more than you can use at one time. Otherwise the resin will gel, taking on the consistency of something between Jello and rubber. Note: the only thing that will remove resin from hands and tools is acetone. It evaporates so fast you have to see it to believe it, so get about twice as much as you think you'll need.

When the resin has set, you can break away the plaster molds, put everything together except the stubs, and proceed with tuning.

tuning

The stub wires should be soldered or welded to their radiating elements, but not yet connected to each other.

Prune the stub wires to exact length, using capacitive coupling – as loose as possible – to the hot end of a grid-dip oscillator tank coil. Using a receiver to check the oscillator frequency, resonate the three lower elements, with their stub wires, at one wavelength each. Ground one end of the top element to a metal screen or sheet and resonate it to ¾ wavelength. While doing this, try to keep all the stub wires parallel to maintain constant capacitance between them.

Install the radials and tune them all to ¼ wavelength. Now solder the wire ends together, or solder a shorting wire in place, to complete all the phasing stubs; then temporarily ground the end of the matching stub. Check the resonant frequency of the entire antenna with the

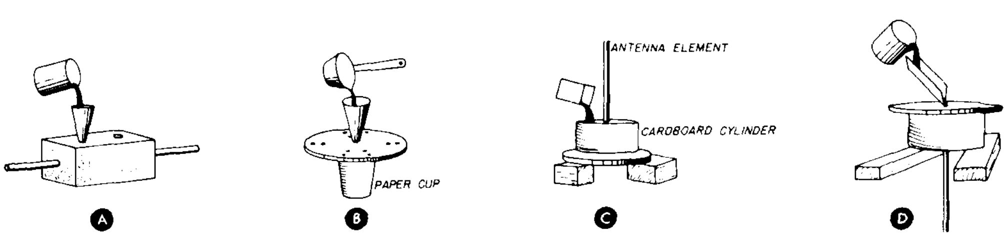
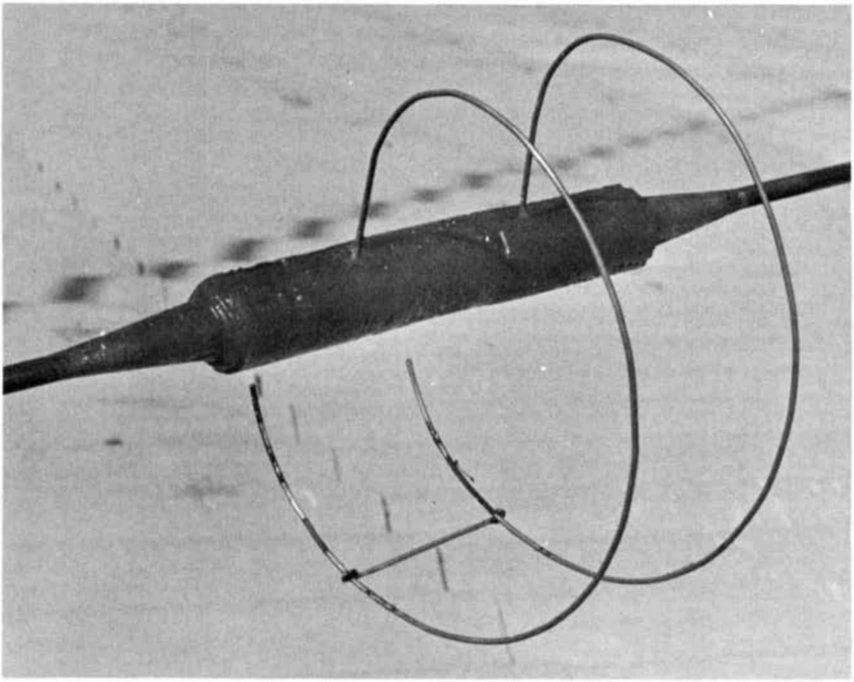


fig. 7. Making the insulators. Final step in casting an element insulator in resin is shown at A (see text) The base insulator is made by pouring a wax pattern, B, around which a plaster mold is formed, C. The wax pattern is then melted out of the mold, and the mold is filled with polyester resin, D.

gdo capacitively coupled to the top end of the antenna, as before. Note that the antenna will resonate at any odd multiple of the quantity (operating frequency divided by 19). For example, if the operating frequency is 190 MHz, the antenna will also resonate at 170, 150, 130, etc., and 210, 230, 250 MHz, etc. So be careful not to tune it on the wrong harmonic. With this in mind, adjust all the stubs equally, a little at a time if necessary, to get the antenna on frequency.

Now set up the antenna in a clear area, at a convenient working height for adjustment of the matching stub. Temporarily connect the coax to about the middle of the stub, and check the swr. If it isn't 1 to 1 (hi hi), move the coax a bit to either side and test again. When you've found the point of minimum swr, and if it isn't quite close to 1 to 1, then shorten the stub a bit by moving the ground point, and try again. If this doesn't improve things, try lengthening the stub. By alternately adjusting the length of the stub and the position of the tap, you should be able to get close to a 1 to 1 match. When you're satisfied with the swr, drill, punch and/or file a hole at the proper place and install a chassis-type coax connector. Reconnect the coax to the connector, and recheck the swr. You may have to readjust the tap a fraction of an inch.

Now you can put 'er up as high as possible, and sit back and enjoy all the new signals you'll hear on the two-meter band.



Matching-stub detail. Stubs are tuned initially using a grid-dip oscillator, then pruned to correct length and soldered or welded to elements.

references

1. *ARRL Handbook,* Headquarters Staff, American Radio Relay League, Newington, Connecticut.

2. R. L. Crawshaw, WA0NGV, "5/8 Wavelength Verticals," *73,* May, 1970, p. 36.

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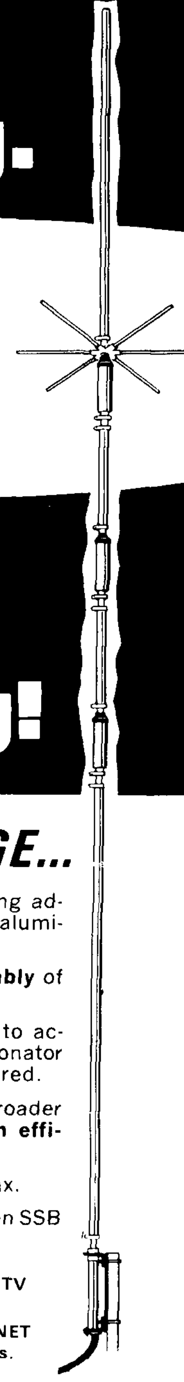

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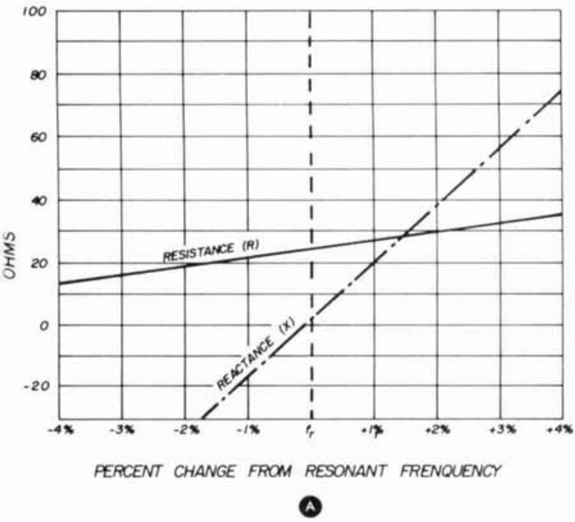
William I. Orr, W6SAI, EIMAC Division of Varian, San Carlos, California 94070

How convenient it would be if all Yagi beams presented a 50-ohm, unbalanced, non-reactive load at the feedpoint! Unfortunately, this is not the case, as most single-band Yagis exhibit a balanced feed-point impedance in the range of 18 to 30 ohms. Off-resonance, the impedance becomes complex, varying in the typical manner shown in **fig. 1A.** Moreover, when using a center-fed dipole the feedpoint impedance is balanced to ground, and an unbalanced coaxial feed system can result in degraded antenna performance. Poor front-to-back ratio, noise pickup and TVI may be some of the problems arising from improper attention to system balance.

A number of interesting matching and balancing systems have been evolved from time to time to solve these problems, and the better solutions work quite well. This article discusses an adjustable transformation linear balun of a type that has seen service in commercial installations over the years. However, its use in amateur circles has been restricted, possibly because of lack of knowledge regarding its operation. The balun will provide an adjustable step-up impedance match plus an accurate transformation from an unbalanced to a balanced mode for load values of about 10 to 50 ohms. Best of all, it is easy to adjust. Here's how you design, construct and tune this interesting device.

the L-network

The adjustable balun is derived from the basic L-network shown in **fig. 1B.** By the use of a combination of a series and shunt reactance the low-impedance load may be matched to a high-impedance source. Transformation ratios up to ten or more are common. Two lumped constant L-networks are shown in **fig. 2.** They are conjugate networks, the sign of the series and shunt impedances being reversed between the A and B versions. The A network is rather common in amateur equipment;[1] it may be recognized as the output section of the popular pi-L network circuit.



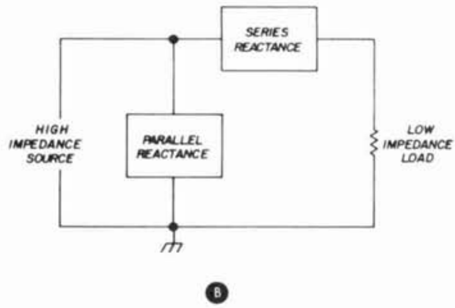
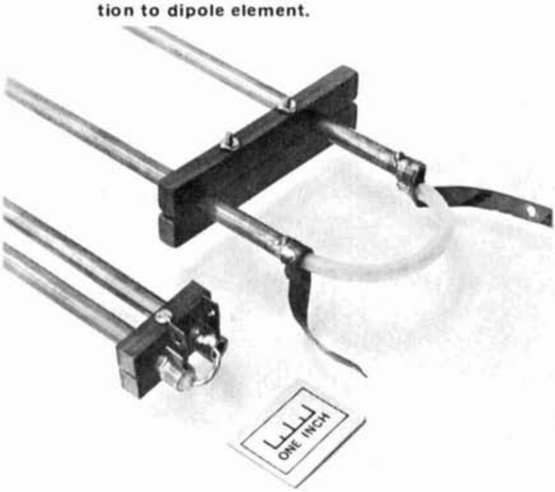


fig. 1. Yagi-beam impedance plot in A is similar to that of a dipole. Resistive component increases with frequency; reactive component is negative below resonant frequency and positive above it. L-network in B consists of series and shunt reactances and may be used to match a Yagi to 50-ohm coaxial line.

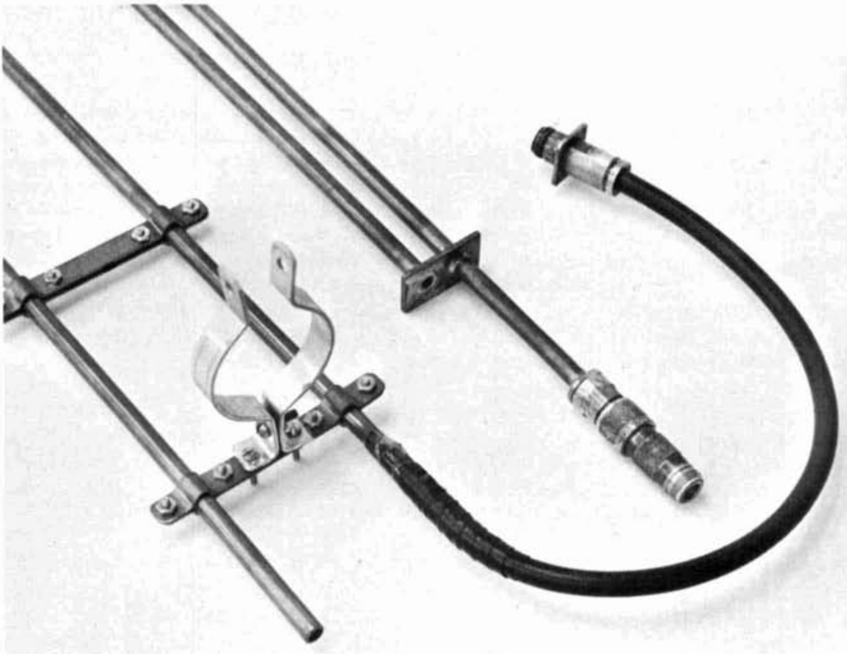


Vhf (left) and hf (right) balun construction. Balun tubes are locked in position by phenolic blocks. Inner conductor of coaxial line crosses over and is soldered to opposite tube. Short lengths of copper ribbon provide easy connection to dipole element.

The configuration in **fig. 2B** is used less often although it performs in the same general fashion as the A network. This second version of the L-network is the one used in the adjustable antenna balun described here.

In both versions, X_L and X_C represent real components, and R represents a resonant antenna load. If the antenna is deliberately made *non-resonant,* however, it may be adjusted to simulate a complex impedance containing the desired value of either X_L or X_C. Specifically, if the dipole antenna element is longer than resonance, it exhibits inductive reactance (X_L) at the center terminals; if it is shorter than resonance, it exhibits capacitive reactance (X_C). Thus, varying the length of the antenna beyond the resonant point eliminates the real components X_L (in network A) and X_C (in network B). The L-network may be reduced to an off-resonant antenna, and either a parallel capacitor or inductor may be used, depending upon the type of network.

may take the form of a shorter-than-resonant dipole. In addition, the lumped inductor X_L may be removed and a shorted segment of transmission line substituted as shown in **fig. 4.**



Base end of hf (left) and vhf (right) baluns. Adjustable shorting bar is visible on hf balun. Extra shorting bar has aluminum boom clamp mounted on it. Coaxial line passes out of balun tube and has female type-N coaxial fitting (UG-23B/U) fitted at end of line. Vhf balun has one adjustable shorting bar (not in photograph) with copper shorting bar sweated to bottom of balun tubes. One tube is a few inches longer than the other and has a modified UG-18B/U coaxial plug soldered to the tube. In the hf balun, the coax braid is soldered to the end of the copper tube and the joint wrapped with vinyl electrical tape. The braid is completely removed in the vhf balun with the inner conductor of the line soldered directly to the coaxial fitting; the inner conductor is passed through the tube to the opposite end.

balanced L-network

There still remains the problem of connecting an unbalanced coaxial transmission line to a balanced antenna element. **Fig. 3** shows the network of **fig. 2B** redrawn for a balanced condition. The ground point is moved to the center of coil X_L, and two capacitors, each double the value of X_C are placed in series with the load. As before, if the load is considered to be an antenna, the series capacitance

The configuration is the mechanical heart of the adjustable balun. A shorted transmission line less than one-quarter wavelength long presents an inductive reactance at its open end. A shorter-than-resonance dipole presents a capacitive reactance at its terminals. If the length of the line segment (or stub) and the length of the dipole are properly chosen, the components of the impedance matching network are reduced to a few lengths of tubing, two of which are the halves of the driven element in the beam antenna.

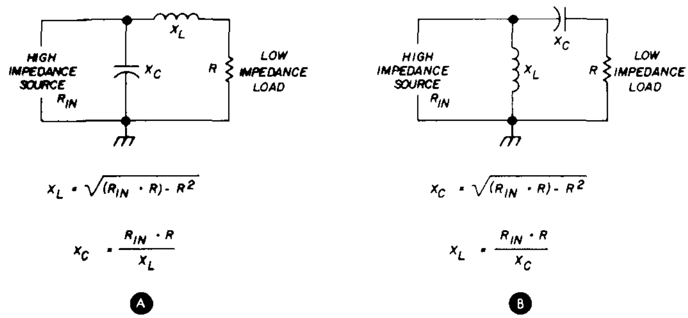
The linear L-network is easily converted to a practical balun transformer as shown in **fig. 5.** Points A and B of the balun are balanced to ground and present the correct impedance to match the shortened dipole. The unbalanced coaxial line may be brought into the balun through one of the balun tubes, with the center conductor of the coaxial line crossing over at the end of the device to contact the opposite balun tube, as shown in the illustration. Of course, the impedance of the coaxial line must be held to the original value as it passes through the balun tube. By adjusting both the shorting bar on the balun and the length of the dipole this simple device will provide excellent balance and transformer action.

Balance is achieved by permitting the outer shield of the coaxial line to assume the potential of the balun tube as it passes from the grounded end (C) to the terminal end (B). Cross-connecting the center conductor to the opposite balun leg insures 180° phase reversal is maintained.

network transformation

The reason the L-network is able to transform one impedance value to another is that, for any series circuit consisting of a series reactance and resistance, an equivalent parallel network which possesses the same impedance characteristic can be found.[2] The general case for determining the values required for any two impedances to be matched by the L-networks of **fig. 2** are summarized by the following equations:

fig. 2. Conjugate L-networks. Network A is preferred when load reactance may be negative. Network B is preferred when load reactance is positive. For reactance ranges common to Yagi antennas, either network may be used.



$$\frac{R_{in}}{R} = Q^2 + 1 \qquad (1)$$

$$Q = \frac{X_s}{R} \qquad (2)$$

$$Q = \frac{R_{in}}{X_p} \qquad (3)$$

Where R_{in} = the input impedance, R = the load impedance, X_s = the series reactance, X_p = the parallel reactance, Q = the circuit Q, and the series and shunt reactances are of opposite sign.

For easier usage with 50-ohm lines, these formulas may be reduced to the ones shown in **fig. 2** with the relationship

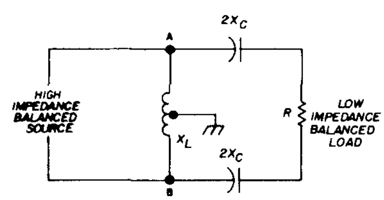


fig. 3. The L-network of fig. 2B redrawn for a balanced source and load. Points A and B are at equal and opposite potential to ground.

between X_s, X_p, R_{in} and R given in **fig. 6.** The reactance values are in ohms and may be translated to picofarads and microhenries with the aid of a reactance chart.*

balun design

Once the transformation ratio and the values of series and parallel reactance

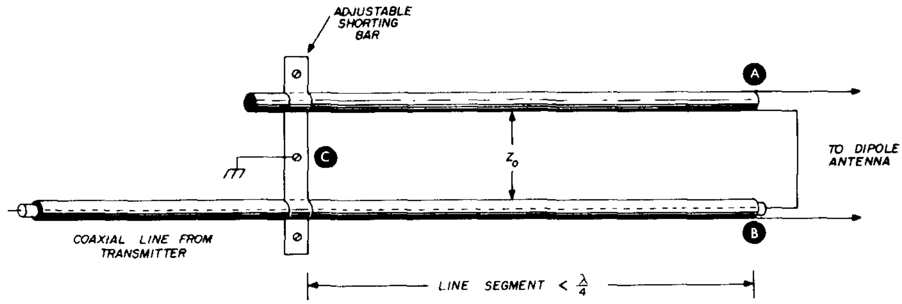


fig. 5. Linear transformer of fig. 4 is modified into balun by passing coaxial line down one leg. Points A and B are balanced to ground. Inner conductor of coaxial line is cross-connected to opposite balun leg. The impedance transformation is adjusted by varying length of the balun and length of driven element of antenna.

have been established, the physical balun may be designed from transmission-line formulas. The fact that a shorted, two-conductor transmission line of the proper length exhibits inductive reactance at the terminals makes it possible to substitute such a line for the inductor in an L network. The amount of reactance shown by the line segment is determined by the characteristic impedance and the electrical length of the two-conductor line. The inductive reactance of a shorted lossless balun line, less than a quarter-

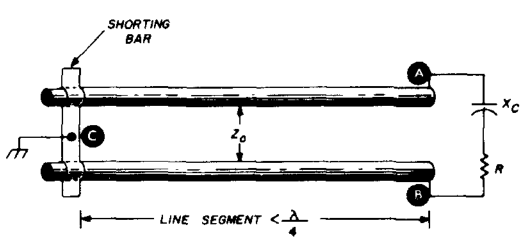


fig. 4. The inductor X_L in fig. 3 may be replaced with a segment of shorted transmission line. Points A and B are at equal and opposite potential to ground, C.

wavelength long, constructed in this fashion, is:

$$X_L = Z_O \tan l$$

where X_L = inductive reactance in ohms, Z_O = characteristic impedance of the balun line, and l = length of the balun line in electrical degrees.

Fig. 7 is a plot of balun line length (l) in electrical degrees as a function of the ratio of load impedance to balun impedance (σ). A plot of the ratio σ in terms of line length in feet for the 20-meter band is given in **fig. 8.** These charts provide sufficient information to build your own linear balun.

practical balun transformer

A balun transformer built along these principles is shown in the photographs. For convenience the balun is made of 3/8-inch diameter hard-drawn copper tubing. The feedline, RG-8A/U cable, will just pass through the tubing when the braid and the vinyl jacket are removed from the line. Using a center-to-center spacing of 3 inches, the balun line will have a characteristic impedance (Z_O) of about 325 ohms.

The Smith chart may also be used for impedance transformation. See P. H. Smith's book, "Electronic Applications of the Smith Chart," published by McGraw-Hill.

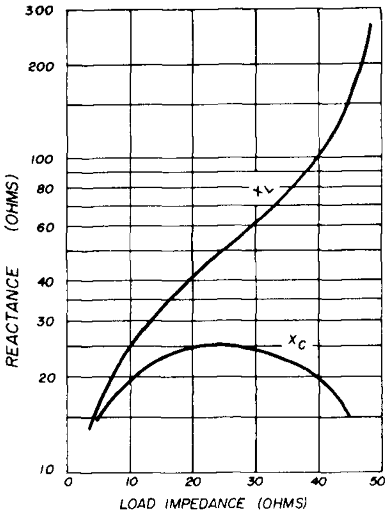


fig. 6. X_L and X_C values for antenna load R. This chart may be used for determining balun reactance values when a 50-ohm transmission line is used. For example, if the load impedance (antenna impedance at resonance) is 25 ohms, the capacitive element (X_C) of the balun of fig. 2B is 25 ohms, and the inductive element (X_L) is 50 ohms. The chart may be used with the balun of fig. 2A if the nomenclature of the curves is reversed (X_L becoming X_C and X_C becoming X_L).

Assume the impedance of the transmission line is 50 ohms and the antenna load is 20 ohms. Using **fig. 6,** the value of X_C is found to be −24.5 ohms, and the value of X_L is +41.5 ohms. Turning to **fig. 7,** the ratio of X_L to balun characteristic impedance (σ) is 41.5/325 = 0.127 as noted on the y-axis. The value for l, as found on the x-axis is about 7.5 electrical degrees.

To get the answer directly in feet, **fig. 8** may be used for the 20-meter band. In this example for σ = 0.127 (read as 0.125 on y-axis) the balun length is about 1.4 feet, or 16 inches.

The chart of **fig. 6** has indicated that the series reactance (X_C) for this example is −24.5 ohms. This reactance takes the form of a shorter-than-resonance driven element. The amount of shortening required is a function of the length to diameter of the element and the feedpoint impedance at resonance of the element.* The amount of shortening may be computed easily for a single dipole element, but no information exists (that I am aware of) that permits this computation to be made for a multi-element Yagi beam. Consequently, the shortening necessary to bring the driven element to the proper reactance value is best determined by the heuristic method — cut and try! For a three-element 20-meter beam, shortening the driven element about three to six inches each side seems to bring things into the ball-park.

*As antenna length decreases, feedpoint impedance decreases, too. The decrease typically runs about 10% to 15% for the range encountered in matching a three-element Yagi beam to a 50-ohm transmission line.

adjusting the balun

The balun transformer may be pre-set and attached to the beam antenna. The

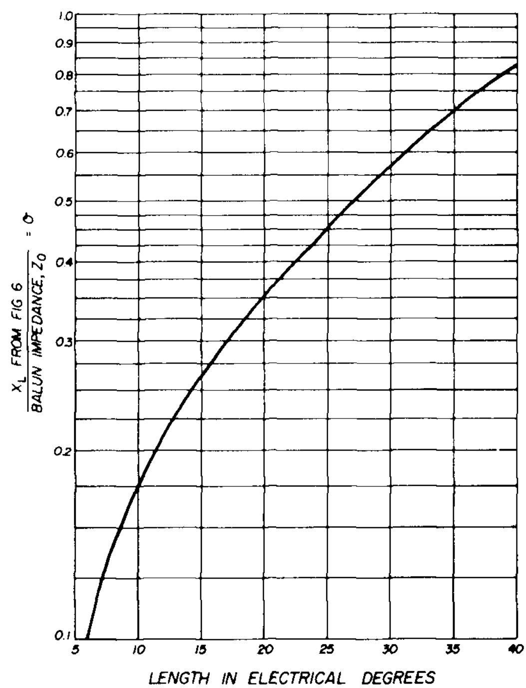


fig. 7. Balun length in electrical degrees as a function of the ratio of the load impedance to the balun impedance (X_L/Z_o).

balun can run parallel to the boom for convenience at a distance of about six inches from the boom. Positioning the balun closer to the boom will necessitate a change in setting. The driven element, for a starter, should be shortened about three inches on each tip (for 20 meters).

The excellence of adjustment is ascertained by running an swr curve across the band, making a measurement every 50 kHz or so. Balun length and driven-element length are then adjusted to drop the swr curve to a 1-to-1 ratio at or near the center of the band. Adjustment is not critical, and if you log your adjustments you will quickly be able to estimate the degree of change necessary to adjust the system "on the nose." Adjustments of balun and dipole length are interlocking, but setting the balun to the length in **fig. 8** for a given value of antenna load and preshortening the driven element a few inches will insure that the starting point is not too far out of line.

For convenience the feedpoint impedance of the three-element Yagi beam may be taken as 20 ohms. In fact, it is possible to calibrate balun length versus terminal impedance in the home workshop using a grid-dip oscillator, an antennascope or swr meter and a handful of 1-watt composition resistors of known value. The calibrated transformer balun may then be used backwards, as it were, to determine the feedpoint impedance at resonance of the antenna.

Various adjustable baluns are in use at W6SAI. A permanent one is placed on the beam antenna, and two others are calibrated for use around the shack on experimental antennas. The balun for high frequency work is about five-feet long and has center-to-center spacing of 3 inches. The vhf balun is about the same length (approximately 1½ wavelengths at 144 MHz) with a center-to-center spacing of 1¼ inches. The extra half-wavelength was added to the vhf balun to permit measurements to be made without the operator being in the immediate field of the antenna.

Baluns of this general type may also be used as step-down transformers to match balanced load impedance in the range of 50 to 300 ohms to low-impedance coaxial lines — but that's another story.

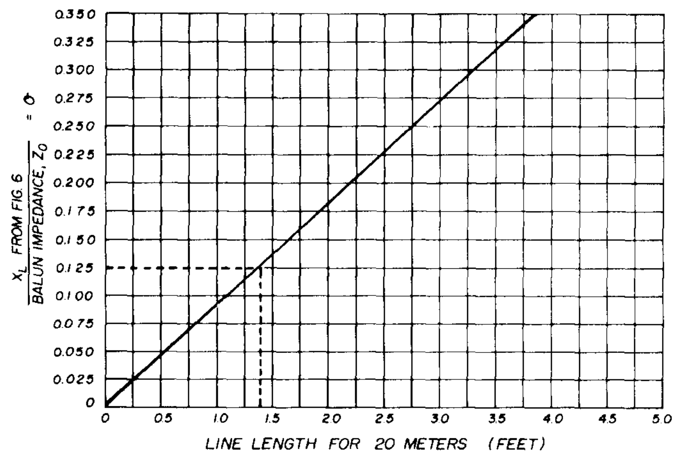


fig. 8. Balun conversion chart for 20 meters. Balun length in feet may be determined if resonant antenna load and balun impedance are known. Ratio of these two items is found on y-axis, and balun length is read on x-axis. Chart may be used for other bands (multiply lengths by 2 for 40 meters, divide by 1.5 for 15 meters, divide by 2 for 10 meters, etc.

references

1. William I. Orr, W6SAI, editor, "Radio Handbook," 18th edition, p. 288, Editors & Engineers, New Augusta, Indiana.
2. Gray and Graham, "Radio Transmitters," Chapter 5, Mc-Graw-Hill, New York,

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More Details? CHECK—OFF Page 94

a practical experimenter's approach to time-domain reflectometry

Time-domain reflectometry represents one of the easiest methods of analyzing transmission-line problems. The system shown here is easily duplicated in your shop

David M. Allen, WAØPIA, 2500 West 65th Street, Shawnee Mission, Kansas 66208

The use of time-domain reflectometry for analyzing transmission lines has enjoyed little popularity among experimenters who must finance their own projects. In fact, there are probably many amateurs who have never heard of this technique. Essentially, time-domain reflectometry is a closed-circuit radar system that displays transmission-line impedance "bumps" and discontinuities on an oscilloscope.*

This system has been used by repair crews for many years to locate faults in high-voltage transmission lines. A pulse burst is sent continuously down the transmission line. If the pulse encounters a short or open circuit the reflection travels back to the sending point, where it is compared in phase, time and amplitude with the original pulse. This comparison indicates the distance to the fault as well as its nature.

With new high-speed oscilloscopes it has become practical to apply the time-domain reflectometry technique to high-frequency transmission lines. The faster the transmitted pulse, the greater the distance resolution, since distance is related to time. Hence, distance resolution has shrunk from hundreds of yards to fractions on an inch, and commercial systems permit accurate measurement of reflections only a thousandth of a volt in amplitude.

Although commercial time-domain reflectometry equipment costs in the thousands of dollars, the basic technique is quite simple, and if the experimenter is willing to sacrifice the extreme accuracy of commercial equipment, he can duplicate the basic system at relatively low cost.

The only expensive requirement is a good oscilloscope, preferably one with triggered sweep, with bandwidth extending to 10 MHz or beyond. The upper limit on scope bandwidth is the prime limiting factor in measuring small discontinuities along a transmission line. Aside from the requirement for a good scope everything else can be built or is readily available in your shop. With this

*For more information on time-domain reflectometry, see Hewlett-Packard application note 67, "Cable Testing with Time-Domain Reflectometry." Available from Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304.

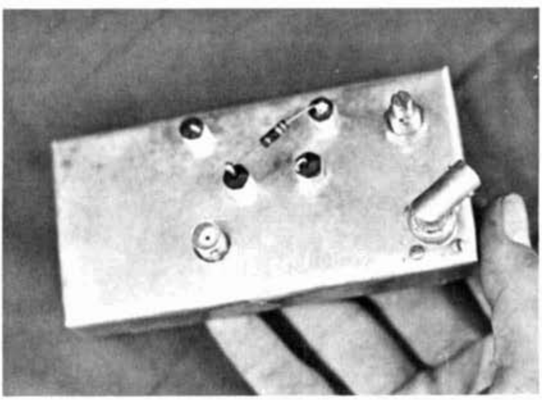
simplified approach transmission-line impedance cannot be measured within a tenth of an ohm accuracy, nor can transmission-line lengths be measured in one-foot lengths, but accuracy and resolution are good enough to be quite useful, and will provide answers to transmission-line problems where none were previously available.

fundamentals

The time-domain reflectometry (TDR) system is based on the propagation of an energy pulse down a transmission line into the load at the other end. A scope is used to monitor the pulse. It takes a finite length of time for the pulse to travel down the transmission line; this length of time is very short and depends upon the length of the transmission line. As the pulse travels through the line it may or may not be upset. If discontinuities exist along the line, part of the pulse energy will be reflected back toward the generator.

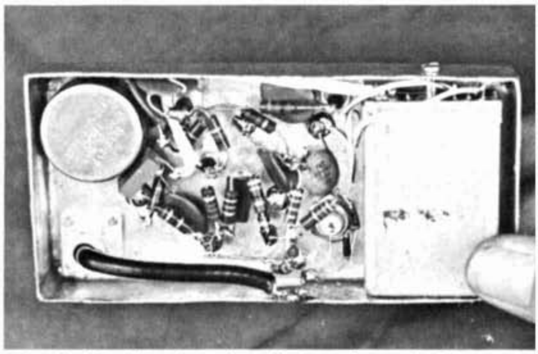
Since the scope is connected across the output of the pulse generator any energy that is reflected will be displayed. The original outgoing pulse is sharp-cornered and flat-topped; when reflected energy is added the flat top develops ripples and humps. The position of the ripple along the normally smooth top of the pulse corresponds directly to the length of time taken for the pulse to travel to the discontinuity and back again.

Schmitt-trigger pulse generator and 1-MHz source are built into small steel chassis.



If the transmission line is perfectly matched the pulse will be loaded down, and its voltage amplitude will be reduced, but the pulse top will remain smooth and flat. On the other hand, if the coax has water in it or is otherwise contaminated, or if a splice is poorly done (or any number of similar maladies) there is a mismatch and the pulse displayed on the face of the scope will be distorted. The oscillographs, **figs. 7** through **10**, show typical forms of distortion.

The input pulse must be very short and fast, and the scope must have charac-



Inside the time-domain reflectometry unit. The 1-MHz source is in the shield can to the left.

teristics equal to (and preferably better than) the pulse's fast rise time and short duration. The duration of the pulse determines the distance resolution of the system. For example, a two-second pulse is short enough for a transmission line 186,000 miles long (the pulse must travel twice the length of the transmission line before it gets back to the scope, thus, two seconds instead of one). Although the velocity factor of the coax, typically 0.66, will slow things down somewhat, pulse lengths this long are obviously not practical. However, the pulse can be easily shortened, and a pulse length of 1 microsecond is suitable for approximately 324 feet of coax or 480 feet of open-wire line. This puts transmission-line lengths within manageable limits.

In commercial time-domain reflectometry systems much shorter pulses are used with special sampling oscilloscopes. In a typical setup the combination of a very-fast-rise-time pulse generator and sampling scope provides an overall frequency response of 2.3 GHz or better.

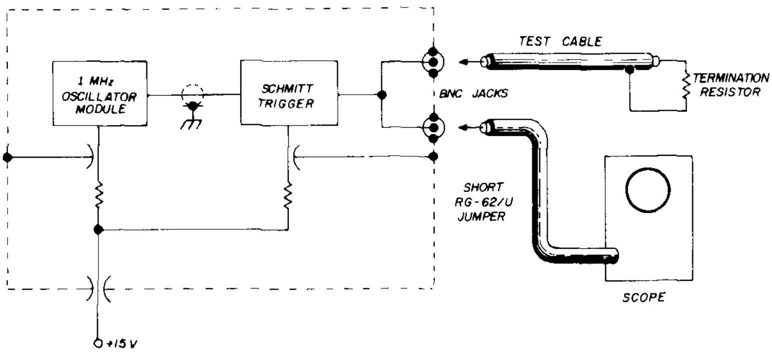


fig. 2. Practical time-domain reflectometry system uses 1-MHz crystal-controlled oscillator, Schmitt-trigger pulse generator and high-frequency oscilloscope.

This corresponds to a rise time of 150 picoseconds (150 trillionths of a second) which means that transmission-line discontinuities less than a half-inch apart may be resolved and isolated.

Although the pulse length for a practical amateur system doesn't have to be this short, the requirements for the pulse are fairly stringent. In my TDR system the pulse repetition rate was chosen at 1 MHz. For a fast-rise-time smooth pulse harmonics beyond 30 MHz will be present. Fortunately, adequate semiconductors are readily available, and the necessary construction techniques are no more than those required for a good 100-kHz crystal calibrator.

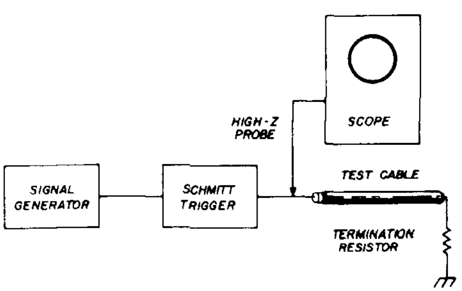


fig. 1. Original time-domain reflectometry system built by author indicated feasibility of simplified approach.

equipment

Figs. 1 and **2** show two different approaches to getting a workable time-domain reflectometry system going. **Fig. 1** was my first attempt; nothing was built but the Schmitt trigger circuit, and it was only loosely haywired together. Friends viewed the assemblage with skepticism; the Schmitt trigger resembled floor sweepings more than anything else. However, it worked, and from that initial success evolved the system in **fig. 2.** This is basically the same except that a 1-MHz driving source was used. A crystal-controlled 1-MHz driving source is particularly valuable where sweep-time calibration of the scope is in question, since the pulse generator then doubles as a very accurate time-base calibrator.

The 1 MHz source I used was taken from commercially built equipment and puts out a crystal-controlled 1-MHz sine wave. It can be easily duplicated, or a standard signal generator may be used. It does not take much power to drive the Schmitt trigger. A simple 1-MHz driver circuit is shown in **fig. 4.**

The Schmitt trigger circuit is a standard design; component values were juggled in the prototype to provide a clean, stable pulse with fairly low impedance. The hysteresis of the circuit was made as low as practicable while still allowing sufficient pulse-length adjustment. The 2500-ohm pot sets the switching threshold, and the pulse length with a sine-wave driving signal. Pulse length is also a function of the amplitude of the 1-MHz source. Resistor R1 is used to set drive-signal amplitude by loading generator output down to the level required by the Schmitt circuit.

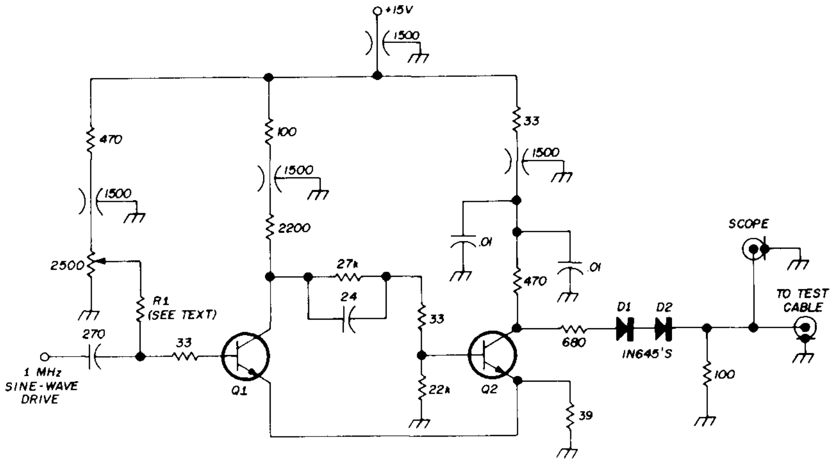


fig. 3. Schmitt-trigger pulse-generator circuit. Transistors are surplus silicon npn types; Motorola HEP50 are suitable. Value of R1 depends upon 1-MHz amplitude and source impedance.

The transistors are small-signal, high-frequency switching types. In my unit I used devices from surplus digital equipment. I don't know anything about them except that they are silicon npn. With the 2500-ohm threshold pot in the circuit transistor substitution should cause no problem, only readjustment of the pot.

When the final trigger circuit was built it worked when power was first applied, and was tested by hooking it into a communications receiver. As the threshold pot was varied for symmetrical on-off characteristics, the even harmonics went through a null of several dB as read on the S-meter. Since theory says that there will be no even harmonic energy in a perfect square wave it was assumed that the pulse generator was working properly. This was verified later with an oscilloscope.

The 680-ohm resistor in series with the Schmitt circuit output prevents excessive loading of the circuit due to low cable impedance. The two diodes in series with the output are to offset the voltage developed across the 39-ohm emitter resistor and the saturation voltage of Q2. When these voltages are offset pulse output will be referenced against a 0-volt baseline instead of being elevated above ground. The diodes are silicon switching types and are not at all critical. I used 1N645s.

Adjustment of the 2500-ohm threshold pot is not critical. If the driving voltage at the base of Q1 has the proper amplitude the threshold action of the pot will occur across a few degrees of rotation near the center of its range. Once the circuit is switching properly the narrow range of the pot's adjustment is used to vary the length of the positive pulse output. In my unit, 0.6 microsecond pulses provided ample time for work.

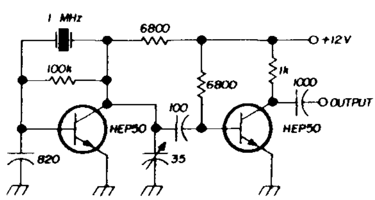


fig. 4. Crystal-controlled 1-MHz oscillator.

operation

The pulse generator output must be

hooked directly to the transmission line without excessive lead lengths. The scope connection is very critical. A high-impedance scope probe with a 10:1 divider is satisfactory, but the scope must

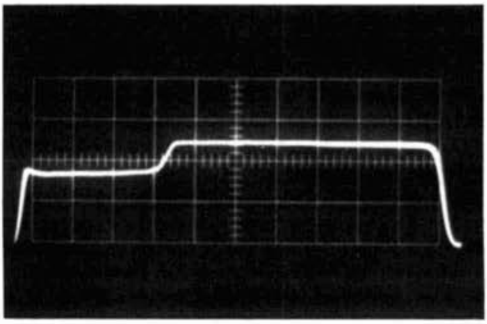


fig. 7. Transmission-line display. From left to right: 68-feet 50-ohm RG-8/U, 25-feet 93-ohm RG-62/U, 100-ohm termination. Termination occurs approximately at center screen; right half of pulse displays no information. "Step" in display occurs at transition from 50- to 100-ohm transmission line.

have adequate sensitivity. I found it more expedient to hook the pulse output directly into the scope with a *very* short length (less than 6 inches) of low-capacity coax cable such as RG-62/U. If there are any ground loops present in the system they will probably show up as excessive overshoot and/or ringing on the front edge of the pulse. This is where high-frequency construction techniques are very important.

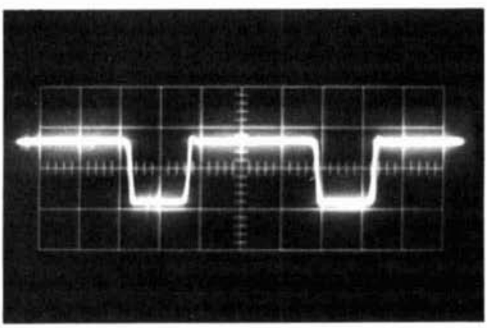


fig. 5. Rectangular pulse output from Schmitt trigger. Pulse rate, 1 MHz; sweep time, 0.2 usec per division.

Once a clean pulse is visible on the scope (similar to **fig. 5**) scope sweep time can be adjusted to fill the entire screen with the top of the pulse as shown in **fig. 6.** At this point the pulse generator

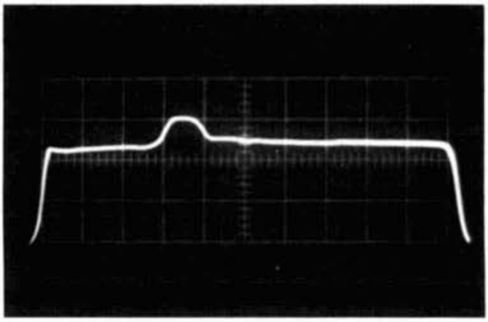


fig. 8. Transmission-line display. From left to right: 68-feet 50-ohm RG-8/U, 25-feet 93-ohm RG-62/U, 25-feet 50-ohm RG-58/U, 51-ohm termination. Bump indicates length of 93-ohm RG-62/U.

output is terminated directly at its output. The next step is to hook the unit to a transmission line. However, the following precautions must be observed: the transmission line must be terminated by a resistive load that is dc coupled, and there must be no frequency-selective devices (coaxial baluns, matching stubs, etc.) anywhere in the line. Impedance variations and discontinuities should now be visible on the top of the pulse; **figs. 7, 8,**

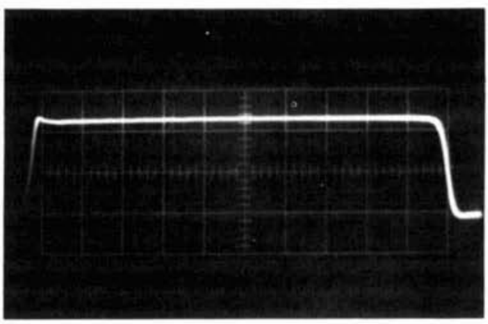


fig. 6. Same pulse as in fig. 5 but with sweep time decreased so top of one pulse fills scope face.

9 and 10 show examples of what to look for.

The scope display in **fig. 7** shows the effect of increasing the impedance of the line. This trace shows a length of 50-ohm line (RG-8/U) connected to a length of 93-ohm line (RG-62/U) followed by a 100-ohm termination. The step in the trace occurs at the connection point between the 50- and 93-ohm lines. The termination is at approximately the center of the screen; the right half of the trace contains no information.

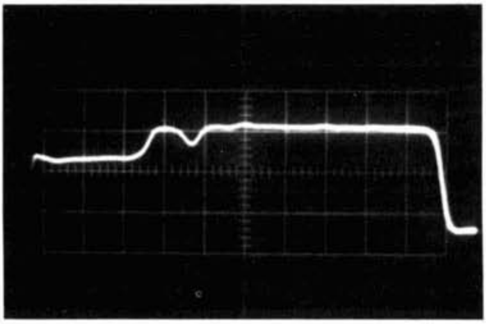


fig. 9. Transmission-line display. From left to right: 68-feet 50-ohm RG-8/U, 25-feet 93-ohm RG-62/U, 5-feet 50-ohm RG-58/U, 100-ohm termination. Because of scope's bandwidth limitation, the 5-foot section of 50-ohm line did not get down completely to the 50-ohm level.

In **fig. 8** you can see another example of impedance increase. In this case three sections of coaxial line were connected together: a 50-ohm section followed by a 93-ohm section followed by another 50-ohm section and a 51-ohm resistor termination. The bump in the trace corresponds to the short section of 93-ohm line.

Fig. 9 shows a 50-ohm line connected to a 93-ohm line, followed by a short 5-foot section of 50-ohm line and a 100-ohm termination. The first step in the trace is the input to the 93-ohm coax. The dip to the right of the step indicates the location of the short section of 50-ohm line. Because of bandwidth limitations imposed by the oscilloscope, the pulse reflection from the 5-foot section of 50-ohm line did get down completely to the 50-ohm level.

In **fig. 10** you can see the effect of a discontinuity in the transmission line. In this case 130-feet of 50-ohm coax was terminated with a 50-ohm dummy load. The discontinuity, a 24-pF capacitor shunted across the line, is indicated by the bump in the trace. The capacitor is 70-feet from the input. In this display the vertical gain of the scope was increased to make it easier to see the discontinuity. Note that overshoot at the beginning of the trace is now objectionable.

limitations

Since the output pulse has frequency components to 30 MHz or beyond, but no higher than 100 MHz, this low-cost system cannot be used for waveguide, Goubau-line or other transmission lines that have a low-frequency cutoff point. Although the system described here is designed for coaxial transmission lines there is no reason why a similar system with balanced output could not be designed for open wire line and twisted pair. This system provides tangible answers to questions that have previously been guessed at, and provides visible goals in otherwise hit-or-miss situations.

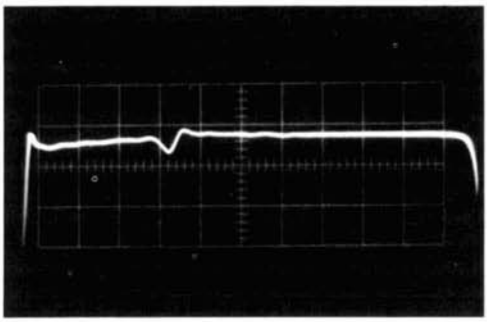


fig. 10. 130-feet of 50-ohm transmission line with 50-ohm termination. Discontinuity (24 pF shunted across line) at end of 70 feet. Vertical gain was increased to make the discontinuity more visible; note that overshoot is now objectionable.

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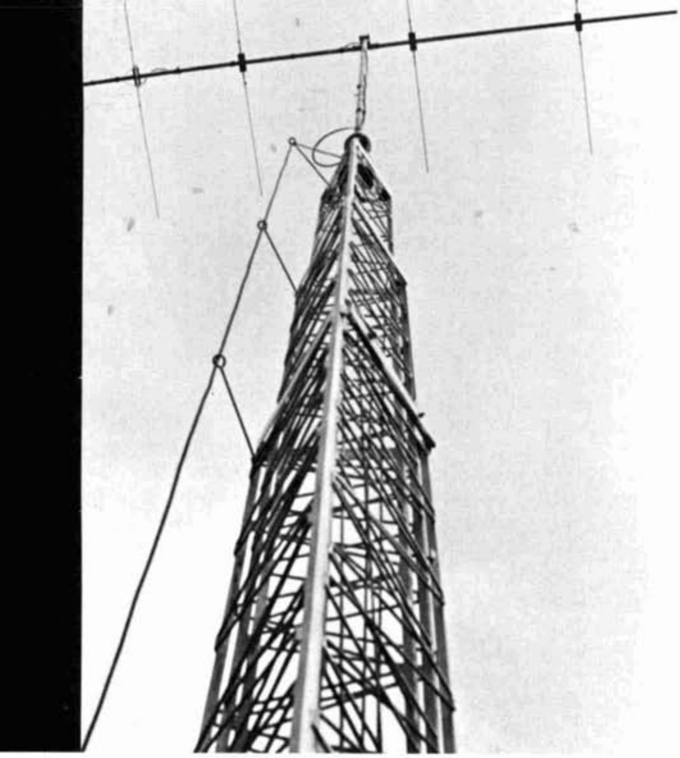


homemade tilt-over antenna tower

Construction details for a triangular, 70-foot tower you can build for a fraction of the cost of a ready-made structure

Gene Nelson, WA3EWH, Belle Vernon, Pennsylvania

Many hams would like to have a good tilt-over antenna tower for as little money as possible. This was my wish also, but I didn't do anything about it until a good friend, WA3AHM, started needling me about building one. This article describes the result of my answer to this challenge – a 70-foot tilt-over tower for only $44.62 in material costs. I used material purchased from local junk dealers for all structural members except the 3/8-inch round-rod diagonal trusses (**fig. 1**), which were donated by friends. If purchased, the 3/8-inch round rod would come to about $15.00 extra – still a pretty good bargain when you consider the cost of a commercially built tower of this type. Accessories such as gears, lift motor, cables, and tilt-over winch are additional expense items, of course.

construction

This article is presented with the assumption that you've had some welding experience. If you haven't and wish to build the tower, you can have the entire assembly welded professionally and still come out ahead of the current market price for a tower of this size.*

I've included some hints based on my experience that should help if you've never undertaken a project such as this. The main point to bear in mind is that the verticality of the finished structure will depend on how accurately you measure the templates and the care with which the parts are positioned during welding. A small shift in alignment during assembly will be magnified many times in the completed tower.

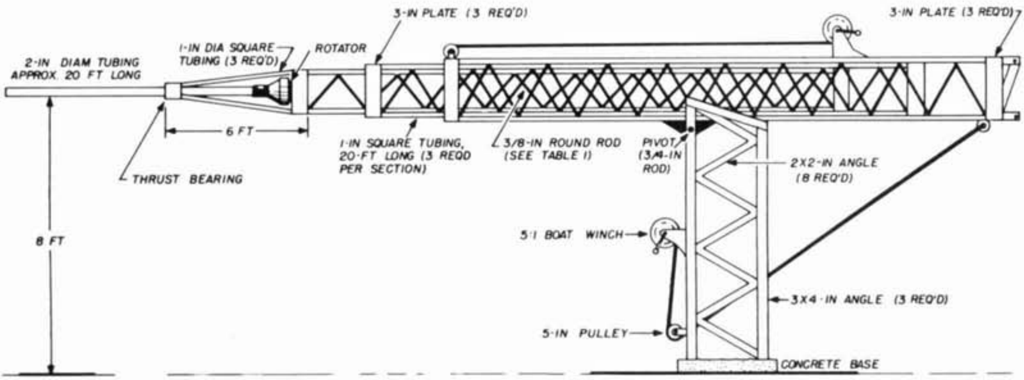


fig. 1. The 70-foot tower in the tilt-over configuration. The tubing extension at top is adequate for a 6-meter yagi antenna; other antennas will require extensions using different tubing sizes and lengths.

Clean lines and true verticality result from careful jig measurement and prealignment before welding and placement in concrete base.

templates

My reply to WA3AHM's challenge about building a triangular tower was, "You can't keep the triangular elements

table 1. List of materials for the homebrew tilt-over tower. All material is soft iron.

quantity	description	size
1	round	3/4" x 25"
2	angle	3" x 4" x 8' 6"
1	angle	3" x 4" x 6' 8"
8	angle	2" x 2" x 27"
66	round	3/8" x 23"
66	round	3/8" x 22"
66	round	3/8" x 21"
10	square tube	1" x 20'
18	plate	1/16" or 1/8" thick x 3" wide; approx. 19" long

*An estimate for the complete welding job, based on precut and accurately dimensioned parts, is about $50.00 for labor and welding materials. With some energetic bargaining, this cost could be reduced. **editor.**

aligned during construction." Then I came up with the idea of making three jigs, or templates, from one 4 x 8 sheet of 5/8-inch-thick plywood. The detail of the jigs is shown in **fig. 2.**

After laying out one piece of wood in the hexagonal shape shown, I made two more and nailed all three pieces together. Three circles were inscribed on the top piece, then each circle was divided into six equal parts using a large pair of dividers.

Next, one-inch squares were laid off at each corner of the three triangles. These were drilled with a ¾-inch bit and shaped into square holes with a saber saw. (These holes will accept the main longitudinal members, which are 1-inch-square lengths of tubing. See **table 1** and **fig. 1.**) The 1-inch-square holes should allow the tubing to slide through the wood easily, but with a slight amount of drag. It might be necessary to stagger the holes slightly in the center piece to provide solid support for the tubing in the jigs.

setup

The jigs were separated and numbered 1, 2, 3 in relation to the way they had been nailed together. The 1-inch tubing was then placed through the holes in jig 2 and allowed to extend about six feet beyond the end of the jig. Jig 1 was placed just over the end of the six-foot protrusion of the tubing, and jig 3 was placed over the far end of the tubing. It is important that the number of all jigs face in the same direction. Otherwise accumulative alignment errors will creep in, which will affect the verticality of the final structure. (You don't want the neighbors to think you're a CBer!)

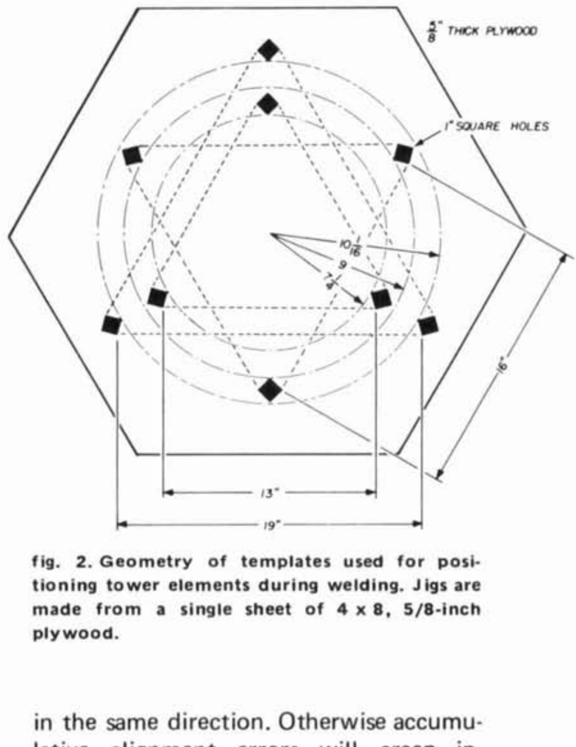
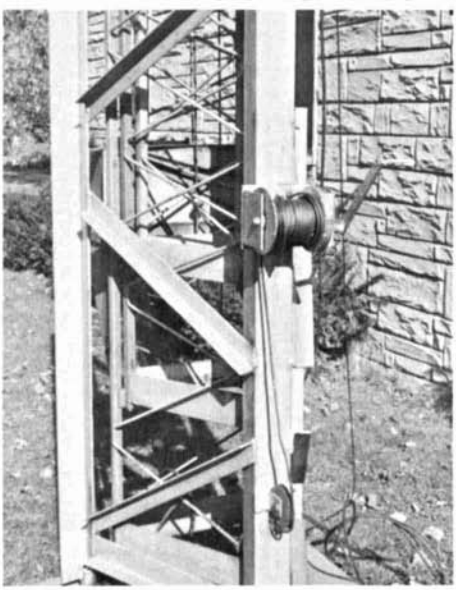


fig. 2. Geometry of templates used for positioning tower elements during welding. Jigs are made from a single sheet of 4 x 8, 5/8-inch plywood.

Details of the tilt-over stub and boat-winch.

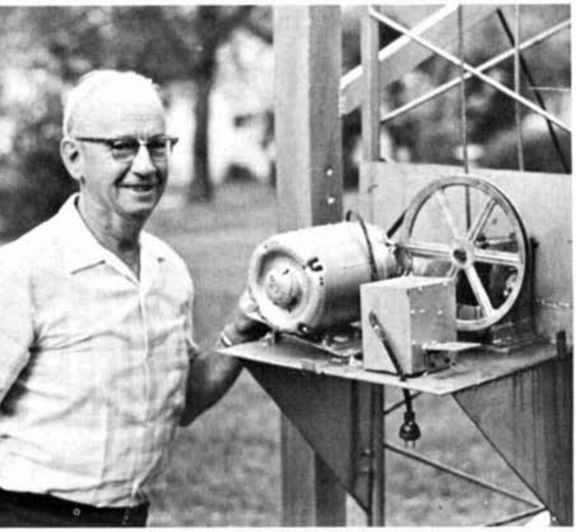


Choose a level spot on which to set the jigs and tubing. You'll need some wooden wedges to level the jigs. Place a string over the tops of jigs 1 and 3, and adjust jig 2 for level if necessary. Then run the string along the corner of the jigs to make sure there is no side twist in the assembly.

welding

The 3-inch plates were welded around the triangle at jig 1 first. Then the 3/8-inch round rods were placed zigzag fashion up the side of the triangle and tack welded. This procedure was repeated on all three sides of the tower section, up to movable jig 2.

A problem in welding a structure of this type is positioning the diagonal truss members and keeping them in place while welding. I used a magnet salvaged from the yoke of an old TV set to hold the pieces in place during the tack welding.



Electromechanical elements for raising and lowering the tower. A 1/3-HP motor and 40:1 gear train are used.

Each diagonal truss was bent slightly (approximately ½-inch radius) before welding. This enhances the appearance of the structure.

The next step, after tack welding the diagonal members, was to move jig 2 approximately six feet and recheck for level and twist. The tack welding was continued until jig 2 was against jig 3. Then jig 3 was removed, and jig 2 was left in place. The 3-inch plate was welded around this end of the triangle. Next, both jigs were removed, and the 3/8-inch round rods were welded permanently. This completed one section of the tower; the other two sections were constructed similarly. Three-inch-long pieces of ¾-inch angle were then welded at the corners of the sections to act as guides when the sections are raised and lowered.

tilt-over stub

This part of the assembly was built from 3 x 4-inch angles (longitudinal pieces) and 2 x 2-inch angle trusses. The tilt-over stub is triangular and mounted in a concrete base. Use extra care here to obtain an absolutely vertical structure. Make several measurements, then recheck each before the concrete is poured. This work is extremely important if the tower is to be vertically true.

A length of ¾-inch round rod completes the assembly as a pivot piece for the tilt-over stub.

accessories

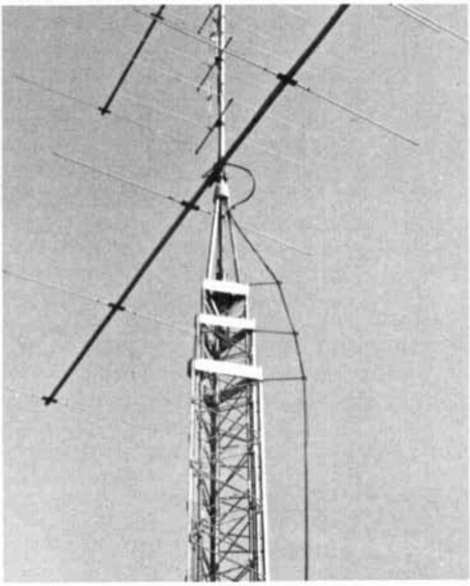
The lifting and lowering mechanism consists of a 1/3-HP electric motor and a 40:1 worm-and-gear arrangement. The tower is tilted by a 5:1-ratio boat winch and pulley assembly. The cables for the entire tower are 1/4-inch galvanized stock.

acknowledgment

Several amateurs in this area have used these jigs to build similar towers. I'd like to thank all who have contributed information for this article.

ham radio

Top of tower construction.



the double
bi-square array

The ressurection of an old classic that provides high performance on the high-frequency bands

Bernie Ontiveros, W6FFF, 118 South Alisos Street, Santa Barbara, California 93103

The bi-square antenna was originally described in the April, 1938 issue of *RADIO* magazine by Woody Smith, then W6BCX and editor of the magazine. I was working for the magazine at the time and thought I would build one some day. Now I have, more than 31 years later!

The original configuration with one point downward is necessary for the single pole mounting, but the same antenna is shown in W6SAI's "Quad Handbook," with one side parallel to the earth as used in the conventional quad arrangement. This is called the XQ antenna, meaning Expanded Quad.

The bi-square array, a derivation of the Lazy-H, has a broadside gain of about 5 dB with a bi-directional pattern. It is twice the size of the conventional quad element, as each side is a half-wave long. This means that it is hardly practical to rotate except on 10 meters. On that band some have been built with a reflector or director with a resultant unidirectional pattern and gain of around 9 dB. KV4AD has had a big signal on 10 meters with a variation of this rotatable arrangement.

A 10- and 15-meter pair of bi-square arrays may be mounted concentrically; with another similar pair mounted at right angles. Instant switching of direction and frequency may be accomplished at the operating position as shown in **fig. 2.**

construction

The dimensions of the bi-square array are not too critical as the simple matching method shown here resonates the antenna sufficiently when tuned for minimum swr. Each side of the 10-meter array is about 16½ feet long, and each side of the 15-meter array is about 22½ feet long. The open-ended stubs are 8½ feet long for 10 and 11½ feet long for 15.

This is not a high-powered antenna as shown here. The plastic insulators are unavoidably at points of high rf voltage and RG-58/U coaxial feed line is used for convenience. This is satisfactory in my case since the longest feed line is less than 20 feet, and the maximum power is that attained by a 500-watt PEP (input) transceiver. High powered operation will call for better insulation and RG-8/U feedline.

The whole system is hung on a lightweight wood pole consisting of a pair of 12-foot 2X4s spaced with blocks of 2X4 as a fixed base unit. A 2X3 is butt-spliced to a 2X2 top section. The bottom of the 2X3 is inserted between the 2X4s and fastened with two bolts. With one bolt in to act as a hinge, the whole upper part is pushed up, and the second bolt put in to secure the mounting.

Four nylon lines, about 2/3 up the pole will suffice for guys during installation. After the arrays are in place they will serve as the final guying.

It is a good idea to make a scale drawing of the antenna to locate the placement of pulleys for symmetrical rigging. Those for the 15-meter antennas at the top should be offset a few inches vertically and on adjacent sides of the pole to avoid entanglement. The same applies to the pulleys for the 10-meter antennas at the plotted distance down the pole.

The pulleys are small aluminum types with nylon rollers, with eyebolts you put on and enough bolt length to go through the pole. The nylon line is a utility type that comes in 100-foot hanks and has a diameter of slightly less than 3/16 inch.

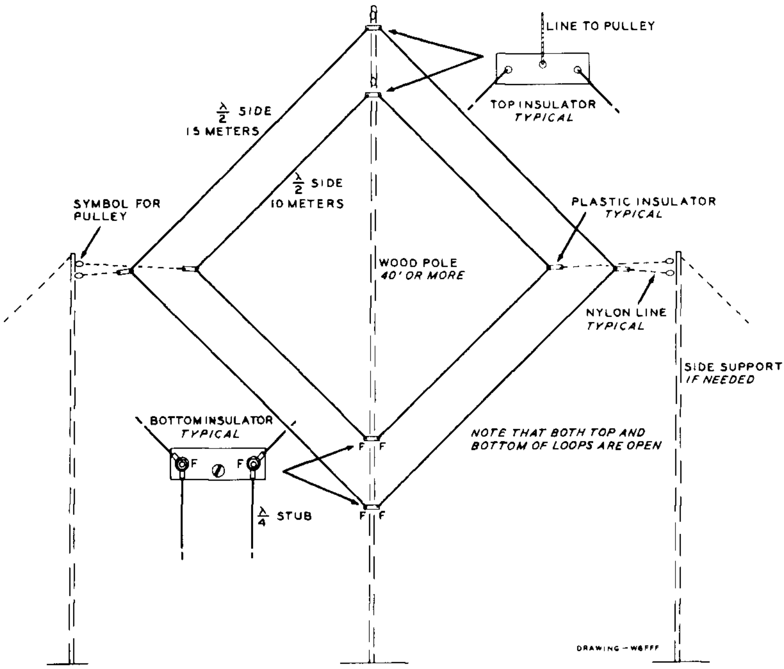


fig. 1. Bi-square array for 10 and 15 meters for one bi-direction. For doubled directional coverage a similar array is hung on the same pole at right angles.

The top 15-meter antenna goes up first, the sides are pulled out, the bottom placed, and the whole thing pulled snug. The others follow in the logical order.

(The drawings in the antenna books always show perfect squares with side guys going out to an invisible fence or ground stake. However, with my 50 foot wide lot the best I could achieve with fences was a skinny diamond. Some 20-foot sections of tv mast squared up the arrays.)

Now the stubs may be installed, straight out and tight, trying to keep the 4 stubs as close to 90 degrees from each other as possible. Install the coaxial feedlines and tune up.

tuning

Tuning up is simplicity itself. Slide the coaxial line connector to the point of minimum swr near the center of the band and that's it. This will hold pretty well over the whole band with acceptable swr since this is a fairly low-Q antenna.

Further sophistication may appeal to some, such as resonating the whole antenna with a shorting bar and then finding the spot for attachment of the feedline, perhaps with some type of balun. After several months use I put simple bazooka quarter-wave sleeves on two of the antennas, but as no difference was noted, good or bad, I just left them on.

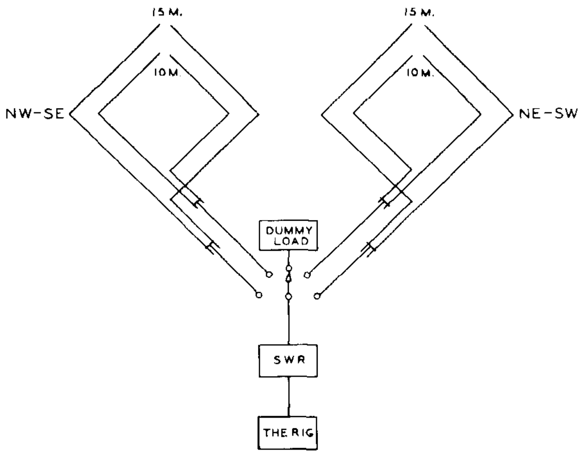


fig. 2. The full array. This is four separate antennas; any single one may be used since there is no dependence on any of the others.

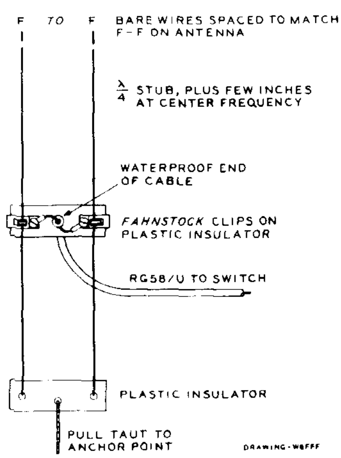


fig. 3. The movable feed point. After positioning the clips may be soldered to the wire and the whole thing covered with a waterproof cover.

performance

After a year's use a pretty good evaluation of the antenna is possible. The instant switching of directions is interesting as it often shows a 5 or 6 S-unit difference between the antennas, both locally and distant. The 10-meter antennas show more discrimination than the 15, probably due to better electrical spacing above ground. The exact center between beam paths doesn't seem too lively, but that may be due to areas of lesser ham activity, as I have received some good reports along those paths from Antarctica, South Africa and VK9.

My particular setup of SW-NE, through New Zealand and Spain, and NW-SE, through Japan and Argentina, seems to favor those areas.

A good long-term check on this antenna has been possible through almost daily contacts over the past year with ZL3LE on 10 meters, and with ZL3KA on 15 meters through all sorts of conditions. Both Bill and Jack agree that I am competitive with any of the W6s except for certain well known big antenna operators, and they of course are also running 2 kW PEP which helps a bit.

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for the experimenter!

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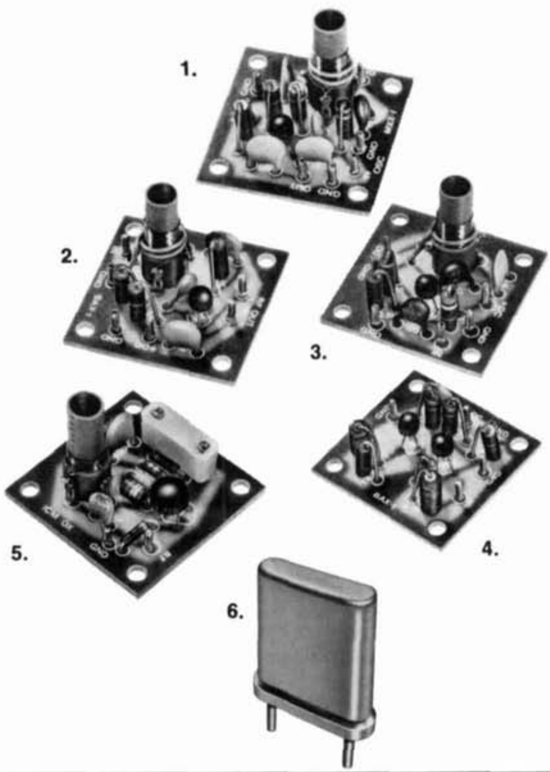

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uhf transmission lines

For maximum performance on 432 MHz and above you must select low-loss transmission lines — here are some of the types most suitable

Dolph Vilardi, WA2VTR, 14 Oakwood Terrace, Spring Valley, New York 10977

Most discussions of transmission line for amateur radio seem to describe the various types available, leaving the ultimate choice to individual decision. While this may be a satisfactory approach for the high-frequency bands, and possibly vhf, at uhf (432 MHz and above) the choice is narrowed down to a very few types. Nominal losses inherent in the chosen transmission line plus impedance mismatch bring total losses to a point which is completely unacceptable.

Assuming a reasonably good test setup, let's consider the example of a 1296-MHz antenna with an unknown mismatch (ordinarily considered acceptable at high frequencies). The antenna is fed with 80 feet of *good quality* RG-8/U line. When 60 watts are fed into the line at the transmitter, a reflected power of 1 watt is indicated at the transmitter (which would appear to be a fairly acceptable vswr).

Now let's see what we actually have. Eighty feet of RG-8/U has 8-dB line loss at 1296 MHz. With this loss 9.6 watts of power arrives at the antenna. Remember that we *measured* 1 watt reflected. This means that the actual power reflected from the antenna was 6 watts. Therefore, the actual power radiated by the antenna is the difference between the power that arrived and the power that is reflected. Since 9.6 watts arrived, with 6 watts reflected, the effective radiated power is 3.6 watts. Clearly this is unacceptable.

The solution to this problem lies in as nearly perfect matching of the transmission line to the antenna as possible and the use of low loss line.

Table 1 shows some of the lines that may be used at uhf. If in the previous example we had matched the transmission line to the antenna, used a line which had a nominal loss of 3 dB and measured one-half watt of reflected power we could have the following: 60 watts at the transmitter, 3-dB line loss (30 watts at the antenna) and ½ watt reflected power (1 watt is reflected back at the antenna).

Thirty watts minus 1 watt equals 29 watts effective radiated power, an eight-fold increase compared to the previous example. All with the same transmitter. The cost of the transmission line would be far less than the cost of quadrupling transmitter power. Moreover, the equivalent gain would be obtained at the receiver since an antenna system is reciprocal on receive and transmit.

From the standpoint of nominal loss the poorest line that should be used at these frequencies is equivalent to *good quality* RG-17/U. Remember that poorly made line may have impedance bumps due to variations in concentricity, dialectric quality and braid characteristics. Quality is important.

A solid center conductor is mandatory. Of course, coaxial fittings should be *those made for the line.*

Manufacturer's specifications regarding minimum bending radii should be carefully followed since distortion of the

table 1. Losses for coaxial transmission lines suitable for amateur use. RG-8/U is included to show how poor it is in comparison with other types.

type	O. D.	shield	jacket*	attenuation per 100 feet (dB) 432 MHz	1296 MHz	power loss (1296)
RG-8A/U	0.405	single (braid)	PVC-2	7	12	93.7%
RG-9/U (RG-214/U)	0.420	2 (braid)	PVC-2	7	12	93.7%
RG-14/U	0.545	2 (braid)	PVC-2	3.8	7	80%
RG-17A/U (RG-218/U)	0.870	1 (braid)	PVC-2	2.4	4.5	67%
RG-19/U	1.120	1 (braid)	PVC-2	1.8	3.6	55%
RG-231/U	0.500	alum tube	none	2.1	3.5	55%
RG-331/U	0.500	alum tube	PE	2.1	3.5	54%
RG-360/U	0.750	alum tube	PE	1.7	3.0	50%
RG-332/U	0.875	alum tube	none	1.4	2.5	42%
RG-333/U	0.875	alum tube	PE	1.4	2.5	42%

*PVC-2 indicates non-contaminating polyvinyl chloride; PVC-1, contaminating polyvinyl chloride is found on regular RG-8/U and should not be used. PE is polyethylene.

transmission line can cause serious impedance disturbances at 1296 MHz. Specifications should also be adhered to regarding burial of lines. It should be realized that plastic is permeable to water vapor at varying rates; pinholes in the plastic covering are nearly unavoidable in manufacture.

Some of the gas-filled lines have excellent nominal loss characteristics but unless some means of pressurizing is available stay away from them since moisture inevitably gets in and destroys the low-loss characteristics. Unless pressurization is available stick with foam-filled lines.

Twinlead is often recommended for uhf because of its *nominal* low-loss characteristics, but in actual use it is quite undesirable since it requires great care in dressing, insulation from surrounding structures and the strict avoidance of sharp bends. In addition, line radiation is a problem, as is impedance matching. When it rains the line becomes practically useless. My advice is to forget it.

It should be mentioned that the short piece of flexible line around the rotator often represents a fairly large proportion of the total line loss in a good system. Use the best you can get such as double-braided RG-9/U or better yet, RG-14/U or Times FM8. Remember that 7 feet of RG-8/U around the rotator represents 0.7 dB or nearly 10% power loss.

Of course, waveguide has excellent characteristics at these frequencies and makes excellent low-loss line. However, the same problems of pressurization occur as in air-supported coax although not to as great an extent. Also, problems at corners and bends and transformations to coaxial cable (for use with a rotator) present certain design problems. High cost is another factor which rules it out.

In conclusion some mention should be made of the type of coaxial fittings you use. It goes without saying that they should be constant-impedance types. This automatically rules out the commonly used series-uhf fittings such as the PL-259. I strongly suggest that you standardize your uhf system to N-type fittings.

N-type fittings are constant-impedance types and have the added advantage of being fairly weatherproof. In addition, the N-type connector's low-cost availibility on the surplus market makes it even more attractive. It is made in a wide variety of fittings so it can be used with almost any transmission line which you choose. Its characteristics at 1296 MHz are excellent, and it can carry a great deal of rf power without breaking down.

It should be obvious from the above discussion and **table 1** that under all conditions the transmission line should be as short as possible.

ham radio

low-cost compact antennas for 20 meters

A selection of simple antennas based on plastic-pipe booms and element supports for the antenna experimenter

John McFarland, W4ROS, 12 Sandra Drive, Port Richey, Florida 33568

All compact antennas are compromises, whether they are dipoles, verticals or beams. For low swr they must be operated over rather narrow frequency ranges, and efficiency is not as great as with a full-sized antenna. However, by using elements at least 1/8-wave long, inefficiencies may be kept to a minimum.

In the *tripole* antenna I have tried to overcome some of the disadvantages of miniature antennas by adding a third element as shown in **fig. 1.** Although this antenna looks like a ground plane at first glance, it is not; it consists of an inverted-vee dipole with a vertical element connected to one side. Performance of this arrangement has been excellent, and I have received good signal reports on both 20 and 40 meters.

The vertical support may be made from varnished bamboo or ½-inch plastic pipe. If you use plastic pipe, use plastic fittings to couple the sections of pipe together. The vertical element for the 40-meter version (originally described in *Florida Skip*) is shown in **fig. 1.** The vertical element for the 20-meter tripole consists of a 16-foot, 6-inch section of number-14 wire taped to a 17-foot bamboo (or plastic) pole; the inverted-vee elements of the 20-meter version are 16½-feet long.

The vertical element and one of the inverted-vee elements are connected to the center of the coaxial feedline; the other inverted-vee element is connected to the outer braid of the coax. To tune the antenna, use a grid-dip meter to indicate resonance. In the 40-meter tripole the windings of loading inductance L2 are expanded to increase frequency, and compressed to lower resonant frequency.

tripole beam

Two compact tripole antennas may be combined into a beam as shown in **fig. 2.** Although this particular antenna was designed for 20 meters, similar designs could be used on the other bands. The compactness is particularly useful for space-cramped amateurs who want to operate on 160, 80 and 40 meters.

In the 20-meter tripole beam, the boom is a 1-inch square aluminum pipe, 101-inches long. Each of the tripole elements are 8-feet, 8-inches long. Construction is shown in **fig. 2.** Each of the elements is center loaded with coils wound on a 5-inch section of plastic PVC pipe 3/4-inch in diameter; fill the form with 4 turns number-18 plastic-insulated wire, spaced 1/16-inch. The two 48-inch aluminum tubing elements are held together with 12-inch lengths of ½-inch PVC pipe.

Each aluminum element is pushed 2 inches over the end of the center insulator, leaving 46 inches of active element. The plastic coil form slides over the 1-inch center insulator and is connected to the aluminum elements with short pigtails. (Note that all coils are wound in the same direction.) This movable coil form is used to tune the antenna to resonance by moving it to a different position on the center insulator.

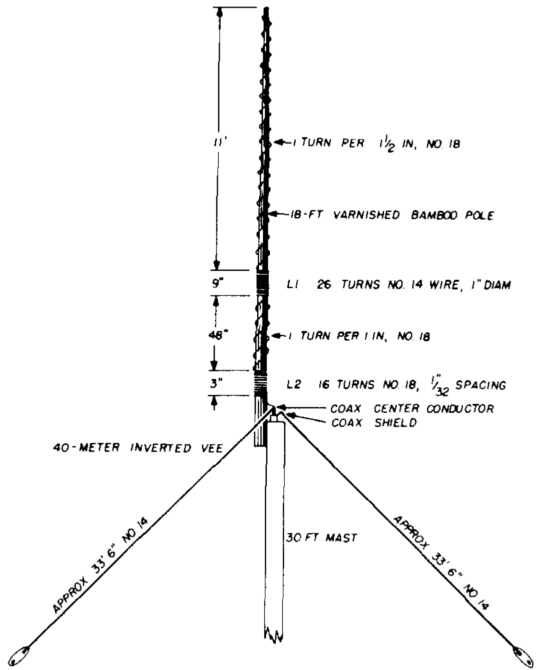


fig. 1. Tripole antenna for 40 meters. Grid-dip the vertical element to 7250 kHz. Adjust resonance with L2.

Once each element has been resonated, the movable coil form is cemented to the center insulator. This is a rather high-Q antenna so one frequency setting will permit operation over 100 kHz of the 20-meter band for swr less than 1.5:1.

Each of the six tripole elements is held to the boom with plastic tee fittings, available at your local hardware store. When all the elements are in place on the boom, connect the base of the reflector elements together with a 4-turn coil of number-14 wire, 1½-inch in diameter, 2-inches long. The radiator is fed with a ¼-wave matching transformer made from two sections of RG-58/U; the 50-ohm coaxial line from your transmitter is connected to the bottom of the matching transformer as shown in **fig. 2.** One center conductor of the matching section is connected to one of the horizontal elements; the other center conductor is attached to the vertical element and the remaining horizontal element.

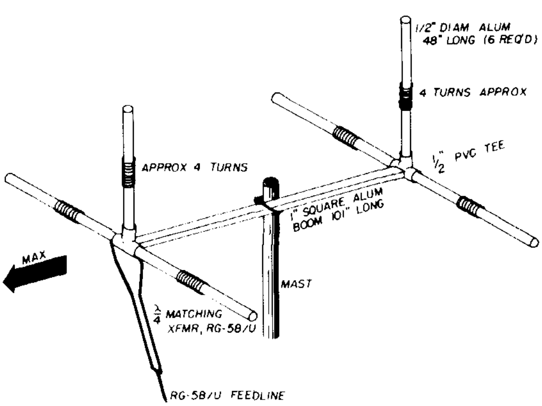


fig. 2. Tripole beam uses plastic-pipe and aluminum elements. All plastic elements shown in fig. 3 can also be used.

plastic-pipe tripole beam

The basic tripole system shown in **fig. 2** is easily, and less expensively, made with PVC-pipe supports and wire elements. For this simplified construction, use an long, may also be used for the boom. Each of the tripole elements is mounted on a plastic tee-fitting which is mounted to the boom. The three elements of the reflector are connected together with a

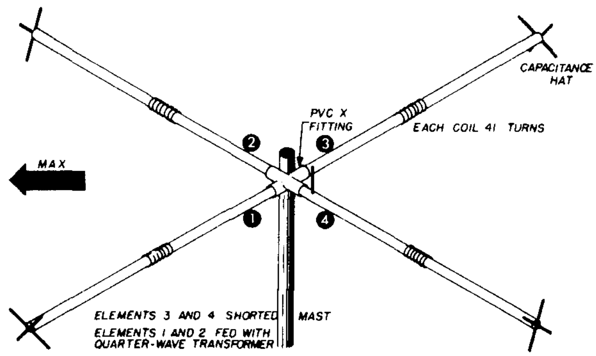


fig. 4. X-bar antenna uses four elements of the type shown in fig. 3. This antenna may be used horizontally, as here, or vertically.

8-foot, 8-inch length of plastic pipe for each element. The loading coil is wound on the outside of the tubing, and after tuning, is cemented in place. Drill a small hole in the pipe on each side of the coil, and connect the coil to 4-foot sections of wire inside the pipe as shown in **fig. 3.** Plug the ends of the pipe with wooden dowels to keep moisture out.

Each of the loading coils consists of 30 turns number-18 plastic-insulated wire on a 1-inch diameter form with a winding

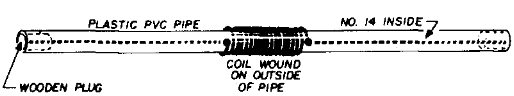


fig. 3. Plastic-pipe element consists of center loading coil and wire elements inside the pipe.

length of 7 inches. This coil, with a capacitance hat made from two 12-inch lengths of number-14 wire, provides resonance on 20 meters. Tuning range of this all-plastic antenna is on the same order as the more conventional design shown in **fig. 2.**

A section of plastic pipe, 101-inches

coil and tuned 5% lower than the radiator. The radiator is fed in the same way as shown in **fig. 2.** The tripole elements may also be mounted to the boom with plastic X fittings so the elements are symmetrically spaced 270° apart.

x-bar beam

The X-bar beam antenna is an extension of the tripole beam that uses four compact elements instead of three. Element construction is the same as that shown in **fig. 3.** The radiator and reflector each consist of four elements, attached to the 101-inch plastic boom with plastic cross fittings. The X-bar antenna is fed with a matching section as shown in **fig. 2.** Performance is slightly improved over the three-element version.

x-bar compact antenna

The X-bar compact antenna shown in **fig. 4** was developed as a result of experience with the X-bar beam. This antenna consists of four PVC pipe elements, and may be used either horizontally or vertically. I mounted one version of this antenna on a short tilt-over mast extension which could be lowered for vertical polarization, and put up (like an umbrella) for horizontal operation. Under some skip conditions I found that switching from vertical to horizontal increased signal strength. However, the swr

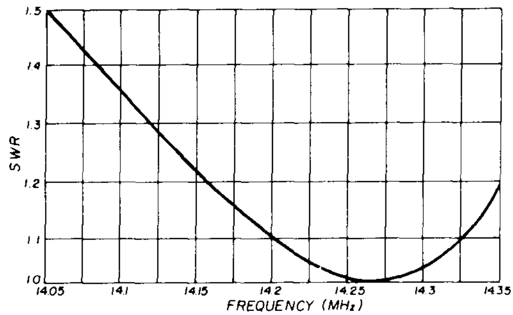


fig. 5. Swr performance of an X-bar antenna using plastic and aluminum elements.

changes from horizontal to vertical, with a slightly higher resonant frequency in the vertical position.

Each of the elements in the X-bar antenna is the same as those shown in **fig. 3.** For vertical operation the coils should be 30 turns; for horizontal operation, the coils should be 26 turns, number-18 plastic-insulated wire. With a horizontal mounting the quarter-wave matching transformer was made with 75-ohm RG-59/U; swr was nearly flat for 50-kHz each side of resonance, with an swr of 1.3:1 for a total frequency range of 150 kHz.

The X-bar antenna can also be built with the plastic and aluminum elements shown in **fig. 2.** The swr performance of the aluminum X-bar antenna with capacitance hats is shown in **fig. 5.** These measurements were made with the antenna 9-feet off the ground. For tuning it is much easier to prune the capacitance hats than to adjust the loading coils. The capacitance hats on elements 1 and 2 are 12-inches long; the element hats on elements 3 and 4 are 6-inches long.

For better swr performance two elements of the vertical X-bar antenna can be combined with full-size quarter-wave wire elements as shown in **fig. 6.** This antenna is much more directional than a dipole, and provides much broader frequency coverage. The swr is less than 1.5:1 for the entire 20-meter band. The matching transformer used with this antenna is the same as that shown in **fig. 1.**

antenna tinker kit

After building the various antennas described so far it occurred to me that these same elements could be combined in any number of ways to provide useful antennas. The elements can be built in several ways, including the aluminum and plastic-pipe version in **fig. 2** and the lower cost all-plastic-pipe version in **fig. 3.** There are several other ways of making elements, including wrapping the ends of the plastic pipe with aluminum foil and

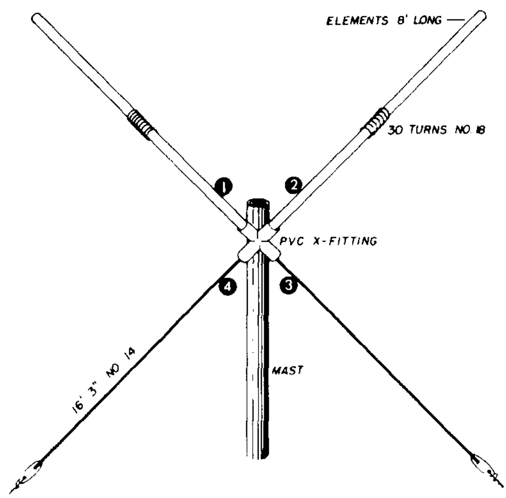


fig. 6. Improved performance is provided by two compact elements with two full-sized quarter-wave wire elements. Elements 1 and 2 connected to 1/4-wave transformer; elements 3 and 4 connected to shield.

doing away with the internal wire elements. To connect the loading coils to the aluminum foil, arrange the pigtails in the form of a sine wave and place them on top of the first layer of foil; put another layer of foil over the pigtails and tape it in place.

Another method of making elements is shown in **fig. 7.** In this element holes are drilled along the length of the plastic pipe and aluminum ground wire is woven in and out of the pipe as shown in the drawing. Each section of wire is 7-feet long. With this arrangement the loading coil is smaller; about ten turns around the ½-inch pipe is about right for 20 meters.

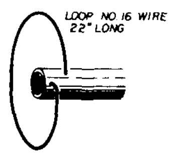
Although these elements are shown without capacitance hats, hats can be used. I have used the wire hats shown in

fig. 7. Another method of making low-cost antenna elements.

fig. 2. as well as the loops shown in **fig. 8.** The loops in **fig. 8** are made from a 22-inch piece of number 16 wire. The antenna element is tuned by changing the length of the loop. With the capacitance loop, the center loading coil consists of 42 turns number-18 plastic-insulated wire for resonance on 20 meters.

These compact elements may be arranged in many different configurations, including horizontal and vertical dipoles, inverted vees, upside-down inverted vees, X-bars, X-bar beams, tripole beams, conventional beams, ground planes, and various phased arrangements. Because of their low cost and ease of construction, this type of element is ideal for the

fig. 8. Capacitance hat made with a loop of wire. Resonance is adjusted by changing the length of the loop.



antenna experimenter who wants to try different types of antennas.

tuning

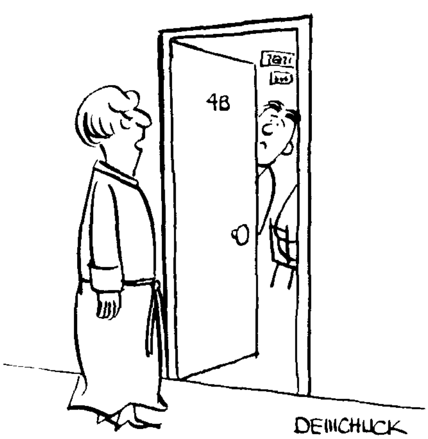
To tune each of the compact elements you need a grid-dip meter and a full-sized half-wave dipole about 5-feet off the ground. First, grid-dip and dipole and adjust it for the frequency at which you want to operate. Mark the point on the grid-dipper dial. For best accuracy use a communications receiver to check the calibration of the grid-dip meter. Use a 2-turn link to couple the grid-dip meter to the dipole.

Now connect the compact element to one side of the dipole and prune the capacitance hat (or adjust the loading coil) until the system resonates at the same frequency as the dipole did by itself. Resonate the rest of the elements one at a time with the same system.

To tune the coils you can temporarily connect a 50-pF trimmer capacitor across the loading coil of an element that has been previously resonated with the wire dipole. Without disturbing the trimmer or the grid-dip meter, connect the trimmer across the loading coils of the other elements and adjust the coils for the same resonant point on the grid dipper. This way you know the coils in all the elements have the same inductance.

For best results use white PVC pipe instead of black. The white reflects the rays of the sun and holds up much better in the weather.

ham radio



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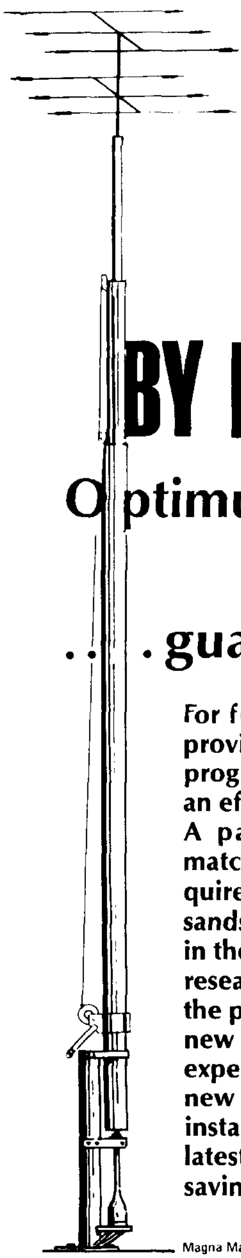

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More Details? CHECK—OFF Page 94

type-F coaxial-cable fittings

The case for 75-ohm transmission line in amateur applications

Serge Ticknor, K2MDO

The type-F coaxial connector has been the standard fitting of the Community Antenna Television (CATV) industry for several years. Exactly why hams haven't adopted these low-cost, high-performance coax fittings is not clear. I personally believe it's because of a general lack of awareness of their adaptability to amateur use.

The F fittings are available for 75-ohm cable only. In many cases, 75-ohm cable is preferable to 50-ohm cable for at least three reasons:

1. The impedance is more adaptable to the popular ham antennas (an exact 4:1 impedance ratio for 300-ohm folded dipoles using a balun feed, or 1:1 for a center-fed dipole or coaxial vertical).

2. Less attenuation is offered by 75-ohm cable than in an equivalent size and length of 50-ohm cable (an important consideration at the higher amateur frequencies).

3. 75-ohm cable is widely used in CATV and many home TV installations, making it economical and readily available.

advantages of F fittings

Advantages of F fittings are derived from their very reason for being developed. Cable television required a fitting with good rf characteristics throughout the uhf range, ease of installation, and economy. Before the development of the F fitting, connectors in general use were the automobile type, uhf, type N, and type BNC; each with its limitations.

The auto-type connector has obvious high-frequency and mechanical limitations. The uhf connector, still used by many hams, is rugged but bulky. Great care must be taken during assembly, particularly when soldering the coax braid to the connector shell. The frequency limitations of the uhf connector are well known despite its name. Many years ago, when it was first developed, the term "uhf" meant the region around 200 MHz.

Type-N and BNC connectors have fairly good high-frequency characteristics and are waterproof, but cost is high. These cable fittings consist of several intricate parts that must be carefully assembled to the cable. The parts include a center pin, shell, sealing washer, ferrule, braid compression ferrule, and clamp nut. Assembly or salvage of these fittings is difficult and must be done with great care.

Blonder-Tongue coax connectors BTU-590, BTF-590, BTU-591 and BTF 591 (from left to right).

the F connector

A typical type-F cable fitting, such as the F-59A, consists merely of a short mandrel permanently attached to a swivel nut, with an integral cable-clamping ferrule attached. The cable is stripped and pressed into the fitting, and the ferrule is compressed onto the cable. The center conductor becomes the center matching pin; and the connector, instead of the braid, becomes the outer conductor.

With this design there is negligible impedance discontinuity, even through 1000 MHz. This is because near-identical physical relationships exist between the cable outer braid and inner conductor, and a second dielectric hasn't been introduced to affect the impedance of the assembly. Internally, the connector is merely a physical continuation of the cable; so a near-perfect transition exists.

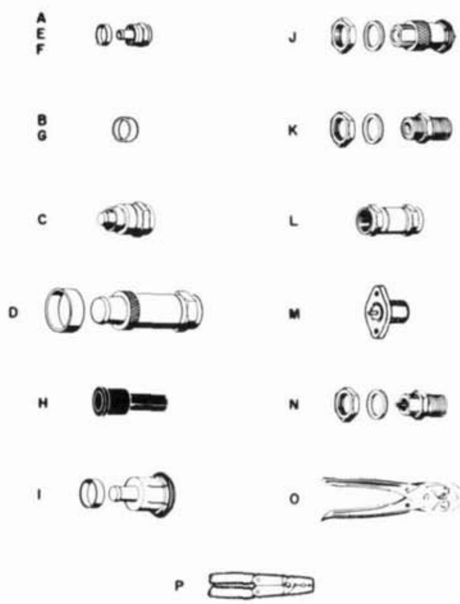

fig. 1. Available type-F connectors and accessories (items are identified in table 1).

A variety of fittings is available (**fig. 1** and **table 1**). Chassis jacks are also available, as are quick-disconnects and splices. All are available for RG-6/U, RG-11/U, and RG-59/U cable. In addition manufacturers supply switches, variable attenutable 1. Type-F fittings and accessories

sketch (fig. 1)	description	Jerrold	Blonder Tongue	Channel Master	Winegard	JFD
	Type-F Cable Fittings for RG-59/U					
A	Swivel type, male; uses center conductor of cable for center pin; mates with any F-type jack	F-59	BTF-591	—	F-59	C-7106
B	Cable crimping ferrule for above connectors	1051	HR-59	—	F-59	C-7113
C	Similar to A with built-on ferrule	F-59A	—	7194	—	—
D	Waterproof male connector	—	BTU-592	—	—	—
	Type-F Cable Fittings for RG-11/U					
E	Swivel type, male; uses center conductor of cable for center pin	—	BTF-110	—	F-11	C-7109
F	Swivel type, male; has its own center pin	AF-101	—	7196	—	—
G	Cable crimping ferrule for above connectors	1059	HR-11	—	F-11	C-7114
	Weather Boot					
H	Waterproof weather boot for all RG-59/U and RG-11/U fittings	WB-56	—	7197	—	—
	Type-F Push-on Quick Disconnect Cable Fittings					
I	Connector uses center conductor of cable for center pin; constructed for direct insertion of cable	—	BTF-59P	—	—	C-7116
J	Connector uses its own center pin; requires additional attachment to F-type fitting on cable	F-91	QDP	—	FP-59	—
	Adapters					
K	Double female coupling adapter; couples two male F-type connectors together	F-81A	GF-81	7195	F81-M	C-7108
L	Double male coupling adapter; couples two female F-type connectors together	F-71	AD-3	—	—	C-7110
	Chassis Panel Fittings					
M	Female chassis connector; has two rivet or screw holes for mounting	—	BTF-100	—	—	—
N	Female chassis connector; 3/8 in. dia. mounting hole with nut	F-61A	—	7193	—	C-7105
	Crimping Tools					
O	Heavy duty, continuous parallel jaw chuck for RG-59/U and RG-11/U	PL-602	—	7188	—	—
P	Economy type, scissors-jaw pliers	PL-659	CR-2	—	CR-1	—

ators, and other devices usable by hams — all adaptable to type-F fittings.

weatherproofing

A weatherproof connection is only required outdoors, so the extra cost of a weatherproof fitting such as the type-N isn't justified for indoor use. Some manufacturers supply a rubber or plastic boot for F fittings used outdoors; however, alternate weatherproofing methods can be used.

I've found that adequate weatherproofing is assured by tightly wrapping the connectors and an inch of the cable with electrician's tape. Only a quality brand of PVC plastic electrical tape should be used; inferior imported or off-brands must be avoided.

The tape must be applied to a clean, dry surface. The tape will not stick properly in cold weather. In cold weather a silicone-filled boot is the best answer.

power-handling capability

The type-F fitting was designed for CATV/MATV without transmitting in mind. The type-F fitting will not degrade the rf-power rating, since spacings and dielectrics are the same as the cable. With certain chassis and adapter fittings, the spacings and dielectrics may differ since they are not made with cable. A derating of 50% of the maximum power rating for the cable should be adequate if you don't like to experiment.

For ac/dc current ratings, manufacturers of CATV/MATV equipment don't generally allow a type-F fitting to handle much over 1½ amperes. The experimenter will find that he will have no problem running higher currents, sometimes as high as 6 amperes.

salvaging used fittings

Type-F connectors can be salvaged without damage. Simply cut away the old ferrule with diagonal pliers and reassemble using a new ferrule. If a new ferrule is unavailable, a suitable one can be made from a piece of copper tubing.

assembly tools

With a little care an F fitting can be assembled with a pair of household pliers. For a good crimp, a crimping tool is suggested. This tool crimps the ferrule neatly in two places with less danger of splitting the ferrule. Heavy-duty and light-duty types are available. The parallel jaw tool is also very handy for miscellaneous jobs around the shack; for example, as a hand-vise or for straightening parts. A crimping tool is worth the extra cost if much crimping is done.

conclusion

It is my observation that many hams who are also involved in CATV/MATV work find many uses for type-F fittings. Most of my test equipment and ham gear has been converted to type-F fittings. Standardizing on this one fitting saves a lot of time and trouble hunting up various adapters and different cables.

acknowledgement

I would like to thank the following persons for their help in providing catalog information and technical assistance: George S. Bahue, Blonder-Tongue Inc.; Dick Mapes, Channel Master Corp.; Jim Emerson, Jerrold Electronics Corp.; Jerry Balash, JFD Electronics Corp.; W. E. St. Vrain, Mosley Electronics Inc.; and Hal Sorenson, Winegard Company.

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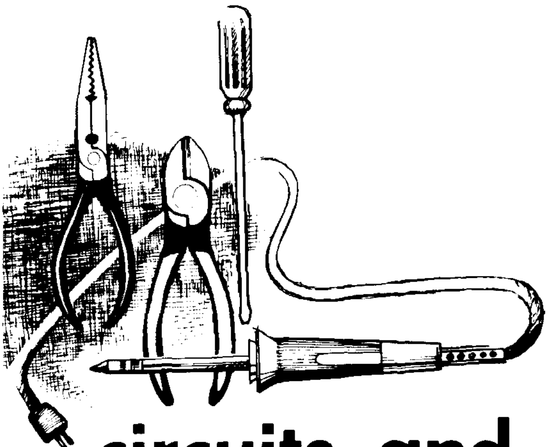

circuits and techniques

ed noll, W3FQJ

anti-QRM methods

Take note of your specific QRM problems today. Condemnations and groans are no help. Furthermore, QRM is likely to become more severe over the next several years. The short-skip, long-skip combination will prevail on 15 and 20 meters with long-skip signals diminishing and becoming more vulnerable to short-skip QRM. Twenty meters will fill to the brim as DX conditions fail on 10 and 15.

There will be a steady migration of DXers to the low-frequency bands. Ham population will increase, perhaps at a much faster rate outside of the United States. Night conditions on 40 and 80 will be as trying as ever; even 160 meters is bound to experience crowding. Is it a hopeless situation? It doesn't have to be!

In addition to those important essentials of gentlemanly operating practice and using no more power than necessary to maintain proper communications, each of us can take a number of steps to alleviate the severe QRM problem. Some are operational; others, technical.

operational considerations

There are a number of things we can do that will encourage all-band occupancy and the efficient and effective use of each band.

1. Use vhf for local rag-chewing and some of the more localized net activities.

2. Press for the legal restoration of the entire 160-meter band.

3. Do not give up so easily on the DX possibilities for 10 and 15 during minimum sunspot. Look for some new breakthroughs. Transequatorial (north-south) TE propagation[1] by way of chordal hops is a possibility for 6, 10 and 15 meters. Perhaps special emphasis should be given to 10 meters during the upcoming sunspot minimum. Massive cooperation among North, Central and South American hams could well uncover some unusual possibilities.

4. Continue with experimentation on unusual propagation paths on vhf/uhf, 10- and 15-meter bands. Are there any steps that can be taken through IARU that could implement satellite tests by radio hams worldwide?

5. In the USA we might set aside some spot frequencies to be retained by gentlemanly agreement for special technical activities. Such would be a boon to QRP experimentation, slow-scan television, low-frequency DX propagation tests and others.

The above activities and others as well would spread amateur activities more uniformly among the various bands and would make a major contribution toward QRM reduction on overcrowded frequencies.

There are technical steps that each of us can take to minimize or eliminate some of our own QRM problems.

1. Use a separate receiving antenna[2] or, perhaps a means of switching quickly among various antennas (including the transmit antenna) to find the one that will minimize a given QRM situation.

2. Use more directional antennas on 40, 80 and 160 meters. A directional receiving antenna is particularly helpful when QRM is bad.

3. The 10/15/20-meter directional beams as we know them today may not be the ultimate answer, especially as receiving antennas, in the medium and low sunspot years. The back pickup can be quite substantial and this is often in the short-skip direction when communicating with a long-skip station. The various phased arrays, although their forward gain may not be as high, can be designed with back direction nulls. A receiving antenna with an adjustable null point would aid in tuning out a specific piece of QRM.

4. There is a decade of amateur experimentation to be done on antennas with means of changing polarization and vertical angle to match propagation conditions of the moment.

5. Rotating loops function well on 20, 40, 80 and 160 meters for receiving. They may have some utility even on 15 and 10. A well-balanced shielded loop (circular or ferrite) has two deep nulls which can be used to tune out QRM. Sensitivity is often quite unimportant for routine operations on 40, 80 and 160.

6. Miniature receiving antennas such as the coil-loaded dipole or helix show great possibility for crowded strong-signal conditions.

7. The performance of loops and small antennas can be enhanced with the use of antenna-mounted preamplifiers, or preselectors positioned ahead of the receiver.

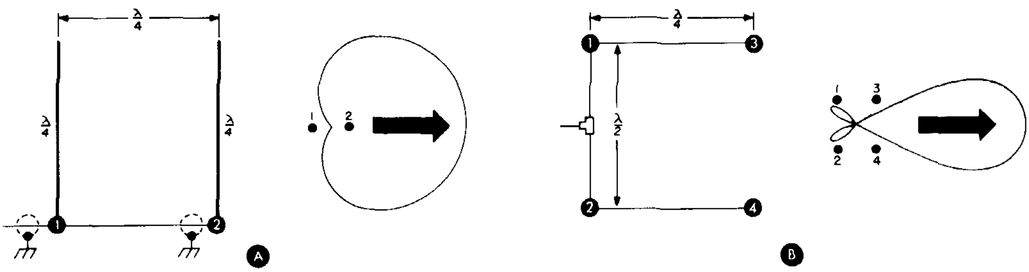

fig. 1. Layouts and patterns of phased quarter-wave verticals.

8. Tuners, input attenuators and couplers often improve receiving signal-to-noise and signal-to-interference ratios. If your receiver is prone to intermodulation distortion a well designed rf preamplifier and attenuator can cut back on splatter.

the transceive antenna

The antenna used for both transmit and receive modes is limited in its capabilities for establishing optimum receive conditions. Emphasis is on the most efficient transfer of power to the antenna and maximum radiation in a given direction. Some means for switching receiver input to one or more additional antennas even of a very simple type is a boon in reducing QRM. This applies in general to all bands, even in some cases for DX reception. It is a particularly useful capability for 40, 80 and 160 meters. In fact, on 80 and 160 the DX enthusiasts use separate transmit and receive antennas to reduce QRM successfully. Switching between horizontally and vertically polarized antennas is common practice on 160. Quite often on 80 meters high horizontal transmit antennas are used along with a vertical receiving antenna. In many installations of this type either antenna can also be used for transmit.

Also popular are two phased verticals.[3,4,5,6,7] Usually a pattern switching facility is included. Verticals as effective transmit and receive antennas have not been fully exploited on the 10-, 15- and 20-meter bands. A properly fed and matched array of verticals can result in a very pronounced drop in pickup and radiation from the back. The back sensitivity of an antenna and lost power that is radiated to the rear are two causes of long-skip, short-skip QRM.

Two quarter-wave verticals spaced 90° and fed 90°-related, result in the attractive cardioid pattern in **fig. 1A.** Two such 90° pairs spaced 180°, **fig. 1B,** sharpen the forward pattern.[3,4] A suitable switching arrangement permits easy pattern changing whenever you want to enhance performance in another direction. Three verticals of this type spaced a quarter wavelength in a triangle permit complete rotation of the directional pattern (**fig. 2**).

Of course, QRM can also arise from the same direction as the desired signal with a short-skip station playing havoc with a long-skip signal. The big question is how much can be done to minimize this problem with a controlled vertical-radiation pattern.

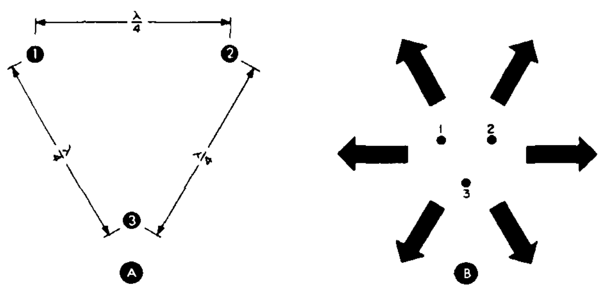

fig. 2. Three vertical antennas in a triangle (A), omnidirectional pattern (B).

separate receiving antenna

In an era of high sensitivity receivers the separate receiving antenna provides an effective weapon for combating QRM. Even a low horizontal dipole (**fig. 3**), rotated by a low-cost tv rotator, is surprisingly effective. You only have to aim the dipole elements in the direction of the interference to make use of its rather effective null. When receiving a reasonable signal, even a DX one, the antenna

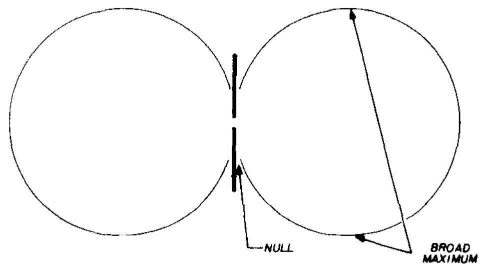

fig. 3. The dipole as a receiving antenna.

can be turned away from the desired bearing and still deliver a useful signal to the input of a sensitive receiver. If your receiver lacks sensitivity use a preselector ahead of its antenna input. It is common experience that an S3 to S4 signal in the clear is easier to read than an S7 to S9 signal clobbered by over-riding QRM. Full length dipoles can be used on 10, 15 or 20 meters; for three-band operation use a dipole with loading coils.

The quarter-wave vertical receiving antenna, loaded or full length, is popular on 40, 80 and 160 meters for DXing.

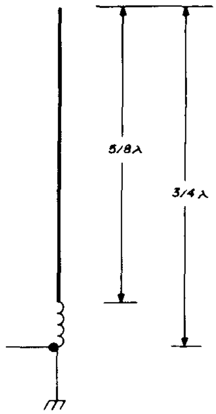

fig. 4. The 5/8-wave vertical antenna.

Such a vertical is less sensitive to high-angle signals with a consequent reduction in QRM. Two or three verticals provide directional horizontal patterns as well and a further reduction in QRM level.

Phased receiving verticals, ground mounted with suitable ground planes, do well as receiving antennas for 10, 15 and 20. Although a high beam may help you punch a stronger signal into a given

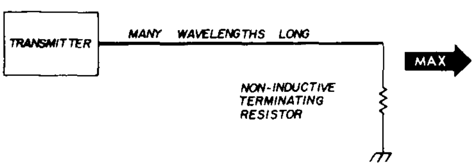

fig. 5. Beverage antenna.

corner of the world, the lower and limited-gain vertical array will often permit you to sort out the desired received signal from a maze of QRM.

The 5/8-wavelength vertical with its lower vertical angle has not been evaluated extensively in phased systems.[5] This may well be one of the finest receiving antenna systems available. A low impedance at the feed point is established with a loading coil that electrically tunes the vertical to 3/4 wavelength (**fig. 4**). A 5/8 wavelength vertical is approximately 20 feet long on 10, 30 feet on 15 and 40 feet on 20.

Long-wire antennas such as the Beverage[8,9] have demonstrated excellent possibilities for receiving from a single direction. W1BB and others have used them successfully in receiving 160-meter DX signals from Europe when other receiver arrangements were troubled with noise and QRM. The Beverage is a low long-wire antenna with its far end terminated in a non-inductive resistor. The antenna displays maximum receive sensitivity in this direction (**fig. 5**).

miniature receiving antennas

The short tuned antenna can be made to have rather deep nulls; at the same time the overall pattern is quite broad, either a figure-8 or cardioid. In heavy QRM the antenna can be rotated and the null positioned in the direction of the interference. In addition the mini antenna with its lower sensitivity cuts back on noise and intermodulation problems if they are a problem with your receiver.

A small loop antenna can be built for 40, 80 and 160 that gives you a good directional receiving pattern.[10,11,12] Loops can be used on 10, 15 and 20 meters as well. They are a particular help during strong short-skip conditions. In fact, the strong, short-skip conditions on 20 meters during the evening don't differ too greatly from those on 40. A receiving antenna of this type can be helpful for DXing when bands are cluttered with QRM. Although loops do not have the

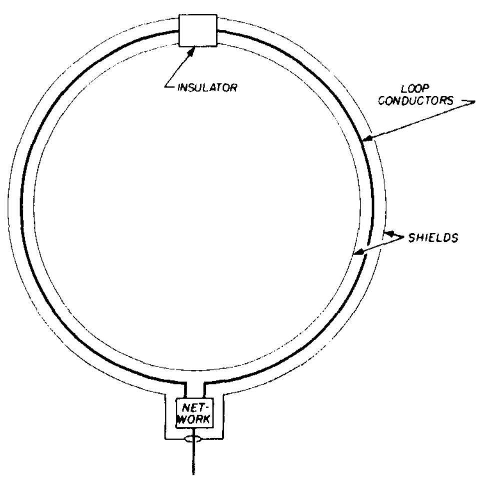

fig. 6. Basic loop antenna.

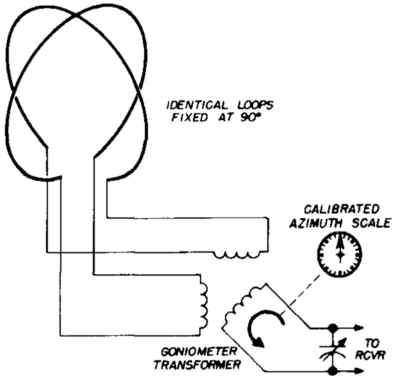

fig. 7. Bellini-Tosi fixed-loop goniometer.

sensitivity of your big antenna their deep nulls can often help you tune out QRM. The loop antenna and its transmission line should be kept well isolated from other antennas and lines to obtain a deep pattern null.

There are three basic types of miniature antennas: loop, ferrite core and helical dipole. Robert L. Nelson, K6ZGQ, has set down several rules of thumb for planning such an installation.[2] A practical level of radiation resistance and antenna efficiency for ham operation is obtained when the linear dipole-type antenna is longer than about 4 feet. The area enclosed by a loop configuration should be no greater than about 2 square feet.

Such antennas have been covered extensively in the literature as receiving loops and direction-finding antennas.[13,14] The much discussed Army loop is a larger specialized version of the same design. It is, of course, not as directional as a well built and shielded loop antenna.

Typical 160-meter loop diameter is two to three feet and consists of three or four turns of insulated wire. A capacitor or inductor-capacitor network is used to resonate the loop as shown in **fig. 6.**

The loop coil is surrounded by a conducting shield which is connected to ground. The shield is broken at the top to provide an electrical opening for the signal. Soft drawn copper tubing can be used as the shield.

There are various other loop configurations worthy of consideration. Two loops mounted near each other and properly phased can be used to obtain a unidirectional pattern with deep nulls. Two loops mounted at right angles to each other and using a Bellini-Tosi goniometer provide an electronically rotatable antenna pattern of the same type obtained with a single rotatable loop (**fig. 7**).

Many modern direction finders use a ferrite core and a tuned winding as in **fig. 8.** A typical ferrite directional antenna for the 2- to 8-MHz region consists of 14 turns of number-18 wire wound on a 3/8 by 6-inch ferrite loopstick.[14] It is tuned by a 200-pF variable. The nulls of a ferrite loop are perpendicular to the core (**fig. 8**). The axis of the core is in the direction of maximum sensitivity.

A short tuned vertical can be used

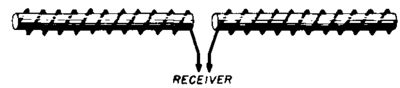

fig. 10. Helical dipole.

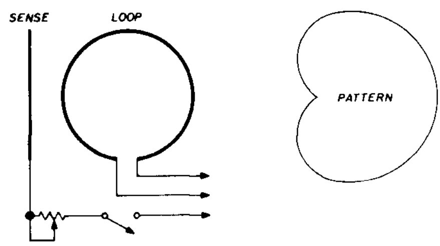

fig. 9. Loop with sense antenna produces cardioid pattern.

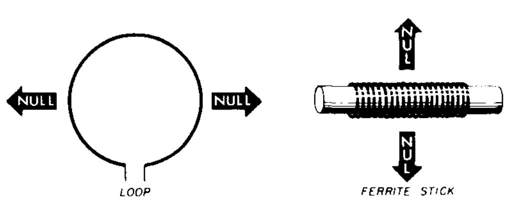

fig. 8. Nulls of loop antenna and ferrite loopstick.

with a directional loop or ferrite stick to obtain a more unidirectional pattern as in **fig. 9.** (Its action is similar to the sense antenna of a direction-finding combination of loop and sense.) Some sort of attenuator is a part of the vertical, a necessity for equalizing the signal levels picked up by the loop and vertical. When signal currents are equalized, switching in the vertical creates a deep null toward the rear.

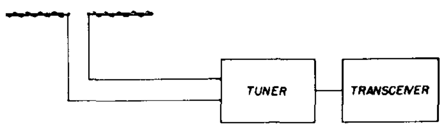

fig. 11. Helical dipole for transmit and receive requires tuner.

A helically-wound dipole is attractive for miniature receiving-antenna construction because of its horizontal polarization. Horizontal polarization is advantageous for those areas where there is a high level of vertically-polarized manmade noise. Two helical windings on each side of a dipole feed point, **fig. 10,** permit a resonant antenna system with a short linear length. An advantage of the helical configuration is that antenna resistance does not differ much from that of a full-sized dipole unless the antenna is made extremely small. It can be used for both transmit and receive. Complete data for building helical antennas is given by W2EEY.[15]

A linear helix with a length reduction factor of 0.3 (length 1/3 the length of a full-size dipole) usually provides practical operation over the cw or phone portions of a given low-frequency band. This antenna can be used with a tuner, **fig. 11,** to extend its bandwidth if it is to be used as a transmit antenna.

An even greater length reduction can be obtained with end loading, as suggested by K6ZGQ[2] (**fig. 12**). Capacitive hats, about 3 feet in diameter, can be made of stiff wire. Antennas no longer than 6 feet can provide operation on bands 20 through 160 meters; only the number of helical turns have to be

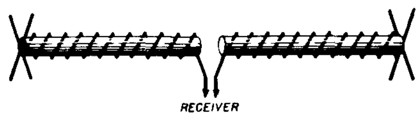

fig. 12. Ended-loaded helical dipole reduces overall length.

changed. Two of these antennas can be mounted a short distance apart (approximately 0.05 wavelength) and fed out of phase. This produces a more unidirectional pattern and less pickup off the back.

receiver input systems

When using miniature and low-gain antenna systems that emphasize pattern rather than gain, additional amplification can be helpful. Antenna-mounted amplifiers have been used successfully in fm and tv reception and in other specialized receiving systems. Field-effect transistors and certain linear integrated circuits appear to be naturals for this application.

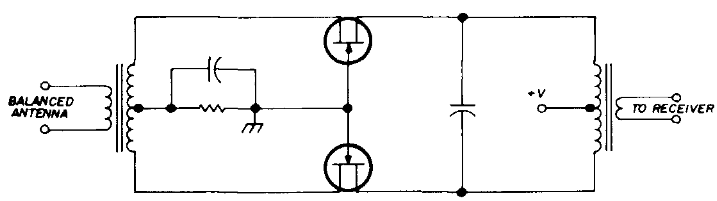

fig. 13. Common-gate dual fet amplifier is suitable for antenna-mounted amplifiers.

The dual jfet[16] and dual-gate mosfet[17] are particularly attractive because of low intermodulation distortion and their ability to handle a considerable range of signal levels without distortion.

When balanced feedlines are used a dual fet can be connected in a push-pull common-gate configuration, **fig. 13.** No neutralization is required.

Amplifiers of this type can be mounted in small weatherproof containers mounted at the antenna terminals. The dc supply voltage can be fed over the same coaxial cable that brings the signal down to the receiver. Such an installation can help substantially in building up the signal picked up by a highly directional but low-gain miniature antenna.

Antenna-mounted amplifiers for phased vertical systems are another possibility. The output of each individual vertical, **fig. 14,** can be supplied to a receiver-located tuner/phaser combination. The directional pattern of the antenna system can be oriented by controlling the relative phase and amplitude of the signals delivered by the vertical receiving antennas.

The integrated circuit is also attractive for antenna-mounted amplifiers. A case in point is the RCA CA3028A,[18] **fig. 15.**

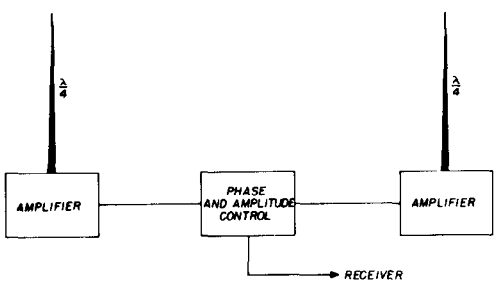

fig. 14. Phased verticals with amplifier and remote pattern control.

It consists of a single-stage differential amplifier, a constant-current transistor and suitable biasing resistors. Only a few external components are needed to build up an amplifier, **fig. 16.**

The same IC can also be operated as a converter. The implication here is that i-f conversion can be made at the antenna terminals. This early conversion to the i-f frequency can be helpful in reducing intermodulation distortion. The converter could possibly be tuned with a dc controlled voltage-variable capacitor diode.

Perhaps the ultimate in antenna-mounted amplification is the recently

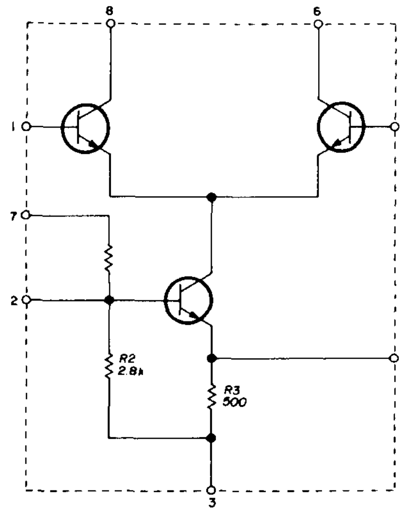

fig. 15. Internal circuit of the RCA CA3028 integrated circuit.

developed voltage-probe receiving antenna.[19] The antenna proper is a 2-inch rod loaded with a small disc and followed by a three-stage fet amplifier consisting of a low-noise input stage, driver and output stage. It will out-perform a 13-foot, 4-inch whip antenna from 7.5 MHz down and a 3-foot whip at all frequencies below 40 MHz.

There is a definite trend in the design of modern amateur communications receivers toward the thorough reduction of intermodulation distortion.[20,21,22,23,24,25] Even the best commercial receivers are often not able to cope with the wide range of incoming signal levels, intermod and splatter. A good agc system and fet input are helpful. There are great possibilities for the direct-conversion receiver and other designs that have low noise content, wide dynamic range and low distortion. An assist to these objectives is an input system of relatively low gain ahead of the second mixer. A low-noise first mixer and a quiet low-noise i-f chain are important. An attenuator ahead of the receiver input, with or without tuner, can help to reduce intermodulation distortion.

If you suspect noise level and intermodulation distortion in your receiver is affecting sensitivity try a good low-noise preselector (with wide dynamic range) ahead of your receiver.

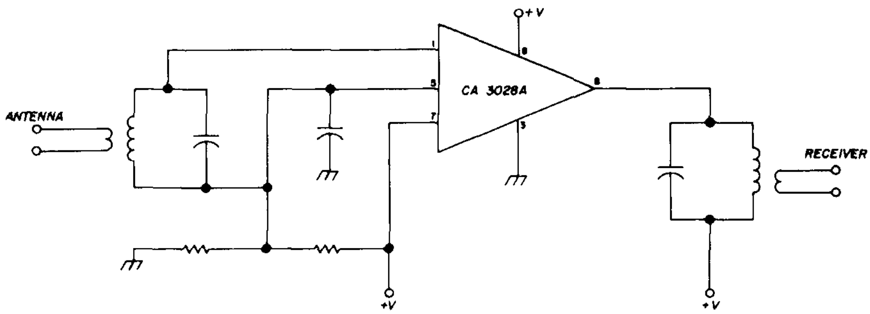

fig. 16. Using the CA3028 ic as an i-f amplifier.

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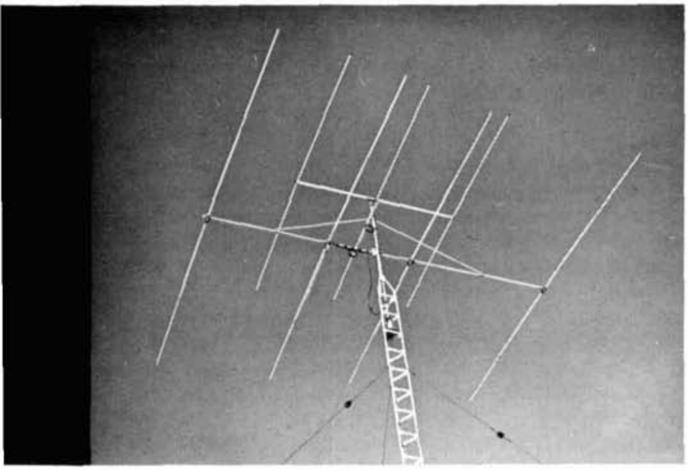
ham radio



single feedline for multiple antennas

A decoupling scheme for exciting separate antennas with one transmission line

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Many articles have appeared that discuss the merits of single-band rotary beams versus those featuring multiband operation. One popular solution to multiband antenna operation is the tribander. This approach has two disadvantages: Element spacing can be optimized for only one of the three bands, and resonant traps and impedance-balancing devices introduce ohmic losses. Both effects can't help but compromise overall antenna efficiency.

Another solution to multiband antenna operation is the log periodic array. While theoretically the most satisfying solution, the log periodic antenna isn't too practical for most amateurs because of cost and structural complexity. In addition, the size of the log periodic antenna diminishes in its effect as frequency increases, while its gain remains essentially constant.

Still another multiband antenna approach uses interlaced elements on a single boom. This scheme permits more optimal element lengths, reduced ohmic losses, and proper spacing with minimal element interaction. Still, the interlaced beam is tricky to adjust and clumsy to install.

The only real solution to effective multiband antenna operation is to use a separate antenna optimized for each favorite band. This implies the use of separate feedlines for each antenna, or complex remote-control circuits for transferring a single transmission line between antennas.

This article describes an efficient method of feeding separate antennas on two or more bands with a single coax cable using a well-known principle of transmission-line theory. Superior antenna performance can be obtained at moderate cost.

economic considerations

A point often overlooked is that you can purchase three separate antennas of excellent mechanical and electrical quality for nearly the same price as a 20-, 15-, and 10-meter tribander. In fact, when considering only 10 and 15 meters, you can own separate 4-element yagis on each band for just a little more than the list price of one of the new 3-element dual-band antennas. Thus for a comparable investment, it's quite easy to achieve far superior performance in terms of measurable forward gain, directivity, and f/b ratio together with an exact impedance match; not to mention the absence of weather-susceptible traps. Moreover, such antennas can be home constructed using standard catalog boom-and-mast hardware for even greater savings.

At the risk of being accused of beating the cost issue to death, I'd like to make one more point. Consider that the price of a couple hundred feet of *good quality* coax with connectors comes quite close to that of a good commercial 3-element 10-meter beam. If you add the relays, control wiring, and switches necessary for separate antenna selection with a single feedline, the feed-system cost will be even higher.

the gimmick

A review of basic theory shows that, in the case of a half-wavelength transmission line, voltage and current are identical at the input and output terminals of the line. Hence the input impedance of any line, regardless of its characteristic impedance, is exactly the same as the load impedance, providing the line length is an *exact multiple of a half wavelength.* Such a line, therefore, may be used to transfer an impedance to a new physical location without changing the line's intrinsic characteristics. A typical application of this principle to achieve common-line feed for two different single-band antennas is shown in **fig. 1.**

Assume that each antenna has been individually adjusted to reflect 52 ohms pure resistive load at each respective nominal operating frequency, f_c. The 10-meter yagi is connected in parallel with the 15-meter yagi; hence it is also connected to the main feedline via a short length of coax. This interconnecting piece acts as our simple decoupling gimmick, which is electrically one-half wavelength long at $f_c = 21.3$ MHz of the lower-frequency antenna.

At 21 MHz the 10-meter yagi reflects a complex load consisting of $X_C + R$, with a net impedance much higher than 52 ohms, because its resonant frequency is far removed from 21 MHz. This same net high impedance is repeated one-half wavelength away (at 21.3 MHz) across the input terminals of the 15-meter yagi. The 15-meter beam reflects a much lower load (52 ohms) to the main transmission line; so the 15-meter beam absorbs power, while the 10-meter beam accepts essentially no power.

At 28 MHz, the 15-meter yagi reflects the much higher net impedance consisting of $X_L + R$. When operating on 10 meters the 10-meter yagi absorbs power, while the 15-meter yagi accepts virtually no power. The interconnecting gimmick line

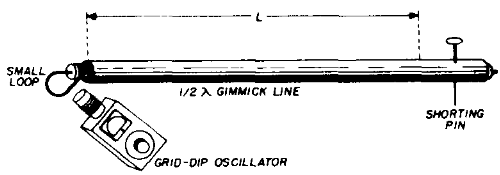


fig. 2. Test setup for determining appropriate length of the decoupling gimmick. Length, L, is trimmed for the operating frequency of the lower-frequency antenna.

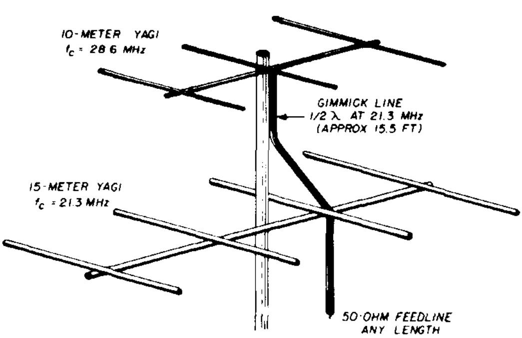


fig. 1. Decoupling method for isolating two stacked beam antennas. The 1/2-wave gimmick may be coiled into a loop and fastened to the mast or to the boom of the higher-frequency array.

looks simply like a short continuation of the main transmission line.

construction and installation

Construction of a decoupling gimmick is very simple, as it is nothing more than a piece of coax trimmed to a fairly critical length. As a start, consider overall length to include all connections; i. e., coax fittings, terminal lugs, etc. Cut a piece slightly to the high side in length using:

$$L = \frac{500}{f_{MHz}} \times \text{velocity factor}$$

where $f_{MHz} = f_c$ of lower-frequency antenna

Install appropriate terminals or coax fittings to one end only. At this same end, temporarily provide a small loop, either by bolting terminals together or by fastening a ¾-inch-diameter loop to a coax fitting. The setup is shown in **fig. 2.** Short-circuit the opposite end by driving a large pin or nail through both shield and inner conductor. Using a grid-dip oscillator with a calibrated receiver, determine the resonant frequency of the initial length of cable. Then change the position of the shorting pin in gradual steps until the desired f_c is obtained. Cut off the excess cable, install appropriate fittings, and your decoupling gimmick is complete.

If your antennas are spaced closer together than the overall decoupling gimmick length, form the excess cable into a coil about 8 inches in diameter. Tape the coil to the mast or to the boom of the higher-frequency antenna.

experimental data

My installation, consisting of 10- and 15-meter gamma-matched beams, is shown in the photograph. The antennas are stacked 5 feet apart and consist of 3 elements on a 10-foot boom for ten meters and 4 elements on a 21-foot boom for 15 meters. Several experiments resulted in the following data.

Each antenna was tuned individually while completely divorced physically from the other. The data, shown in **table 1**, was acquired using a home-made swr bridge and field-strength meter.

table 1. Measured data using home-made test equipment. The standing-wave ratio was unity at fc.

antenna	forward gain (dB)	fc (MHz)	f/b ratio (dB)	bandwidth for 1.75 swr (kHz)	horizontal beamwidth at 3-dB points (deg)
10-meter beam	8.1	28.6	23	950	50
15-meter beam	9.3	21.27	27	600	43

Next, both antennas were mounted in final position on the mast. Alternately, one yagi was excited directly with the other completely disconnected. Rough data was taken as above, and results were essentially identical except that the 10-meter yagi was detuned; its resonant frequency was about 50 kHz higher.

The decoupling gimmick was installed, and the data in **table 1** was rechecked. Results were again identical, except that the 1.75:1 swr bandwidth decreased about 75 kHz for each antenna. This was considered to be well within usable limits of operation.

A reflected-power meter was inserted between antenna terminals and connecting lines. With moderate power applied, forward power to each *off-frequency* antenna was small compared with total transmitter output; in each case, reflected power was nearly equal to forward power. This confirmed that the decoupling scheme was indeed providing proper antenna isolation.

conclusion

The system described has been in operation for nearly two years. Many notable DX stations around the world will attest to consistent signal punch, notable scores in DX competitions, and distinct recognition in rare-country pileups. This system has made significant contributions toward my list of confirmed countries in the ARRL DX Century Club listing.

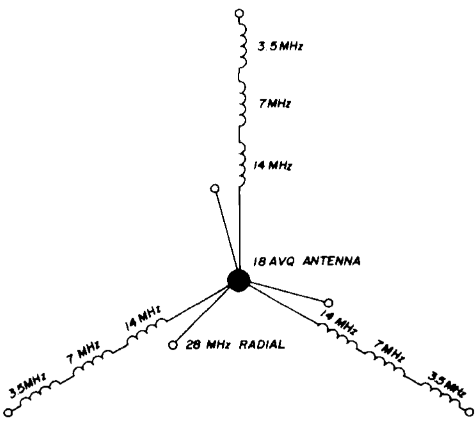
ham radio

More Details? CHECK—OFF Page 94

the ham notebook

multiband ground-plane

Although the popular Hy-gain 18AVQ multiband vertical antenna is designed to be mounted on the ground, it can be used as an elevated ground plane. All that is required is a suitable arrangement of inductance-loaded radials that provide resonance on each of the amateur bands.



radial loading coils

14 MHz	29 turns no. 20, 1.5-inch diameter, 16 turns per inch (Air-Dux 1216T)
7MHz	46 turns no. 18, 2-inch diameter, 16 turns per inch (Air-Dux 1616T)
3.5 MHz	94 turns no. 18, 2-inch diameter, 16 turns per inch (Air-Dux 1616T)

fig. 1. The Hy-Gain 18AVQ multiband vertical can be used as a ground-plane antenna by using a system of inductance-loaded radials.

JA1QIY reports excellent results with the system shown in **fig. 1.** The radials shown in **fig. 2** provide high performance on 3.5, 7, 14 and 21 MHz; a separate set

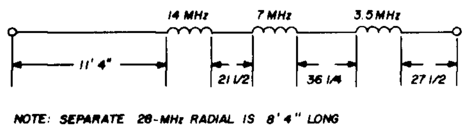


fig. 2. Construction details for the loaded radials.

of radials is used for ten meters. The radials permit the antenna to be put above surrounding objects where it can do the most good. If the radials are allowed to slope away from the 18AVQ they can also be used as guys. With the radials sloping away from the antenna at about 45°, the antenna provides a relatively good match to 50-ohm coaxial cable. The dimensions in **fig. 2** are for the cw end of the band, but with a little cut and try, equal performance can be obtained on the phone bands. The multiband swr of the JA1QIY antenna is shown in **fig. 3.**

JA1QIY has reported excellent DX performance with this antenna, particularly on 80 and 40 meters. On 80 he has worked Soviet Russia, Korea, Okinawa and the Philippine Islands; on 40 he has been able to work into the United States

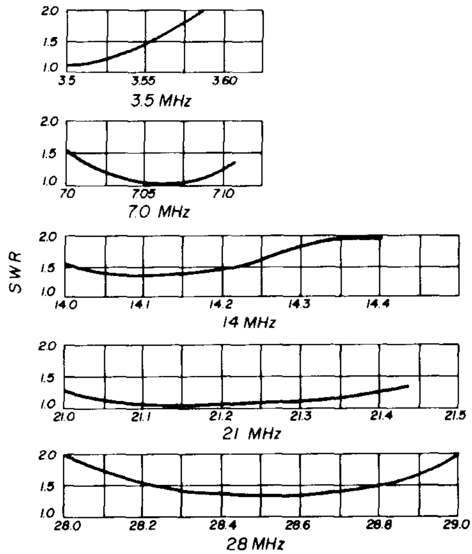


fig. 3. Swr performance of the multiband ground plane. Loaded radials were designed for the cw end of each band.

and Canada, no small feat with relatively low power.

In the original version of this antenna each of the radial loading coils is mounted around a length of phenolic rod. However, ceramic strain insulators could be used for more strength and better performance in wet weather. The 28-MHz radials are spaced a few inches away from the low-frequency radials.

multitester

Although most ham shacks have at least one volt-ohmmeter or vtvm, a low-cost utility multitester can fill in when you have to make simultaneous voltage and current measurements. The multitester in **fig. 4** covers the most useful voltage and current ranges and uses a low-cost 1-mA meter movement. The multiplier and shunt resistors, and diode are mounted on the selector switch, a Centralab PA1001. All resistors can be 5% carbon composition types, although for higher accuracy 1% precision resistors should be considered. However, to keep the cost down, carbon composition resistors provide acceptable accuracy for most purposes. R1, the 100-mA shunt, consists of 5-feet no. 36 wire wound around a high-value resistor. The 1-mA meter is an imported unit, such as the Lafayette 99F50528.*

*Available from Lafayette Radio Electronics, 111 Jericho Turnpike, Syosset, L. I., New York 11791. $2.95 plus postage; shipping weight, 12 ounces.

silver/silicone grease

A common problem with station ground systems is corrosion at the main ground connection. Some amateurs try non-conductive grease to eliminate this corrosion but this leads to improper grounding conditions. Silver/silicone grease is prepared by Technical Wire Products, Inc. (427 Olive Street, Santa Barbara, California 93101) for use on knife switches in power substations. However, it is useful to amateurs who want to protect their ground-system connections from corrosion and resultant loss of effectiveness. The silver/silicone grease is water repellent and is available in 2-ounce tubes (part number 72-00016) or 1-pound jars (part number 72-00015). For more details on this grease, write to Technical Wire Products, Inc. for a copy of Data Sheet CS-725.

Bill Welch, W6DDB

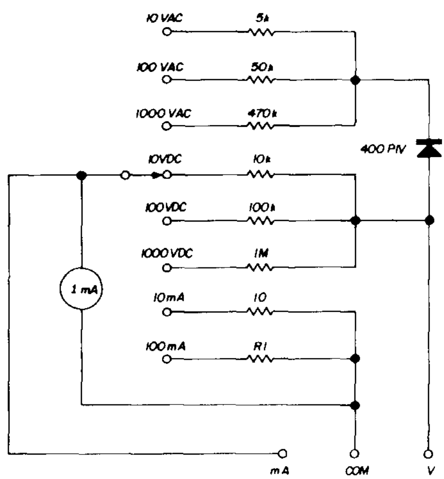


fig. 4. Simple utility meter. R1 is 5 feet no. 36 wire wound around high-value resistor.

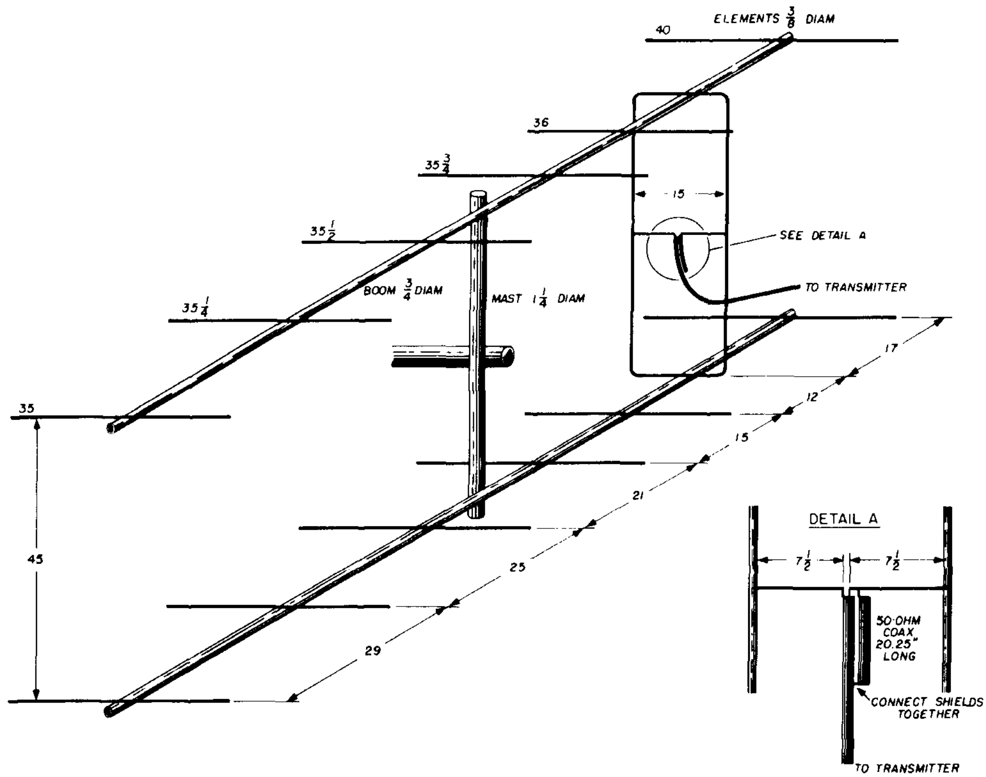


fig. 6. Details of two-meter slot antenna built from salvaged tv-antenna tubing and thin-wall conduit.

power-supply hum

The power supply described by Hank Olson in the February 1970 issue of *ham radio* was built for a solid-state receiver. The receiver was very quiet until the antenna was connected, then I found a wild example of "tunable hum." A 0.1 μF disc ceramic capacitor was connected as shown in **fig. 5**, and the trouble was cured completely. In my case it was convenient to connect the capacitor across one-half of the secondary, but it is equally effective across the entire secondary winding.

Bill Wildenhein, W8YFB

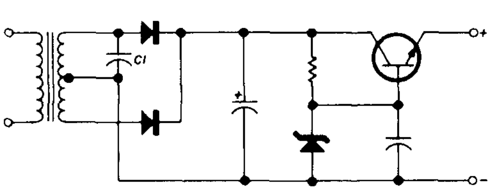


fig. 5. Capacitor C1 reduces power-supply hum.

two-meter fm antenna

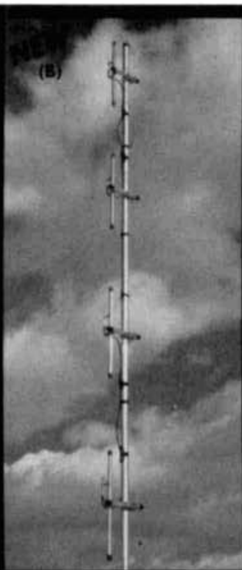
The antenna shown in **fig. 6** was assembled from a few old TV antennas for about $3.00. My location is surrounded by mountains as high as 11,500 feet. The antenna shown has given good results by bouncing signals off the mountains. Stations 120 miles away sound almost like locals.

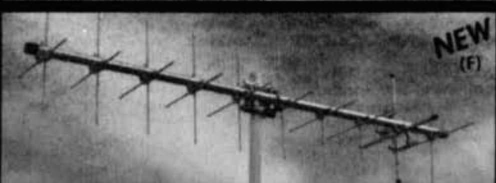
construction

The booms and crosspiece are made of 3/4-inch thin-wall conduit. All elements are 3/8-inch aluminum tubing salvaged from old TV antennas. The corners of the driven element are made of soft aluminum, assembled with ¼-inch bolts with the heads cut off.

I drilled holes in the conduit to accept the elements, which are held in place with sheet-metal screws. The booms are secured to the crosspiece with U-bolts at the balance point.

Bill Done, WB6KYE





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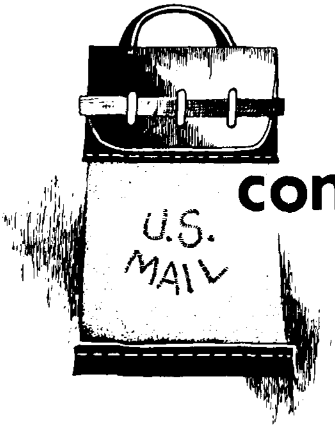

comments

inverted-vee antennas

Dear HR:

In my experience with an inverted-vee antenna for 40 meters, 67.5 feet long with the apex at 30 feet and the ends 15 feet off the ground, resonant frequency was 7.18 MHz. This suggests that inverted-vee length is:

$$\text{length (feet)} = \frac{485}{f_{MHz}}$$

The resonant frequency was indicated by a very deep and sharp null with an Omega-T antenna noise bridge.

It may be of interest to comment on the affect of adding a parasitic inverted-vee director, 64.13-feet long (5% shorter than radiator), at the same apex and end heights, spaced 16 feet in front of the driven element. (Judging from Yagi data this is good spacing for gain, but not for bandwidth.) The director raised the resonant frequency 114 kHz to 7.294 MHz. This suggests:

$$\text{driven element (feet)} = \frac{492}{f_{MHz}}$$

$$\text{director length (feet)} = \frac{467}{f_{MHz}}$$

Element spacing was 0.11 wavelength.

The Omega-T noise bridge indicated a driving-point impedance of 27 ohms for this two-element inverted-vee Yagi. Two such antennas were used on 40-meter phone and cw during the 1950 ARRL Field Day with good success. A 38-ohm Q-section will match 27 ohms to 50-ohm coax, two 22.93-foot lengths of RG-59/U (length = 165/fMHz) were soldered in parallel to make a 37.5-ohm Q-section. According to the book, the Q-section should be made from twin lead, but with the double-coax Q-section swr was less than 1.4:1.

Another two-element inverted-vee Yagi with a director 3% shorter than the radiator resulted in the following formula:

$$\text{driven element (feet)} = \frac{490}{f_{MHz}}$$

$$\text{director length (feet)} = \frac{467}{f_{MHz}}$$

Element spacing for this array was also 0.11 wavelength.

Bob Hume, WB6AQF
Palos Verdes, California

ground rods

Dear HR:

Driving of 6-foot ground rods is easy in good loam, but many of us live in areas where the top soil is sandy or rocky, and you cannot find even a very poor ground with a 6- or 8-foot rod. It is necessary to get through hardpan or layers of rock to find moisture, to say nothing of water. I had to go down 18 feet.

Some small ground rods are made so they can be threaded together, but the

driving cap furnished with them comes loose with each blow of the sledge and buggers the threads. Also, when threaded they unscrew underground.

The same is true of well hardware. Ordinary ground points tend to pack the soil around them, and thus insulated themselves from actual ground. Well points will do the same, but due to their greater diameter, they pack less. A 1½-inch well point can be driven into soft soil, but the threads get mashed even when using the fitting made for driving.

The easiest way in the long run is to get a 1½-inch well point and several sections of extension pipe. Drill a ¼-inch hole at the top of one pipe and hang two buckets of rocks from the top. I used 5-gallon paint cans. Fill the buckets with rocks and then fill the leftover space with water for weight.

Cut off the end of an old 3/8-inch hose and drop the end down into the well point. Use a pair of chain tongs and take about three or four turns in the assembly with the water running easy. Then take half a turn back; keep the water running.

The pipe should run down about an inch for each 4 turns. After running it into the ground as far as necessary to reach the ground-water level fill the pipe with copper sulfate and stick a funnel into the top. It will catch enough rain to melt about 5 pounds of copper sulfate a year. A 25-pound sack of copper sulfate costs about $6.00 wholesale.

I finally ran my 18-foot ground in after only 10,000 turns or so!

Keith Olson, W7FS
Belfair, Washington

checking coaxial cable

Dear HR:

I wonder if any other amateurs have stumbled onto a very useful secondary function of my QRP wattmeter (April 1970 *"ham radio"*), *coaxial cable quality checking.* You simply feed the output of your QRP rig or exciter into the rf wattmeter. This will give a reading (let's say) of 7 on the meter. Next, the cable to be tested is inserted between the exciter and the wattmeter. If the cable has a nominal 50 ohms impedance the wattmeter reading should be reasonably close to the earlier reading. If not, the watts lost in a given length of 50-ohm cable can be directly calculated by subtracting Watts_{far} from Watts_{near} as read directly from the QRP wattmeter.

Neil Johnson, W2OLU
Tappan, New York 10983

fm deviation measurement

Dear HR:

Accurate fm deviation measurements are much more involved than they may seem. The i-f and discriminator must be extremely broad. Pulling out the i-f filter and reducing the size of the discriminator load resistors by about 3:1 is a good start. It's also a good idea to tweak the discriminator for best linearity — it's probably not as good as you might think.

In reference to the fm deviation meter described in the *ham notebook* section of the December, 1970 issue, a somewhat less expensive calibration procedure involves switching in a 455-kHz crystal first, than a 440-kHz or 470-kHz crystal in place of the second conversion oscillator crystal. If you don't have a dc-coupled oscilloscope, you can use the same technique used at the Motorola factory: use an audio-frequency multivibrator to switch between a 440-kHz and 470-kHz oscillator, and couple the output into the receiver i-f strip.

If the whole thing sounds a bit cumbersome, you can set your deviation quite adequately for amateur purposes by bellowing into the microphone, and adjusting the deviation control to just below the point where first limiter current starts to kick downward with modulation. This may not sound very sophisticated, but it's probably at least as accurate as most homemade deviation meters.

J. A. Murphy, K5ZBA
Tulsa, Oklahoma

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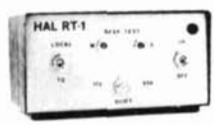

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HAL now offers a parts kit for the AK-1 AFSK osc. Drilled G10 glass PC board plugs into 12 pin edge connector for compatibility with the **HAL** ST-6, or for ease of use alone. Requires 12vdc. $27.50. Shipping extra. Write for parts list.

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Postage is not included in the prices of **HAL** products. Please add 50¢ on small parts orders, and $2.00 on larger kits. Shipping is via UPS when possible, and via insured parcel post otherwise. Please give a street address.

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More Details? CHECK—OFF Page 94

new products

hallicrafters five-band transceiver

A new and improved version of the popular Hallicrafters SR-400, Cyclone II, ssb cw transceiver is being introduced. Known as the model SR-400A, Cyclone III, the new 5-band ssb cw transceiver is "feature-packed" with the newest and advanced electronic circuits and control designs developed for operation in all environments – field, radio shack or mobile. Full coverage is provided for the 80, 40, 20, 15 and 10 meter bands.

The ssb power of the new SR-400A has been increased to 550 watts PEP. An exclusive power-amplifier-tube balancing circuit eliminates the need for matched tubes. No longer does the amateur operator have to purchase final amplifier tubes in matched pairs.

Also, Hallicrafters has engineered the SR-400A with a new built-in 100/25 kHz crystal calibrator which helps locate band edges on the new sub-bands. The Hallicrafters' patented Receiver Incremental Tuning (RIT) permits ±3 kHz adjustment of receiver frequency independent of the transmitter is now calibrated, making it even more versatile and easier to use. Also available is an optional fixed station blower kit; it consists of a quiet, heavy-duty air blower and connections for use in the power amplifier section to prolong tube life.

The new SR-400A, like its predecessor, is ideal for the sophiscated DXer when used with the HA-20 remote vfo. The operator can listen to two frequencies simultaneously. It is also excellent for "tail ending." The HA-20's dial is calibrated for true 1 kHz readout. An expanded vswr meter with remote bridge connection allows the operator to continuously check antennas performance.

For the cw operator the SR-400A provides such added features as semi-automatic break in, cw filter (200 Hz), cw sidetone and grid-block keying. The SR-400A also features upper- and lower-sideband selection, constant tuning rate on all bands, smooth gear-driven tuning mechanisms with 1-kHz readout, choice of vox or ptt (built-in), 6-pole 1650-kHz crystal-lattice filter for optimum selectivity and sideband response, built-in notch filter to supplement sharp cw selectivity, frequency zero adjust, complete metering and separate receiver and transmitter rf and audio controls.

For the amateur who wishes to further extend the capability of the new SR-400A, Hallicrafters has provided optional accessories such as solid-state ac and dc power supplies, mobile mounting rack, and a 4-inch communications speaker for mobile installations.

The new SR-400A cyclone III weighs 26 pounds and is priced at $995 amateur net. The HA-20 vfo is priced at $199.95. The new SR-400A will be available from franchised electronic distributors throughout the United States. For more information, use *check-off* on page 94.

More Details? CHECK–OFF Page 94

callbook supplement

The *Radio Amateur Callbook* has announced an innovation in their line of publications. Beginning with the Spring 1971 *Callbook,* there will also be published a supplement, available to those subscribers who have purchased the preceding issue and would like to up-date their information without purchasing a complete book. Those amateurs who purchase the current edition may also order the supplement to the next complete edition for a modest cost. This is on an experimental basis, pending response from the amateur fraternity.

Supplements will contain all new licenses and silent keys, as well as call letter, class and address changes that have taken place since the preceding issue of the *Callbook.* For further information write The *Callbook,* Lake Bluff, Illinois 60044, or use *check-off* on page 94.

electronic designer's handbook

The "Electronic Designer's Handbook: A practical Guide to Transistor Circuit Design" by T. K. Hemingway is now in its second edition. This up-to-date handbook provides a complete reference on transistor circuit design to the depth required for practical engineering design. Part 1 provides detailed coverage of the transistor used as a switch and as a small-signal amplifier, as well as circuit operating principles and consideration of transistor parameters in practical design. The designer will find part 2 of particular value for its description of unusual circuits, and the straightforward discussion on how novel design can be synthesized and modified to serve in a number of practical applications. The content is specifically intended to show the reader how to design his own circuits. As opposed to presenting superficial knowledge of a great number of circuits, specific circuits are presented and analyzed in detail so that the reader, armed with the underlying design techniques, can apply them to developing his own specific circuits.

Part 3 discusses the practical difficulties encountered in the design and testing of prototype circuits, offering many useful hints for solving a number of problems rarely mentioned in other books, and containing a particularly interesting and useful chapter on circuit layout and wiring. Much of the math has been relegated to the appendix. This book is specifically oriented to serve the needs of the practical designer, whether he be a novice or professional. 294 pages. 304 illustrations, $9.95 from Tab Books, Blue Ridge Summit, Pennsylvania, or use *check-off* on page 94.

automatic tone encoders

The new solid-state Alpha miniature continuous-silent-tone encoder is designed for use in all two-way radio communications systems and equipment. This compact, easily installed unit provides an end to interfering signals and the necessity of listening to co-channel users by requiring that transmissions to base station radios be accompanied by a predetermined subaudible tone to activate the receiver. The silent-tone encoder (ST-85H) can be used where the base station only is to be quieted. The new transistorized circuitry (eliminating mechanical reeds and relays) makes this thoroughly field-tested unit stable and reliable.

Tone frequencies are available over a wide range (20.0 to 203.5 Hz) and can be changed by simply plugging in a TN-91 of the frequency desired. Each silent-tone contains two sections, the encoder network (ST-85H), and the tone determining network (TN-91H), and features small size, built-in voltage regulation and one year warranty.

For more information write to Alpha Electronic Services Inc., 8431 Monroe Avenue, Stanton, California 90680, or use *check-off* on page 94.

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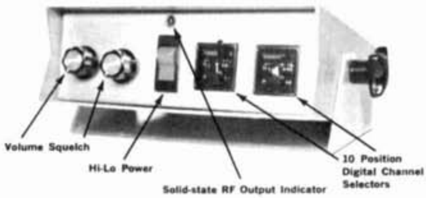

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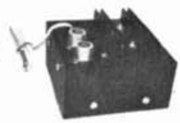

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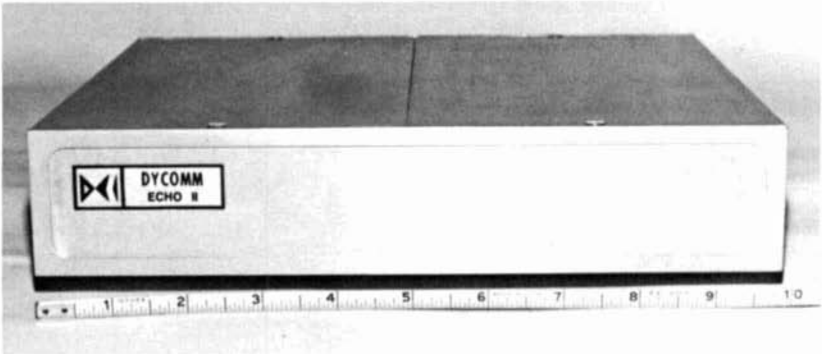

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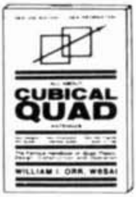

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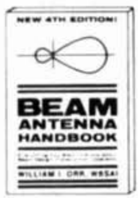

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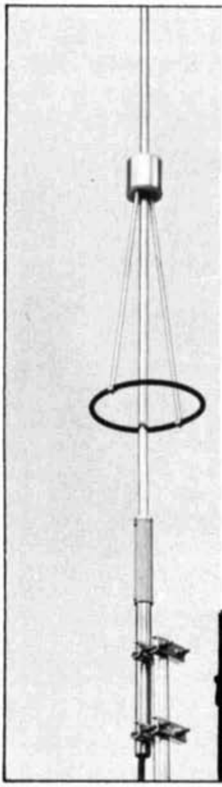

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V.S.W.R.—1.5:1 or less	Polarization—Vertical
Bandwidth—±3.5 MHz	Connector—PL-259
Impedance—50-52 ohms	

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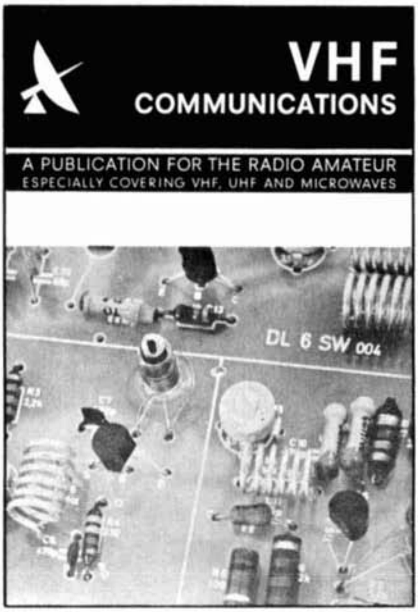

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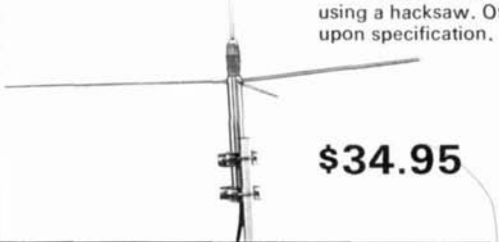

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Gain—3db
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Bandwidth—±3.5 MHz
Impedance—50-52 ohms
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Polarization—Vertical
Connector—PL-259

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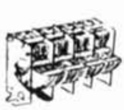

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USED CB GEAR, accessories, all types. Homebrew 3KW AM-SSB linear, 2; 4-400A tubes w/chimneys, blowers metered power supply, 19" rack, 4 ft. high on casters, 80-10 meters, also new gear, $270.00. SASE lists. David Driver Electronics, Wholesale-Retail Equip., P. O. Box 1163 - 107 N. Main St., Lexington, N. C. 27292. Phone: (704) 246-4089.

EXCLUSIVELY HAM TELETYPE 19th year, RTTY JOURNAL, articles, news, DX, VHF, classified ads. Sample 30¢. $3.00 year. Box 837, Royal Oak, Michigan 48068.

AM SIGNAL GENERATORS: AN/URM-25D; 10 khz to 50 mhz; Internal Modulation; Crystal Calibrator; Precision RF Attenuator; RF output and percent of modulation metered. Reconditioned and aligned. With cover and accessories $170; Generator only $150. Brochure offering other Test Equipment available. James Walter, 2697 Nickel, San Pablo, California 94806.

STOLEN RADIO EQUIPMENT. $100.00 reward for information that leads to the return of the following: Drake R4B receiver serial #9733C, Heathkit SB400 transmitter, Heathkit HX30 with astatic mobile mike, Receiver NC240D, Navy grey, Oscilloscope Eico MDL 425. If you have information concerning the above, please call collect to: John A. Hultquist, Jr., K6GSS, 660 Timberpine St., Sunnyvale, Calif. 94086. 408-246-6499, Work Phone 962-4329, 415 962-3904.

THE BIRMINGHAMFEST this year will be on May 2 at the Armory on Oporto Avenue (just off U.S. 78 East - near Eastwood Mall). For entertainment, prizes, contests, net meetings, eyeball QSO's and fun for the entire family, plan to attend. For further information contact the Birmingham Amateur Radio Club - W4CUE, P. O. Box 603, Birmingham, Ala. 35201.

CODE PRACTICE TAPES - Novice - General - Extra Class - Specify - $8.00 each. W9CJJ, 1105 Schaumburg Road, Schaumburg, Illinois.

ORIGINAL EZ-IN DOUBLE HOLDERS display 20 cards in plastic, 3 for $1.00, 10 for $3.00 prepaid. Guaranteed. Patented. Free sample to dealers. Tepabco, John K4NMT, Box 198R, Gallatin, Tenn. 37066.

ASK FOR FREE LIST of used Ham gear or for prompt personal attention on any new gear. Mail your order direct to VanSickle Radio, W9KJF, Indianapolis, Indiana 46205. 40 years experience.

826 TUBES WANTED FOR CASH. Pay $100. each for 445A WE Klystrons. C. Hutnan, 308 Hickory St., Arlington, N. J. 07032

AM SIGNAL GENERATORS: AN/URM-25D; 10 khz to 50 mhz; Internal Modulation; Crystal Calibrator; Precision RF Attenuator; RF output and percent of modulation metered. Reconditioned and aligned. With cover and accessories $170; Generator only $150. Brochure offering other Test Equipment available. James Walter, 2697 Nickel, San Pablo, California 94806.

CONNECTICUT HAMS: Come and see all the goodies at Roger S. Miner Surplus Electronics, 246 Naugatuck Ave., Milford, Conn. 06460. Telephone 877-0555.

WANTED R390, R390A, R389, 51J4, 51S1, Racal, Nems, Clarke, Marconi receivers. SWRC, P. O. Box 10048, Kansas City, Missouri 64111.

VHF NOISE BLANKER — See Westcom ad in Nov., Dec. '70 and Mar. '71 Ham Radio.

SIGNAL GENERATOR, 2-400 MHz, Measurements Model 80, $175.00; HP-200CR Audio Oscillator, $75.00; BC-221 Frequency Meter, original calibration, $68.00. K2DA, 449 Hill St., Boonton, N. J. 07005.

MODEL 32 TELETYPE with stand, 5 level working, new ribbon and belts $175.00. SP-600JX (with crystal controlled feature for nets) $200.00. Carl M. Schulte, WA2KBZ. Telephone 201-493-4088 or Callbook address.

SURPLUS CRYSTALS BLANKS: Range 4100-6800 kHz. 7200-8600 kHz. Assorted freq. our selection. 30/$1. Nat Stinnette Electronics, Umatilla, FL 32784.

TOROIDS! Lowest price anywhere. 40/$10.00 POSTPAID (5/$2.00). center tapped, 44 or 88mhy. 32KSR page printer, reconditioned, perfect $225. MITE UGC41KSR page printer, reconditioned, $250. Mod28 Sprocket to friction kit, $25. 28LBXD TD, $70. 28LPR reperf with gear shift, $170. Model 15KSR, $65. Matching RA87P.S. Unused, $7. Lorenz 15KSR, $75. Sync motors, $7. 14TD, $20. DPE punch, $14. HP200CD Oscillator, $95. R390/URR, $550. 11/16" tape, 40/$10.00. 33ASR, complete, $700. Stamp for listing. Van W2DLT, 302H Passaic, Stirling, N. J. 07980.

BRING YOUR GEAR. The Bow Radio Association and The Contoocook Valley Radio Club, Inc. are co-sponsoring an AUCTION and FLEA MARKET on Sunday, May 23, 1971. The flea market will start at 10:00 a.m. (please bring tables) and the auction will start at 2:00 p.m. There will be refreshments and recreation. The address is: Keyster Pond Cottages, Henniker, N. H. off Routes 202 and 9 near Junction of Route 127 (near Hopkinton Town Line).

SOLID STATE HAM PRESELECTOR, 80-10 meters, highly sensitive - economical. Free brochure. Waban Laboratories, Box 17, So. Sudbury, Mass. 01776.

WANTED. Gonset G43 receiver. Need not be working. John Gibson, 1305 Tevlin, Berkeley, Calif. 94706.

SELL: MINT CONDITION HT-37 $165, SX-117 with speaker $215. Both for $365. Bob Scheib, #93, 1316 S. Duff, Ames, Iowa 50010.

DON'T BUY QSL CARDS from anyone until you see my free samples. Fast service. Economical prices. Little Print Shop, Box 9848, Austin, Texas 78757.

SURPLUS MILITARY RADIOS, Electronics, Radar Parts, tons of material for the ham, free catalogue available. Sabre Industries, 1370 Sargent Ave., Winnipeg 21, Manitoba, Canada.

TELETYPE #28 LRXB4 reperforator-transmitter "as is" $100; checked out $175. Includes two 3-speed gearshifts. Alltronics-Howard Co., Box 19, Boston, Mass. 02101. 617-742-0048.

TELL YOUR FRIENDS about Ham Radio Magazine.

More Details? CHECK—OFF Page 94

WABASH CO. Amateur Radio Club's third annual Hamfest, Sunday, May 23. Rain or shine. Door prizes, major prizes and much more. For information write Bob Mitting, 663 Spring, Wabash, Indiana 46992.

FOR SALE: HAM RADIO, first 36 issues, excellent condition, best offer. Wanted: 1938 ARRL Handbook. W9CWH, 706 N. Elmhurst Ave., Mt. Prospect, Illinois 60056.

75S-3B, 32S-3, 516F-2; mint, functioning perfectly; $1125. Box 278, Lexington, S. C. 803-359-4372. Tom Sessions, Jr.

GREENE — center of dipole insulator with . . . or . . . without balun . . . also the GREENE DRAGON FLY antenna . . . send for free flier . . . GREENE, Box 423, Wakefield, R. I. 02880. W1CPI.

MECHANICAL FILTERS: 455 Khz. 2.1 Khz $18.95. 300 Hz $22.95. J. A. Fredricks, 314 South 13th Ave., Yakima, Washington 98902.

75A2 RCVR with vernier dial and Collins Filter Kit and two filters $200.00, HW-22 $80.00, Heath HX-20 and Supply $125.00, New 6C21 tubes $15.00, Model 14 Base $10.00, Cover $10.00 both for $15.00. W8CEG.

KWM-2 Zero hours since reconditioned Noise Blanker-Notch filter Heavy duty AC and DC power supply's Mobile rack. Best Offer. W8FUF, 8200 E. Jefferson, Detroit, Michigan 48214.

WANTED - USED Drake TR4, AC pwr speaker; Drake L4B linear with power; Collins KWM2, AC pwr & speaker; Collins 30S1 linear with power; Drake MN-2000 network. H. F. Cushing, W6LXZ, 5224 Bobbie Ave., San Jose, Calif. 95130.

SETH THOMAS DIGITAL CLOCKS with seconds indication reg. $27.95 value only $13.95 postpaid while they last. Laboratory clear, for sale or trade: Singer Meterics Spectrum Analyzer SPA#3 200CPS-15MC R/mount $800.00 new cost $3500.00, HP520A 10 MC scaler R/mount $75.00, GR805C sig. gen. 500KC-50MC cal. output $250.00, ME74/U AC VTVM like new $50.00, TS375A/U AC-DC VTVM like new $50.00, SP 600 JX rec. 500KC-54MC retubed recal. our lab. $275.00, manuals are included all units. Want HP608D,E,F, or 390A series rec. Wawasee Electronics Co., P. O. Box 36, Syracuse, Indiana 46567.

ROCHESTER, N. Y. is the location for the 38th annual Western New York Hamfest and VHF Conference on Saturday, May 15th. New location is the Monroe County Fairgrounds, Rte. 15A, just north and east of N. Y. Thruway exit 46. Advance registration and banquet only $6.75. Advance sale closes May 8th. Send check to Western New York Hamfest, Box 1388, Rochester, N. Y. 14603. Activities start Friday night followed by a full day of technical programming with outstanding speakers. Special activities include MARS, AREC and QCWA meetings, YL program, code contests and a huge flea market.

HOOSIER ELECTRONICS Authorized dealers for Drake, Hy-Gain, Ten-Tec, Galaxy, Regency, Hallicrafters. All equipment new and fully guaranteed. Write today for our low quote. Hoosier Electronics, Dept. G, R. R. 25, Box 403, Terre Haute, Indiana 47802.

TOROIDS 44 and 88 mhy. Unpotted, 5 for $1.50 ppd. W. Weinschenker, Box 353, Irwin, Pa. 15642.

QSL'S — BROWNIE W3CJI — 3111B Lehigh, Allentown, Pa. 18103. Samples 10¢. Cut catalogue 25¢.

"DON AND BOB" new guaranteed antenna specials. Monarch KW SWR relative power dualmeter bridge 14.95; CDE Ham-M 99.00; TR-44 59.95; AR22R 29.95; EZWAY 4300 7.5 ft. tower sections 10.00 ea.; TRI-EX W51 329.00 prepaid; MW65 299.95 prepaid; Saxton 300 open-wire line 4.50/C; #14 antenna wire 100 ft. 1.95; B&W 650 dummy load/wattmeter 49.95; write quote beam, tower packages. Mastercharge, BankAmericard, GECC. Prices FOB Houston. Madison Electronics, 1508 McKinney, Houston, Texas 77002. (713) 224-2668.

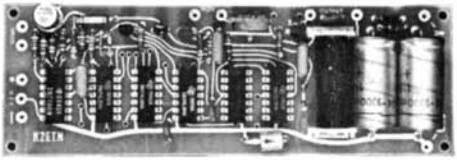
HRO-500 National receiver with speaker, very good condition, $700. Transceiver power supply, $35. Wanted, a Mainliner or ST-6 RTTY converter, 5-6 element 20 meter beam. W1BRJ, 7 Pickwick Rd., Marblehead, Mass. 01945.

THE K2ETN KEYER

Now, a Keyer with every feature of the most expensive units without the unnecessary frills. Berkshire Inst. has designed a complete ready to use Keyer on a single printed circuit board. Use your own Key and incorporate it in your station console or power supply. Built-in regulated power supply operates from 6.3 VAC or 7½ VDC and only requires 60 Ma.

—Self Completing Dots & Dashes.
—Dot & Dash Memory.
—Automatic Character Spacing.
—Iambimatic Output.
—Dot or Dash Injection.
—Built-in Variable Pitch Side Tone.
—6 to 80 WPM.
—Reed Relay Output for Compatability With any Rig.

Introductory Offer $34.95



BERKSHIRE INST., INC.

170 Chestnut St. Ridgewood, N. J.

CAMP ALBERT BUTLER INVITES
HAM RADIO ENTHUSIASTS OF ALL AGES

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This Summer! Our 12th Season

STUDY INSTRUCTION
LEADING to GENERAL ADVANCE
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This co-ed Amateur Radio Camp, Y.M.C.A. owned and operated, can accommodate 60 campers. There is no age limit. We have had campers from 7 through 74 years of age. It is very helpful if you can copy 5wpm or have a Novice or Technician ticket but it is not necessary. Time is divided between radio classes in code and theory and usual camp activities, such as swimming, archery, riflery, hiking, etc. Golf privileges are included at the beautiful New River Country Club course.
Entire staff consists of licensed hams who are instructors in electrical engineerng in some of our finest colleges and universities. Camp opens July 31st and closes August 14th. Tuition of $200.00 includes all camp expenses: room, meals, notebooks, textbooks, and insurance. Send for our brochure.

C. L. Peters, K4DNJ
General Secretary
Gilvin Roth Y.M.C.A., Elkin, N. C. 28621

Please send me the Booklet and Application Blank for the Camp Albert Butler Radio Session.

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CITY .... STATE .... ZIP ....

A "broadband" isn't an all girl orchestra.

ITS A BALUN FROM LA-TRONIX

SPECIFICATIONS

Bandwidth	3 through 30 MHz Continuous
VSWR	1:1 (when terminated with a balanced 52 ohm load)
Power Rating	1 kw DC
Impedance Ratio	1:1 at 52 ohms
Input Connector	SO-239

Mod. LA-BN330

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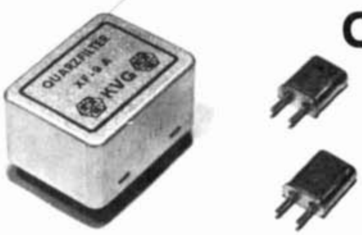


CRYSTAL FILTERS

By KVG of WEST GERMANY

High performance 9 and 10.7 MHz crystal filters for SSB, FM, AM and CW application. Symmetrical input and output. Small size (1 27/64" x 1 3/64" x 3/4") perfectly suited for miniaturized solid-state equipment.

Filter Type		XF-9A	XF-9B	XF-9C	XF-9D	XF-9E	XF-9M
Application		SSB-Transmit.	SSB	AM	AM	FM	CW
Number of Filter Crystals		5	8	8	8	8	4
Bandwidth (6dB down)		2.5 kHz	2.4 kHz	3.75 kHz	5.0 kHz	12.0 kHz	0.5 kHz
Passband Ripple		< 1 dB	< 2 dB	< 2 dB	< 2 dB	< 2 dB	< 1 dB
Insertion Loss		< 3 dB	< 3.5 dB	< 3.5 dB	< 3.5 dB	< 3 dB	< 5 dB
Input-Output	Zt	500 Ω	500 Ω	500 Ω	500 Ω	1200 Ω	500 Ω
Termination	Ct	30 pF	30 pF	30 pF	30 pF	30 pF	30 pF
Shape Factor		(6:50 dB) 1.7	(6:60 dB) 1.8	(6:60 dB) 1.8	(6:60 dB) 1.8	(6:60 dB) 1.8	(6:40 dB) 2.5
			(6:80 dB) 2.2	(6:80 dB) 2.2	(6:80 dB) 2.2	(6:80 dB) 2.2	(6:60 dB) 4.4
Stop Band Attenuation		> 45 dB	> 100 dB	> 100 dB	> 100 dB	> 90 dB	> 90 dB
Price		$21.95	$30.25	$32.45	$32.45	$32.45	$23.00

HC-25/U crystals: 8998.5 kHz (USB), 8999.0 kHz (BFO), 9000.0 kHz (carrier) 9001.5 kHz (LSB). $2.75 each.

10.7 MHz filters with bandwidth: 14 kHz, 16 kHz (for 5 kHz freq. dev. FM), 32 kHz, 38 kHz (for 15 kHz freq. dev. FM) $30.25 each.

9 MHz crystal discriminators for max. freq. dev. of 1.5, 3 and 8 kHz. $17.95 each.

10.7 MHz crystal discriminators for max. freq. dev. of 10 and 20 kHz. $15.95 each.

SPECTRUM
INTERNATIONAL
BOX 87 TOPSFIELD
MASSACHUSETTS 01983

More Details? CHECK—OFF Page 94

WORLD QSL BUREAU — see ad page 93.

TOWER WANTED . . . 54 ft. or higher, med. or heavy duty. A. Emerald, 8956 Swallow Avenue, Fountain Valley, California 92708.

W3GKP has new call, QTH: William L. Smith, K4RJ, Route 7, Box 315, Franklin, NC 28734.

SELL EXTRA SWAN 250 with 117XC, $225 plus shipping. Lafayette HA 750 6 Meter Transceiver, $70 postpaid. Both excellent. Robert Monroe, WB9EIP, 502 Millikin Bldg., Decatur, Illinois 62523.

TRANSCEIVER NCX5 Mark 2 with AC power supply. Factory overhauled perfect $350.00. Sonar transceiver 10, 15, 20 meters, 200 watt PEP, SSB with factory AC and DC supplies $300.00. Swan power supply Model 117XC and 14X DC Module $70.00. Communicator 4-6 meter transceiver, mike and 5 crystals $150.00. Manuals for all units. Gerald Tetrault, R. F. D. 4, Box 165, Manchester, N. H. 03102.

MANUALS — $6.50 each: R-390/URR, R-390A/URR, BC-348JNQ, URM-25D, BC-639A, URT-7, TS-497B/URR, CV-591A/URR, OS-8A/U, UPM-45. Hundreds more. S. Consalvo, 4905 Roanne Dr., Washington, DC 20021.

QSLS. SECOND TO NONE. Same day service. Samples 25¢. Ray, K7HLR, Box 331, Clearfield, Utah 84015.

YOU ALL COME TO International Independent County Hunters Convention in Kansas City, July 2, 3, 4, 1971. SASE to WA0SHE for information.

FREQUENCY METER, Lampkin 105-B, trade for Heath 401 Transmitter or sell for $225. New condition. Bill McVey, KL7GFB, Box 623, Sitka, Alaska 99835.

THE 17th ANNUAL Breeze Shooters Hamfest will be held at White Swan Park, Parkway West near the Greater Pittsburgh Airport on May 23. This is the "largest" amateur event in the Western Pennsylvania area so plan to attend. Plenty of free parking, large amusement park for the XYL and harmonics. *Talk-in frequency is 29.00 and 146.94.* For additional details write D. J. Myslewski, K3CHD, 45 McMahon Drive, Irwin, Pa. 15642.

TELETYPE MODEL 28 MANUALS: Bulletin 270B, Vol. 1, Service / adjustments, $10 each. Vol. 2, parts, $5. Bulletin 269B, Projector Set, $5. AN/FGC 25, 26, 57 depot maintenance manual TM11-5815-244-35/TO31W4-2FGC-232, $7 each. Postpaid. Kernaghan, 1911 Halekoa Drive, Honolulu, HI 96821.

THE FOUNDATION FOR AMATEUR RADIO, INC. announces the annual award of the John Gore Memorial Scholarship for either graduate or undergraduate study. The Scholarship pays $500 for the academic year. Licensed radio amateurs who intend making a career in electronics or related sciences may now request the application for the academic year 1970-1971. Requests should be addressed to the Chairman, Scholarship Committee, 8101 Hampden Lane, Bethesda, Maryland 20014. Requests for applications must be postmarked prior to May 31, 1971. To be eligible for the award, applicants must have completed at least one year in an accredited college or university and must be enrolled in a course of studies leading to a degree. They must also be radio amateurs holding a valid FCC license of at least a general class level. Preference will be shown to applicants from the District of Columbia, Maryland and Northern Virginia; however, applicants wherever resident are eligible.

COLLINS S LINE and other gear for sale, SASE for complete list. J. Lynch, Box 9638, 533 East Dunlap Ave., Phoenix, Arizona 85020.

HT-37 LIKE NEW, in perfect condition $150. Bob Ensminger, 11388 Campus, Loma Linda, Calif. 92354.

WANTED HRO COILS A, B, D, and E. Advise condition and price. WA6QVS, 428 - 28th Street, Richmond, Calif. 94804. (415) 232-3427.

1 TR4 DRAKE at ½ price. Like new, used very little. Dropping my license. K4CNT, Thomas B. Peeler, 1873 Waverland Dr., Macon, Ga. Phone 912-742-1326.

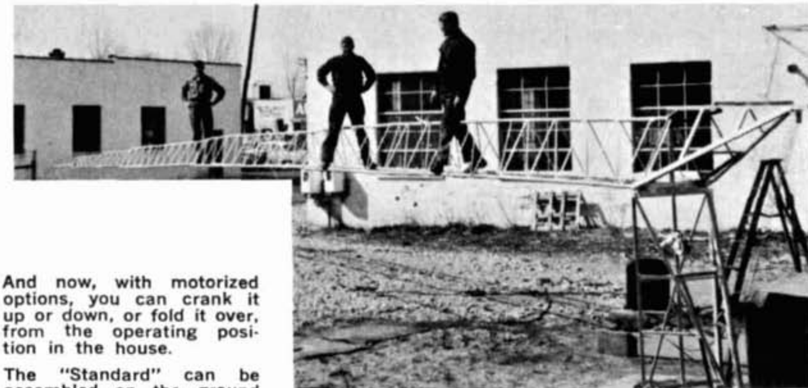
YOUR AD belongs here too. Commercial ads 25¢ per word. Non-commercial ads 10¢ per word. Commercial advertisers write for special discounts for standing ads not changed each month.

More Details? CHECK—OFF Page 94

The STANDARD, by Heights

THE MOST IMPORTANT FEATURE OF YOUR ANTENNA IS PUTTING IT UP WHERE IT CAN DO WHAT YOU EXPECT.

RELIABLE DX — SIGNALS EARLIEST IN AND LAST OUT.



And now, with motorized options, you can crank it up or down, or fold it over, from the operating position in the house.

The "Standard" can be assembled on the ground with nothing more than a *wrench and a spade.* No guys, no climbing necessary. Strong and beautiful.

See your local distributor, or write for 12-page brochure giving dozens of combinations of height, weight and wind load.

NOW In New Larger Facilities to expedite your orders.

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Almont Heights Industrial Park
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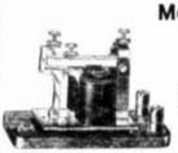

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Non-profit - Historical
Fraternal
Dues $2 per annum
Write: S. L. McLean, GS&T
5125 Arvada Street
Torrance, Ca 90503

OUR APOLOGIES

Our ad for the Two Meter SSB Transmitter on page 77 in the March **Ham Radio** should have read:

"Circuit board Only $4.95 plus 25¢ shipping"
SPECTRUM INTERNATIONAL
Box 87, Topsfield, Mass. 01983

THE BIGGEST SIGNAL

Patent D 219106

Unconditionally guaranteed

GREENE . . . center insulator . . . an absolute water tight sealed assembly . . . with or without **BALUN.**

Greene center insulator with **BALUN**	**$15.00**
Greene center insulator no balun	**$10.00**
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Flier **FREE**	**postpaid U. S. A.**

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FREQUENCY STANDARD

Only
$32.50
(less batteries)
POSTPAID USA

- ***Precision crystal***
- ***Fully guaranteed***

- ***Markers at 100, 50, 25, 10 or 5 kHz selected by front panel switch.***
- ***Zero adjust sets to WWV. Exclusive circuit suppresses unwanted markers.***
- ***Compact rugged design. Attractive, completely self contained.***
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YOU CAN PROVIDE EYESIGHT FOR SOMEBODY

Over 100,000 people do not have sight because not enough other people have been willing to have their eyes used for this purpose when they die. It requires planning with one's family and doctor so that there is no delay when the time comes. Eyes must be removed within 4 hours after death and the corneas used for transplantation to their new owners within the next 24 hours.

This is where the Eye Emergency Network is so helpful – making it possible for hospitals having eyes available, and those needing eyes, to become known to each other quickly. Then the M.D.'s talk privately by telephone to determine the suitability of the eyes and how they shall be shipped and delivered.

The need for eyes is international. During the past year one collecting group in Baltimore supplied eyes for 57 hospitals in the U.S.A., and for hospitals in Alaska, Europe, Asia and the S.S. "Hope", thanks to the speed of our modern jet aircraft.

MILLIONS OF PLEDGES ARE NEEDED

– K1RA

More Details? CHECK–OFF Page 94

USED TEST EQUIPMENT

All checked and operating unless otherwise noted, FOB Monroe. Money back (less shipping) if not satisfied.

Beckman 5500-100kHz counter-timer	125
Boonton 202D-175-250mHz sig gen	285
Boonton 207E-Univertor for sig gen	95
GR736 A-Wave analyzer	249
GR821A-Twin-T Imp. bridge	235
GR1603A-Z-Y bridge	176
Gertsch FM3/PS3 20-1000MHz freq mtr	275
HP120AR-200kHz scope	135
HP175A-50mHz scope-main frame only	450
HP524B-10mHz freq counter	325
HP524B-W/plug-in to 100mHz	[illegible]85
HP525A-10-100mMz plug-in for above	115
HP525B-100-220mMz plug-in for above	135
HP525C-100-500mMz plug-in for above	225
HP526B-Time interval plug-in for above	65
HP608A-10-500mHz stand sig gen	400
Meas 65B-75kHz-30mHz sig gen	265
Meas 82-20Hz-200kHz, 80kHz-50mMz stand sig gen	275
NE Eng 14-20C-10mHz freq counter (as is less time standard)	180
NE Eng 14-20C-complete, checked	295
NE ENG 14-20C-W/plug-in to 100mHz	355
NE Eng 14-21C-10-10mHz conv for abv	114
NE Eng 14-22C-100-220mMz conv for abv	135
NE Eng 14-24C-Time interval conv for abv	65
Tektronix 513D-20mHz scope	275
Tektronix 517A-Hi-speed scope	545
URM25E-10kHz-50mHz stand sig gen	215
USM24C-8mHz time base scope	125
USM50-22mHz time base scope	145
USM105A-Mil version HP160 scope w/dual trace plug-in	550

(Send SASE for complete list)

GRAY Electronics
P. O. Box 941 Monroe, MI 48161

Specializing in used test equipment

Digital Frequency Meter

- Monitors your "transmitted" signal
- Measures kHz and MHz
- Operates with any exciter-transmitter (1 to 600 watts — up to 35 MHz)
- Large-bright "Nixie" display
- Now - 100 Hz (.1 kHz) Readout through 35 MHz

FM-6 Kit $119.50

(170 MHz Prescaler - $45.00 extra)

Micro-Z Co.

Box 2426 Rolling Hills, Calif. 90274

KW BALUN KIT STILL ONLY $5!

The AMIDON Toroid Balun Kit makes a modern, compact antenna transformer that can be wired for either 4:1 or 1:1 impedance ratio. The balun is ideal for use between a coaxial feedline and a balanced antenna. It reduces coax radiation and properly balances the energy for application to the antenna's feedpoint. The balun also acts as an isolation device and removes the capacity of the coax from the antenna which extends the low SWR frequency range of the array. Baluns made from this kit can be used to advantage on these antenna types: Dipole, Quad, Beam, Inverted Vee, Windom and Folded Dipole.

SEND FOR FREE FLYER!

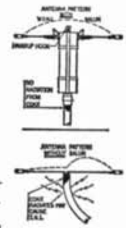
AMIDON Associates

Pack & Post: 50¢

12033 OTSEGO STREET · NORTH HOLLYWOOD, CALIF. 91607

THE BIG SIGNAL

"W2AU" BALUN $12.95



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LET YOUR ANTENNA RADIATE, NOT YOUR COAX.

Now all stainless steel hardware. SO239 double silver plated. Handles full KW input—THEN SOME! Broad banded 3 to 40 Mc. Helps TVI problems by reducing coax line radiation. Built-in Lightning arrester protects balun, could save your valuable gear.

2 Models. 1:1 matches 50 or 75 ohm unbalanced (coax line) to 50 or 75 ohm balanced load. 4:1 matches 50 or 75 unbalanced (coax line) to 200 or 300 ohm balanced load.

Available at all leading dealers, if not, order direct.

$ FOR $ YOUR BEST BALUN BUY

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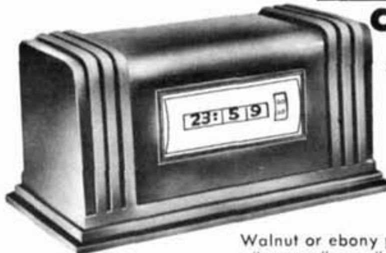

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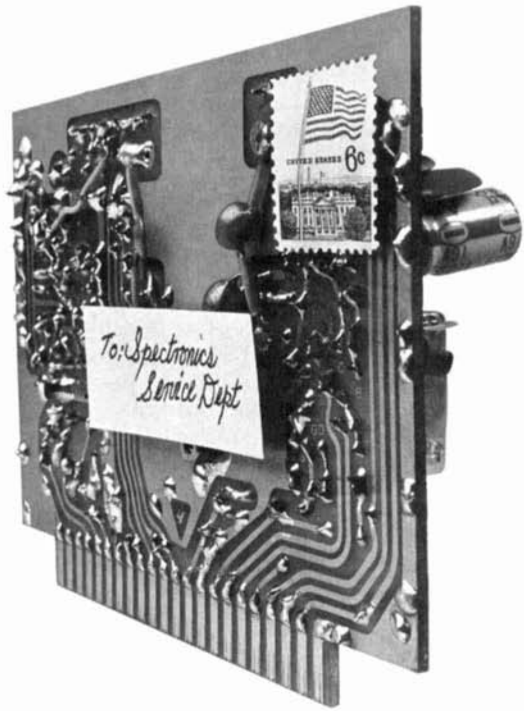

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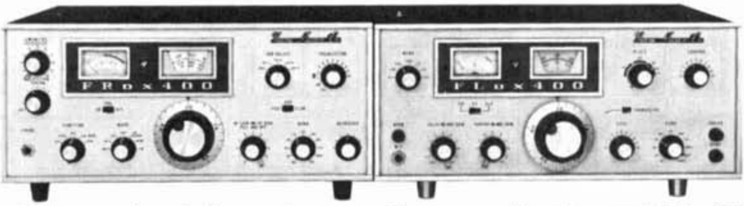

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