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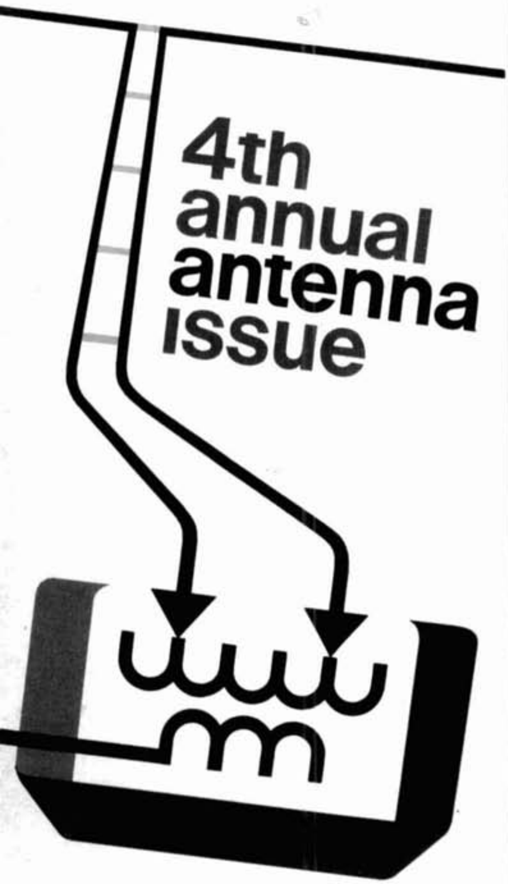

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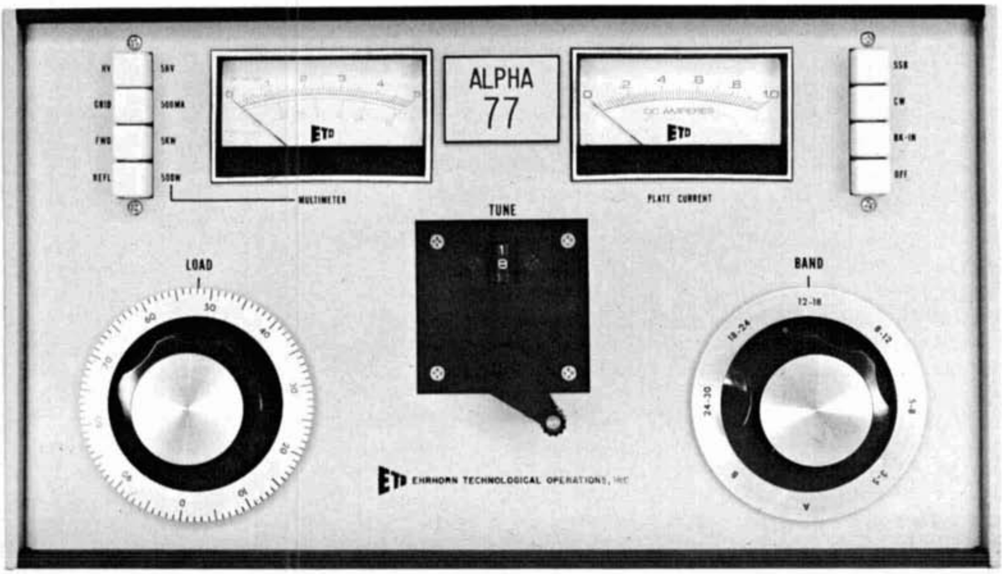

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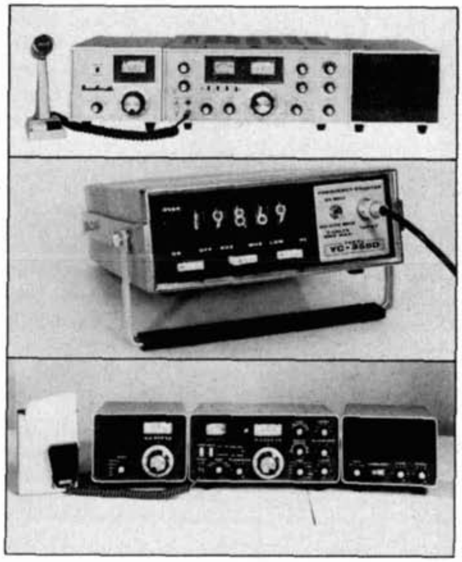

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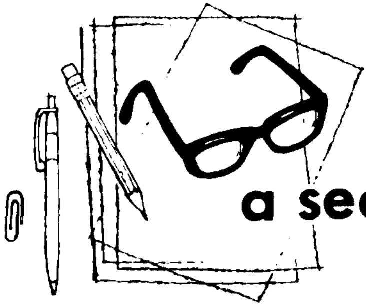

a second look

by jim fisk

One of the more serious problems which has plagued amateurs who operate on the vhf and uhf bands is that of rf interference — interference with television sets, stereo and hi-fi systems, intercoms and even tape recorders, practically any consumer electronics equipment that uses solid-state circuitry. Nor is the condition restricted to vhf. I was involved in a tense situation with one of my neighbors a few years ago when my 20-meter ssb signal wiped out a recording on his expensive solid-state tape recorder. No matter of electronic tricks, other than a big copper shield box, completely eliminated the interference, and the problem was only finally resolved when he and his damn recorder departed for Arizona!

Amateurs are not alone in their plight, either. Television, am and fm broadcast engineers are faced with daily interference complaints from nearby homeowners who don't particularly appreciate the cacophonic symphony of football telecast interference to "Saturday Afternoon at the Opera," or vice versa.

What is needed is Congressional or FCC action to require all manufacturers of tv sets, stereos and am receivers to build interference suppression into their designs. Some lead bypassing and narrow filters at the input would go a long way toward solving the present problem.

Last year, Congressman Charles M. Teague of California introduced a bill in Congress which would amend the Communications Act of 1934, requiring that "apparatus designed to receive broadcasts" would meet FCC standards to be adopted so that "all interference from any amateur station operating on its assigned frequency will be filtered out." Unfortunately, no action was taken by Congress before it adjourned.

However, Mr. Teague has re-introduced his bill to the 93rd Congress (HR 3516) so we may have some action this year, but getting the bill re-introduced is a small part of the battle. First, the Chariman of the House Interstate and Foreign Commerce Committee must be convinced to call a hearing on the bill. To do that we will need a lot of letters. Once approved by the Committee, the bill can be presented to the members of Congress for a vote. However, all this will require a massive letter-writing campaign. You can bet that the manufacturers will be lobbying against any legislation that will make their product more complex or more expensive, so amateurs will have to work extra hard to gain favorable and speedy Congressional action.

Right now, while you're thinking about it, write a letter to Mr. Staggers, Chairman of the House Interstate and Foreign Commerce Committee, as well as to your own Congressman, indicating your support for HR 3516. Letters of support should also be sent to Mr. MacDonald, Chairman of the Communications and Power Sub-Committee; in all probability it is this Sub-Committee which will hear HR 3516. The addresses *are given below.*

The Honorable Harley O. Staggers
Chairman, House Interstate and
Foreign Commerce Committee
2366 Rayburn Building
Washington, D.C. 20515

The Honorable Torbert H. MacDonald
Communications and Power
Sub-Committee
Room 2125 Rayburn Building
Washington, D.C. 20515

Because of the importance of this bill to amateurs, I will make petitions available to interested readers who send me a self-addressed, stamped envelope. This petition can be circulated among your friends and neighbors. We need all the help we can get.

Jim Fisk, W1DTY
editor

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low-cost
RX impedance bridge

Complete calibration and application information on the simple W2CTK impedance bridge

Bill Wildenhein, W8YFB, 41230 Butternut Ridge, Elyria, Ohio 44035

In the September, 1970, issue of *ham radio*, W2CTK described a simple impedance bridge capable of independent readout of R and X values.[1] Readers familiar with laboratory bridges will appreciate the potential of this instrument, but may doubt the accuracy of such a simple device. Less experienced readers may have shied away from this bridge since the original article showed only the use of Smith charts to interpret the bridge readings.

This article is written to compare the accuracy of W2CTK's bridge with a Boonton 250A. Some construction points are clarified, techniques are presented to substantially improve measurement accuracy, a wider range of applications is presented, and a step-by-step procedure is included for those who are unfamiliar with bridge calculations.

construction

First, let's tackle construction: **Fig. 1** shows the complete schematic of the impedance bridge, but only a part of the schematic will affect accuracy. **Fig. 3** shows the basic bridge. This portion is the heart of the unit and should be wired with short, heavy leads. A suggested layout is shown in **fig. 4.** The photograph may help with parts placement. Notice that the rear of the panel around the basic bridge has been stripped of paint to insure good grounding of bridge components. Be sure to use a *composition*-type potentiometer; a wirewound pot is completely useless.

A pot with a linear taper will result in the most useful dial calibration. The 56-ohm resistor can be any value from 47 to 68 ohms with no affect on final accuracy, once the R dial is calibrated with that particular resistor. Of course, this resistor must also be a composition type. Some wirewound resistors look like composition types, but are identified with one extra wide color band. Some, made during the Great War and sold surplus for years afterward are, in fact, wirewound, but do *not* have the identifying color band.

The variable capacitor can be any value from 150 to 365 pF. The lower values will limit the X range of the bridge, but have slightly better dial readability. The upper ranges have the opposite characteristics. Any of the values will result in an accurate bridge, but a 250-pF capacitor is about optimum. The diode can be any germanium type, similar to a 1N34. The .005-μF disc capacitor and the diode should have very short leads. Heat sink the diode while soldering it in place.

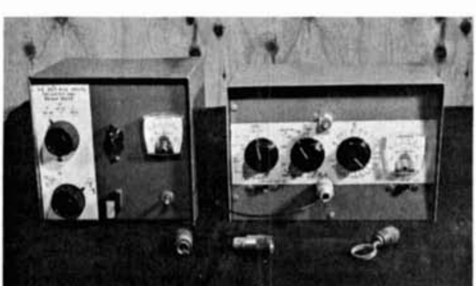
calibration

For convenience I will go over the calibration procedure. First, connect the basic bridge as shown in **fig. 5.** This hookup allows calibration of the R pot with dc. W2CTK is correct in his statement that rf measurement accuracy will not be impaired with this procedure. The rather shallow null obtained with this bridge is the major source of error, and will limit you to about 5% of calibration accuracy on both R and X measurements. Total error consists of this 5% *plus* the percentage error of resistors and capacitors used to calibrate the bridge.

For convenience, the battery can be fed into the RF IN jack. The 10k resistor is included so you don't bang the meter hard if the bridge is badly unbalanced. Connect a known resistor across the LOAD jack. Lead length is of no consequence here, since this is a dc calibration. For the same reason, wirewound precision resistors are also permissible. Touch the end of the 10k resistor to the center pin of the RF IN jack. Adjust the 100-ohm pot to bring the meter down to zero. Near zero you can touch the battery end of the 10k resistor to the center pin to improve the sensitivity of the adjustment.

If you continue turning the pot in the same direction, it will go below zero. The correct point is where the meter needle just reaches its zero resting position. Mark the R dial with the value of resistance you used for reference. Repeat the procedure for various resistors, or combinations of resistors, to obtain as complete a calibration as you wish. If you use new 5% resistors, your probable accuracy of R readout will be 10%.

Best R range for this bridge is approximately 20-ohms to about 3000 ohms.



Homemade RX impedance bridge, right, and rf source, left.

Below 20 ohms you may be limited by available X dial range – even with an essentially resistive load. Above 3000 ohms the dial graduations become quite close together, limiting the accuracy of readout. My bridge is calibrated to 5000 ohms, but it is difficult to get precise readings at that point. If you wonder about the variable capacitor in the circuit during this part of the calibration, forget it. It merely forms a convenient connection to the load jack.

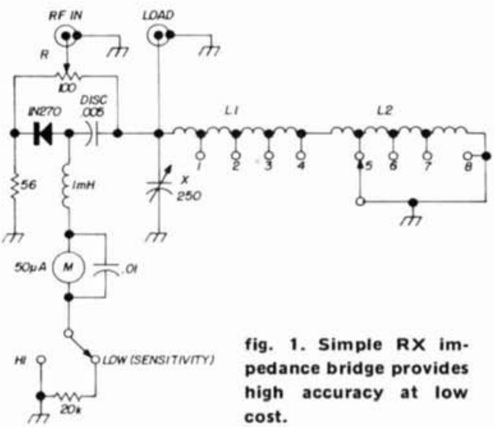


fig. 1. Simple RX impedance bridge provides high accuracy at low cost.

After R dial calibration is complete, disconnect the lead from the variable capacitor to the 100-ohm pot. The variable capacitor is now the only component connected to the LOAD jack. The easiest way to calibrate the capacitor is to connect a capacitor bridge to the load jack and calibrate the capacitor in about 10-pF increments from 250 to 100 pF, and in 5-pF increments below 100 pF. There is no need to be concerned about stray capacitance here, so long as it is minimized. You are interested primarily in the difference between two readings, not so much the absolute value.

If you have no capacitor bridge available, you can get an excellent calibration using the external hookup shown in **fig. 6.** A coil is connected to the load jack with provision for placing reference capacitors across the LOAD jack. A source of rf power is link coupled to this coil, and a vtvm ac probe is connected across the coil to read the peak voltage when the coil and X dial capacitor is resonant at the rf input frequency.

The important thing here is to make a rigid setup, mechanically. The coil and coupling link must be quite rigidly held with respect to one another. The rf source must be stable. The entire setup must be held in a fixed position relative

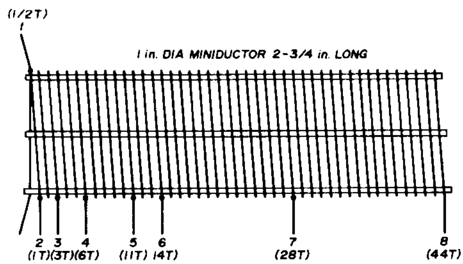


fig. 2. Construction of L1 and L2 in the RX impedance bridge.

to the metalwork of the impedance meter to minimize variations in distributed capacitance.

The coil can be a 3-inch length of 1-inch diameter 16-pitch Miniductor. Later, this same material can be used for the bandswitched coil, so there is no loss. Cut the coil wire about 3 turns in from one end. Heat the ends and push them out of the support bars to provide connecting leads an inch or so long. Do not cut the plastic support bars between the two coil segments. They will help maintain the coupling. Mount the coil as shown in **fig. 6**.

With the setup of **fig. 6** assembled on a scrap of wood and connected to the LOAD jack of the impedance meter, first set the 250-pF X dial capacitor to maximum capacitance. Mark the dial accurately to indicate maximum. (It is advised to do the same for the R pot. This gives you a reference point in case the dial setscrews loosen and it is necessary to reposition them without re-calibrating.)

Feed an 80-meter rf source to the link and adjust the coil tap for a peak reading with the X dial capacitor at maximum. When this point is found, it must be maintained for the balance of the capacitor calibration. Solder it carefully in place. Connect, say, a known 100-pF capacitor to the binding posts. Re-peak the vtvm with the X dial capacitor. That point is 250 minus 100 pF = 150 pF. With only two 100-pF, one 50-pF and one 25-pF mica capacitor you can calibrate a 250-pF bridge capacitor in increments of 25 pF throughout its range. With care, you can estimate the intervening 5- or 10-pF increments with acceptable accuracy.

It would be worthwhile to buy this group of capacitors new in 5% tolerance or better. (These are available in silver mica to 1% quite reasonably.) If you use a grid dipper for this calibration you will find the dipper frequency pulls as the X dial approaches resonance, making it difficult to maintain exact frequency. For that reason it is better to use an 80-meter crystal-controlled oscillator.

This completes the calibration. You can now complete the wiring of the bridge. **Fig. 2** shows a suggested coil made from the Miniductor coil stock. If you used other than the suggested 250-pF variable capacitor the tap points will have to be changed. The only criterion for selecting tap points is this: On each amateur band from 3.5 to 30 MHz set the taps so that the band can be tuned at near maximum (about 200 pF) and near minimum (about 50 pF). This is necessary to get best X dial range in measurements. The easiest way is to unsolder one end of the wire from the 100-ohm pot to the variable capacitor, install the coil, then set each tap using a grid dipper. (The 100-ohm pot would swamp the tuned

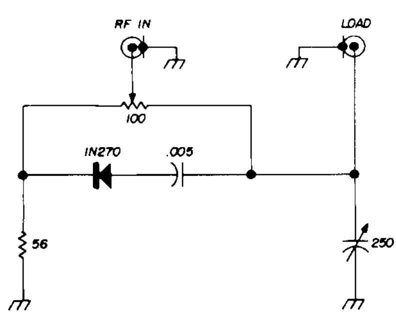


fig. 3. Basic circuit of the impedance bridge.

circuit if left in, and would make it difficult to find a dip.) Unsoldering and re-soldering this lead will not affect bridge calibration if the wire is carefully repositioned.

rf source

The next concern is a source of rf to drive the bridge. Most solid-state dippers will lack the power necessary to do a good job. Some vacuum-tube grid dippers will also be marginal. In any case, a dipper has poor stability, so I would advise building an all-band crystal oscillator. The one shown in **fig. 7** covers 3.3 to 33 MHz with fundamental FT-243 surplus crystals. It will operate on the fundamental, second, third or fourth harmonic and provide ample drive for the impedance bridge. In my case I use a pair of 80-meter crystals and a pair of 40-meter crystals to do 90% of my work.

Layout is not critical. Just keep your rf leads short and direct, and your bypass capacitors installed with short leads. It is worthwhile to use up some of the old vacuum-tube gear in the junkbox on projects like this. Take an evening to do the metalwork nicely! It can be housed in a wrap-around made from a discarded piece of galvanized iron flashing. A spray can of gray lacquer will give it a professional touch. This oscillator will find many other bench uses other than as a bridge driver. For example, it can be used as a driver for experimental solid-state power amplifiers, as a temporary local oscillator for converters or transmitter mixers, as a frequency marker, as a QRP CW transmitter, etc. I find it useful as an rf source for calibrating wavemeters for novices and as a reference antenna driver in antenna tinkering. If you have an old set of plug-in coils, they can be used with somewhat improved efficiency.

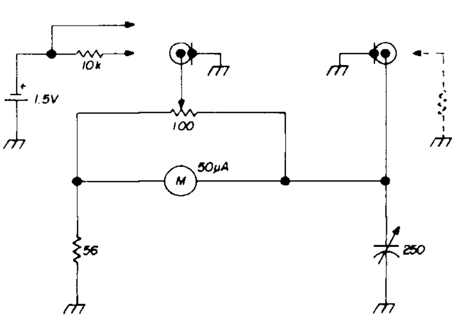


fig. 5. Test setup for calibrating the R potentiometer.

bridge operation

Now, let's put the bridge to work. The following abbreviated procedure will be followed with some notes on methods of improving accuracy and interpretation of the results.

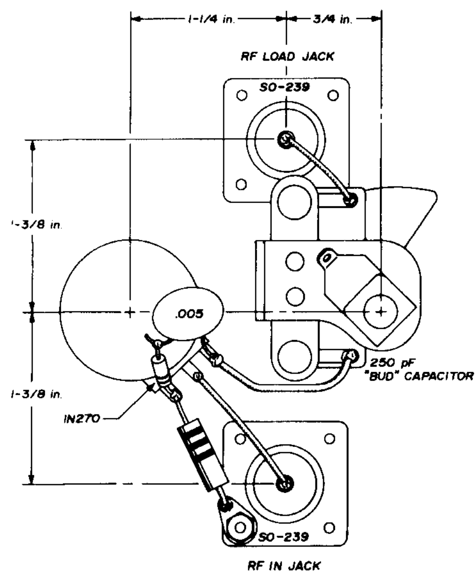


fig. 4. Suggested layout of the bridge resistor and capacitor.

initial balance

1. Set the R dial to maximum resistance.

2. Feed rf at the desired frequency into the RF IN jack.

3. With nothing connected to the LOAD jack, alternately vary the R and X dials for best null.

4. Note the exact reading in pF on the X dial.

measurement

5. Connect the unknown load to the LOAD jack.

6. Again adjust the R and X dials for best null.

7. Note the exact readings of the R and X dials.

8. The R dial reading obtained in **step 7** is

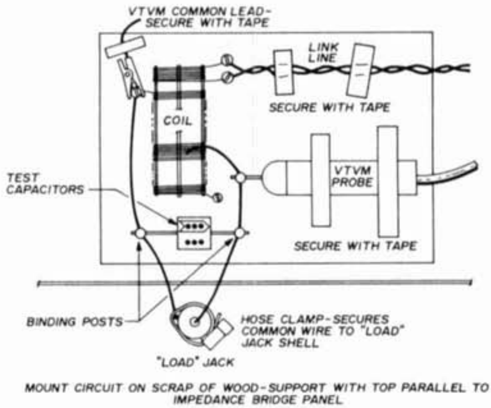


fig. 6. Test setup for calibrating the X capacitor.

the actual resistive component of the load. The *difference* between the X dial reading of **step 4** and the X dial reading of **step 7** is the reactive component of the load (C_p).

9. If both X dial readings are the same the load is purely resistive.

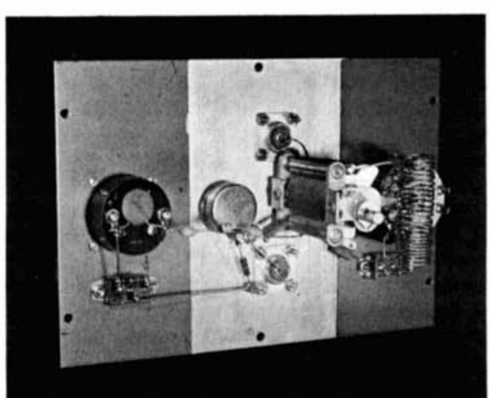
10. If the X dial reading of **step 7** is a higher capacitance than in **step 4,** the load is *inductive*. If the **step 7** reading is lower, the load is *capacitive*.

A little trick I use to get the best null is to view the meter from an angle so a little slit of white background shows through between the meter needle and the zero mark on the meter. In this way very small meter variations can be seen. You will find that by using a crystal-controlled oscillator for the bridge driver the X dial reading in **step 4** will be very accurately repeated, so once you know that number of pF for a given amateur band on a given bandswitch position, you can use the same crystal and skip the initial balance procedure. This is a big help when many measurements are necessary.

For example, I had an experimental tilted longwire antenna I wished to prune for best compromise on a number of bands. Since each pruning required a walk down the valley to the willow tree and back, it could be a full afternoon of work. However, knowing accurately what the X dial would be for initial balance setting it was possible to make a fast measurement on all bands from 80 through 10 meters and really see where the antenna was resonant. Inside of an hour I had it accurately set.

If, in **step 6,** you find it impossible to obtain a null, it means you ran out of X dial range. For example, if the X reading obtained in **step 4** were 25-pF and your load was *capacitive* by 50 pF obviously you would run out of dial range. So, switch to another bandswitch position, repeat the *initial balance,* and perhaps now the reading in **step 4** will be 200 pF. Again bridge the unkown load, and this time (assuming the load was 50 pF capacitive) the X dial will read 50 pF lower than the initial balance setting and you will have no trouble finding a null.

Of course, if the load is horribly reactive, it may be impossible to find any null. You could then grid dip the load to try to find where it was resonant, and this will tell you which way to go to get the load into the bridge range. If the load cannot be easily grid-dipped, you can



Construction of the RX impedance bridge.

make bridge measurements at other frequencies to find a frequency where it does fall within the bridge range. This same problem is common in laboratory impedance bridges. The Boonton 250A doesn't have nearly as much X dial range as W2CTK's simple bridge.

homebrew bridge and calculated it will look *like* 21.35 ohms. Try to approach that kind of accuracy with an *antennascope* or other simple impedance bridge.

However, I felt that, although the difference in impedance measurement was negligible, many experimenters might

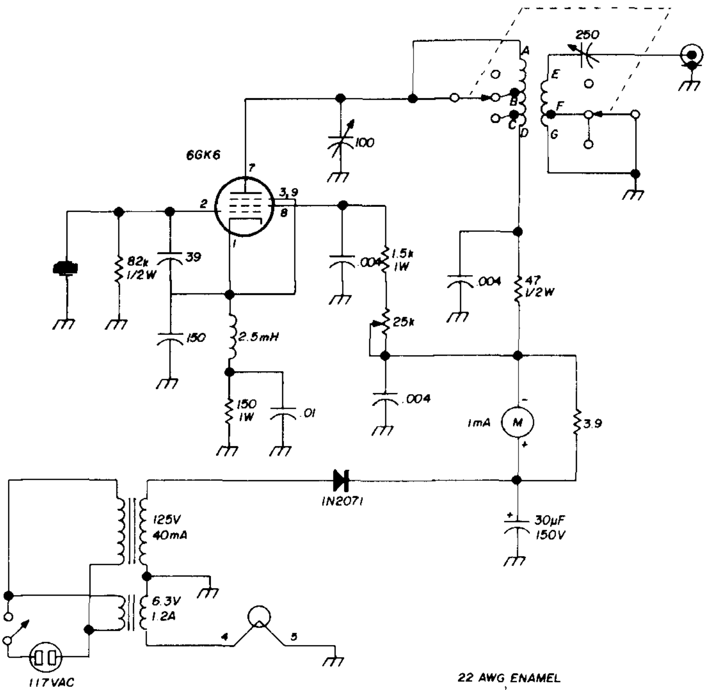
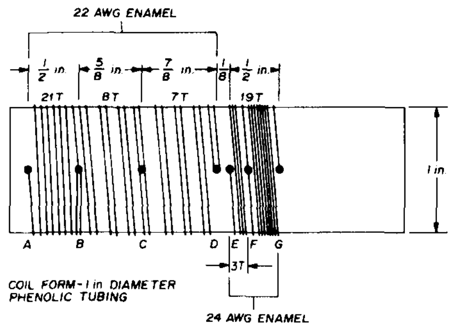


fig. 7. Circuit for the 3.5- to 33-MHz oscillator/multiplier used as an rf source with the RX impedance bridge.



From a point approximately 150 or 200 ohms and higher on the R dial the foregoing procedure will yield excellent accuracy. Below about 150 ohms an error creeps in which will add approximately 5% additional error, at worst. The X dial does not follow a Boonton 250A. At first glance the error appears to be large, but it is not. For example, a 22-ohm resistor measured with the Boonton measured 60-pF inductive. With the homebrew bridge it measured 130-pF inductive. From the worked-out formulas in **table 1** you see that resistor (as measured by the Boonton) results in an actual impedance of 21.82 ohms. As measured by the

like to correct the bridge to read out very closely with a laboratory bridge. In this way a low-impedance load could be measured and the nearly correct reactance could be found that would make the network a pure resistance. In **fig. 8** resistors of different manufacturers, in 1/2-, 1- and 2-watt sizes and all values from 18 to 2200 ohms were checked on the Boonton and on the homebrew bridge. In all cases lead length was held to one-half inch. The line marked *A* is the results with the Boonton. Incidentally, the slope of the lines implies a constant series inductance of .0268 Microhenry; this is the resistor lead inductance.

You can construct a similar correction graph for your bridge if you wish. On a piece of 2x2 cycle log graph paper lay out the curve *A* line from a point 16.5 ohms on the top line to a point at 165 ohms on the bottom line. Now, select a number of *composition resistors from your junkbox* — values from 22 to 100 ohms. Carefully measure these on your bridge at 14 MHz using half-inch leads protruding from points of contact with the load jack. The C_p values are the values of capacitance *which are the difference between the initial balance* value and that obtained in actually measuring the resistor. The R_p values are those read off the R dial when bridging the resistor. Plot these values for a number of resistors. Then draw a line *parallel to the A line and* through the approximate average point of your values.

To use the chart refer to **fig. 8:** That chart says that at 55 ohms the Boonton would read 9 pF, but mine would read 22.5 pF. If my R_p reading is 55 ohms, my C_p reading will probably be about 13.5 pF too high. Incidentally, as you tinker with this bridge, perhaps measuring the same resistor on each band, you may suspect something amiss when you consistently get the same value for C_p. You might suspect this number to be frequency dependent, but it is not. If you ran that same resistor through the range on a Boonton, you would find a slight downward shift in R_p as you go from 3.5 to 28 MHz (perhaps shifting from 28 to 27 ohms) but the C_p value would consistently hang in there.

A load which is not nearly pure R (as these are) will show the expected variations in C_p with frequency. If you feel that the half-inch lead length is gilding the lily, first bridge the resistor with full lead length, then repeat the measurement with half-inch leads. Don't be surprised if the C_p value of a 27-ohm resistor shifts as much as 50 pF. This effect is most noticeable at low resistances (50-ohm lines, etc.) and should serve as a warning of what can happen with sloppy clip lead lashups. I've seen otherwise competent engineers and technicians completely *blow an rf measurement* due to lack of feel for these little details.

If you are an engineering student, you will find this little bridge a valuable help in getting acquainted with rf measuring techniques. The Boonton RX meter goes all the way to 250 MHz, so you can appreciate the fact that it can get pretty hairy at times to get valid measurements.

using the bridge

Now, let's look at the business of *making sense out of the numbers you get* from your bridge. **Table 1** is a set of formulas with worked examples to give you another method beside Smith charts as explained by W2CTK. The formulas assume F = MHz, R, X and Z in ohms, C in pF. *you may wonder what ω represents.* It is 2πF. A handy little trick in amateur work is to remember that, for the low end of the bands, on 3.5 MHz, ω = 22, at 7 MHz, ω = 44, at 14 MHz, ω = 88, 21 MHz, ω = 132, 28 MHz, ω = 176.

The homebrew bridge reads a load in *parallel* values. The example in **table 1** is for an almost pure resistance. It will be seen that the bridge read a 22-ohm resistance with a 56-pF capacitor in parallel. Actually, the 56 pF was in an *inductive* direction. This is the same as saying, "What coil in parallel with 56 pF will be resonant on 14 MHz?" You could find this on an ARRL Type A Lightning Calculator in less than 5 seconds. In the same length of time the calculator also says it would be a half-inch diameter coil, 1-3/4-inches long, 28 turns. You *know* a coil of those dimensions wouldn't likely be inside that resistor! If you are completely unfamiliar with the calculations you might be inclined to think it is a wire-wound resistor.

However, look at **table 1** and find the parallel reactance; it is 203 ohms. Such a large value of reactance in parallel with such a small resistance will hardly affect the resistance. It is the same as hanging an rf choke across the end of a pi network for safety. The pi net sees only the 50 ohms. If you continue down to the first calculation for impedance you see the carried out all your calculations to a number of significant figures both impedances would have come out identically. This last set of values sounds more reasonable! In fact, you actually do have a 21.74-ohm resistor in series with a pair of tiny coils (the resistor leads).

Now, suppose you had been using this

table 1. Mathematical formulas which may be used with the impedance bridge if you do not use a Smith chart. In all examples f = 14 MHz, Rp = 22 ohms, Cp = 56 pF and $\omega = 2\pi f$.

1. Parallel reactance $Xp = \frac{10^6}{\omega Cp} = \frac{10^6}{6.28 \times 14 \times 56} = \frac{1\,000\,000}{4928} = 203$ ohms

2. Parallel inductance $Lp = \frac{Xp}{\omega} = \frac{203}{88} = 2.30$ microhenries

   or $Lp = \frac{.159160\ Xp}{F} = \frac{.159160 \times 203}{14} = \frac{32.3}{14} = 2.30$ microhenries

3. $Q = \frac{Rp}{Xp} = \frac{22}{203} = 0.1083$

4. $Q^2 = 0.0117$

5. Absolute Impedance $|Z| = \frac{Rp}{\sqrt{1 + Q^2}} = \frac{22}{\sqrt{1.0117}} = \frac{22}{1.008} = 21.82$ ohms

6. Equivalent series resistance $Rs = \frac{Rp}{1 + Q^2} = \frac{22}{1.0117} = 21.74$ ohms

7. Equivalent series reactance $Xs = \frac{Xp\,Q^2}{1 + Q^2} = \frac{203 \times 0.0117}{1.0117} = 2.347$ ohms

8. Equivalent series inductance $Ls = \frac{Cp\,Rp^2}{(1 + Q^2)10^6} = \frac{56 \times 22^2}{1.0117 \times 1\,000\,000} = 0.0268$ microhenry

9. Absolute Impedance $|Z| = \sqrt{Rs^2 + Xs^2} = \sqrt{21.74^2 + 2.347^2} = \sqrt{478.1} = 21.85$ ohms

10. Equivalent series capacitance $Cs = Cp\,(1 + \frac{1}{Q^2}) = 56\,(1 + \frac{1}{.0117})$

    $= 56\,(1 + 85.4) = 56 \times 86.4 = 4838.4$ pF

    or, $Cs = \frac{159160}{F\,Xs} = \frac{159160}{14 \times 2.347} = \frac{159160}{32.858} = 4840$ pF

total impedance of the 2.3 microhenry inductance in parallel with a 22-ohm resistance is 21.82 ohms. The coil hardly made any change.

Any parallel network can be converted to an equivalent series network or vice versa. From **table 1** you see that an equivalent series resistance of 21.74 ohms in series with an equivalent series inductance of 0.0268 microhenries results in an impedance of 21.85 ohms. Had you bridge to measure a wide-band balun for your antenna. Suppose the balun was supposed to look like 22 ohms. Unless you have a feel for the effect of reactance you might have felt the balun was junk, while, in fact, it was almost a perfect match! For that reason it is worth taking the time to work out enough examples to get familiar with the arithmetic. Then, since the little bridge is quite accurate, you can be very sure of your results.

The impedance was figured in two ways to provide you with a means of back-checking your work. Whenever you convert from parallel to series values it will be worthwhile to use this as a proof that the series values were correctly figured.

How else can you use these numbers? Suppose you made a mobile antenna out of some odd scrap. You could end up with somewhat similar numbers to those

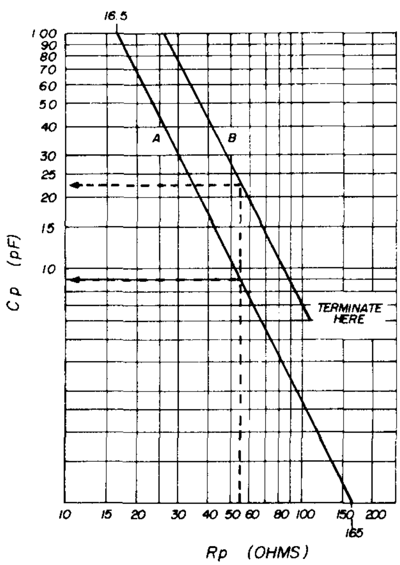


fig. 8. Calibration curves for the homemade impedance bridge (B), and a commercial Boonton 250 RX meter (A). These same curves can be plotted for your own bridge. See text.

in the example. If the antenna looked like 22 ohms in parallel with 56 pF *inductive,* you could make it 22-ohms resistive by merely hooking a 56-pF capacitor from whip to ground. If it looked 56-pF *capacitive* you could hook a 2.3-microhenry coil between whip and ground. Or, you could use the equivalent series values. If it showed 56-pF *inductive* on your bridge you could put about 5000-pF in series with the lead from the whip to the coax. If it looked *capacitive* you could put a 0.0268-microhenry choke in series from the whip to the coax. Of course, this example is pretty ludicrous, since it would be foolish to correct such a tiny inaccuracy. However, it gives you an idea of how very close you can work in antenna matching with this simple device.

applications

Another application would be to transform that 22-ohm whip to 50 ohms to match a transmission line. You might look up the arithmetic of L networks in the ARRL Handbook, but perhaps you are a bit unsure that the values you figured were correct. In such a case you can use the bridge backwards: Connect the L network to the whip, make the initial balance on the bridge, and connect it to the 50-ohm side of the L net. Set the R dial of the bridge at 50 ohms. *Don't touch the bridge!* Diddle the L network until the bridge nulls.

Perhaps you have an 80-40 dual dipole and want to include a balun to divorce your line from the antenna, but you can't afford the cost of the big toroid. Take a fat loopstick from a junked BC set and wind your 1:1 balun on it. Of course, you have no idea of the characteristics of the loopstick material. Connect one end of the balun to the bridge and solder a 51-ohm composition resistor to the other end. Vary the number and spacing of turns until it looks good. Remember that with a 51-ohm impedance it takes a fair amount of reactance to ruin the final impedance. Once the balun is done, put a dab of epoxy on the wire ends to hold them in place and you are in business at practically no cost.

Perhaps you built a little synchrodyne receiver and used an unmarked surplus toroid of unkown characteristics for an antenna coil. The set works fine except that when it's connected to a 50-ohm line it went dead. Don't spend a lot of time guessing the proper turns ratio! Perhaps the IC you were using called for 400 -ohms for best noise figure. Put a 390-ohm resistor across that winding, then bridge the antenna winding. When you get it around 50 ohms, non-reactive, put the receiver on the 50-ohm line and it will perform.

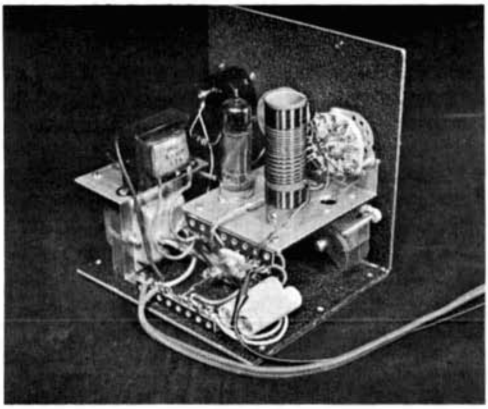
Perhaps you built a kilowatt linear from your junkbox. You carefully designed the pi network, but aren't sure the taps are correctly set on the coil to provide the proper plate load to the tube. Leave the linear turned off. Connect a composition resistor of the value you chose for the correct plate load from plate to ground. If the pi net is far from frequency you might not be able to bridge it, so set if for resonance with a grid dipper. Now look into the 50-ohm end of the pi net and adjust it to see if it will show 50 ohms with the capacitor values you calculated. If it does, you can be sure the plate sees the same load as the one you used from plate to ground. This will insure that the efficiency is up to the point you had calculated.

Of course, the impedance bridge is really useful in antenna work, but there are a few odd things you might run into. In the first place, if you bridge the coax at the transmitter end, it doesn't say that the antenna impedance is the same. Only if you take the time to bridge a good half-wave line (or multiple of half waves) and connect the end of that line to the antenna – will you get a valid reading.

W2CTK describes bridging a half-wave line. Essentially, make up one end of the coax, couple it to the bridge, terminate the far end with a 51-ohm resistor, check and snip, reterminate, check and snip until it reads 51 ohms, non-reactive point. Snip tiny pieces off so you don't whiz by!

If you bridge high-impedance antennas, you may run into certain quirks. My long wire showed the usual. The bridge was connected securely to the ground line coming in the basement window. This is a piece of number-4 wire about 3-feet long going to a ground rod outside the window. At that point it branches out with about 1000-feet of buried radials plus another hunk of number-4 to a second ground rod about 10-feet away. On 10 and 15 meters the bridge showed a lot of hand capacitance, and the null was quite dubious. The solution was to take the bridge outside the house, lay down a few strips of broiler foil on the ground, clamp them to the ground stake, clamp the bridge to the foil as close to the stake as possible, then lie down on the foil to put myself as near ground potential as possible. Now I had good nulls and accurate measurements. That 3-feet of number-4 lead was enough to put the bridge *above ground.*

Another odd factor showed up on 80 meters. The null would not go to zero and it wasn't hand capacitance. I shut off the bridge driver and the meter still read upscale. I soon realized that this antenna was quite nearly a quarter-wave long at



Construction of the rf power source.

the frequency of the local BC station. Measuring with my rf voltmeter showed a steady 200,000 microvolts of signal. *That* antenna makes a good one for checking cross modulation of receivers.

conclusion

In conclusion, I feel that this instrument is an extremely useful device for the hamshack. With just a little care in construction and calibration it is remarkably accurate for its simplicity and low cost. I hope that the additional information presented here will encourage others to duplicate the device so that W2CTK can be properly credited with the importance of his little gem.

reference

1. Henry S. Keen, W2CTK, "A Simple Bridge for Antenna Measurements," *ham radio*, September, 1970, page 34.

ham radio

40-meter log-periodic antennas

How to design and build simple, high-performance wire beams that provide 8- to 10-dB gain and low swr over the entire 40-meter band

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In a previous article I described two fixed *log-periodic antennas* of the doublet type which cover the complete frequency range from 14 to 30 MHz.[1] These two antennas are suitable for use on 10, 15 and 20 meters. After that article appeared I received a large number of inquiries from amateurs who were interested in building a similar antenna for 40 meters. Although I didn't have a special requirement for a 40-meter beam, the possibility of building a log periodic for 40, 20 and 15 was interesting and presented a challenge.

Since there was space available between some of the high pines and cedars on my property, the large log-periodic beam shown in **fig. 1** was assembled. To reduce size and weight as much as possible, this log periodic is a *skip-band* type with a portion of the frequency range between 7.0 and 14 MHz deleted. Since this portion of the spectrum is not assigned to the amateur service, it is easily deleted and reduces the number of elements and the length of the antenna.

My available space only allowed a maximum antenna height of about forty feet, so I suspected that the beam would have little gain on 40 meters. However, after running on-the-air tests for a few days, practically all the stations off the front of the antenna reported 8 to 10 dB gain from the 40-meter log periodic as compared with my non-gain 40-meter doublet. Reports from stations off the back of the beam indicated a front-to-back ratio of about 10 dB (signal strength about the same as the non-gain antenna). Gain on 14 and 21 MHz is about 10 dB, and front-to-back ratios are about 15 dB, very similar to the three-band log-periodic previously described in *ham radio.*

forty-meter beams

Since many of the operators who work 40 meters are not interested in the higher bands, I decided to try a log-periodic for single-band use on the 7.0-MHz band. This would use a minimum number of elements and reduce the overall length, but still retain the gain indicated by the 40-20-15 log periodic.

The first 40-meter beam I built used six elements; the gain of this antenna was about 10 dB. Another log periodic was then built with only five elements; signal reports still indicated the same forward gain.

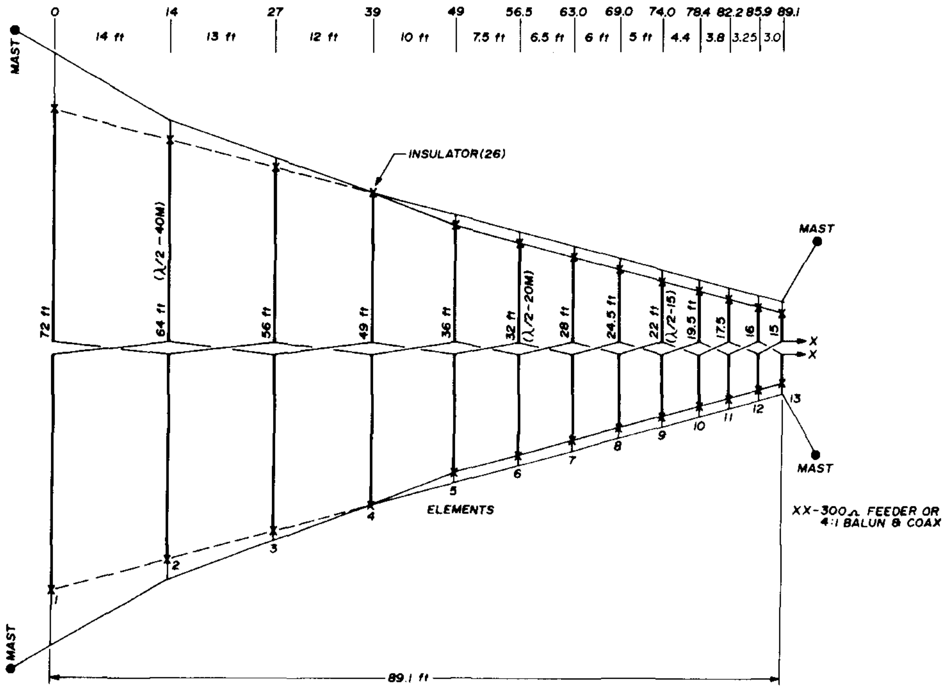

fig. 1. Three-band log-periodic antenna for 40, 20 and 15 meters. Forward gain of this antenna is 8 to 10 dB.

These signal reports were very encouraging, but I wanted to obtain more accurate data, especially front-to-back ratio and side selectivity. As two high trees about 250-feet apart were available to the east of the three-band log periodic shown in **fig. 1**, I decided to put up a 5-element, single-band, 40-meter log periodic. Since only two high trees were available, I decided to use an inverted-vee configuration (center high, element ends low).

This arrangement would probably also

be better adapted to the needs of the average amateur because the antenna could be erected with two telescoping TV masts. With the two masts 60-feet apart, a single 40-meter log periodic can be installed in a space 60-feet wide by 75-feet long.

With inverted-vee construction a center A line between the two masts supports the open center feedline and the

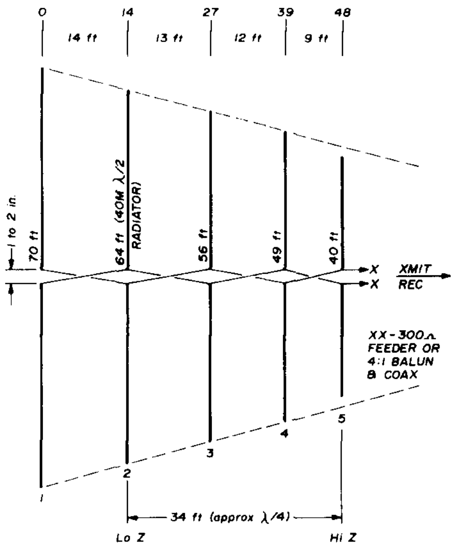

fig. 2. Simple single-band 5-element log periodic for forty meters. This antenna may by used in either the horizontal or inverted-vee configuration.

five elements. Each of the elements droop down about 45 degrees. The dimensions of this antenna are shown in **fig. 2.**

At my station the 40-meter inverted-vee log periodic was installed parallel to the 40-20-15 log periodic, at the same height, but about 150 feet away. By switching between the two beams I was able to determine what losses, if any, I had sustained by going to five elements in an inverted-vee arrangement.

I estimated that I would be lucky to obtain 5- or 6-dB gain with this shortened log periodic, but after about a week of on-the-air tests, I was convinced that there was little or no difference in forward gain between the two antennas. However, the front-to-back ratio of the five-element log-periodic was not quite as good as the 40-20-15 antenna. The signal reports that I received were usually confirmed by the S-meter at my station.

dual log-periodic beam

Another 5-element, inverted-vee, forty-meter section was mounted to the rear of the first beam and headed in the opposite direction (see **fig. 3**). The rear elements of the two back-to-back log periodics were spaced about 20-feet apart. On-the-air tests indicated that forward gain was still 8 to 10 dB. Reports from stations to the rear or off to the side of the antenna are about equal to a non-gain antenna, indicating a 10 dB front-to-back ratio.

construction

Monofilament fish line (40-lb test) is used for the element end insulators and also serve as the element support lines. These lines are brought down to posts or ground anchors. For one of the log periodics which I built I hung a line between several small trees and tied the monofilament end insulators to these. Square lucite insulators **(fig. 4)** are used as center insulators and support the open-wire center feeder.

The most recent log periodics which I have built have eliminated the center A

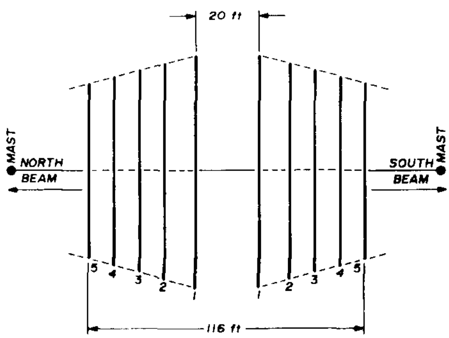

fig. 3. Single-band 40-meter log periodic for north-south communications consists of two back-to-back 5-element antennas (see fig. 2). This antenna, when used in the horizontal configuration, 50-feet above ground, provided 12-dB forward gain.

line. In these antennas the center is supported entirely by the center feeder. However, special precautions are required during assembly if you use this method of construction; the A line is easier if you are building your first log periodic.

It will be noted from **fig. 2** that the open-wire center feedline between the second element and the rear element is approximately one-quarter wavelength long. The feedpoint impedance at the center of the front element is 100 to 300 ohms; the quarter-wave line acts as a transformer between the low-impedance at the center of the second element and the feedpoint at the rear. Three methods of feeding the antenna are suggested:

1. Open-wire tuned line with an antenna tuner in the shack.

2. A broadband 4:1 balun between the log-periodic feedpoint and a coaxial feedline to the shack.

3. 300-ohm TV twin-lead from the log periodic to the shack with a 4:1 balun at the shack with coax to the transmitter. I used this method of feed since my other log periodics are fed with 300-ohm tv line.

performance

Compared with my center-fed 40-meter doublet which is 50-feet high the inverted-vee log periodic consistently provides signal reports 8 to 10 dB better. Comparison with a commercial trap vertical mounted on the roof of the house indicate essentially the same thing. These are not just spotty tests, but are consistent, reliable reports from several old acquaintances in Florida with whom I have been working on 40 meters for several months. They were quite familiar with my normal signal on 40 using the two non-gain antennas before I put up the 40-meter log periodic.

After several weeks of testing I decided to increase the height of the 5-element south beam to at least 50 feet and use horizontal elements rather than the inverted-vee configuration. The results from this change were hard to believe. The signal reports were consistently at least 12 dB better as compared to the doublet, also 50-feet high. All signal comparisons were made when fading was at a minimum and there was no skip.

The front-to-back ratio of the horizontal log-periodic antenna is approximately 12 dB. This is near the possible maximum for log periodics built and tested here over the past two years,

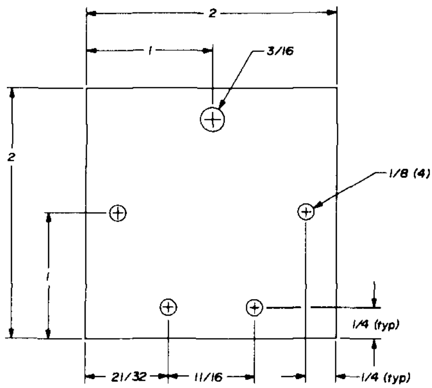

fig. 4. Center insulators for the log periodic antenna. Material is ¼" lucite or plexiglass.

reports from the back and sides are about the same as with the doublet I use as a standard.

As with any horizontal log periodic, the forward lobe is broader (about 100 degrees) than with most beams. This is good when you must use a fixed beam to cover a certain part of the country. Considering that most 40-meter beams are limited to 3- to 5-dB gain, the greater gain of the log periodic is certainly worth considering if you have the necessary space to put one up. By doubling the element lengths and spacing distances it should be possible to make a very excellent 80-meter beam.

I would appreciate hearing from anyone who builds and tests one of these antennas.

reference

1. G.E. Smith, W4AEO, "Three-Band High-Frequency Log-Periodic Antennas," *ham radio*, September, 1972, page 28.

ham radio

high-performance quad-yagi arrays for 432 and 1296 MHz

Complete construction details for rear-mounted Yagi arrays for 432 and 1296 MHz

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With the increased local activity on the 432-MHz band, I decided I needed a better 432-MHz antenna. Previously, I had been using an 11-over-11 arrangement with three-half-wavelength spacing and 300-ohm feed-line. However, my fifteen watts was just not doing a satisfactory job. Received signal reports were only S3 to S7, even during good band openings.

After building several box-frame type 1296-HMz antennas with good results, I decided to try the same type of construction for 432. The box frame eliminates the need for a vertical mast between directors which detunes the array and downgrades antenna performance.

Also, I figured that if I could eliminate all the unnecessary baluns, and use copper driven elements and increase the number of Yagis, I might have a good beam. I was right. My signal reports went from S3 to S8 when switching from the

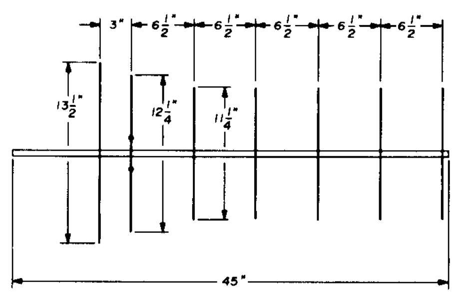


fig. 1. Seven-element 432-HMz Yagi. Boom is ½" square aluminum tubing with 1/8" walls. Reflector and directors are ¼" aluminum rod; driven element is 3/8" copper tubing.

old 11-over-11 to the new box array. K2RIW in New Jersey recently gave me a report of S9+67 dB, so the antenna is really doing the job I wanted it to.

The antenna consists of four seven-element Yagis, spaced two half-waves. The four antennas are installed on the front of a square aluminum-angle frame which measures 27-inches per side. The antenna booms are 45-inches long. The entire array is fed with 75-ohm tv-type coaxial cable, which is lighter weight and has less loss than comparable 50-ohm coax.

construction

The driven element is made from 3/8-inch copper tubing. An 8-32 screw hole is drilled at the center of the element and a double-U clip is formed around the center of the element to keep it from deforming as you tighten up the screw. The U-shaped clips I used came from an old tv antenna. Wood dowels pushed into each end of the element and a solder-filled center would also keep the element from being deformed.

The phasing-line connections are made 1½-inch on each side of the center of the element (spaced 3 inches). A 6-32 screw hole is drilled all the way through the element and a 6-32 nut is soldered on one side. This can be done by polishing the copper with steel wool and sweat soldering the nut in place while it is being held temporarily with a 6-32 screw. Solder paste will speed things up; after soldering, the excess paste can be removed with lighter fluid. When connecting the phasing lines use two brass washers.

The reflector and directors were made from ¼-inch aluminum rod I salvaged from an old Telrex tv antenna. A hole is drilled in the center of each element to pass a 6-32 screw.

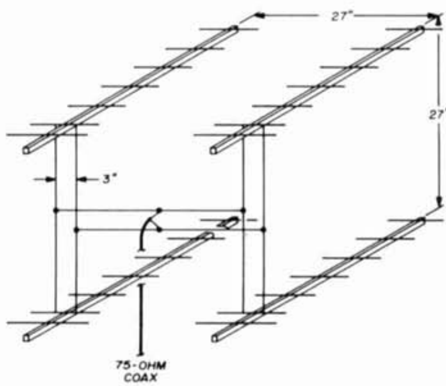
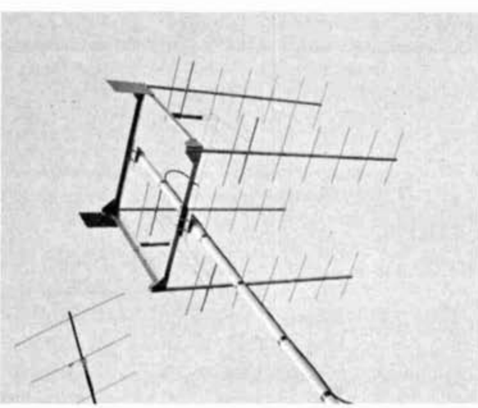


fig. 2. Phasing lines for the 28-element, 432-MHz quad array. Plexiglass or lucite spacers are used only at the junctions of the horizontal and vertical phasing lines.



The 432-MHz quad-Yagi array installed at W3AED.

The ½-inch square aluminum boom may require some searching. However, if you can't find one at your local building-supply store, it can be obtained on special order from firms that specialize in glass store fronts. A 6-32 screw hole is drilled in the boom for each of the elements. Then a slot is filed at right angles to the boom to hold each element in place.

the frame

The sides of the frame which holds the four Yagis are made from 1x1-inch aluminum angle, 1/8-inch thick. The material for the right-angle aluminum corner plates (see **fig. 4**) came from a local glass and store front company that builds six-inch aluminum columns.

When building the frame, attach the horizontal members to the corner angles first. Then the holes for the mast U-brackets are drilled. One of the flat faces of the aluminum angle faces toward the Yagi antennas. The corner brackets are mounted on the outside. The individual Yagi booms are attached to the corner brackets with 8-32 screws, as shown in **fig. 3.**

The wind vanes on the back of the antenna shown in the photograph are made from 5x8-inch pieces of aluminum sheet, although they may not be necessary if you don't live in a high-wind area. I also added a special plate to allow double U-clamps at each cross section of the box frame. Again, this is not essential, but I live in a hurricane area.

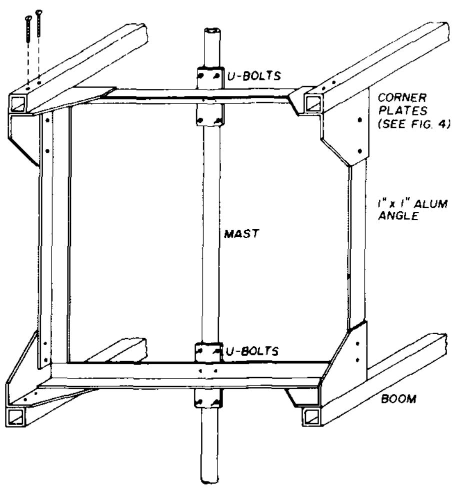


fig. 3. Construction of the rear-mounting frame. For 432 MHz the horizontal aluminum angles are 27-3/4" long; the vertical aluminum angles are 26½" high. For 1296 MHz the horizontal aluminum angles are 23½" long; the vertical aluminum angles are 22" long.

phasing lines

Each of the phasing lines is two half-waves long and made from number-14 wire, **fig. 2.** When using soft-drawn wire for this purpose I put one end in a bench vise and gave it a good pull. This gets rid of any future stretch and straightens the wire for immediate use.

Plexiglass spacers are used only at the junctions of the phasing lines. No additional support is required where the coaxial cable is connected. When installing the coaxial cable the shield braid should be cut back only far enough to spread the cable (1-inch maximum). After soldering, tape the connection well and tape the coax to the mast so the connection end of the coax faces down — this will help keep water out of the coax.

I used seventy-five feet of 75-ohm Jerrold CAC-82 coaxial cable with my array. This cable has a copper shield like RG-59/U and is packaged in 50-, 75- and 100-foot rolls.

1296-MHz array

Some readers might be interested in a four-bay, 13-element Yagi array I use on 1296 MHz which uses similar construction to the 432-MHz antenna. With this antenna and a three-stage preamplifier I have received signals from as far away as northern New Jersey and Norfolk, Virginia. Although I don't have the equipment to measure gain, performance appears to be within about 0.5 dB of the 1296-MHz Yagi described by W2CQH.[1] This indicates that gain is approximately 14 to 15 dB.

The boom for each of the 13-element

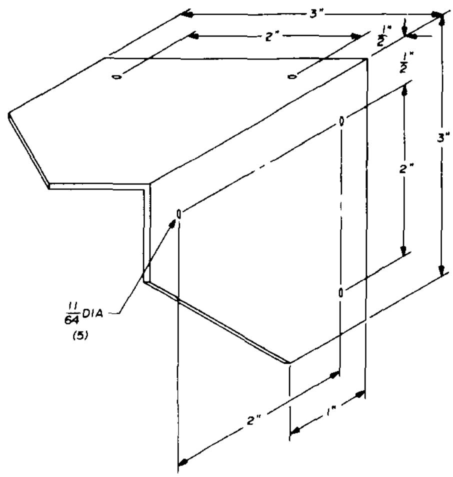


fig. 4. Corner angles for the rear-mounting frame are made from 3x3" aluminum angle, 1/8" thick. All holes are for 8-32 screws. These corner angles are installed on the outside of the aluminum angle frame.

Yagi beams is half-inch U-shaped aluminum angle, 0.050- to 0.075-inch thick. The driven element is brass. Other elements are aluminum rod. Element length and spacing is shown in **fig. 5**.

The upper and lower Yagis are placed face to face so that the phasing lines do not cross the booms. The conductors of the 300-ohm phasing lines are made from number-12 wire, spaced 1 inch. The vertical phasing lines are twisted at the center to meet the horizontal phasing line.

The design of the phasing lines on the 1296-MHz antenna is based on the fact that an impedance of 300 ohms, when connected to a 425-ohm matching section, exhibits 600-ohms impedance. When the two 600-ohm sections are connected in parallel, the input impedance is again 300 ohms. A 4:1 balun at the center feedpoint converts the 300-ohm input impedance to 75 ohms, a perfect match to 75-ohm tv type coaxial line. I used a 50-foot section of Jerrold 82 tv transmission line, which has a copper braid.

Although this 75-ohm tv coax comes pre-packaged in lengths of 50, 75 and 100 feet, any length over 50 feet is much too lossy on 1296 MHz. If you need more than 50-feet of transmission line at your station you should consider placing the first stage of your rf amplifier right at the antenna.

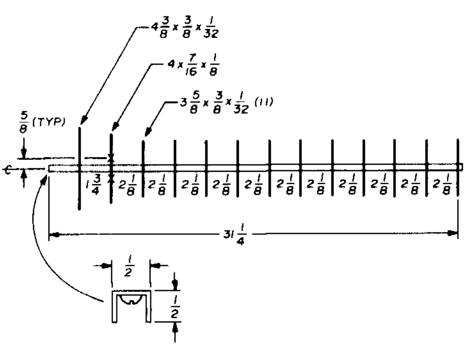


fig. 5. Construction of the 13-element, 1296-MHz Yagi beams used in the four antenna array. The individual Yagis are mounted on a square frame similar to that shown in fig. 3.

rf filter

A number of amateurs have had trouble on 1296 MHz because they did not place a 1296-MHz filter ahead of their rf amplifier. Many of the popular 1296-MHz preamplifiers run wide open and pick up a lot of undesired signals. Occasionally,

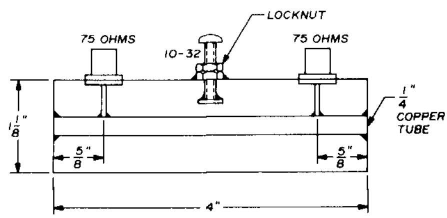


fig. 6. Half-wave 1296-MHz rf filter prevents problems with spurious signals and self-oscillation. For 50-ohm input impedance, connectors should be spaced ½" from the ends of the line.

they also oscillate when connected to a resonant antenna. The simple half-wave rf filter shown in **fig. 6** solves these problems.

The half-wave filter is built into a 4-inch long brass or copper box, 1-1/8-inches square. For use with 75-ohm lines the connectors should be spaced 5/8-inch from the end of the line. For 50-ohm lines this spacing should be ½-inch. By spacing one connector ½-inch and the other 5/8-inch, the filter can be used to match 50-ohm cable to a 75-ohm transmission line.

When the filter is inserted in the line, the 10-32 tuning screw is adjusted for maximum signal. The screw is then locked in place with the locknut. I am presently using this filter ahead of three rf stages with good gain and no oscillation.

I would like to take this opportunity to thank Cy Dirickson, W3BSV, who helped with the design and testing of these antennas.

reference

1. R. Fisher, W2CQH, "A Successful 1296-MHz Yagi," *ham radio*, May, 1972, page 24.

ham radio

antenna and feedline facts and fallacies

New experiments provide some interesting facts about old antenna and feedline fallacies

Carl C. Drumeller, W5JJ, 5824 NW 58 Street, Warr Acres, Oklahoma 73122

How many times have you heard discussions, often heated, about the following subjects? Does a dipole antenna fed with a coaxial cable radiate more from the leg fed by the cable's center conductor than from the one fed by the shield? If so, does the use of a balun at the feedpoint correct the imbalance of radiation?

Does a coaxial cable feeding a load mismatched to cause a 4:1 vswr have radiation from or standing waves upon its outer conductor?

Does a coaxial cable feeding a dipole antenna, with the feeder running at right angles from the antenna, have current on its outer conductor? If so, does the use of a balun at the feedpoint correct the condition of undesired radiation?

Does one leg of the dipole antenna plus a quarter-wave of the outer conductor of the coaxial feeder constitute a vee antenna, thereby causing a high-voltage rf potential to appear at the quarter-wave spot and at even multiples of it on the transmission line?

Well, I've heard these questions countless times and have even taken part in some of the arguments. The distinguishing factor about all these discussions is that no one really knew what the answers were. Oh, everyone was quite sure in his own mind that he knew the answers perfectly. But, and this is the point I want to make here, not a single person had ever taken part in an experimental determination of the truth or fallacy of the several contentions! Let's have an end to such a deplorable situation.

Three amateurs, W5TMY, W5KE and myself, each retired and blessed with ample free time, each with over thirty years of professional experience in the field of electricity and electronics, decided to do something about establishing demonstrable and reproducible facts relating to the disputed questions. My place was selected for the experimental setup as I have a backyard of ample dimensions, and my 50+ years collection of equipment and instruments contained everything we needed.

The basic equipment consisted of a Drake TR-4 transmitter, A Drake MN-4 matching device (helps minimize harmonics), 52-ohm coaxial line, a 7-MHz dipole antenna in the clear and low enough to permit an indicating device to be pulled along it, and a sensitive device for measuring relative amplitude of radio-frequency current (current, *not* voltage). See **fig. 1** for details of this indicator.

The vinyl jacket of a portion of the coaxial cable was removed to permit exploring the radio-frequency current on it over a half-wave expanse. The cable was run at right angles to the antenna and was at the same height as the antenna. Every effort was made to preserve absolute symmetry. A W2AU balun, especially made with a male coax connector at one end and a female connector at the other end, was used for altering the feedpoint circuit.

experiment 1

Purpose: To ascertain whether the currents in the two halves of a dipole antenna are equal when fed from an unbalanced source, a coaxial cable.

Procedure: The antenna was energized, the radio-frequency current indicator was adjusted for 45/50th full-scale deflection at the spot of maximum current, and the *indicator was* pulled by means of an attached string along the length of the dipole half. Without adjusting the indicator, the action was repeated on the other half of the dipole.

Findings: The maximum current in the half fed by the center conductor of the coaxial cable was approximately 40% greater than that in the half fed by the cable's shield.

Conclusion: Feeding a dipole from an unbalanced feeder results in an imbalance of currents in the two halves of the dipole, *probably* resulting in a distorted radiation pattern.

experiment 2

Purpose: *To ascertain whether the* currents in the two halves of a dipole antenna are equal when fed from a balanced source: a balun coupling a coaxial cable to the antenna's feedpoint.

Procedure: A balun was inserted between the cable and the antenna; then **experiment 1** procedure was repeated.

Findings: The maximum current in each half of the dipole was very nearly equal.

Conclusion: The use of a balun helps to obtain balanced radio-frequency currents in the two halves of a dipole.

experiment 3

Purpose: To ascertain whether having a coaxial cable terminated in a mismatched load causes radio-frequency currents or standing waves to be present on the outer conductor of the cable.

Procedure: A length of 52-ohm coaxial cable, more than a half-wave long and having insulation stripped from the outer conductor, was terminated with four

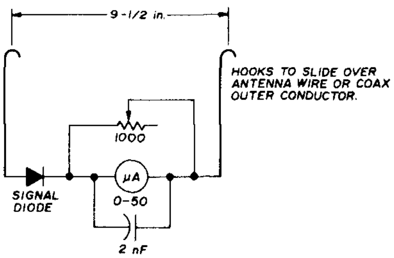


fig. 1. Construction of the sensitive rf current indicator.

52-ohm Termaline dummy loads, thereby causing a 4:1 vswr to be present on the line. The line was matched to the transmitter through an MN-4 matching device, and 200 watts of rf power was fed into the line. The sensitive rf current indicator was pulled along the length of the line.

Findings: No radio-frequency current was detected on the outer conductor on the coaxial cable.

Conclusion: Having a mismatched load does *not* result in the radiation of rf power from a coaxial transmission line. However, this does not imply that having an *unbalanced* load may not cause current to be present on the outer conductor.

experiment 4

Purpose: To ascertain whether there is rf current on the outer conductor of a coaxial cable directly feeding a dipole antenna.

Procedure: A length of coaxial cable, more than a half-wave long, stripped of its outer insulation, was strung at right angles to the dipole and at the same distance above ground. The transmitter was loaded to 200 watts, and the sensitive rf current indicator was pulled along the transmission line. An indication of full-scale (but not pegging the meter) deflection was observed. In an effort to obtain a comparison of relative power at this maximum current point and that at the maximum current point on the dipole, the transmitter power output was re-

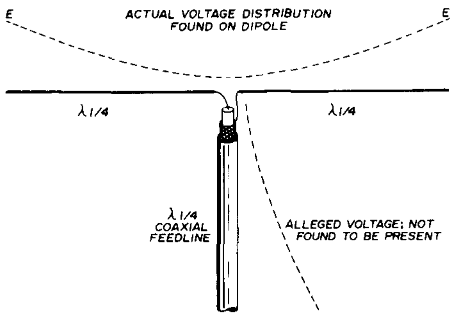


fig. 2. Rf voltage curves on the dipole and coaxial feedline were plotted as reciprocals of the current measurements.

duced to a value too low to be read on the MN-4's rf wattmeter (probably less than one watt). Even at that low power it was necessary to severely shunt the microammeter on the indicator in order to prevent its being violently pegged by the antenna's rf. (*Note:* The point of maximum rf *current* was approximately one-half wave back from the feedpoint.) **Conclusion:** There indeed is rf current on the outer conductor of a coaxial cable having an unbalanced feed to a dipole. This current, however, is *very* small. The radiated power ratio, cable versus antenna, can only be estimated; probably it lies between 1:1000 and 1:10,000. The assumption that there is a high-voltage point on a cable's outer conductor a quarter-wave back from the feedpoint is *not* valid.

experiment 5

This started out as a duplicate of **experiment 4** but with the balun in place. No rf current was detected on the cable's outer conductor; so the experiment was terminated.

the results

Let's evaluate the results. The use of a balun gives some small advantage, both in balancing the radiation from the dipole and in diminishing the radiation from the coax.

The assumption that a mismatched (mismatched, not unbalanced) load, which engenders a moderately-high vswr, causes standing waves upon and radiation from a coaxial transmission line is without basis. Somebody will have to come up with a new excuse for all those mysterious cases of TVI, "hot" microphones, etc., that have been explained off as, "standing waves on the transmission line."

A transmission line does not transform itself into a vee antenna consisting of a half dipole plus a quarter-wave of transmission line outer conductor. Again, some new excuses are needed.

For your own evaluation of these findings, please consider that the experiments were conducted under rigid control. All findings were duplicated by another person before being accepted. Two of the persons involved are retired electronic engineers, the other a retired electrical foreman; all are experienced radio amateurs. The instruments used, with the exception of the homebuilt rf current indicator, were high-grade, equal to what might be found in a laboratory. Every effort was made to have all findings factual — not to "prove" some previously-held assumption.

Although this article is being written by one person, I want to emphasize that J. D. Odneal, W5TMY, and Ellard W. Foster, W5KE, were equal participants in the project. It could not have been conducted without their co-equal participation.

If you have reason to doubt our findings, I beg you not to dispute them solely from a theoretical basis. Duplicate the experiment, then express your opinions!

ham radio

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80-meter antenna

for a small lot

If you live in a stucco house on a small city lot, here's how to install an 80-meter antenna

Alfred Stahler, W6AGX, 5521 Big Oak Drive, San Jose, California 95129

Housing tracts with small, uniform, close-spaced lots exist throughout the United States. In California the typical house on such a lot uses stucco construction. This is fine for the climate, but the galvanized-steel wire mesh used to support the stucco plaster is usually well grounded at each electrical outlet to the ac ground as well as to the cold-water pipe. Since this conductive, well grounded, two story, "shield can" rests approximately in the middle of the lot, it represents a non-ideal support for an amateur antenna; particularly a long, low-frequency antenna.

Faced with these facts, I tried to build an 80-meter antenna that would fit on the 60- by 100-foot lot, require no towers, be unobtrusive and be broadband enough for reasonable swr over the CW as well as phone portions of the band. I tried several configurations from U, L and V, ending up with the final Z shape shown in **fig. 1.** The desired broadband characteristics, in all cases, were dependent upon the "double bazooka" concept which combines the characteristics of a resonant coaxial length with a radiating dipole.[1]

Because of the odd shape due to the lot size restrictions and the influence of the stucco-house "shield can" I found little correlation between published theory and my experimental measurements. I proceeded on a cut-try-measure-cut-try-etc. basis until the trends yielded a reasonable antenna.

The physical layout of the antenna, house and lot is shown in **fig. 1.** The coaxial center section of the antenna runs along the peak of the roof and then down the roof lines toward the two supporting

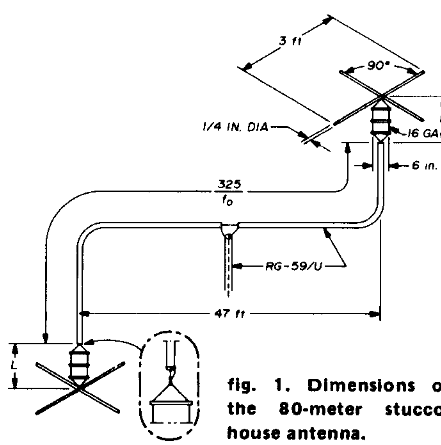

fig. 1. Dimensions of the 80-meter stucco-house antenna.

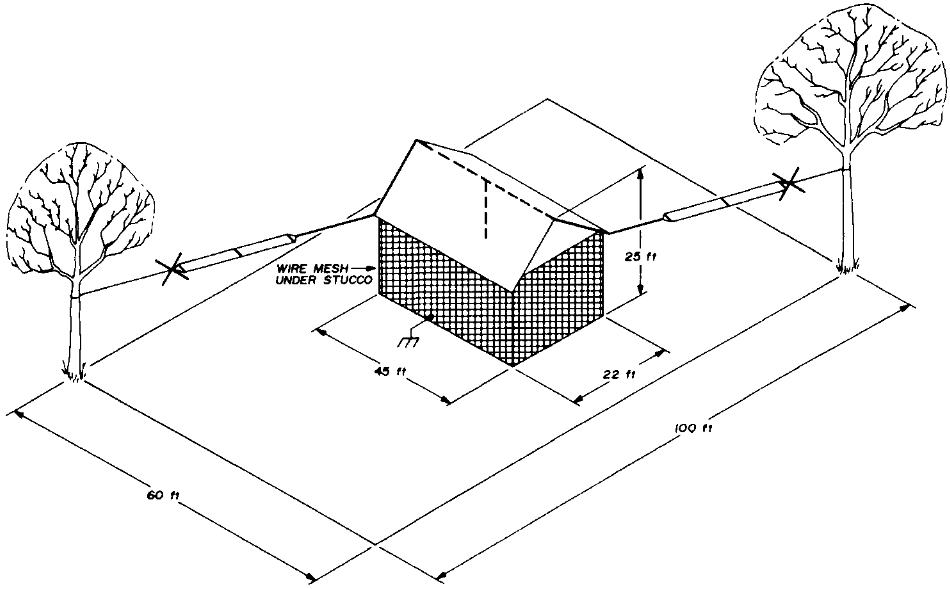

fig. 2. Installation of the 80-meter antenna.

trees. The coax feedline runs down vertically through the house to the transmitter. At the ends of the coaxial section are sections of open-wire transmission line with capacitance hats. The hats are made of two ¼-inch diameter, three-feet long, crossed aluminum rods. The dimensions of the antenna are shown in **fig. 2.**

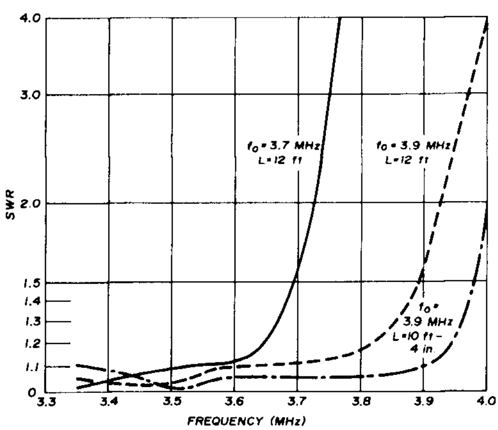

fig. 3. Standing-wave ratio vs frequency for different antenna lengths. The length of the open-wire sections at each end of the antenna is given by L; f_0 is the design frequency in MHz where the length of the center section (in feet) is given by $325/f_0$.

Fig. 3 shows the measured swr vs frequency for several versions of this antenna. It can be seen that the influence of the Z-shape and the stucco house have drastically changed performance from that predicted in reference 1 for an isolated dipole. However, by trial and error the final geometry performs quite well over a large portion of the 80-meter band. Signal reports have been good, and the antenna seems to exhibit dipole-type directivity if the transmitting axis is assumed to be in a line with the antenna end points.

The rf voltage at the tips of the capacitance hats is very high so they should be placed well away from leaves, branches and people.

I hope that other amateurs who are restricted to life on similar house lots will be able to use this antenna configuration on 80 meters. Perhaps a similar arrangement could be developed for 160 meters.

reference

1. D. DeMaw, W1CER, *The Radio Amateur's Handbook,* 48th edition, A.R.R.L., Newington, Connecticut, 1971, page 368.

ham radio

simple antennas for two-meter fm

Here is a selection of simple vhf antennas which can get you on the air at minimum cost

Willard R. Moody, WA3NFW, Apt. 201, 5231 Kenilworth Avenue, Hyattsville, Maryland

The two-meter fm band is booming and the results are exciting, chiefly because of repeaters which make even crummy antennas acceptable for receiving and transmitting. Of course, if you have the money, you can spread yourself and buy commercially-made antennas which represent topnotch engineering design.

Looking through the Lafayette Catalog, for example, you can find a nice Ringo antenna which covers 135 to 175 MHz for $12.50. This is a vertical which may be used for mobile operation with the metal body of the car serving as a ground plane. It has a gain of 3.75 dB over an isotropic antenna. If there is one thing I've learned about verticals it is that a good ground system is necessary. However, if the thing is way up on a mast, far from ground, four radials will do the job. The radials should be slightly longer than the vertical radiating element, perhaps by 10%.

Since most mobile installations use vertical antennas it helps if the receiving antenna at the base station is also vertical. In some cases it doesn't seem to matter,

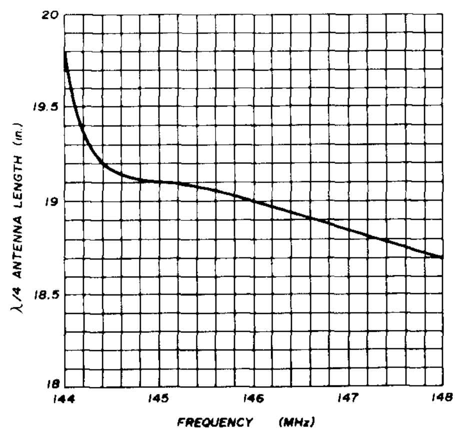

fig. 1. Length of quarter-wave two-meter antennas.

especially in hilly country or wherever there are numerous reflections which may change the relative polarization. The usual rule, however, is a vertical receiving antenna if the source transmitter uses a vertical.

In the *ARRL Radio Amateur's Handbook* halos and other weird horizontally-polarized antennas are shown, but hams don't seem to want to mess up their expensive autos with screwball antennas. The vertical is relatively unobtrusive, especially on two meters. I have seen some halos on masts mounted to bumpers on Volkswagens, and one guy even had a 10-meter whip on the front bumper of a VW.

The two-meter antenna can be relatively short. In a motel one ham took the oven grill out of the oven and used it as a ground plane for a small vertical with a magnetic mount on two meters, driving it with a Drake TR-22. He had a barrel of fun with it, using only a watt of rf power to get out. The repeater is a great thing.

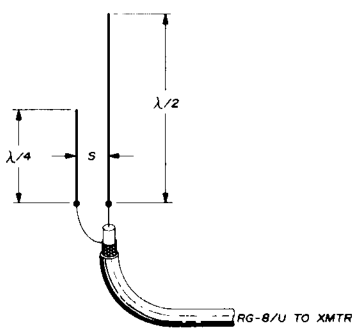

fig. 2. The vertical J-antenna is an efficient radiator. Spacing S should be 2 inches or less.

On page 429 of the Lafayette Catalog, Antenna Specialists has a roof-mount antenna for $22.95, net. It is equipped with a stainless-steel whip with copper and nickel plating for low rf resistance. For home use a 7-element Cushcraft beam goes for $13.95 net and gives a forward gain of 11 dB. That's a lot of gain, and it really makes a difference. An 11-element, 2-meter Yagi antenna, Cushcraft, has a forward gain of 13.2 dB and goes for $17.95. At these prices, it hardly pays to build one yourself. Yet, the ARRL Handbook is full of material that assumes you are a radio engineer, master mechanic and have the facilities of a well equipped radio laboratory and machine shop. Some hams may have such facilities on their jobs, but access to them is a different matter.

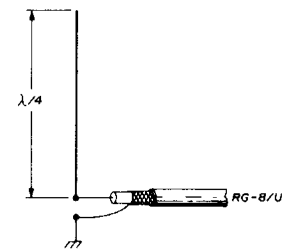

fig. 3. Simple quarter-wave vertical.

A 22-element, 2-meter Yagi, Cushcraft, has a fantastic gain of 16 dB and sells for $49.50 net. Of course, the thing has to be put up on a mast somewhere, which may be the chimney of your little house, or you can buy an expensive mast for the backyard. Being poor, I can only dream of such goodies.

Heavy-duty antenna rotors may run $69.95 or more, depending on what you select. A directional antenna must be rotated unless you are interested in operating in only one direction.

simple antennas

The simple quarter-wave antenna shown in **fig. 1** is from 18 to about 20-inches long for the 2-meter band. Around the center of the band, 146 MHz, which is where most of the activity seems to be, a quarter-wave is about 19 inches. You can use brass rod or even copper

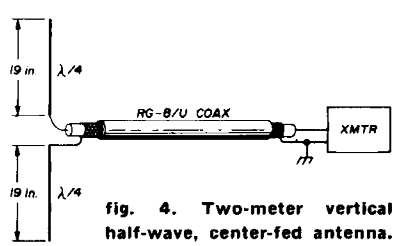

fig. 4. Two-meter vertical half-wave, center-fed antenna.

tubing, and no. 14 hard-drawn enamel wire clipped to a 2x4 could even be used. Such antennas, while comparatively crude, are inexpensive and they work.

Other simple vertical antennas are shown in **figs. 2** and **3.** These require good grounds if not far above earth, not more than 10 feet, and ground-plane radials if they are mounted on a mast. By going to half-wave center-fed antennas the ground troubles are reduced, although any antenna generally works better over low resistance ground.

A simple beam is the Lazy-H (see **fig. 6**). This antenna works well on the high frequencies as well as on 6 and 2 meters. It can be put up in a horizontal plane above the house on a boom and rotated.

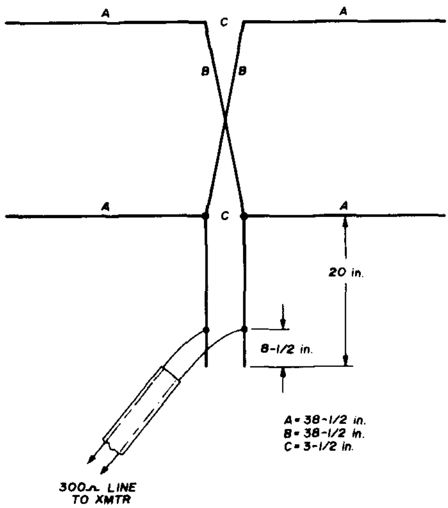

fig. 6. Directional Lazy-H beam for two meters may be either vertically or horizontally polarized.

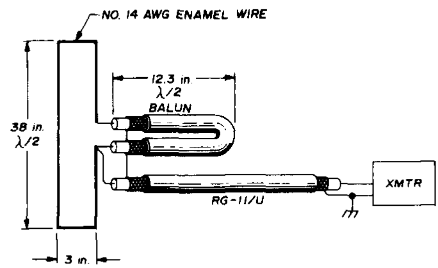

fig. 5. Vertical half-wave folded dipole for two meters.

The Lazy-H is one of my favorites. It can also be mounted in a vertical plane on the wall of a room in an apartment. Ordinary zip cord has been used for both the elements and the feed. However, fairly fine no. 22 enamel wire can be used for the elements and the feedline can be comparatively light-weight RG-59/U. The impedance at the feedpoints should permit using 50- or 75-ohm coax cable directly. If necessary, a quarter-wave matching stub may be used.

circular antenna

By bending some copper or brass rod into a circle you arrive at the antenna shown in **fig. 7**. This antenna can be used in a horizontal or vertical plane and fed with coax. The coax should be kept as short as possible to avoid losses which tend to mount up at vhf. Some cable characteristics are shown in **table 1.** If you have an antenna with 16 dB gain and you lose 6 dB in the cable run you still have 10 dB left, but with a cheap vertical a 6-dB loss is intolerable.

rabbit ear antenna

The rabbit ear antenna, **fig. 8,** may be used as a horizontally polarized half-wave

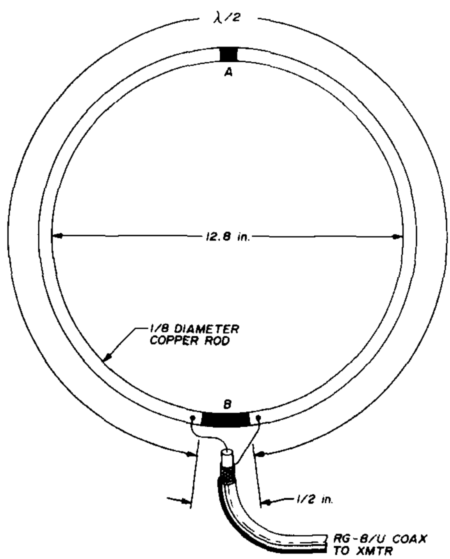

fig. 7. Two-meter circular rod antenna.

table 1. Vhf characteristics of common coaxial cables.

	impedance (ohms)	loss (dB/100 feet at 150 MHz)
RG-58/U	52	6.0
RG-59/U	73	4.5
RG-11/U	75	2.5
RG-8/U	52	1.8

antenna (19 inches for each element at 146 MHz). See **fig. 1** for other dimensions in the two-meter fm band. Some of these tv antennas are well made and others are junky. Try to get a substantial, well-built one. The 300-ohm line may be clipped near the base, leaving tabs long enough to solder to a piece of 50- or 75-ohm coax.

The length of each element can be

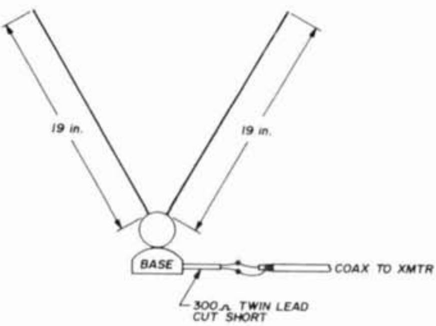

fig. 8. Television rabbit-ear antenna may even be used on two meters. The length of the elements is adjusted for resonance on the desired operating frequency.

adjusted with a tape measure or an engineer's scale. Each element can be tuned and resonated by the sliding action or trombone-like construction. This makes a simple and convenient low-power antenna. A Drake TR-22 will work into it, but don't try to feed a kilowatt to it unless you like smoke.

So, as the old saying goes, you pay your money and take your choice. If you are loaded, buy a commercial antenna. If you are watching the budget try one of the simpler types. They seem to work fairly well although some of them are not much for appearance.

ham radio

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how to tailor your antenna for optimum performance

A few ideas for building simple antennas, and tailoring commercial ones to your individual operating habits

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Tailoring your antenna for your particular area and getting it to work properly can do wonders for your enjoyment of amateur radio. If "clothes make the man," and a tramp with a shave, a warm bath and a new suit looks like a company first vice president, then you can do a lot better by tailoring your antenna for that proud feeling.

We, nearly a half-million hams, live in a myriad of locations and conditions. Few of us have found the antenna which suits ourselves let alone the rest of the fine people in this hobby.

Particularly difficult is the challenge to the apartment dweller. There are an increasing number of tract and land-rental legal restrictions written into deeds and rental agreements. More than a few communities have very restrictive laws on antennas. To all of this add the watchful eye of your spouse and your neighbors' objection and you will see just a few of the problems you face when choosing an antenna.

Space is the prime guide when choosing an antenna, with cost and appearance being secondary factors.

the dipole

This simple antenna consumes little space, is the least expensive and can be made almost invisible. By fanning out the individual wires, you can obtain satisfactory multiband operation. The swr is most simple to bring to unity by adjusting the leg lengths and the angle between the elements. Performance can be enhanced by the addition of a balun.

Placing the dipole in a position free of wave obstruction and at least one-quarter wavelength above ground can give some real fine performance. The preferred height above ground is one-half wavelength, but we don't always achieve perfection in our antenna tailoring.

beams

Utilization of the driven element, reflector and director is best seen in the beam antenna where you use aluminum tubing, coils and a rotating mechanism. You can handily operate a beam on one band or a combination of three. The most popular arrangement is the 10-, 15- and 20-meter combination. The two great advantages of such a beam are the gain and the directivity of the signal, which cuts out considerable interference. A Yagi beam, resonated to the correct frequency, balun and half-wave transmission line is the best antenna system which I have tried. This is the experience of very many other hams, too. A good, well-tailored Yagi is hard to beat.

Many amateurs are short on aluminum tubing and fittings, coils, rotators and the tailoring ability to make such an array as described above. Fortunately, there are two types of wire beams which are easy to build and inexpensive as well. The first is the three-element 20-meter wire beam shown in **fig. 1.** It consists of a driven element, with balun, placed one-half wavelength above a reflector of wire, which is 5% longer than the driven element. This will radiate a greater signal at right angles to the driven element. This may be increased by placing a director one-quarter wavelength in your preferred direction. The director should be 5% shorter than the driven element.

With a grid-dip meter and an antenna bridge you may adjust the driven-element to director spacing to the desired operating frequency and input impedance, with the gain checked with a ham friend a couple of hundred miles away. This antenna will really whistle.

The second wire beam is a two-element job with a little different and easier tailoring as shown in **fig. 2.** The driven element is made of light-weight aluminum tubing. I obtained 1/2 inch

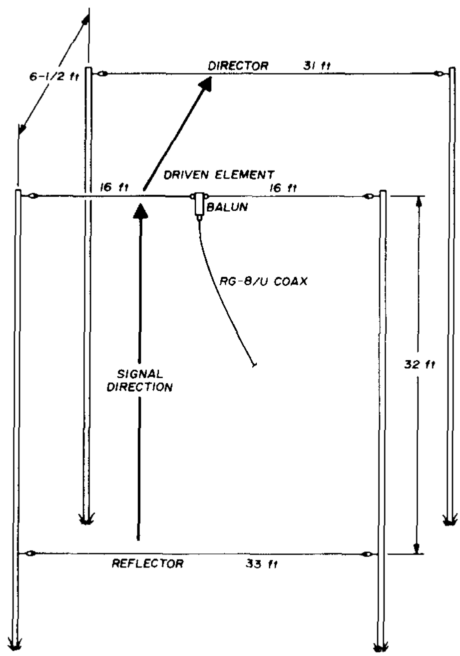

fig. 1. Three-element 20-meter wire beam with stacking of driven element on reflector. Director is parallel to the driven element.

surplus aluminum tubing which was made so that one six-foot length would slide into another. With these sections I made two such lengths, each 16-feet long. These two elements are separated with a piece of wooden dowling with the stabilizing bolts attached to each side of the balun. The RG-8/U coaxial transmission line was cut to one-wavelength long at the operating frequency of 14.270 MHz and attached to the transmitter.

This driven-element dipole arrangement is attached to a bamboo spreader supported by a nylon bridle. The director wire is 31-feet, 4-inches of number 14 copper wire, placed 6½-feet toward my desired direction. I raised this array eight feet above the roof and my signal doubled.

Now before I could brag about this, my happiness was dampened a bit when I heard the loudest station on 20 meters telling his friend in New York about his 20-meter wire beam made with three elements — all of number-25 wire. I was

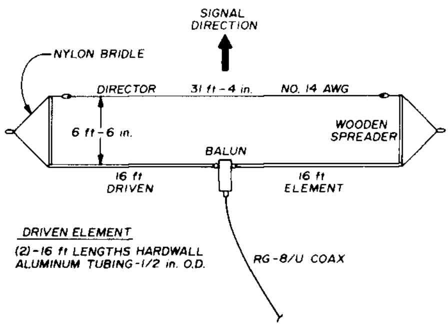

fig. 2. Wire and aluminum tubing beam for 20 meters.

reading all this on the back of this beam so I know, now, he is a better tailor than I.

verticals

The vertical antenna is dandy for limited space as long as you observe a few good tailoring rules. Verticals require a good clear space and perform best with a good ground plane or radial system. The better these conditions are met, the better the function. However, it is a surprise how well a vertical will work with less than ideal conditions. A vertical cut to the desired frequency with one wire to a water pipe, ground stake or even a base of random chicken wire, will occasionally do a passable general and DX job. This is almost as good as a system with a system of radials or a ground-plane.

Single-band verticals can be phased in the same manner as beams for gain and directivity. I find that the vertical is the easiest of all antennas to resonate to frequency and impedance match. Furthermore, these adjustments can be made without climbing towers or raising and lowering the elements. Minimal work gives maximal success.

quads

This closed loop and its cousin, the Delta Loop, have a full-wave driven element and reflector working to give a fine gain and directivity. Performance is great with a quad but I can personally vouch for the large size and fragility of this type of antenna. Here is a place for you to tailor yourself a real fine antenna if you have the space and skills which I found I lacked.

rhombics and long wires

The rhombic is beyond the usual ham as it takes a lot of space which most of us don't have. I saw a grand rhombic in use on field day — my only observation was that they burned out the finals in my transceiver with their tuning and transmitting. My interest in rhombics is now at a low ebb.

The long wire antenna has come into wider use lately. Recently, I heard an Alaskan operator describe a unique way of getting his long wire into a tree top. He fixed a string onto an arrow which he shot over the top of the tree and then teased up his insulated 400-foot long wire. His signal was tremendous.

My experience with my own long-wire antenna tuner, and a commercial model as well, has indicated good performance but poor in the area of tvi. I now use my long-wire antenna tuner on my bamboo fishing pole balcony antenna cut for 15 meter CW, with a short coaxial transmission line to the tuner. The swr is nearly 1:1 and I have no television interference. **Fig. 3** shows my bamboo fishing pole balcony antenna which uses the metal railing as a ground plane. I use the ground in the electric base plug in the shack for the antenna tuner ground.

miniaturizing

The ham antenna can be shortened by use of several different techniques. You can insert a coil to shorten the overall length, or use a capacitance hat. The addition of coils causes some lumping of the antenna which will reduce the Q factor and narrow the bandwidth somewhat, but this is minimal if your tailoring is good. Of course, bringing the ends of the elements off at an angle will forshorten the necessary space, too. The long-wire tuner will work with one-quarter wavelength antenna with a good ground. During vacation I have used my bamboo fish pole with 40 feet of wire

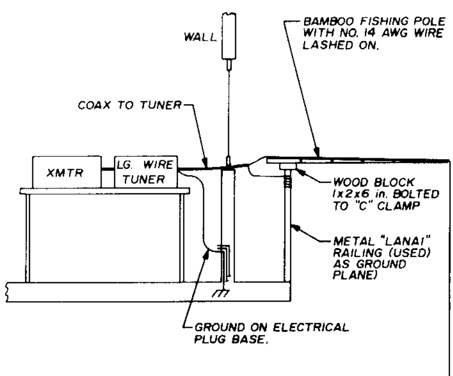

fig. 3. Fishing pole antenna with random length wire for portable operation on 10 through 40 meters.

over a balcony to work 10 through 40 meters with the tuner.

Hams are very ingenious when it comes to figuring out how to get a signal out. I know one amateur who put his miniature vertical slightly on its side in his attic and he works the world. Another friend of mine had a dipole with director and reflector in his attic. Balcony railings and drain pipes can sometimes work well as ground planes. For camouflage I have used pale blue auto spray paint on rope guys, insulators, baluns and coax.

Antenna tailoring has some very sound rules which I think should be followed. First of all, install the antenna high, in as clear an open area as possible. Avoid metal objects; this includes another antenna — such as a drooping dipole on a tower with metal or wire supports. Use rope where possible.

Resonate the antenna at the frequency you wish to use, cut the transmission line one-half wavelength long at your selected frequency and correct the input impedance to 50 ohms. Let the rest of the bands fall where they will if you have a multi-band antenna. Perfection on every band is impossible. Finally, learn to use the grid-dip meter and antenna bridge as these are your best antenna tailoring friends.

conclusions

A good antenna tailor will markedly improve performance on receiving and transmitting. Equally important is the fact that this improvement will often reduce or even eliminate radio, hi-fi, tv and telephone interference. Amateurs who are crowded closely together should include a bit of restraint in the use of power. A 100-watt signal will, with correct antenna tailoring, give you a lot of pleasure and relaxation. If you then add a linear often the entire neighborhood closes in. I have a friend who works the world and has one of the strongest signals from Honolulu. He uses only 500 watts. All of this is done in a large apartment unit packed with potential interference problems.

Don't think that tailoring means that you should build all of your own antennas. Most of us have neither the skill nor knowledge to compete with commercial antennas. Factory-made beams and multi-band verticals are far more attractive and function far better than what I can build. The electronic engineers who build these antennas do a good job of setting resonant frequencies and matching impedance. Their testing is done under far better conditions than most of us have at our disposal and often, after carefully following factory specifications, you will find that the antenna resonates out of the ham bands. Your intelligent adjustments will bring the swr and directivity in line with what the direction sheets show. Currently, my antenna building handicraft is reserved for dipoles, long wires and tricky little antennas for limited space. However, I have found antenna tailoring to be a challenging and rewarding part of the art of amateur radio.

ham radio

four-element collinear antenna for 440 MHz

Complete construction details for a high-performance, omnidirectional antenna for 440 MHz that is built from easy-to-find materials and provides up to 6-dB gain over a dipole

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Regardless of its design, a vertical omnidirectional gain antenna achieves its gain by the same process. It simply compresses the energy down on to the horizon where it is useful, and as a result, it wastes less radiating into the ground and up into the sky. Uhf antennas usually accomplish this by feeding several vertically mounted elements in phase so that the energy will combine itself into a pattern similar to that shown in **fig. 1.** These elements can all be fed in series, as Franklin, the originator of the collinear, did. This is the same system used by many commercial models **(fig. 2)**. The elements can also be fed in parallel as I have done.

At first the series method seems much easier. A few inverted pieces of coax or a wire with some bends here and there and you're done. However, this approach has several big disadvantages. First of all, all the construction errors are cumulative. If you're slightly out of resonance at the

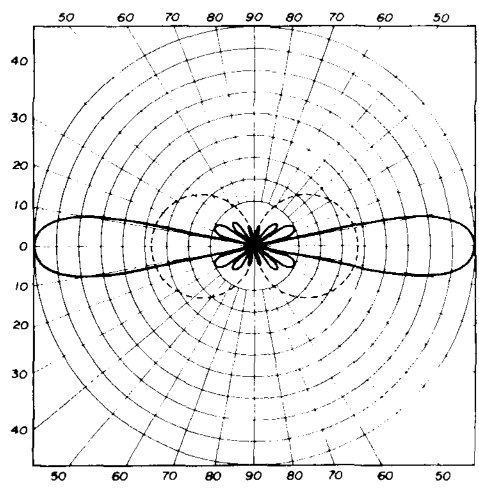


fig. 1. Vertical field strength of the four-element collinear (solid line) vs the dipole (dashed line). Collinear elements are positioned for omnidirectional pattern.

bottom, you can be sure that you're way out at the top. By its nature the series-fed collinear is a very touchy thing to get working properly and has very narrow band-width. Also, it must be supported by a low-loss pole or suspended from above. If it doesn't work when it's built, you have your hands full trying to find out why.

On the other hand, the parallel approach offers several advantages. First, all the elements exhibit 50-ohm input impedance and can be individually adjusted with a wattmeter. Secondly, the design is very rugged and the metal support pole can be grounded for lightning protection. In addition, the bandwidth of the antenna is at least 30 MHz and the elements can be positioned for either an omnidirectional or an offset pattern. Finally, it *will* work the first time you try it!

the dipole

Since the theory of the dipole is well known and covered in great detail in most antenna discussions, I won't dwell on it. The reason I selected the dipole over a folded dipole or a J-pole configuration is because of its simplicity and very wide bandwidth. It is constructed from 1/2-inch copper water pipe and 1/4-inch soft-drawn copper tubing. Both are excellent conductors and are readily available from most hardware stores.

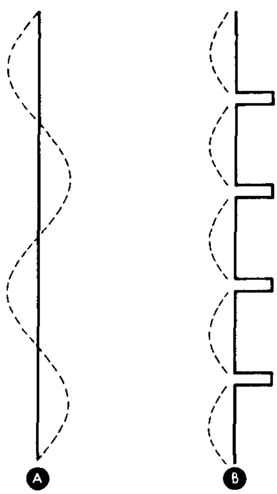


fig. 2. Franklin antennas. Natural standing-wave current distribution is shown in (A). Co-phased standing-wave current distribution is shown in (B).

As shown in **fig. 3,** the impedance of the dipole increases from the center to a maximum of about 70 ohms at the ends. The exact impedance depends on the length-to-diameter ratio of the element as well as the distance from other objects.

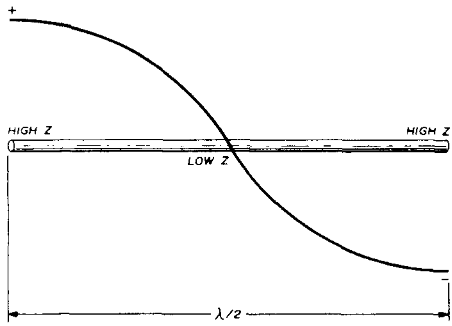


fig. 3. Half-wave dipole. Since there is no voltage to ground at the center, the element may be grounded to the support mast at this point.

At one point along either side a place will be found that will match perfectly into a 50-ohm transmission line. This is where the gamma rod is attached. Because of all the unknown variables, this point must be found by trial and error. With the antenna described here the gamma rod is attached 3-inches from the center.

To compensate for the inductive reactance of the gamma rod and to achieve a perfect impedance match, a series gamma capacitor is required. This consists of a length of number-12 Teflon-insulated wire fitted inside the end of the gamma rod **(fig. 9)**. A variable capacitor could be used but it would be hard to find one as inexpensive and weatherproof as the Teflon-insulated wire. Teflon was picked for its excellent electrical properties as well as for its resistance to the weather.

If Teflon is not available the center conductor of some RG-58/U coax will do, but the length will not be quite the same. If you use number-12 Teflon-insulated wire and follow the dimensions,

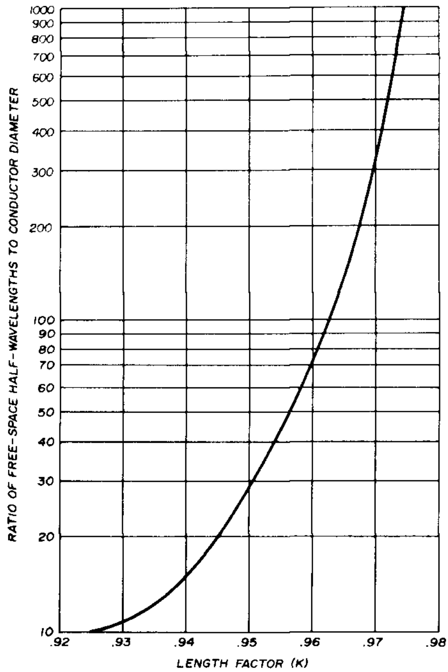


fig. 4. Effect of element diameter on the length of a half-wave dipole.

chances are that no tuning will be required.

As with the input impedance, dipole length is also affected by several variables. The approximate length is given by the formula

$$\text{length (inches)} = \frac{5905k}{\text{freq (MHz)}}$$

The k factor compensates for the shortening effect that increasing element diameter has on the length. This is plotted in **fig. 4.** With a length-to-diameter ratio of 24:1, k is equal to 0.9475. Therefore,

$$\text{length (inches)} = \frac{(5905)\ (0.9475)}{\text{freq (MHz)}} = \frac{5595}{\text{MHz}}$$

or a length of 12.7 inches at 440 MHz. Again, unfortunately, the graph of **fig. 4** doesn't take into account the additional shortening effect of the support mast. The increased capacitance of the mast causes the actual resonant length to decrease by an additional 3½% (12¼ inches). This is mentioned mainly for those of you who wish to scale this basic design to another band. This information will get you close enough so that only a little trimming will be necessary.

matching harness

The function of the matching harness is to split the power evenly and deliver it to the elements in phase and at the proper impedance. **Fig. 5** shows that, in a transmission line of even half wavelengths, the voltage and current are exactly the same at the load as at the input. This is true regardless of the vswr, assuming a lossless line. Therefore, it follows that the impedance is also the same at both ends.

The graph of **fig. 5** also shows that for an odd 1/4-wavelength section the input and the load impedance are inverted. In other words, if at the input the voltage peaks and the current nulls, at the load the current would be at a peak and the voltage would null. This relationship is given by

$$\text{input impedance} = \frac{Z_o^2}{Z_r}$$

Where Z_o is the characteristic impedance of the line and Z_r is the load impedance (must be resistive).

Now, look at the harness schematic in **fig. 6.** Since each 50-ohm dipole is fed with a one-wavelength section the impedance at the input end is also 50 ohms. The four 50-ohm sections pair into two tees. Therefore, the impedance at the tees becomes 25 ohms. The tees are then

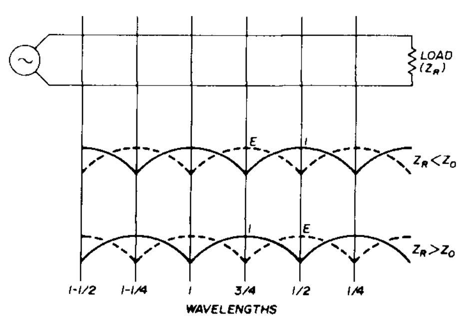


fig. 5. Standing waves on a transmission line terminated in a resistive load.

connected to a 1-1/4 wavelength section of transmission line. Therefore, from the above equation

$$\text{input impedance} = \frac{50\ \text{ohms}^2}{25\ \text{ohms}}$$

$$= \frac{2500}{25} = 100\ \text{ohms}$$

The two 5/4-wavelength lines are then connected through a tee, providing an input impedance of 50 ohms.

antenna spacing

With the dipoles and the harness out of the way only two things remain. The dipole to mounting pole spacing and the dipole to dipole spacing.

The horizontal field-strength patterns in **fig. 7** were plotted using one of the dipoles mounted with a clamp to a pole on the roof of my house. The skewing of the patterns is due to the large relative

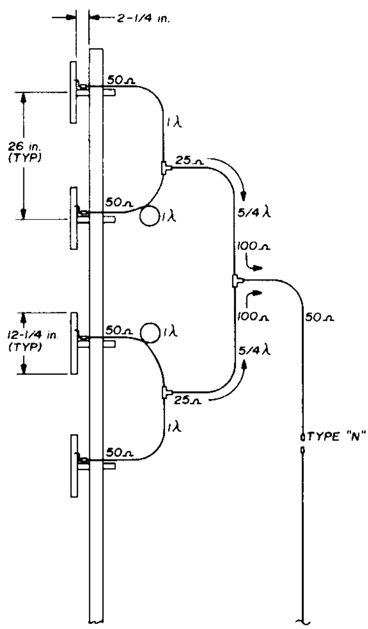


fig. 6. Layout of the matching harness for the four-element collinear. All sections are made from foam-filled Belden 8219 coaxial cable. The 1-wavelength sections are 20-15/16" long from the center of the tee to the solder terminal of the jack. The 5/4-wavelength sections are 26-11/64" long, measured between the centers of the tee connectors. All connectors are weatherproof BNC units (see parts list).

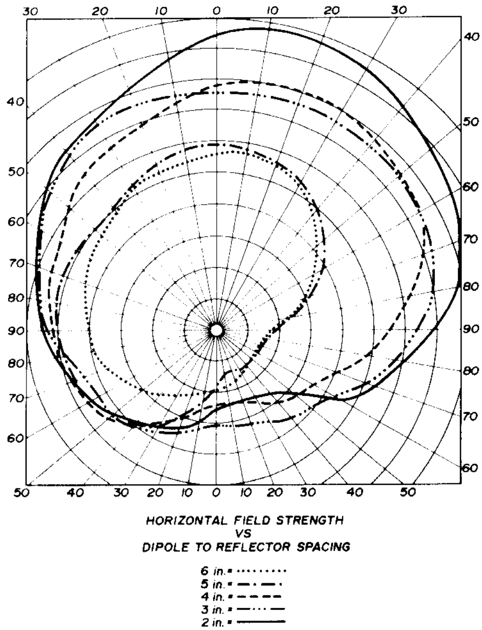


fig. 7. Field strength of single dipole element versus various dipole-to-reflector spacings.

size and close proximity of the clamp. I found that a spacing of 2- to 2¼-inches produced the best match and the highest gain. This corresponds to a spacing of about 0.11 to 0.12 wavelengths.

I didn't run any tests on vertical spacing, but research by others on similar antennas has shown that the maximum gain for a four-element array is achieved with a spacing of 0.97 wavelengths (26 inches at 440 MHz). This, incidentally, is the main reason for using the foam-filled coax. Belden 8219 coaxial cable has a velocity factor of 0.78 as opposed to only .659 for RG-58/U. Therefore, the length of harness made of 8219 cable will be correspondingly longer, thus allowing the elements to be spaced for maximum gain. If RG-58/U is used, the harness will not quite reach, and the spacing has to be reduced slightly. Since the difference is only a few inches, only a few tenths of a dB are lost, so don't worry if you can't find Belden 8219 coaxial cable.

construction

I would suggest that all the copper and

brass be polished before it is cut up, as this is much easier than doing it afterwards and will help to insure good solder joints. If you are going to use a gas stove or a torch be sure to do the actual soldering away from the flame. Otherwise, the rosin will burn and won't do its job.

Remember, at these frequencies the rf is concentrated in the outer few thousandths of an inch of conductor and a good solder joint is more important than ever. After soldering, cooling can be speeded up a bit by dripping a small amount of water on the end of the pipe *farthest* from the solder joint.

However, don't overdo it. Also, be very careful not to move the solder joint while it is cooling. A good solder joint will have a smooth appearance and a nice even fillet. If it's dull and grainy looking it was either moved before it solidified or was cooled too fast.

Dipole construction is simple and straightforward. A tubing cutter is a big time saver and does a very neat job. Other than that, no special tools are required. First, take the 1/2-inch pipe and cut it into eight pieces, each 5-3/4-inches long. In four of these pieces drill a 1/4-inch hole 3-inches from one end (**fig. 9**). From the remaining piece of pipe cut four pieces, each 4-1/2-inches long.

Next comes the 1/4-inch tubing for the gamma match. Make a 3/8-inch radius bend of 90-degrees and cut to size as shown in **fig. 9**. Be careful to leave at least 1/4-inch extra where the gamma rod

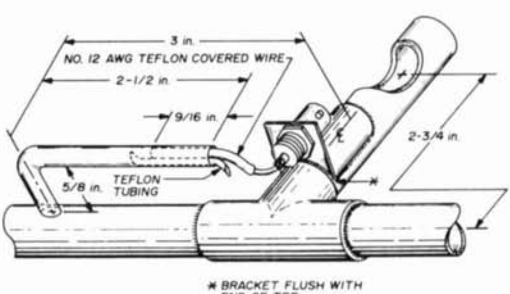
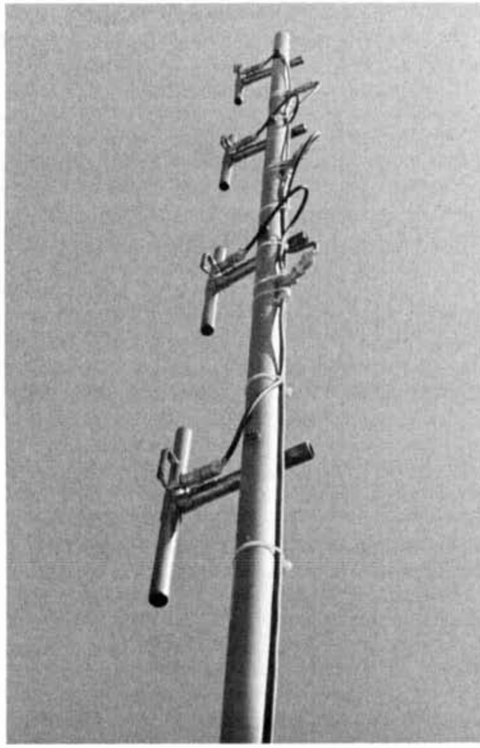


fig. 9. Construction of the gamma match. The Teflon tubing is used only to hold the wire firmly in place.



Collinear antenna with elements placed for skewed pattern. Gain in this configuration is approximately 9 dB. Note placement of harness away from elements.

mounts into the 1/2-inch element. The important thing here is to avoid kinks. After the 1/4-inch gamma rods have been bent, deburr the end that the wire will go into, using a small round file or a drill.

To make the support brackets cut a piece of copper or brass sheet 5/8-inch wide by 6-inches long and drill four 3/8-inch holes as shown in **fig. 10**. Cut and bend the brackets as shown, and then, using a vise or pliers, bend the side that is to be soldered to the pipe to conform to it.

Now, you are ready to begin soldering. First, solder the gamma rod to the pipe element. Pinch the end of the gamma rod a bit so you have a tight fit; then line it up. Hold the gamma rod and the element steady with a damp rag and start soldering. When it cools off, if it's a little out of line, it can easily be bent into shape. Next, assemble the element, temporarily

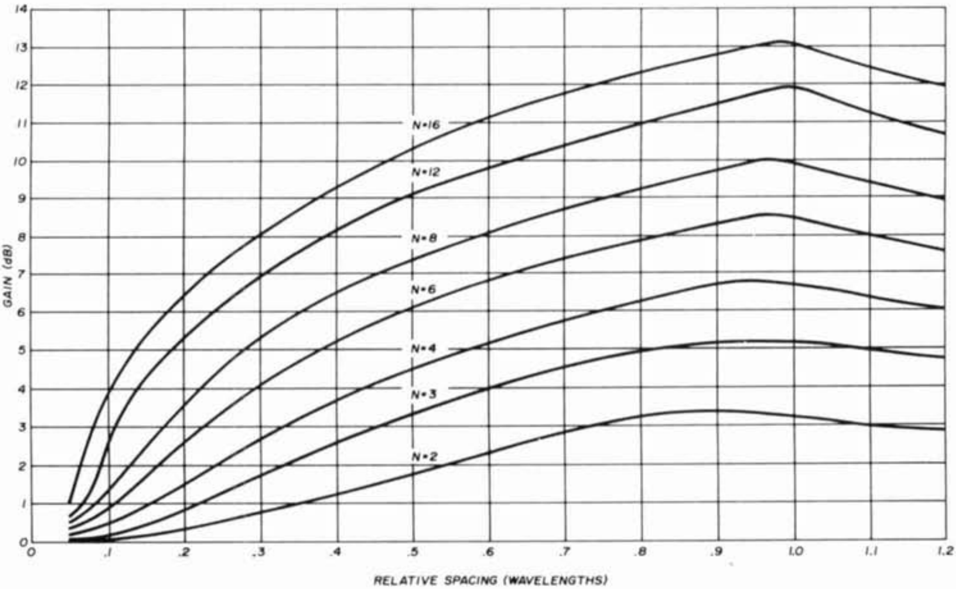


fig. 8. Gain to be expected from an omnidirection collinear array of dipole elements relative to the gain of a single element. N = number of elements.

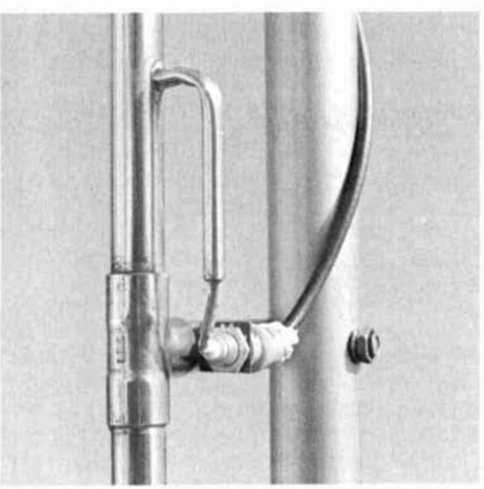
leaving off the connector and the wire.

With the dipole laying on your bench the bracket and the gamma rod should point straight up with the bracket flush with the tee. Drill a small hole through both the bracket and the pipe, and run a screw through them to hold everything steady while you're soldering (the screw can then be removed).

To keep the gamma rod from coming loose while you're soldering the bracket, hold the dipole with a damp rag at the gamma-rod end. Now, solder all the parts together.

When it cools you are ready to cut the mounting hole in the support arm **(fig. 11)**. First, cut a V-shaped hole with a hack saw, being careful to keep the saw blade parallel with the element. Then file the hole to the same radius as the mounting pole. Check your progress often by fitting it to the mast. It's important for the spacing to be an even 2¼-inches the whole length and for the dipole to be parallel with the mast.

You might think that a simple clamp would be much easier, but a glance at **fig. 7** shows what that does to the pattern. Now, give the whole thing a quick going over with the polish and install the connector and the wire. Make sure no strands are sticking out beyond the insulation that could short to the copper tubing. Leave a slight bend in the wire so that it can be adjusted a little each way from the 9/16-inch depth. Jam a piece of Teflon tubing in to hold the wire securely in place.



Construction of the dipole elements, showing the layout of the gamma match.

If you have access to a wattmeter you can now temporarily mount each element on the mast and tune for minimum reflected power. Keep everything, including your body, at least ten feet away when taking a reading. Tape the coax out of the way behind the pole and run it down to the ground. Only a slight adjustment of the wire depth, if any, should be required (with 50-watts input the reflected power should be much less than a watt).

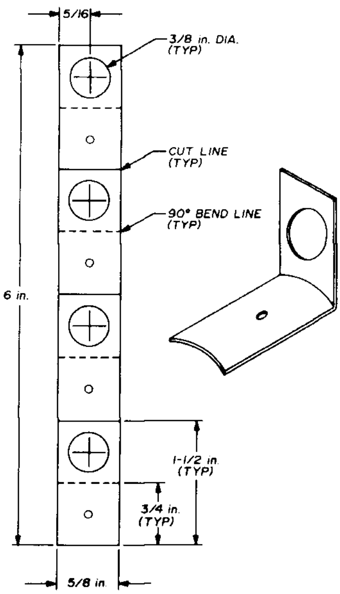


fig. 10. Construction of the mounting bracket. Material is thin brass sheet.

When each element has been tuned remove the rosin and polish with a solvent such as undiluted alcohol, tape over the mating end of the BNC connector and you're ready to put on a coat of epoxy. I sprayed the epoxy on using an aerosol power pack but it can also be brushed on. Cover everything thoroughly. If it's not covered it will corrode, and corrosion is a lousy conductor! When you are done hang the elements up to dry.

harness construction

The construction of the harness is very simple. The lengths are found from

$$\text{wavelength (inches)} = \frac{11800\ \text{(velocity factor)}}{\text{freq (MHz)}}$$

Remember that the connectors are considered to be part of the coax cable and must be included in your measurements **(fig. 6).** I found it easiest to stick a length of masking tape down on my work bench and mark the length out on it. Install a BNC connector on one end of the coax, connect it to a tee and then measure from the center of the tee. I intentionally made my cables a little long and then figured out how much shortening was necessary to make them the right length.

When you have finished all the matching sections assemble the harness and check for continuity between all the center pins. Now, liberally coat all the places that water could ever conceivably enter with silicon sealant.

final assembly

After everything is dry all that is necessary is to mount everything on the mast. If you use the Belden 8219 coax you can use the maximum gain spacing of 0.97-wavelength. If you use RG-58/U you will have to mount the elements slightly closer together. Leave a foot between the top of the mast and the top of the first dipole. Line it up and drill a hole through the pole and the pipe **(fig. 11).**

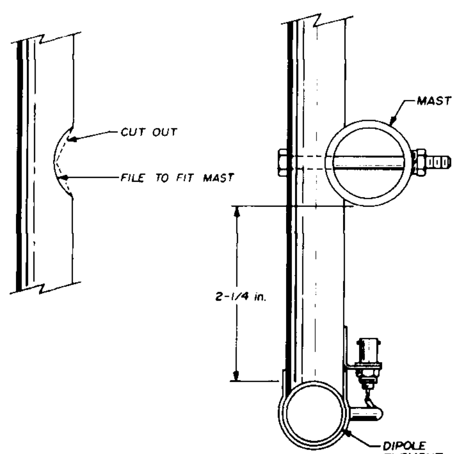


fig. 11. To mount each individual dipole on the mast a small circular section must be cut out of the support pipe.

When you tighten the mounting bolt don't get carried away. The copper pipe deforms quite easily. Be sure to use a lock washer or a self-locking nut. Then run the cable around to the back, away from the element, and secure it with a plastic cable tie or tape.

Next, decide what kind of a pattern you want. The omnidirectional pattern has about 6 dB gain over a dipole and the offset pattern, about 9 dB toward the front **(fig. 12).** If you want the offset pattern all you have to do is mount all the elements facing the same way. If you want the omni pattern point them 90-degrees apart. Mount the bottom element as far down the mast as it will easily go if you use RG-58/U or 78-inches if you use Belden 8219 coax. Don't cheat and use a BNC right-angle connector as that would change the length of the line and mess it up. Next, mount the remaining two elements evenly between the others and secure the harness in place behind the dipoles.

conclusion

If some of the materials listed are not available, don't be put off. Improvise. The BNC connectors were selected because they are *improved* and weatherproof. However, if they are all sealed with silicon sealant, as I have suggested, the older type BNC connectors should work just fine. In fact, if a low-loss weatherproof connection can be devised, no connectors would be needed at all. This would save considerable money and might allow the harness to fit inside the mast out of the weather.

The pool skimmer pole I used for the mast was selected only because of its low cost and availability in California. It can be replaced by almost anything. I hope that you have as much fun building this antenna as I had — you will be pleased with the results.

table 1. Parts list for the four-element 450-MHz collinear antenna.

8 feet	½" hard-drawn copper pipe
2 feet	¼" soft-drawn copper tubing
20 feet	Belden 8219 foam-filled coaxial cable
1 foot	1/16" Teflon tubing
1 foot	number-12 Teflon-insulated wire
1 pint	clear epoxy paint
1 tube	silicon sealant
1 can	Brasso metal polish
4 sets	stainless-steel hardware (2" x ¼" bolts, nuts and washers)
4	½" copper tees
1	brass sheet, 6" long, 5/8" wide
1	12- or 17-foot single-section aluminum swimming pool skimmer pole (or equivalent for mast)
13	UG-88E/U BNC cable-mounted male connectors
3	UG-274B/U BNC tee connector
4	UG-1094A/U BNC female bulkhead mount connectors
1	UG-556B/U type-N female cable connector

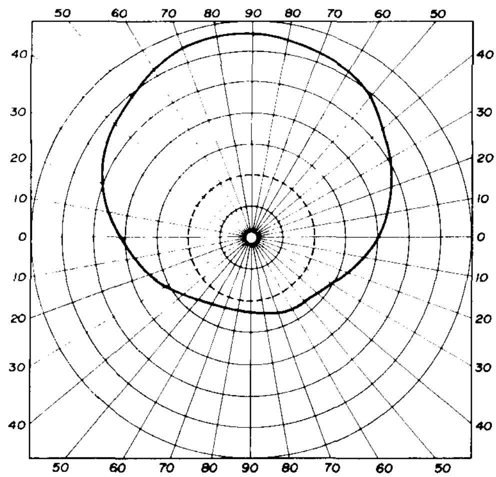


fig. 12. Horizontal field strength of the four-element collinear with all elements facing front. Gain in this configuration is approximately 9 dB. Single dipole is shown for reference (dashed line).

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1. D. Blakeslee, W1KLK, *The Radio Amateur's Handbook,* 49th edition, A.R.R.L., Newington, Connecticut, 1972.
2. E. Tilton, W1HDQ, *The Radio Amateur's VHF Manual,* A.R.R.L., Newington, Connecticut, 1972.
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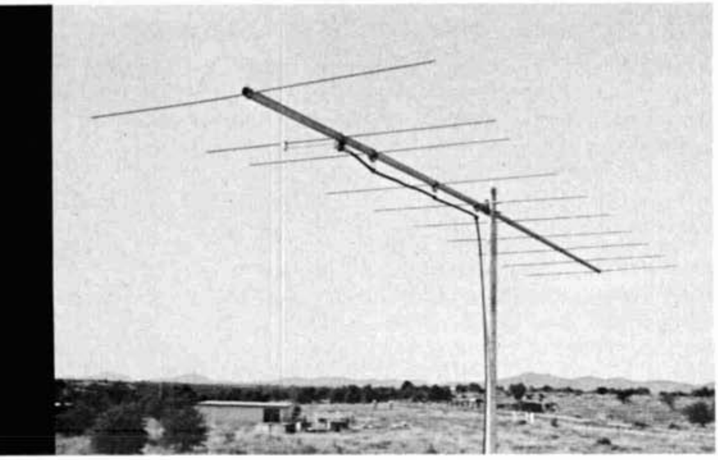

how to design
gamma-matching networks

A complete procedure for designing gamma and tee antenna-matching networks

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When the driving-point impedance of thin linear antenna systems is known, these systems can generally be gamma- or T-matched to a transmission line with excellent results. The gamma-match is used to match an unbalanced coaxial line to either a monopole or a dipole driven element, and the T-match is used to match a two-wire balanced line to a dipole driven element.

I will first discuss the gamma matching procedure, and will follow that with the T-match, showing that it is simply an extension of the technique used to design a gamma match.

gamma match

The layout of the gamma-match, minus the capacitor, is one-half that of a T-match, as shown in **fig. 1**. In this illustration L is the length of one-half of the driven dipole (total length of the driven monopole) and is often near one-quarter wavelength long. The length of the gamma rod, which is parallel to the driven element, is labeled l_Γ. The center-to-center spacing between the gamma rod and driven element is S, and Z_i is the input impedance to the gamma network, including the driving-point impedance.

When the element and gamma-rod diameters and spacings are *much* less than the carrier wavelength at which the system will be used, the geometry of **fig. 1** is *analogous to the electrical circuit shown* in **fig. 2.**[1,2,3] In **fig. 2** the input impedance, Z_i, is equal to

$$Z_i = \frac{(H_z Z_a)(X_s)}{H_z Z_a + X_s} \text{ ohms} \qquad \textbf{(1)}$$

where Z_a is one-half the dipole driving-point impedance (or monopole driving impedance), X_s is the reactance of the gamma rod and H_z is the antenna impedance step-up ratio.

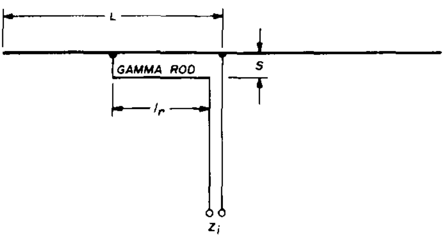


fig. 1. The basic gamma match. L is one-half the length of the driven dipole.

The reactance of the gamma rod X_s, is given by

$$X_s = jZ_o \tan kl_\Gamma \text{ ohms} \qquad \textbf{(2)}$$

where $Z_o = 60 \cosh^{-1}\left(\frac{4S^2 - D^2 - d^2}{2Dd}\right)$ ohms

in air* and $k = 2\pi/\lambda$ radians per meter. The reactance, X_s, is positive when the gamma rod electrical length, given by kl_Γ, is less than $\pi/2$ radians, as will be assumed here.

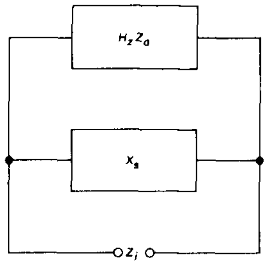


fig. 2. Equivalent circuit to the gamma-matching system shown in fig. 1. Za is one-half the dipole input impedance, Hz is the impedance step-up ratio and Xs is the reactance of the gamma rod.

The formula for the numeric antenna impedance step-up ratio, H_z, is

$$H_z = \left[1 + \frac{\cosh^{-1}\left(\frac{4S^2 - D^2 + d^2}{4Sd}\right)}{\cosh^{-1}\left(\frac{4S^2 + D^2 - d^2}{4SD}\right)}\right]^2 \qquad \textbf{(3)}$$

where D is the diameter of the driven element, d is the diameter of the gamma rod and S is the spacing between the two. This factor is plotted in normalized form in **fig. 3** for use in gamma-match designs. In plotting this graph it was assumed that H_z is at least 4:1, a realistic assumption in most amateur applications.

When the antenna is a self-resonant folded monopole the length of the gamma rod approaches $\pi/2$ electrical radians and X_s becomes much larger than $H_z Z_a$. In this case **eq. 1** is reduced to

$$Z_i = H_z Z_a \text{ ohms} \qquad \textbf{(4)}$$

In this case Z_a is not highly resistive and a low vswr at the junction of the folding element and the coaxial line may not be possible.

The complex input impedance, Z_i, of **eq. 1** may be written as a magnitude M and phase angle as given here

$$Z_i = M \angle\psi \qquad \textbf{(5)}$$

*I derived the characteristic impedance $\sqrt{L/C}$ for the high-frequency lossless line in air from the farads/meter length given on page 78 of *Static and Dynamic Electricity*, W. Smythe, McGraw-Hill Book Company, Inc., 1968, along with an approach similar to that given on page 210 of reference 13. The same solution appears on page 22-23 of *Reference Data for Radio Engineers*, Fifth Edition, ITT Staff, Howard W. Sams & Company, 1969.

where

$$M = \frac{X_s H_z \sqrt{R_a^{\,2}\ X_a^{\,2}}}{\sqrt{(H_z R_a)^2 + (X_s + H_z X_a)^2}} \text{ ohms}$$

$$\psi = \tan^{-1}\left[\frac{H_z\,(R_a^{\,2} + X_a^{\,2})}{X_s R_a} + \frac{X_a}{R_a}\right] \text{degrees}$$

To match a lossless high-frequency transmission-line characteristic resistance, R_o,

$$M \cos\psi = R_o \text{ ohms}$$

The lumped reactance, X_Γ, added in series with Z_i to tune out or cancel the reactive component of Z_i can be determined from

$$M \sin\psi = -X_\Gamma \text{ ohms}$$

For **eq. 5** to have the correct magnitude and phase angle,

eliminates a separate calculation for Z_o. **Fig. 4** is a normalized graph of T vs S/D and D/d, and **fig. 5** is a plot of kl_Γ in degrees vs Q and T. These graphs are extremely helpful when designing a practical gamma matching system.

When **eq. 10** is substituted into **eq. 6**, a solution for Q is a positive discriminant root of a quadratic equation as follows,

$$Q = A + \sqrt{A^2 + B} \text{ ohms} \qquad \textbf{(11)}$$

Where

$$A = \frac{R_o X_a}{H_z R_a - R_o} \text{ ohms}$$

$$B = \frac{R_o\left[(R_a)^2 + (X_a)^2\right]}{H_z R_a - R_o} \text{ ohms}^2$$

$$X_s = H_z\left\{\frac{R_o X_a + \sqrt{(R_o X_a)^2 + R_o\left[H_z R_a - R_o\right]\left[(R_a)^2 + (X_a)^2\right]}}{H_z R_a - R_o}\right\} \text{ohms} \qquad \textbf{(6)}$$

From which

$$X_\Gamma = -R_o \tan\psi$$

$$= -R_o\left\{\frac{H_z\left[(R_a)^2 + (X_a)^2\right]}{X_s R_a} + \frac{X_a}{R_a}\right\} \qquad \textbf{(7)}$$

The electrical length of the gamma rod (see **eq. 2**), kl_Γ, is equal to

$$kl_\Gamma = \frac{2\pi l_\Gamma}{\lambda} \cong \frac{2\pi\, f_{MHz}\, l_\Gamma\ (360)}{(0.956)\ (300)\ (39.37)\ (2\pi)}$$

$$\cong 0.03188\ f_{MHz} l_\Gamma \text{ degrees} \qquad \textbf{(8)}$$

The quantity l_Γ is the length of the gamma rod in inches and the 0.956 coefficient is an average relative velocity along the gamma rod and radiating elements.[4]

As I was developing **eqs. 6** and **7** two ratios often appeared in my calculations. I have called these T and Q:

$$T = \frac{H_z}{Z_o} \text{ ohms}^{-1} \qquad \textbf{(9)}$$

$$Q = \frac{X_s}{H_z} = \frac{\tan kl_\Gamma}{T} \text{ ohms} \qquad \textbf{(10)}$$

These two ratios are useful observations because H_z and Z_o are a function of S/D D/d. That is, when H_z is determined, T can be found, and a solution for Q

When **eq. 10** is used with **eq. 7** a solution for the reactance of the gamma capacitor can be obtained

$$X_\Gamma = -\frac{1}{2\pi f C_\Gamma} = -\ [E + F] \text{ ohms} \qquad \textbf{(12)}$$

This equation may be rearranged to provide the value of the gamma capacitor in pF

$$C_\Gamma = \frac{10^6}{2\pi\ [E + F]\ f_{MHz}} \text{ pF} \qquad \textbf{(13)}$$

Where

$$E = \frac{R_o}{R_a}\left[\frac{(R_a)^2 + (X_a)^2}{Q}\right] \text{ohms}$$

$$F = \frac{R_o}{R_a} X_a \text{ ohms}$$

In **eqs. 12** and **13** the sum of E and F is positive. Otherwise, the phase angle is in the fourth quadrant and the gamma-matching capacitor C_Γ cannot be used. For the reactance of the gamma match, X_s, to remain positive, the electrical length of the gamma rod, kl_Γ, must be less than 90 electrical degrees and **eqs. 6** and **11** have the restriction

$$H_z > \frac{R_o}{R_a} \qquad \textbf{(14)}$$

This equation is very important to broadband array operation. That is, R_a may change considerably with frequency changes and H_z should be large enough to assure the restriction given by **eq. 14**. Furthermore, vswr readings over a broad band reflect the combined characteristics

than 20 to 30 may not be practical.

When the driven element or parasitic elements of an array are arbitrarily pruned, element length and/or spacing, to obtain a resistive driving-point impedance, the forward gain may be reduced. There are many combinations of R_a, X_a, H_z, Z_o

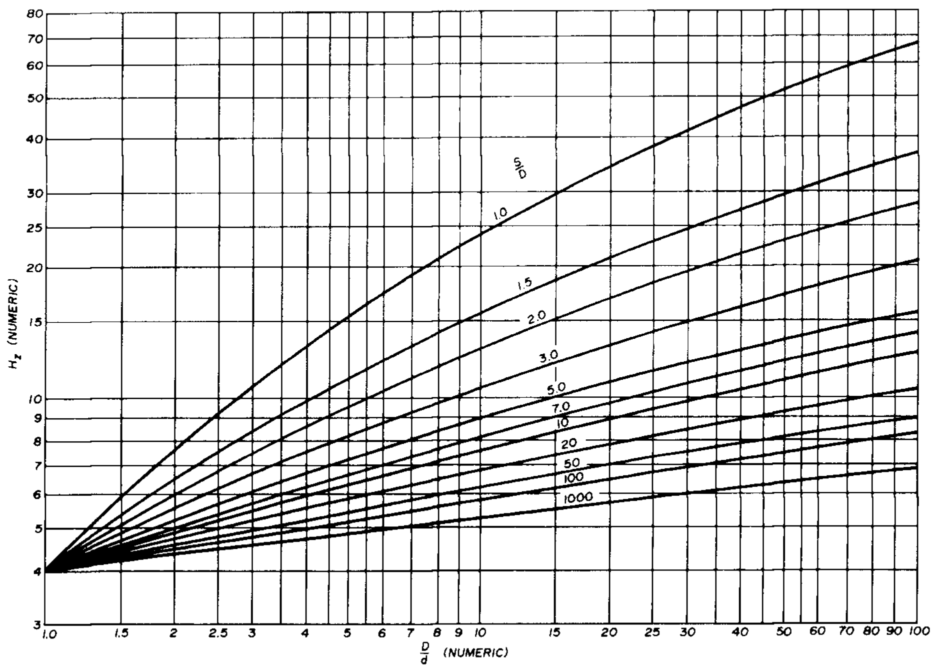


fig. 3. Antenna impedance step-up ratio, Hz, as a function of element diameters and spacing.

of the antenna and the matching network, and a well designed gamma- or T-network will follow the inverse behavior of the antenna driving-point impedance.

Large values of H_z imply small values of S together with large wire diameter ratios, D/d. At the same time, the electrical length of the gamma rod, kl_Γ, should be greater than about 15 electrical degrees to minimize ohmic circuit losses as well as to maximize antenna system bandwidth. However, large values of H_z along with large design values of kl_Γ can lead to construction errors and/or instability in H_z, Z_o, T and Q. When the driven element diameter is not very large an H_z of more

and l_Γ which satisfy **eq. 6**. Also, many *combinations* of D, d, S and C which are correct solutions, but not necessarily best.

For example, if it is desirable to reduce the length of the gamma rod, **eq. 10** shows that Q will be reduced (T is inversely related). Looking further, **eq. 6** shows that a reduction in Q requires an increase in H_z, and **eq. 2** shows that an increase in H_z requires an increase in D/d or a decrease in S/D (or combination of both). From **eq. 3** it can be seen that an increase in D/d increases Z_o, while a decrease in S/D decreases Z_o. The ambiguity here is eliminated by plotting T, given in **eq. 9** and plotted in **fig. 4**.

practical gamma-match

Some time ago I obtained a homebrew 10-element, two-meter Yagi-Uda type in-line end-fire array with somewhat unusual spacings and element lengths. Measurements with the antenna's dissimilar diameter folded-dipole driven element connected to 300-ohm open-wire line indicated that its best overall performance was near lower end of the 144-MHz band. An analysis of element lengths and spacing confirmed this observation, and calculations indicated that best performance was at about 144.6 MHz.

Since I wanted to use the antenna at a somewhat higher frequency, 145.4 MHz, I discarded the folding element (which transfers *any* antenna driving-point impedance, real or complex, to the transmission line) and shortened all the elements. I did not change element spacing or boom length, so performance was compromised somewhat. However, calculations indicated that the array's performance was much improved over the 145.35- to 146.25-MHz segment of the band. The free-space driving-point impedance, Z_a', is slightly inductive, about 14 + j3 ohms at 145.4 MHz where I'll be using the antenna most of the time.

To use the previously discussed gamma-match design equations, the free-space input impedance, Z_a', must be divided by 2. Therefore, Z_a = 7 + j1.5 ohms. Since I planned to use 50-ohm polyfoam RG-8/U with the antenna, R_o = 50 ohms. The diameter of the driven element is 0.375 inch and the diameter of the gamma rod, which is made from number-12 wire, is 0.0808 inch. The spacing between the elements, S, is approximately 0.6029 inch (0.375-inch long insulator plus one-half the diameter of the driven element, plus one-half the diameter of the gamma rod).

With these figures, the gamma-match design procedure can begin by finding two simple ratios:

$$\frac{D}{d} = 4.64$$

$$\frac{S}{D} = 1.61$$

When these two ratios have been found, the antenna impedance step-up ratio, H_z, can be found from **fig. 3**. In this case, H_z is equal to approximately 11.0. The quantity T can be determined with the help of **fig. 4**, approximately 0.046 ohm^{-1} in this case. Now, calculate A and B and use those quantities to find Q:

$$A = \frac{R_o X_a}{H_z R_a - R_o} \cong \frac{+75}{27} \cong +2.77 \text{ ohms}$$

$$B = \frac{R_o \left[(R_a)^2 + (X_a)^2\right]}{H_z R_a - R_o}$$

$$\cong \frac{2562.5}{27} \cong 94.9 \text{ ohms}^2$$

$$Q = +A + \sqrt{A^2 + B}$$

$$\cong +2.77 + \sqrt{102.57} \cong 12.9 \text{ ohms}$$

With the quantities Q and T known, the electrical length of the gamma rod, kl_Γ, in degrees can be determined with the help of **fig. 5**. In this case the gamma rod is approximately 31.0 electrical degrees long. This can be converted into inches by rearranging **eq. 8**.

$$l_\Gamma \cong \frac{kl_\Gamma}{0.03188 f_{MHz}} \cong \frac{31}{0.03188(145.4)}$$

$$\cong 6.69 \text{ inches}$$

To find the required gamma capacitance, calculate the quantities E and F from **eq. 13**.

$$E = \frac{R_o}{R_a}\left[\frac{(R_a)^2 + (X_a)^2}{Q}\right]$$

$$\cong \frac{2562.5}{(7)\ (12.9)} \cong 28.38 \text{ ohms}$$

$$F = \frac{R_o}{R_a} X_a \cong \frac{50\ (+1.5)}{7} \cong 10.7 \text{ ohms}$$

$$C_\Gamma = \frac{1{,}000{,}000}{2\pi\ [E + F]\ f_{MHz}}$$

$$\cong \frac{1{,}000{,}000}{35{,}700} \cong 28 \text{ pF}$$

Thus, the gamma-matching network consists of a gamma rod made from number-12 wire, approximately 6.69 inches long with an axial center-to-center spacing of 0.6029 inch from the *parallel* driven element. The gamma capacitor is about 28 pF, which can be provided by the 7- to 45-pF variable I happen to have in my junkbox.

This same basic design procedure can also be used if the driving-point impedance is slightly capacitive. For example, if my two-meter array driving-point impedance had been 14 - j3 ohms at 145.4 MH_z, Z_a for design purposes would be 7 - j1.5 ohms. The values for D/d, S/D, H_z, T, A and B would be the same as for the previous case, although the A quantity would have a negative sign. This changes the magnitude of Q to 7.36 ohms. Referring to **fig. 5**, the length of the gamma rod is approximately 20.0 electrical degrees, and its length is

$$l_\Gamma \cong \frac{k l_\Gamma}{0.03188 f_{MHz}}$$

$$\cong \frac{20}{0.03188(145.4)} \cong 4.31 \text{ inches}$$

Now, calculate the quantities E and F and determine the value of the gamma capacitor:

$$E = \frac{R_o}{R_a}\left[\frac{(R_a)^2 + (X_a)^2}{Q}\right]$$

$$\cong \frac{2562.5}{(7)\,(7.36)} \cong 49.73 \text{ ohms}$$

$$F = \frac{R_o}{R_a} X_a \cong \frac{50(-1.5)}{7} = +10.7 \text{ ohms}$$

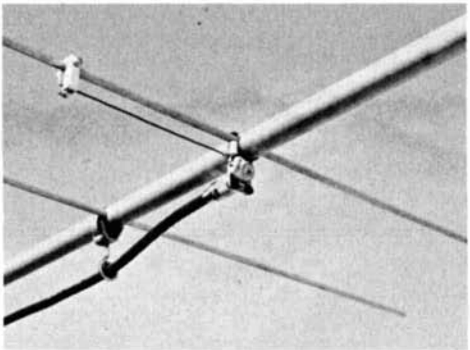
$$C_\Gamma = \frac{1{,}000{,}000}{2\pi\,[E + F]\, f_{MHz}}$$

$$\cong \frac{1{,}000{,}000}{35{,}700} \cong 28 \text{ pF}$$

Thus, when the gamma rod is shortened from 6.69 inches to about 4.31 inches, and no other changes are made, the gamma network will properly terminate the 50-ohm coaxial feedline into an antenna impedance of 14 - j3 ohms.

testing the design

Using an adjustable gamma rod 7.5 inches long and a 7- to 45-pF variable gamma capacitor, I assembled the gamma match to the antenna. When the antenna was erected horizontally, 18-feet above the ground, with the gamma rod adjusted to 6.75-inches long and the gamma capacitor set to approximately 25 pF, the vswr was as follows:



Gamma-matching system for the 144-HMz Yagi beam antenna.

146.3 MHz 1.38:1 vswr
145.4 MHz 1.03:1 vswr
144.9 MHz 1.16:1 vswr

As can be seen, at the design frequency of 145.4 MHz the standing-wave ratio is extremely small.

Calculations indicated that the driving-point impedance of this modified homebrew array becomes slightly capacitive at both 144.9 and 146.3 MHz. Therefore, I began to shorten the length of the gamma rod and increase the gamma capacitance to see if I could obtain a *constant* vswr. With a gamma rod length of 5.5625 inches and the gamma capacitor set to 35 pF I obtained what I was looking for:

146.3 MHz 1.27:1 vswr
145.4 MHz 1.28:1 vswr
144.9 MHz 1.27:1 vswr

I then twisted the antenna boom 90° so that the antenna was vertically polarized on the *metal* mast. Without touching the gamma adjustments, I slipped the boom back and forth until I obtained a minimum vswr of 1.3:1 at 145.4 MHz.

The boom was locked at this point, and both the gamma rod and gamma capacitor were adjusted (in that order) to obtain a minimum vswr of 1.09:1.

I then started to raise the height of the array by increasing the height of the mast. When the array was about two feet higher (13 quarter-wavelengths above ground) the vswr was maximum at 1.6:1. Above this height the vswr began to decrease. I expected maximum mast coupling to occur at odd quarter-wavelengths of mast, and this behavior confirms it.

I locked the antenna at 21 feet above the ground (I wasn't able to reach the gamma capacitor at greater heights) and adjusted both the gamma capacitor and the gamma rod. I then pushed the antenna up to slightly more than 25 feet above ground, the maximum height of the mast, and made the vswr measurements. After several adjustments at the 21-foot level, at the 25-foot height, with a gamma capacitance of 30 pF and a gamma rod length of 5.875 inches, I obtained the following vswr measurements:

146.3 MHz 1.10:1 vswr
145.4 MHz 1.02:1 vswr
144.9 MHz 1.04:1 vswr

performance

Essentially all of the two-meter stations in Tucson, about 35 miles from my station, are vertically polarized, and my propagation is by diffraction over the north end of the Santa Rita mountain range. In running tests with K7RMH in Tucson, I was delighted to find that my British dual-eight skeleton slot antenna, which is 3 to 4 feet higher than the homebrew array, was only about 3 dB better with the same power input. That is, with one-watt rf input, at K7RMH's station I was S9 +30 dB with the homebrew array and S9 +33 dB with the skeleton slot.

Upon further testing with a two-position coaxial switch in the feedline for rapid switching between the line tuner and the RG-8/U coaxial cable, I discovered that the coaxial switch generates a vswr of 1.5:1 at the transmitter. This results in

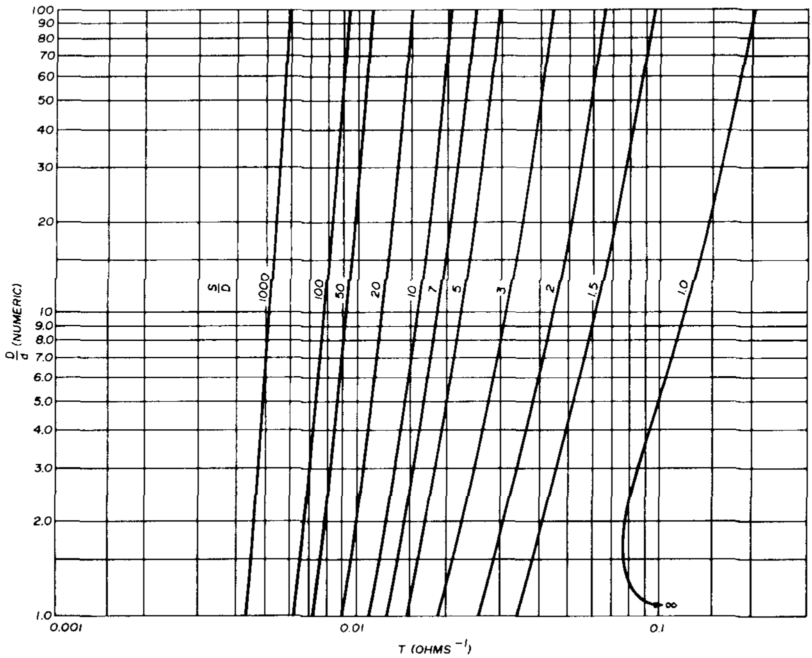


fig. 4. Ratio T (Hz/Zo) as a function of gamma-matching element diameter and spacing.

about a 1.0 dB loss at K7RMH's station which suggests that the K7RMH signal readings are intensity, *not* power, sensitive. This indicates that a change of 3 dB at K7RMH is a *power* change of 6 dB.

Calculations indicate that the gain of the skeleton slot is about 4 dB better than that of the homebrew array. I am using *Propagation* calling for papers on antenna measurements.

It may be that the recent article by W3TQM which described how to determine antenna impedance by direct swr measurements may prove popular with amateurs.[5] I hope to try this procedure sometime to confirm my calculations on

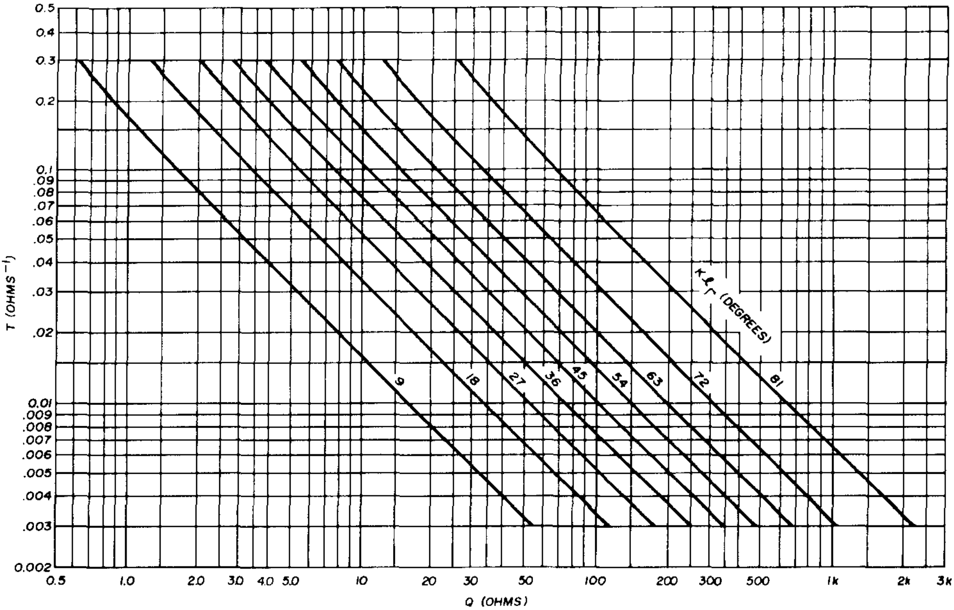


fig. 5. Length of the gamma rod in electrical degrees vs the quantities T and Q. This graph is very helpful when designing practical gamma-matching systems.

about 35-feet of 300-ohm open-wire feedline to the slot antenna, and 50-feet of RG-8/U polyfoam coax to the homebrew array. Assuming that 1 dB more is lost in the coaxial line than in the open-wire feeder, and that the height gain of the slot antenna is 1 dB better, the test results check out very well.

impedance measurements

A problem many amateurs face when designing their own antenna is measuring the driving-point impedance. Often, they do not have the necessary equipment or the technique is long and drawn out, and provides erroneous results. This seems to be underscored by an article in the July, 1972, *IEEE Trans. on Antennas and* the homebrew two-meter array to see how it works out.

Another possibility is the simple complex impedance bridge described by W2CTK.[6] When compared to a commercial RX bridge the accuracy of the W2CTK bridge is quite good. A complete discussion on the use of this instrument appears elsewhere in this issue.

In the absence of impedance measurements, the amateur must generally resort to existing published material which provides the driving-point impedance for various antenna configurations. However, with different (unscaled) antenna layouts, the magnitude and phase angle of the driving-point impedance will be different.

However, a review of some of the

available material suggests that, most of the time, the resistive, R_a, and reactive, X_a, portions of the antenna driving-point impedance will fall within the following limits:

$$+3 \leqslant R_a \leqslant +175 \text{ ohms}$$

$$-70 \leqslant X_a \leqslant +55 \text{ ohms}$$

For estimates of the driving-point impedance, consult references 1, 2, 4, 7, 8, 9, 10, 11, 12, 13 and 14. Computer programs have been developed for calculating the driving-point impedance vs the layout of the antenna, but unfortunately, these programs are generally not available to amateurs.

another design approach

When H_z can have a value of 4.0, **fig. 3** suggests that the S/D ratio can be any value when D/d = 1.0. In this case a decision as to what value of S/D to use can depend upon a *desired* kl_Γ. Using this approach, Q is determined first as a function of the A and B terms on **eq. 11**. At the same time kl_Γ should be greater than about 15 electrical degrees — I would use one of the 18- to 45-degree lines in **fig. 5** if I were not insisting upon a specific gamma-rod length. Then T can be obtained from **fig. 5** as a function of kl_Γ and Q. With T determined, S/D lies along the abscissa of **fig. 4** where D/d = 1.0.

For example, consider a self-resonant vertical monopole antenna on a good ground plane with an assumed driving-point impedance of 34 + j17 ohms at 145.4 MHz. Therefore, R_a = 34.0 ohms and X_a = 17.0 ohms. With a polyfoam RG-8/U feedline, R_o = 50.0 ohms. Since the antenna impedance step-up ratio, H_z, must be larger than the ratio R_o/R_a (see **eq. 14**), if a value of 4.0 is chosen for H_z, in this example it will satisfy that requirement.

With H_z = 4.0, the diameter ratio D/d may be found from **fig. 3** to be 1.0. Assuming driven element and gamma rod diameters of 0.375 inch, the values for A, B and Q are as follows:

$$A = \frac{R_o X_a}{H_z R_a - R_o} = \frac{+850}{86} \cong +9.884 \text{ ohms}$$

$$B = \frac{R_o\left[(R_a)^2 + (X_a)^2\right]}{H_z R_a - R_o}$$

$$= \frac{72250}{86} \cong 840.1 \text{ ohms}^2$$

$$Q = +A + \sqrt{A^2 + B}$$

$$\cong 9.884 + \sqrt{937.78} \cong 40.51 \text{ ohms}$$

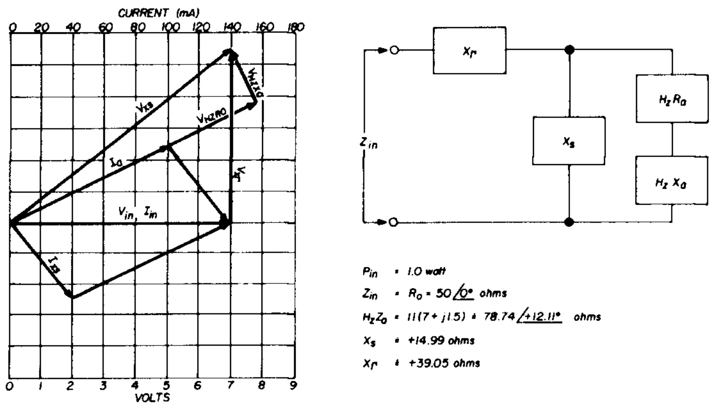


fig. 6. Voltage and current distribution of the gamma-matching network designed to match the 50-ohm coaxial line to the 10-element beam at 145.4 MHz (Za = 7 + j1.5 ohms). Voltage and current values are based on power input of 1 watt.

Using a selected gamma-rod length of 36.0 degrees, the length of the rod in inches is

$$l_\Gamma \cong \frac{kl_\Gamma}{0.03188 f_{MHz}}$$

$$= \frac{36}{0.03188(145.4)} = 7.766 \text{ inches}$$

When kl_Γ is 36.0 degrees, T is 0.018 ohms^{-1} (see **fig. 5**). When both T and D/d are known, the spacing-to-diameter ratio S/D can be found from **fig. 4**. In this case, S/D = 3.3. Therefore, the center-to-center spacing is

$$S = 3.3D = 3.3(0.375) \cong 1.24 \text{ inch}$$

Now, the quantities E and F may be determined, and the value of the gamma capacitor, C_Γ, calculated:

$$E = \frac{R_o}{R_a}\left[\frac{(R_a)^2 + (X_a)^2}{Q}\right]$$

$$\cong \frac{72250}{1377.3} \cong 52.46 \text{ ohms}$$

$$F = \frac{R_o}{R_a} X_a = \frac{50(+17)}{34} = +25.0 \text{ ohms}$$

$$C_\Gamma = \frac{1{,}000{,}000}{2\pi\,[E + F]\, f_{MHz}}$$

$$\cong \frac{1{,}000{,}000}{70{,}711} \cong 14.14 \text{ pF}$$

Therefore, the completed gamma-matching network consists of a 0.375-inch diameter gamma rod, about 7.75-inches long, with a 14pF gamma capacitor.

tee match

Although the previous discussion pertains to the gamma match, the same design philosophy may be applied directly to the tee match. If you want to tee-match a balanced transmission line to an isolated thin linear antenna at the driving impedance point, the driving-point impedance, Z_a', and the line characteristic resistance, R_o', are halved and the procedure for findings S/D, D/d, kl_Γ, and C_Γ for one arm of the tee-match follows that for the gamma match. The results are merely imaged to, or flipped over, to the other arm of the tee- or double-gamma configuration.

For example, to match a balanced feedline to the previously discussed homebrew array, which has an input impedance of 14 + j3 ohms, the gamma-match values on page 51 would be used in each arm of the tee-match to provide a match to *balanced* 100-ohm transmission line. If you want to use 300-ohm balanced line, use the same gamma-match design procedure. However, use R_o = 150 ohms for *each* arm of the tee.

acknowledgement

I want to thank W7ERU for his assistance. Without his computations, reasonable limits and graph plotting would have been a tedious task.

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grounded vertical-tower antenna system

Using your tower as a grounded vertical radiator to obtain efficient five-band operation with one tower

John R. True, W4OQ, 10322 Georgetown Pike, Great Falls, Virginia 22066

After completing a triband three-element quad and erecting it on top of a 54-foot grounded tower, I decided to use the whole tower on 40 and 80 meters as a vertical radiator. A search of the antenna books, magazines and other available sources revealed relatively little information on the *grounded* vertical radiator. I then decided to do a study of the problem. On-the-air requests for information has prompted this article.

As shown in **fig. 1**, the three-section telescoping tower is self supporting, crank-up and tilt-over. A gamma rod using 1¼-inch heavy-wall aluminum conduit was attached to the bottom section of the tower using 1½-inch aluminum angle. Its spacing from the tower was varied from 6 to 18 inches with minimal electrical variation. It was fixed at 15 inches as an optimum mechanical electrical compromise.

To ensure electrical continuity the three telescoping sections of the tower were bridged with flashing copper straps.

Various ground-plane systems have been evaluated. The first system I tried consisted of two 100-foot lengths of 3-foot-wide fence wire on either side of the tower. Twenty-five-feet of this wire was east of the tower and 75-feet was to the west of the tower. This was an attempt to obtain a pattern advantage towards the west. This worked quite well for a year, but since these two lengths of wire were on top of the grass in the backyard, they presented a considerable hazard to anyone walking through the yard.

The last ground-plane system I tried has been in use for more than six months. A plan view of this system is shown in **fig. 2**. A fence was built on wooden posts

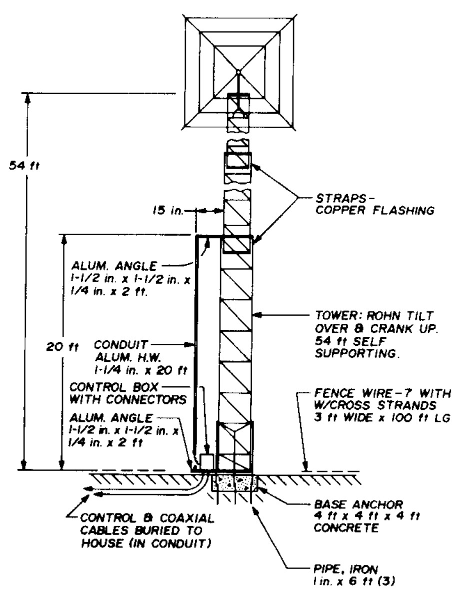

fig. 1. Construction of the 54-foot tower used as a grounded vertical antenna on 40 and 80 meters.

with the bottom wire installed 6-inches above the ground. I used poultry fence wire for this fence because each vertical wire is electrically welded to each horizontal wire, so there are no noisy electrical connections.

This wire provides approximately 0.6 square foot of surface area for each lineal foot of length. As shown in **fig. 2**, the total length of this wire is 190 feet. Seventy-feet of this fence is east of the tower and 120-feet is to the west (including the dog-yard fence). Additionally, 60-feet of the same fence wire is nailed to the rear of the house to augment the fence wire on the posts.

The four directions seen by the base currents provide approximately 2.4 square feet of conductor area per lineal foot of ground plane. This is reduced as the distance from the tower base is increased.

The fence wire is connected to the base of the tower with three lengths of ¼-inch copper tubing: two to the fence on the posts and one to the fence wire nailed to the side of the house. All connections, including fence wire interconnections, are made by brazing with brass rod. No buried wires or radials are used except the ¼-inch copper tubing connections which are 2-inches deep in grass sod.

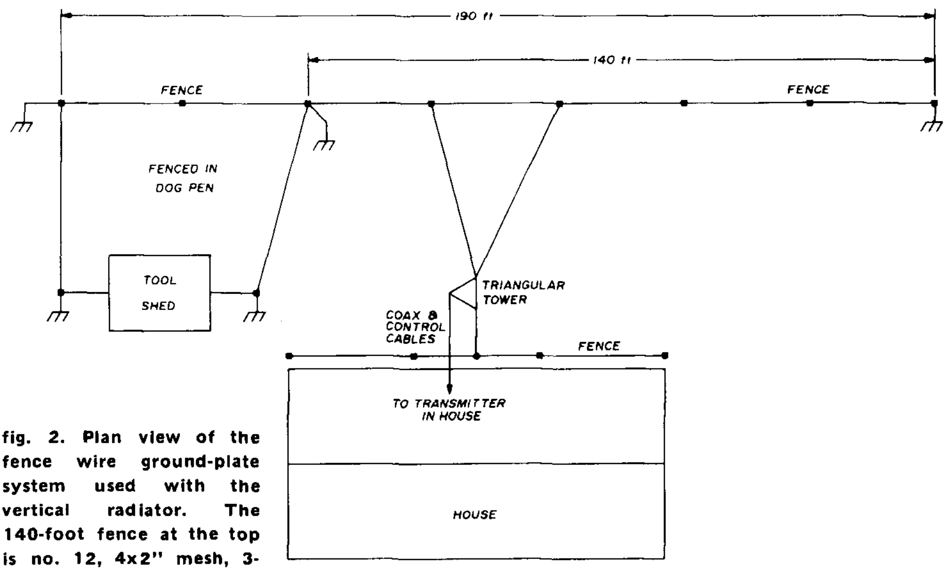

fig. 2. Plan view of the fence wire ground-plate system used with the vertical radiator. The 140-foot fence at the top is no. 12, 4x2" mesh, 3-feet high. The fence around the dog pen is no. 14, 1x2" mesh, 4-feet high. The fencing nailed on the back of the house uses the same material as in the 140-foot fence but is 60-feet long.

electrical measurements

Preliminary electrical measurements indicated that a 10 to 250-pF variable capacitor connected in series with the end of the gamma rod would cancel the inductive reactance seen at that point.

A breadboard layout was constructed and tried out at the tower base. The variable capacitor was adjusted to produce zero reactance as shown on a General Radio model 916A rf impedance bridge. Resistive readings were taken at 50-kHz increments from 3.5 to 4.0 MHz and from 7.0 to 7.3 MHz. The 80-meter band showed 5 to 6 ohms resistive and the 40-meter band showed 42 to 60 ohms resistive.

impedance matching

With the electrical characteristics available, solution of the impedance-matching problem was done by use of a graphic method (see **fig. 3**).[1] The method allows a solution by using only a straight edge, a compass and graph paper. Simple arithmetic is all the mathematics that is required. Additionally, a visual choice of alternate solutions is immediately available during the graphic solution. The accuracy of constants produced is better than available equipment parts.

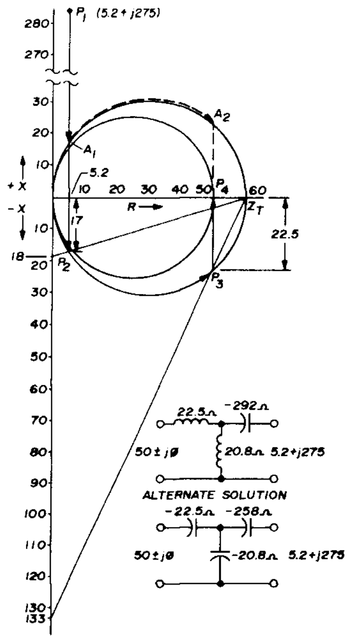

fig. 3. Graphic solution of the impedance-matching problem. See reference 1 for more information on using this technique. The input impedance of the antenna is shown on the graph at P1 (5.2 + j275). The distance from P1 to P2 is 292; since it is in a negative direction this line represents a capacitance reactance of 292 ohms. To get to the 50-ohm point, P4, you must traverse P2 to P3, representing a shunt inductive reactance of 20.8 ohms, and from P3 to P4, a series inductive reactance of 22.5 ohms. An alternate solution is to go from P1 to A1, from A1 to A2, and from A2 to P4. This provides the alternate matching network consisting of three capacitors.

The graphic solution shows that for operation on 75 and 80 meters, an inductive reactance of 20.8 ohms in shunt and an inductive reactance of 22.5 ohms in series will convert the 5.2 (average ohms) resistive component to 50 ohms for matching to the 50-ohm coaxial line. The use of ferrite toroids makes a compact low-Q L-network. By using the rf bridge while building the inductors it is possible to get them right on.

When these inductors are housed in a metal weather-resistant box at the tower base there may be some minor change in the characteristics of the gamma rod and the matching components. If low vswr is not attained re-measure the resistive component with the shield box closed. Then, make another graphic solution and rebuild the required components.

The 40-meter data shows that the resistive component is within tolerance for low vswr without need for a matching network. A dpdt rf relay switches the coaxial line from the L-network on 80 meters directly to the variable capacitor for use on 40.

observations

The tower was elevated from 22- to 32-, 40-, 48- and 54-foot levels with only small changes in the electrical characteristics. Therefore, it would appear that any tower from 25- to over 75-feet in height should be capable of being used as a grounded vertical radiator on 40 and 80 meters, with appropriate matching networks.

Most enterprising amateur antenna design enthusiasts can bum, beg, borrow or otherwise obtain the use of a radio frequency impedance bridge. Most colleges and electronics companies have such a bridge. A permanent solution to the problem of availability of an rf impedance bridge would be the construction of a Macromatcher[2] by a group or club.

The bridge used *must* differentiate between the resistive and reactive components with fair accuracy if you want to properly design the required components to couple the grounded tower, with gamma system, to the coaxial transmission line.

This vertical radiator system has relatively little loss due to ground losses and has proven to be an excellent radiator on both 40 and 80 meters. It could be used on 160 meters with reduced efficiency. In this regard, the vertical radiator would be superior to a horizontal dipole, unless the dipole was half-wavelength above the

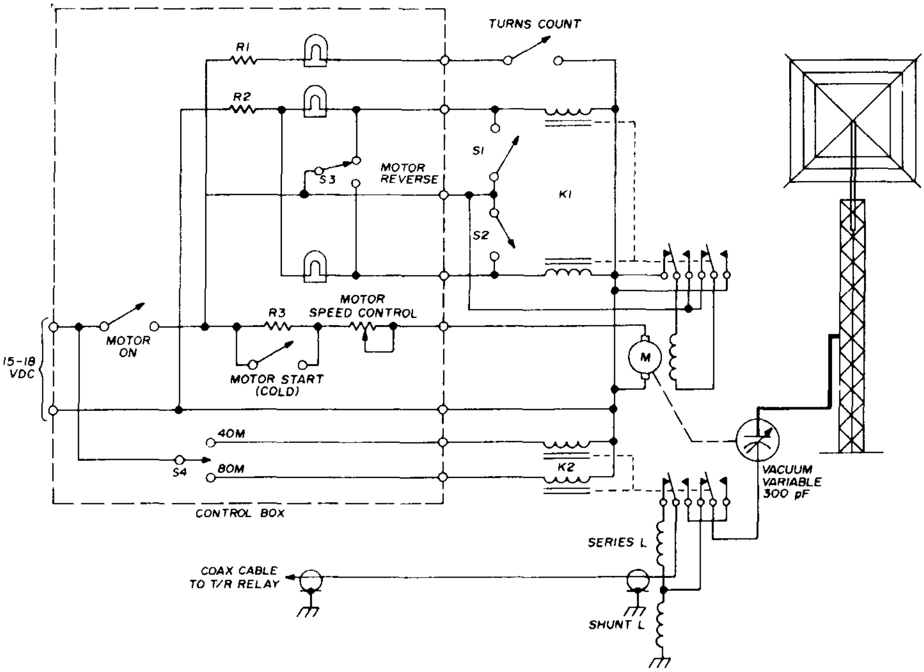

fig. 4. Alternate antenna control system which uses latching ralays to control motor direction and bandswitching. Microswitches S1 and S2 are limit switches on the vacuum variable capacitor. The turns-count switch is actuated each time the vacuum-variable shaft makes one revolution. Resistors R1 and R2 are pilot-lamp current-limiting resistors. Resistor R3 prevents current surges when the motor is cold. The motor is a 24-volt, 1/12 hp unit geared down to drive the vacuum variable. The low-Q series and shunt inductors are wound on 2" Amidon toroidal cores.

ground. Of course, an additional advantage is a lower angle of radiation on 10, 15 and 20 meters.

operation

Both forward and reflected vswr meters are used in the coaxial line. By controlling the motor driven vacuum-variable capacitor until the forward meter peaks and the reflected meter dips to minimum, the exact null-out of the reactance can be seen. The use of the reversing switch and slow speed on the geared-down motor makes it possible to get right on.

Either of two control systems may be used to provide complete control of the remote tuning system located at the base of the tower. One system was described previously[3]. A more complex control system is shown in **fig. 4**. This system has several features worth considering. The most important advantage is its ability to automatically reverse the motor field, hence direction of the vacuum-variable capacitor, when actuating either of the limit microswitches.

A second advantage of the control system in **fig. 4** is the use of latching relays which require no holding current (and hence, no electrical noise). With these relays, once the armature has been shifted and latched by a short burst of current, it can be dropped out by another short burst of current through the unlatching solenoid.

A third remote-control system is on the drawing board and in the parts-collecting stage. This system will follow the general design of the automatic solid-state antenna tuner described by WAØAQC[4].

conclusion

The operational results obtained in the past few months prove conclusively that the vertical tower antenna is an excellent omnidirectional radiator. With the control system outlined here low vswr can be obtained throughout the 40- and 80-meter bands. This broadband effect is the result of the massive tower structure and the effect of a large top-hat of quad (or Yagi) elements.

Unfortunately, there is another set of characteristics for an omnidirectional radiator when used for receiving. Because such a structure is broadband, unless high- and/or low-pass filters are provided, image frequencies and/or broadcast band harmonics could reduce the signal-to-noise to interference ratio. However, the necessary filters are also easy to design using the graphic solution technique. Additionally, signals from all directions may produce interference on the desired operating frequency.

To some, this project may seem an overwhelming task to undertake, however, for those of you who have small back yards and want to get on 40 and 80 meters without using a narrowband Z-shaped doublet or a droopy vee, may find it a necessity. Those of you who are dedicated antenna design and construction enthusiasts should find this a rewarding project.

Acknowledgement is made to Stanley Steinberg for engineering, grammatical and editorial comments, and to Stanley Dlugosz, W3EVB, for the excellent photography presented here. Last, but by no means least, apologies to an understanding wife for many delayed meals and for many piles of junk in the wrong places.

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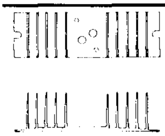

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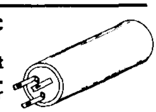

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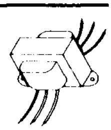

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suitcase antenna

Complete description of a continuously-loaded multiband trap antenna that fits in a suitcase

Brian Warman, VK5BI, Cowell, South Australia 5602

Some amateurs like to take their equipment with them when they travel. Mobiling these days is very easy with modern rigs and the many fine commercial antennas which are available. It is not so pleasant though, to work mobile in today's traffic, and many traveling hams hanker for a ragchew in the comfort of their motel room at the end of the day. What is required here is a portable antenna.

A loaded whip, helical or whatever, needs a groundplane. It is also prone to detuning when moved; these considerations prompted me to look for an alternative and I decided on a dipole.

the antenna

The 5BI Suitcase is a continuously-loaded trap dipole antenna for 80, 40 and 20 meters. It is 65-inches long when assembled, and may be dismantled to fit diagonally into a suitcase. The maximum dimension when dismantled is 33 inches. I have tested it to an input power of 500 watts PEP.

Any antenna which has its radiating portion compressed is going to be inefficient. However, with today's compact high-power transceivers these inefficiencies are less important. What is required of any antenna before it can be used is resonance at the required frequency and an ability to match the transmitter output. When designing a loaded antenna it is necessary to decide on your favorite operating frequency and wind the antenna to suit. Any deviation from this frequency will cause a marked rise in vswr.

The design impedance is determined by the spacing between the sides of the dipole, i.e., the proximity of the two coils. In the case of the prototype the impedance was in the order of 300 ohms on 80 meters.

Before attempting to construct this antenna two pieces of test equipment are essential. Every amateur should possess an antenna bridge of some sort. I recom-

153 turns of number-24 plastic-insulated copper wire. Anchor it at 153 turns and wind a further 9 turns (for the 14-MHz trap) and anchor it again. Now, wind 84 turns for the 7-MHz section and follow this with 15 turns for the 7-MHz trap. Finally, wind 206 turns on each for the 3.5-MHz section.

The traps are resonated as follows: the 14-MHz trap is resonated with 50 pF and the 7-MHz trap is tuned with 100 pF. The capacitors I used were 500-volt micas.

The antenna is used in conjunction

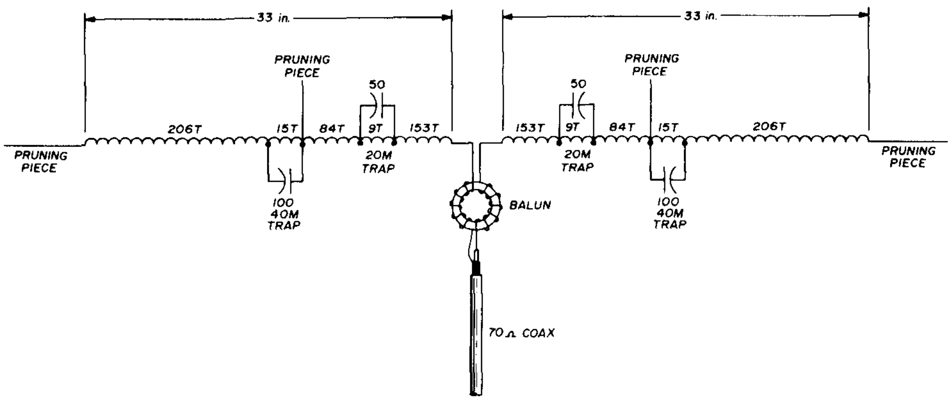

fig. 1. Continuously-loaded trap dipole is small enough, when dismantled, to fit into a suitcase. Antenna can be erected in just a few minutes.

mend the Omega Noise Bridge because of its simplicity and low cost. With this instrument it is possible to read off resonant frequency and impedance quickly and without resorting to math. There have also been a number of constructional articles on similar devices in recent amateur magazines. The other piece of test gear to have on hand for this project is a grid-dip oscillator.

construction

The antenna is wound on two pieces of rigid 1-inch diameter polyethylene plumbing pipe, 31-inches long. My antenna is designed to resonate on 3.60, 7.10 and 14.20 MHz, but as will be explained, it is not difficult to change the resonant frequency.

Each side of the dipole is wound identically. Starting from one end, wind

with a balun transformer and 70-ohm coax feedline. My balun is constructed from two pieces of Mullard FX1588 ferroxcube ring. Make two windings with number-14 copper wire, one of 10 turns and the other of 2 x 5 turns. Connect as shown in **fig. 1.** This provides an impedance of 50 ohms on 20 meters, 80 ohms on 40 meters and 50 ohms on 80 meters. This is well within the matching capability of most modern transceivers. Of course, if you really wanted to get fussy, a separate balun could be constructed for every band.

tuneup

It is important that, when in use and during testing, the antenna be well clear of surrounding objects. The antenna is assembled using a piece of wooden broomstick at the center, giving 2½-inch spacing for the windings. If desired, the traps may be pruned, although I found them to be uncritical. This would be best accomplished by adjusting the trap tuning capacitance although you'll find the figures given to be fairly close.

The antenna is then connected to the bridge and the 20-meter section resonated, if necessary. This is done by connecting a short length of wire to each of the dipoles before the trap. The 40-meter section is adjusted next. In my case 15 inches were added to each 40-meter section and placed at right angles to the plane of the antenna.

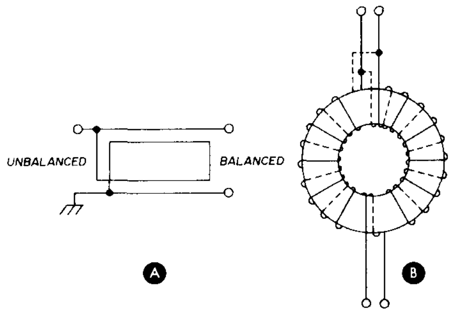

fig. 2. Circuit (A) and construction (B) of a 4:1 *balun for use with the suitcase antenna.* Although the author used a Mullard toroid core, an Amidon T-50-2 core with 10 or more bifilar windings of number-14 wire would be suitable.

On 80 meters I finished up with 4 inches added to the end of the coil. Keep an swr bridge in the line and see that the antenna doesn't swing against any objects; this will alter the resonant frequency.

Keep people away from the ends of the dipole while you're transmitting. I haven't had any corona problems, but the antenna *talks* due, no doubt, to the electromagnetic concentration in the turns. I found the directivity to be about nil.

No difficulty was experienced with rf feedback although trouble had been expected. The transceiver I use is a Yaesu FtDX 400, which is about the same as the FtDX 560 sold in the United States.

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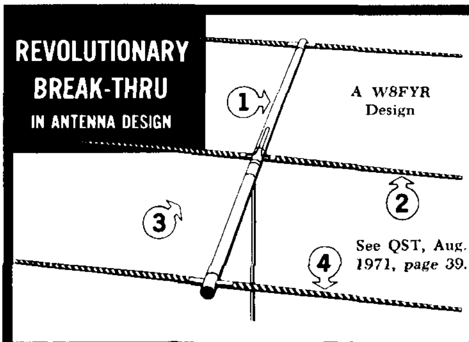

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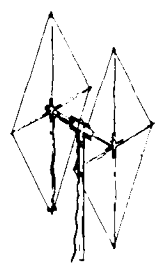

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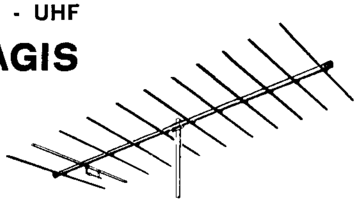

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VHF - UHF

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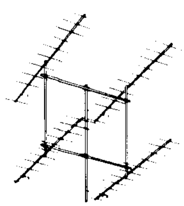

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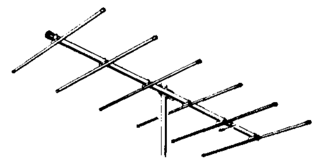
6 METER BEAMS



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RINGO 3.75 DB GAIN

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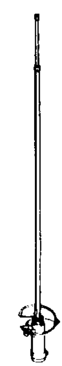

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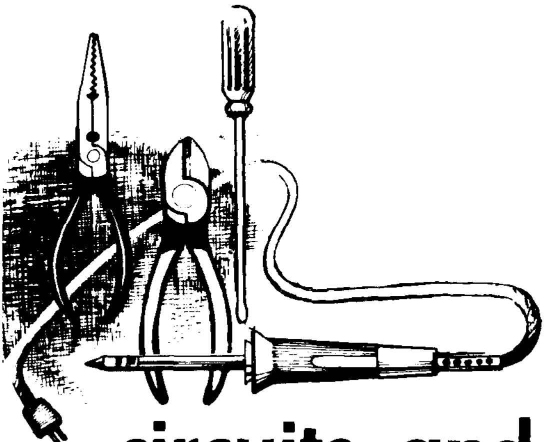
More Details? CHECK—OFF Page 126



circuits and techniques

ed noll, W3FQJ

the antenna lowdown

In the realm of ham radio antennas the second best, and even third best, will get you communicating. Unless you are telepathic you don't make any contacts by dreaming of the ultimate antenna. Too little space, too low, no money, etc., are often self- comforting excuses.

yard-high antennas

Good low antennas perform well for short and medium distance communications and can produce surprises, even in the realm of DX contacts. Low antennas can be built conveniently and economically and are less prone to deterioration by weather extremes. They perform well when they have a large aperture area and, for this reason, should preferably be full-dimension types. Also, the full-dimension type is easier to match and is less critical of design as compared to the smaller dimension DDRR types.

Take a single-element quad, lay it over horizontally, and mount it three- to four-feet above ground and you have a full-dimension low profile antenna, **fig. 1.** This close-to-ground position lowers the antenna resistance of a square full-wavelength antenna to a value that provides direct match to 50- or 70-ohm line. I built versions for 10, 20, 40, 80 and 160 meters and with appropriate length trimming a direct match was obtained on each of these bands. The equation used for determining wire length was:

$$\text{Length}_{ft} = \frac{984}{f_{MHz}}$$

Resonance was found by shortening the antenna between two and three percent. For example, typical wire lengths for 40 and 80 meters were 132 and 245 feet, respectively.

Supports for the antennas were four metal fence posts. The antenna wire sizes varied between number 12 and number 16, insulated. In construction the radiating wire is passed through one hole of the antenna insulator. A short piece of

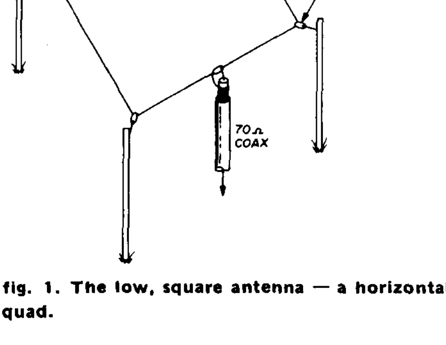


fig. 1. The low, square antenna — a horizontal quad.

wire through the opposite eye holds the antenna at each metal fence post. Typical dimensions are given in **fig. 2.**

On 40, 80 and 160 meters good signal reports are obtained for what is considered normal short and medium distance communications for each of the particular bands. For these ranges signal level readings compare favorably with good antennas of greater height. Performance falls off in the DX range of each of these three bands, indicating further work is needed to lower the vertical angle of radiation. As yet, I have not done any experiments with ground systems beneath the antenna, feed arrangements that include the radiating antenna and ground or tilting the low profile plane.

The economics of this arrangement is attractive because no high support structure is required. It is made from inexpensive wire, and in most cases, the length of transmission line can be made short. Low height means experimental ease. Our tests were made in the 3- to 5-feet above ground range. However, you can anticipate little change in matching if the antenna is raised up 8- to 10-feet and supported on ordinary wash poles.

Space requirements are modest and, in many situations, the erection of a full dimension antenna is possible where it is not feasible to erect a half-wavelength 80- or 160-meter dipole. For example, the 80-meter versions fit into an area that is only about 62-feet square. Performance on the 10-, 15- and 20-meter bands is poor as compared to good high antennas on these high frequencies. As mentioned previously, no experimentation has been done on ground systems that may well bring down the vertical radiation angle and improve performance on 10, 15 and 20.

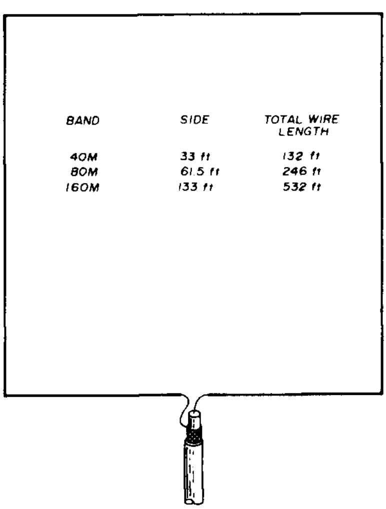


fig. 2. Dimensions for the low horizontal quad on 40, 80 and 160 meters.

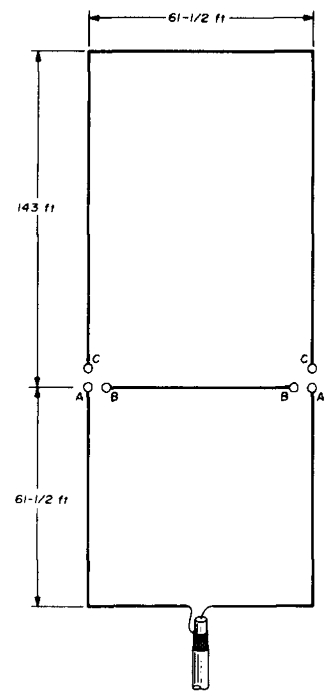


fig. 3. Combination 80- and 160-meter antenna for a long, narrow lot. For 80-meter operation, jumper A to B; for 160 meters, jumper A to C.

two-band version

The shape of such a low antenna need not necessarily be square. It can be made to fit the erection site. The directive characteristics of other than the square configuration have not been thoroughly investigated.

A two-band 80-160 combination has been checked out and performs very well on both bands. This combination consists of a closed square for 80 meters while the 160-meter version is rectangular as shown in **fig. 3.** A good direct match is obtained on both 80 and 160 meters. Wire jumpers are used to select either 80- or 160-meter operation.

multiband open configuration

Tests were made with the far-end open for a square 80-meter version of this antenna, **fig. 4.** The open plan requires the use of a tuner. The T-network type described in the January, 1973, issue of *ham radio* permitted a match on all bands, 6 through 160 meters. Performance was acceptable on 160 meters even though the overall wire length is a bit under one-half wavelength.

If you want a direct match on 80 meters, you need only place a short across the open end of the square. If you desire full-wave performance on 160 meters and have the available space, use the same idea in setting up the antenna for all-band operation. Again, a short connected across the opening will provide a direct match on 160 meters whenever it is desired.

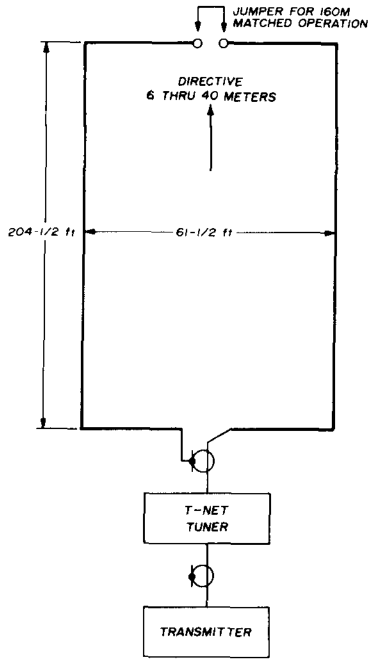


fig. 5. The 160-meter open rectangle antenna for all-band operation has some directivity on 7 MHz and higher.

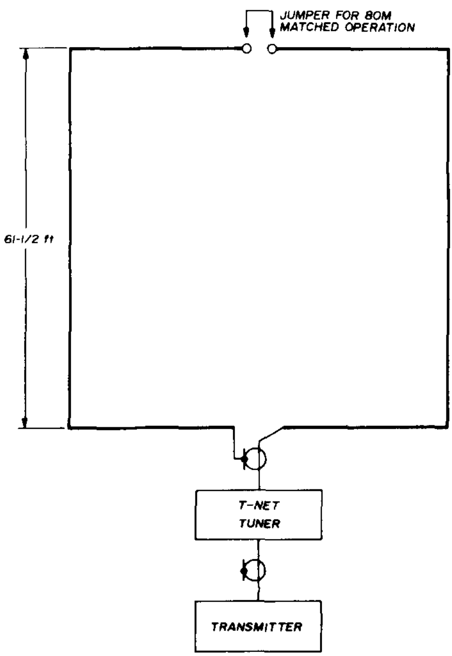


fig. 4. The 80-meter open-square antenna for all-band operation. Total length of wire in the square antenna is 246 feet, 61½ feet per side.

The 160-meter open rectangle, **fig. 5,** also loaded on all bands using the T-network tuner. Good results were obtained on 40, 80 and 160. Due to the long sides the configuration became a good directional gain antenna on 10, 15 and 20, maximum off the far ends.

double-barrel long wire

High band results encourage further study. It is interesting that the separation between wires is about one wavelength on 15 and 20, the two bands of good directivity, **fig. 6.** This provides side cancellation.

If the far ends are terminated in Beverage fashion, how much better would the antenna perform than a regular Beverage? What would be the optimum height for a given band, pair of bands, trio of bands? What is the ratio or improvement using four wires?

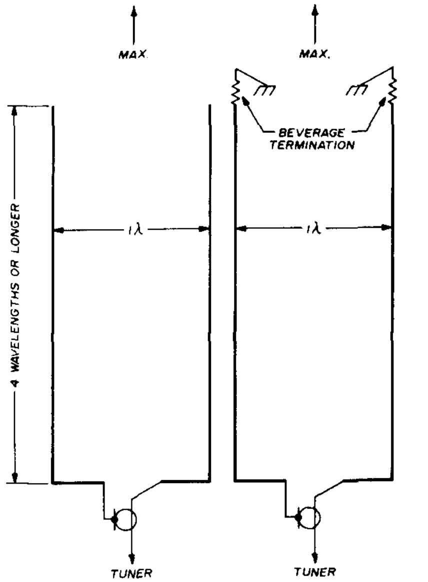


fig. 6. A new directional antenna that shows promise (see text).

There have always been exciting possibilities for low antennas. The proof is in the rather surprising performance obtained in mobile operations. Fixed installations are not so limited in size, and the performance, economics and esthetic aspects of low antennas should not be ignored.

ham radio

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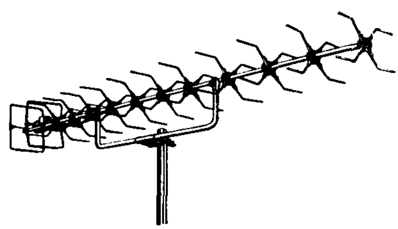

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the ham notebook

homemade antenna insulators

With the advent of various new wire beams and antennas, there is a need for inexpensive, lightweight antenna insulators and feedline spreaders. Here is how you can fabricate these items using readily available materials.

Obtain lengths of dowel rods at your lumber supply house or hardware store. These wooden rods come in 36-inch lengths and in various sizes from less than 1/4-inch to 1-inch in diameter. For number-14 antenna wire, or smaller, half-inch dowels are adequate. For larger wire, use the 3/4- or 1-inch size. For invisible antennas and open-wire feedline spreaders the 1/4- or 3/8-inch sizes are correct.

Measure off the lengths desired, taking into account the probable useage and the size of the pan used to impregnate the rods in paraffin or bees wax. Mark the holes to be drilled (**fig. 1**). Various size holes are chosen for the expected wire size. When the dowel is sawed apart to make the correct lengths, the larger holes will make slots in the ends of the dowels.

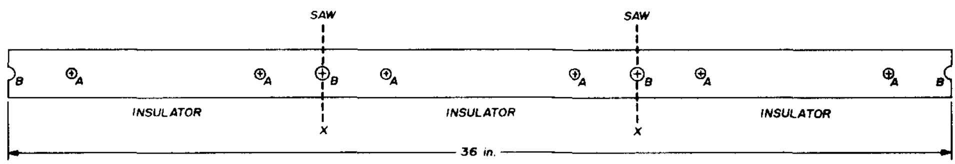

fig. 1. The 36-inch wooden dowels available at your local lumber yard may be cut into convenient lengths and boiled in paraffin or bees wax for use as antenna insulators. The holes marked A are slightly larger than the wire to be used; the holes marked B are twice as large as A.

Drill all holes with the smaller size drill; then re-drill with a larger size at the ends of the insulator. Saw at points X. Smooth the ends with a file or sandpaper and file or saw a slot in the ends where no hole half was made at the original dowel-rod ends.

Obtain several cakes of paraffin wax; read the instructions with care. The wax must be cautiously melted, preferably in a double boiler. If an open flame is used extreme caution must be taken to prevent splashing or other hazards that would result in a fire! An aluminum *Sara Lee* pound cake pan is just right for up to 7.5-inch long rods. The pan can be placed in another larger pan of heated water to make a double boiler.

When the wax is completely melted gently lower the drilled dowels into the pan. Under constant supervision, allow the dowels to boil and bubble for about 30 minutes. By that time the wax will be absorbed as much as possible. When all bubbling ceases, remove the dowels. They are ready for use.

The smaller hole may be used to accept the antenna wire itself, or to pass a serving wire through (in the case of feedline spreaders) to connect to either the antenna or the halyard. Larger holes may be used to accept a tie ring to a halyard, if desired. Keep all holes as small as practical.

A. David Middelton, W7ZC

multiband coaxial dipole

Although many amateurs use single-band coaxial dipoles, I have built a multiband unit that performs quite well on all bands, 80 through 10 meters. The layout of the antenna is shown in **fig. 2**. In case it looks familiar, the idea came from a similar, all wire antenna in the A.R.R.L. *Radio Amateur's Handbook*.

The coil in each of the traps consists of 21½ turns of B&W coil stock, 2-inches in diameter, 8 turns per inch (B&W 3900). The tuning capacitor is a ceramic 47-pF unit rated at 6000 working volts. The coax braid and center wire are soldered together at the ends. The braid is carefully cut at the center for the feedline – the center conductor of the feedline is connected to the braid of one antenna section while the feedline braid is connected to the braid on the other antenna section.

With the dimensions shown in **fig. 2** antenna provides very low swr over the phone segments of both 40 and 80 meters. On the higher bands the swr is less than 1.5:1 over most of the band. For best performance on the CW ends of the bands, the antenna would have to be made slightly longer. Adjust the length of the coax sections for the 7.0-MHz band, and the length of the end wires to resonate the antenna at 3.8 MHz.

H.W. Rieben, W4BDK

portable vhf ground plane

Although I am not Scotch, my resilience factor goes up and down everytime some new (and expensive) piece of ham gear is wanted, but no funds are at hand. It is my opinion that ham equipment is too specialized (and therefore limited) in today's consumer market. However, that's only an opinion and a moot point at that. I am sure the EIA would vehemently argue with me on the subject.

Since I have been in ham radio for many years – although certainly not an old timer – I really get excited when a new idea, for old equipment, comes along. Especially when it doesn't cost too much money. Take, for example, that quarterwave mobile whip standing in the corner of my room. That's the only thing left after the two-legged sharks stripped my automobile of my ham gear. Alas, it was never recovered.

Now, what could be done with a no-hole trunk-mounted whip for two meters? Well, after hunting around the house for a few weeks, an old economy type camera tripod was discovered. This tripod did not have a handle adjustment lever for the camera plane as the more common tripods do. It was constructed of brass tubing with a minimum closed length of 15-inches and a fully extended length of 48 inches. Just perfect for a three-radial portable ground-plane antenna.

The tripod mounting hole for the camera uses a Standard ¼-20 machine bolt. So, a piece of sheet aluminum (3x4x0.2") was drilled and tapped for

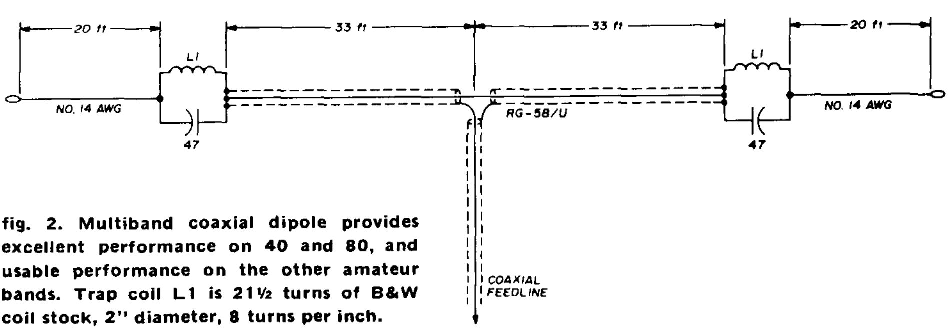

fig. 2. Multiband coaxial dipole provides excellent performance on 40 and 80, and usable performance on the other amateur bands. Trap coil L1 is 21½ turns of B&W coil stock, 2" diameter, 8 turns per inch.

¼-20 at its symmetrical center. The sheet metal was then mounted to the tripod top with a ¼-20 bolt. It resembled a miniature table with long, skinny legs. The whip could then be mounted to the table top by tightening the antenna set screws. Thus, a variable-angled-radial groundplane antenna for two meters.

From experiments using a Bird 43 watt-meter, it was determined that the lowest swr of 1.12:1 occurred when the 15-inch tripod legs were angled almost horizontally to the ground. Of course, the tripod was placed well above ground during these tests. The test frequency was 146.94 MHz.

It is feasible that this construction method would work quite well with almost any type of whip, perhaps a 5/8-wave or even CB antennas. Just vary the length of the tripod legs and the angle and see what develops.

John Sego, K9DHD

effective radiated power

Effective radiated power, not transmitter power, is what counts. Your ERP, especially on two meters, may only amount to less than half of your transmitter's output due to loss in the feedline. This can be reduced by installing exotic coaxial cable, costing over $100.00, or by using some alternative.

Look at the figures. Loss at 144 MHz per 100 feet of RG-58/U is 5.7 dB, RG-58/U foam, 4.1 dB, RG-8/U, 2.5 dB, RG-8/U foam, 2.2 dB, 3/8-inch Heliax, 1.3 dB, 300-ohm tv twinlead, 1.55 dB, and 300-ohm open-wire tv feedline, 0.75 dB.

Foam-filled coax has a slight advantage, but it may not be worth the extra cost, especially for lines less than 100-feet long. The solid sheath Heliax cable is much better, but a 100-foot line of this cable with the special fittings, would cost close to $100.00, so it is out for most hams.

Tv 300-ohm lead-in has low loss and since it was specifically designed for use up to 200 MHz or so, it should be best. On a cost basis it is the most for the least, but its superiority may be neglected by the average ham.

Some objections have been heard regarding its operation during wet weather, but they do not seem to be justified. There are many tv antennas operating around 200 MHz that do not seem to lose weak signals when wet, or show mismatch, although it may exist. A coat of floor wax on the twin lead will prevent moisture changes.

No difficulty in either mismatch or weak signals has been noted on two antennas I feed with this line. Open-wire 300-ohm line is the ultimate in efficiency and is unaffected by moisture. The difficulty is matching it to the usual 50-ohm input impedance termination. An impedance-matching unit is required, and if built of low-loss components it has negligible insertion loss. In fact, the ERP is usually increased due to the better impedance match.

The impedance matching unit shown in **fig. 3** can match any balanced line to any unbalanced line (coax); it will even match 72-ohm coax to 52-ohm coax, if desired. This line tuner will also increase the rejection QRM generated by other services (tv, fm, etc.). It reduces harmonics by about 30 dB, and due to its perfect balance to ground, reduces noise pickup. Of course, a 300-ohm termination is required at the antenna.

This line matcher is actually easier to use than a gamma matching system. Use a 1-to-1 folded dipole, or a step-up dipole for a beam. I use 3/16-inch tubing and number-12 wire for the folded dipole on my beam. It provides a perfect match and is not at all critical.

Using the beam design shown in the *ARRL Handbook,* a beam with a gain of 6 to 8 dB is easily realized. This, with my 10 watter, provides an ERP of at least 40 watts if 100-feet of 300-ohm line is used – four times the power at less cost! If I used RG-8/U the beam would only offset the line loss and my ERP would be 10 watts. Using a half-wave dipole, I would only have an ERP of about 2 watts if

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RG-8/U coax was used for the feedline.

The 2-meter line tuner consists of a 22-inch length of 1/4-inch copper pipe and a small tuning capacitor, which may be a small variable or two pieces of metal about 1½ inches square, spaced about 1/8 inch. Bend the tubing into a U about 2-inches wide and connect it as shown in **fig. 3**. Use a good ground at the center.

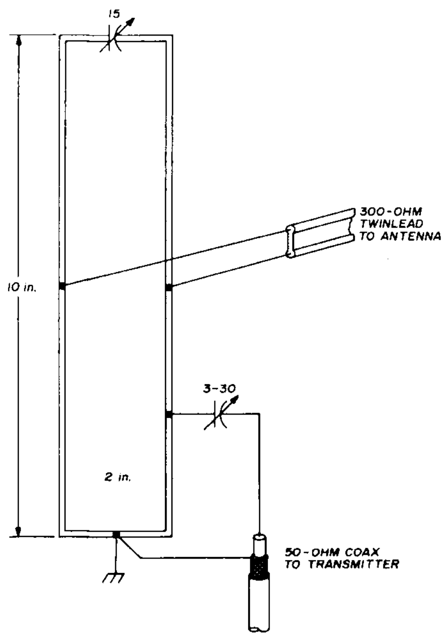


fig. 3. Two-meter line matcher provides good match between 300-ohm twinlead to the antenna and short section of coax to your transmitter. Power loss in 300-ohm plastic twinlead at 144 MHz is about 1.55 dB per 100 feet. Open wire 300-ohm line is only .75 dB per 100 feet.

Tune the line matcher for maximum forward power and least reflected with an swr bridge known to be accurate at 144 MHz.

My 300-ohm feeders are soldered on about half way up, and the 50-ohm short line to my rig is terminated with a gamma match with the tap about 5 inches up. It works – consistent daily contacts are made over 100 miles from a difficult seashore location surrounded by hills and mountains.

Alf Sheffield, VE7CB

printed circuit tool

When working with printed-circuit boards a pair of fingernail clippers makes an excellent tool for clipping off excess wire after a component is soldered in place. I have found that fingernail clippers are much better for getting into limited space than small sidecutter pliers.

Don Farrell, W2GA

code practice

A tape recorder is a great help for improving code speed. You can record messages off the air or practice material from W1AW, then play it back at your leisure. If your machine has two speeds, for example, you may record at 3-3/4 IPS and play it back either at the same speed or at 7 IPS. This means that a recording at 10 wpm may be heard at 20 wpm if you wish.

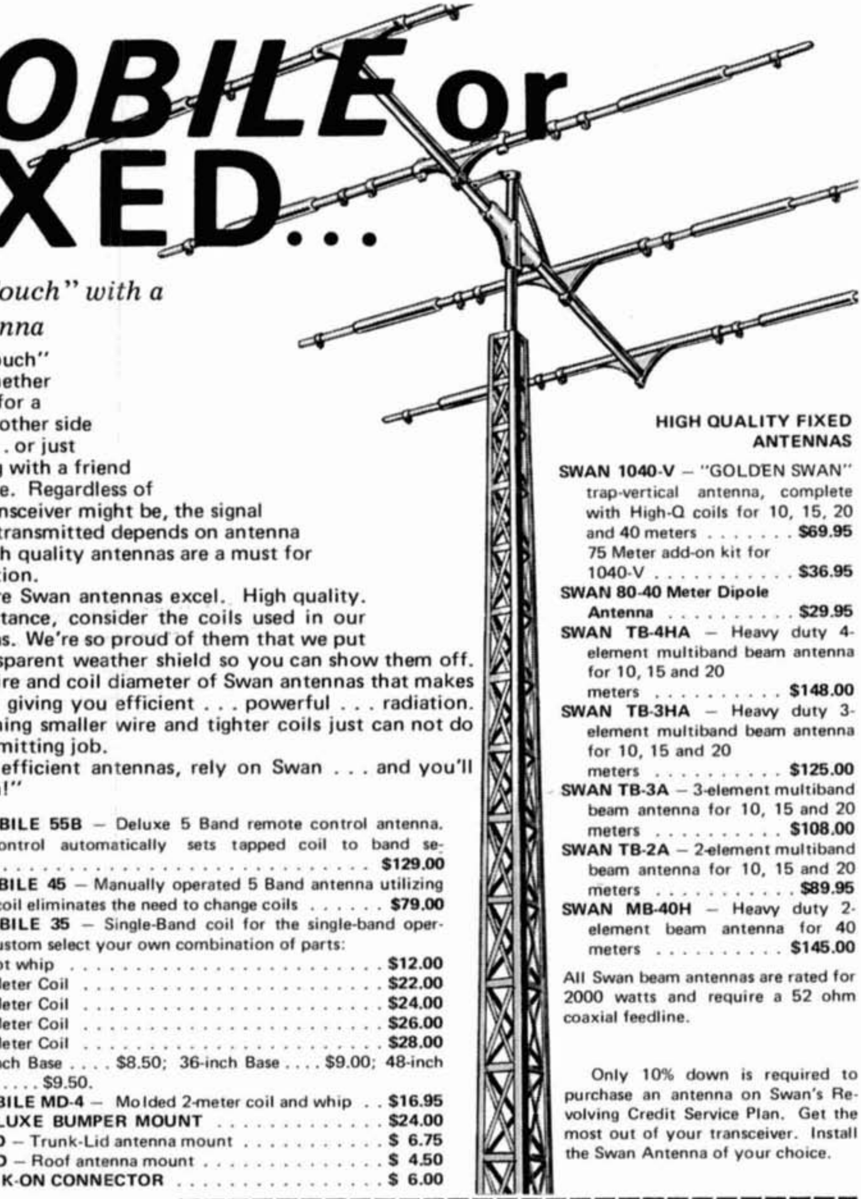
One problem in copying code is the tendency of anticipating what is coming. You may write down letters not actually sent. This habit may be overcome by sending words like "txulg" instead of plain language. Or, plain language may be sent backwards. In this way, the listener is forced to copy only what he actually hears.

Most tape recorders don't have a reverse at normal speed, but here is how to overcome this limitation. Simply put a twist in the tape between the feed reel and the sound head. Of course, this greatly reduces the output volume so you will have to turn up the gain. It also drives the recorded channel in its *reverse* direction. Letters like R and P sound the same in both directions, but L will come out as F, and U will be D. The word "the" will be heard as "eth," and so on. The letter Z in reverse is not a letter at all. If you copy correctly, you will not write down anything because you cannot recognize it.

I have found this method valuable for increasing my code speed and strengthening the habit of copying *only* what I hear.

I. Queen, W2OUX

MOBILE or FIXED...



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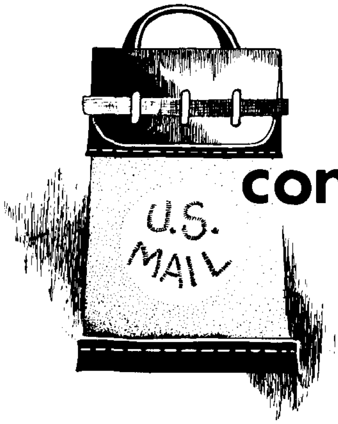


comments

vhf fm receiver

Dear HR:

The Allied Radio Shack stores sell a receiver listed as the *Realistic Weatheradio* cube which tunes the area of 162 MHz. By turning the converter oscillator slub approximately two turns, the radio will tune the two-meter fm band in the area of 147 MHz. I have been quite successful in doing this with little effort. Also, an fet rf amplifier would increase the usefulness considerably. Possibly a ham could build the two-meter fet transmitter described in the February, 1971, issue of *ham radio* and come up with the world's smallest hand-held fm transceiver.

Carl Markle, Jr., K8IHQ
Silver Spring, Maryland

sloping dipole antenna

Dear HR:

The excellent article by W5RUB in the December, 1972, issue of *ham radio* dealing with the DX ability of the sloping dipole antenna prompts me to write. I had been using an off-center fed 66-foot dipole, the so-called Windom antenna. Results were only so-so. It was decided to extend the overall length of the antenna to 88 feet, so 22 feet were added onto the short end, thus giving a balanced center-fed antenna. The East end was raised to a height of 75 feet. The West end is only 25 feet above ground. The antenna runs roughly East-West and is fed with 300-ohm twin line. My dc power input usually runs about 175 watts, and the measured efficiency of the final runs about 60-62 percent, putting 100 to 110 watts into the feedline.

The expected North/South maxima are quite evident; also the tilt toward the West definitely favors contacts in that general direction. Numerous VKs and ZLs have been worked, also American Samoa, KS6, and VK9, Norfolk Island. I have noticed that when abnormal (poor) conditions appear, I have had some unexpected QSOs, but only in directions North or South from my location. These odd responses to my CQs were from a Russian DXpedition to Antartica on the one hand; and over the pole from Tibet, Burma and Indonesia. These contacts took place during periods of magnetic disturbance when East-to West circuits were definitely no good. On the other hand, contacts with Europe are more difficult, S-meter readings from that area being down roughly two S units.

Summing up, the antenna performance has been surprisingly good with respect to the directions which it favors. For the economy-minded ham, perhaps two such antennas, both sloping down from the same high pole, might be the answer to effective DXing on the lower-frequency amateur bands.

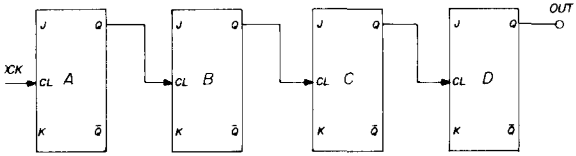
Neil Johnson, W2OLU
Tappan, New York

digital counters

Dear HR:

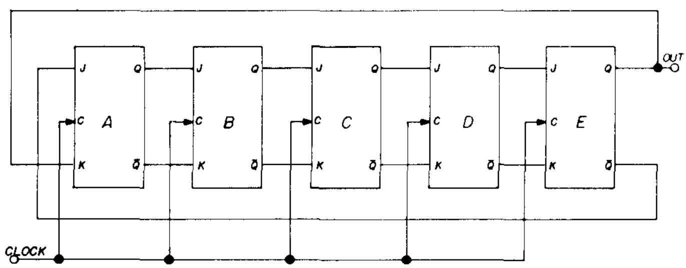
I'm writing to add a crucial remark to the information on counters by Roy Lewallen in the December, 1972, issue of *ham radio*. Everything he states is correct, but his construction is missing an item that may be of interest to many potential IC users.

Consider the case of a Binary Coded Decimal counting unit made of four JK flip-flops in a configuration where the J and K inputs are both tied to +1 to cause toggling:



Admittedly, the decoding is easy enough, but consider the case of a counter going from a count of 7 to 8. Every flip-flop must change its state (A, B and C go from 1 to zero, and D goes from zero to 1). This means that the clock pulse should normally be slow enough to allow *full* propagation through the counter. In the case of the Fairchild μL923, for example, the propagation is 80 nanoseconds per flip-flop, or about 320 nanoseconds for the counter; hence, the input clock frequency is limited to about 3 MHz.

Now, consider the case where the five flip-flops are used in a "2x5" code:



The corresponding code generated is seen to be:

	0	1	2	3	4	5	6	7	8	9
A	0	1	1	1	1	1	0	0	0	0
B	0	0	1	1	1	1	1	0	0	0
C	0	0	0	1	1	1	1	1	0	0
D	0	0	0	0	1	1	1	1	1	0
E	0	0	0	0	0	1	1	1	1	1

This 2x5 code is very similar to Morse code with zero = dash, and 1 = dot. Note that between any two counts of the counter only *one* flip-flop changes state at a time. Hence, the input clock frequency is limited by only a single propagation of 80 nsec, or a limit of about 12 MHz.

I contend that this scheme is just as easily decoded as BCD, and further, in the long run is less expensive because of the slower ICs which may be purchased. I have successfully used this circuit to 10 MHz, and have tested it to 12 MHz.

Stephen R. Alpert, W1GGN
Auburn, Massachusetts

Swan cw monitor

Dear HR:

Recently, my attention was called to an apparent oversight on my part regarding the CW monitor for the Swan 350 which appeared in the *ham notebook* section of *ham radio* for June, 1972, page 63.

This oversight concerns the existence of R1204 (470k), R1202 (470k) and C1204 (0.1 μF) connected from pin 2 of V12 (6GK6) to point "R" in the Swan 350 audio circuitry. With these components in the circuit, V12 will be biased off during transmit and the CW monitor will not be audible. Removal of the connection between pin 2 of V12 and R1202 (or complete physical removal of all of these components, if desired) will eliminate this problem. No ill effects should be noted by this change.

I removed these components years ago during the trial installation of one of the factory CW monitor modifications and never re-installed them since no detrimental effects were noted. All other comments received from builders of the monitor have been favorable, especially those concerning the absence of chirp or yoop during keying.

Paul K. Pagel, K1KXA
Enfield, Connecticut

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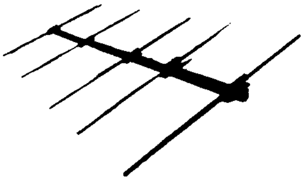

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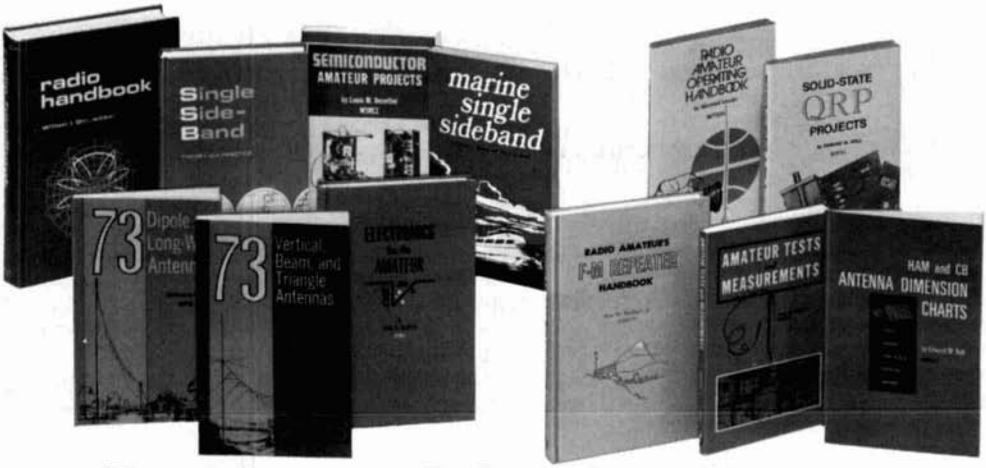

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More Details? CHECK—OFF Page 126

radio handbook, new edition

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In addition, the coverage includes construction information on new high-frequency linear amplifiers of 1- and 2-kW PEP output, a solid-state LED-readout receiver, a high-performance two-meter moonbounce converter, solid-state vhf fm amplifiers, etc.

There are 976 information-packed pages supported by numerous diagrams and photographs. A glossary of terms is provided to identify the symbols used throughout the text. This invaluable reference is a must for both novice and advanced radio amateurs, electronics engineers and technicians – literally anyone interested in the popular radio communications field.

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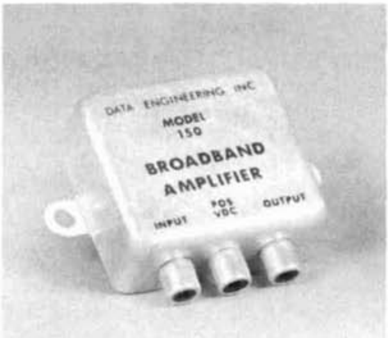
broadband preamplifier



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LM309K	2.50
NE5556	.75
NE5558	1.00
741(MINI DIP)	.45
747	1.10
709	.30
710	.40
711	.40
723	1.00

CMOS

CD4001	$ .75
CD4002	.75
CD4011	.75
CD4012	.75
CD4023	.75

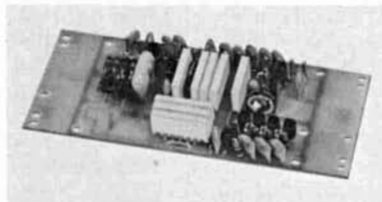
All IC's are new and fully tested, leads are plated with gold or solder. Orders for $5 or more will be shipped prepaid. Add 35¢ for smaller orders. California residents add sales tax. IC orders are shipped with 24 hrs. COD's may be phoned in.............Money back guarantee

BABYLON ELECTRONICS
P.O Box J Carmichael, California 95608
(916) 966-2111

The unit is powered by 12 Vdc and its small size lends itself to installation within the cabinets of existing receivers. The new preamp sells for $17.95. An adaptor for 150- to 250-Vdc operation is $2.95.

Additional information is available from Data Engineering, Inc., Ravensworth Industrial Park, 5554 Port Royal Road, Springfield, Virginia 22151 or by using *check-off* on page 126.

motrac tone kit



The new Alpha sub-audible tone encoder/decoder has been especially designed for use in the Motorola Motrac series of two-way radios. The heretofore expensive and difficult task of converting so called "non PL" Motracs to the use of tone is made simple and practical with the Alpha unit.

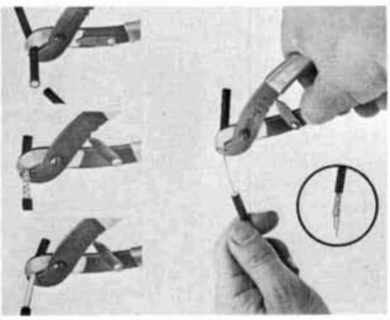
The new unit utilizes thick-film hybrid modules that contain all the active circuitry used for the encoding and decoding of tone. These thick-film modules fit into a unique gold-plated edge connector on the printed-circuit board allowing direct plug-in-plug-out operation for ease of maintenance, modification or change of tone frequency. The thick-film hybrid technique also makes possible an exceptional degree of reliability under severe environmental extremes including high vibration and temperature. The frequency determining modules are laser trimmed to the precise frequency required and are therefore not subject to the reliability problems of reeds and the frequency stability problems of tunable types of tone.

The Alpha SS-80J/192 is completely compatible with all Motorola, General Electric and RCA sub-audible tone systems and is available in standard or special frequencies from 20 to 250 Hz.

More Details? CHECK–OFF Page 126

Provision has been made to accommodate up to six tone frequencies which may be electronically switched if required. The unit also has the capability of automatic revert for common encode or common decode configuration. The multi-frequency circuitry can be provided from the factory or added in the field. Complete step-by-step instructions are provided. For additional information write to Alpha Electronic Services, Inc., 8431 Monroe Avenue, Stanton, California 90680, or use *check-off* on page 126.

coaxial cable stripper



Xcelite has just added to its line of quality professional hand tools a coax stripper/cutter, designed specifically for use with the popular RG-59/U coaxial cable. Featured is a three-position selector lever. With the lever in position 1, the hardened and ground blades cut cleanly through the jacket, shielding and dielectric without fraying to expose the undamaged conductor. Position 2 removes the jacket and shielding, while position 3 strips the jacket off without damage to the shielding, or dielectric. With the selector lever disengaged, the entire coax cable can be cut neatly to length. Handles have cushion grips for user comfort and to lessen fatigue.

The no. 590 Coax Stripper/Cutter has a list price of $4.75. It is available nationwide through Xcelite's local distributors. Additional information may be obtained by writing for Product Bulletin 572L, available from Xcelite Incorporated, Orchard Park, New York 14127, or use *check-off* on page 126.

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Heathkit® 2-Meter FM gear is here!

HW-202 shown above with Tone Burst Encoder installed.

***• All solid-state design • Can be completely aligned without instruments • 36-channel capability** — independent pushbutton selection of 6 transmit and 6 receive crystals **• 10-Watts Minimum Output** — designed to operate into even an infinite VSWR without failure **• Optional Tone Burst Encoder** — mounts inside, gives front-panel selection of four presettable tones*

The Heathkit HW-202 compares with the best wired amateur 2M/FM rigs. Plus it has: 36-channel capability via independent selection of 6 transmit and 6 receive crystals. Solid-state circuitry with complete built-in alignment procedures using only the manual and the front-panel meter allow operation over a 1 MHz segment from 143.9 to 148.3 MHz. Removable front-panel bezel permits installation of the new Heathkit HWA-202-2 Tone Burst Encoder.

10-15 watts transmission into an infinite VSWR — indefinitely, with no failure! The HW-202 needs no automatic shut-down — it continues to generate a signal regardless of antenna condition. Transmitter deviation is fully adjustable from 0 to 7.5 kHz, with instantaneous deviation limiting. Harmonic output is greater than −45 dB from carrier. The push-to-talk ceramic microphone supplied has an audio response tailored to the HW-202.

Excellent reception — 0.5 uV or less produces 12 dB Sinad, or 15 dB quieting. Output at the built-in speaker is typically 2 watts at less than 3% total harmonic distortion. The receiver circuitry utilizes diode-protected dual-gate MOSFETS in the front end; an IC IF that completely limits with less than a 10 uV signal; dual conversion, 10.7 MHz and 455 kHz via a 4-pole monolithic 10.7 MHz crystal filter. Image response is −55 dB or better. Spurious response is −75 dB or better.

The Heathkit HW-202 comes with two crystals used in initial set-up and alignment, give you simplex operation on 146.94. Kit includes microphone, quick-connecting cable for 12-volt hook-up, heavy duty alligator clips for use with a temporary battery, antenna coax jack, gimbal bracket, and mobile mount that lets you remove the radio from the car by unscrewing two thumbscrews. The HWA-202-2 Tone Burst Encoder provides four presettable pushbuttons for instant repeater access. Fixed station operation is as easy as adding the HWA-202-1 AC Power Supply. The HA-202 2-Meter Amplifier puts out 40 watts for 10 watts in, and externally it's a perfect mate for your HW-202.

Kit HW-202, 11 lbs., mailable **179.95***

Kit HWA-202-2, Tone Burst Encoder, 1 lb. . . **24.95***

Kit HWA-202-1, AC Power Supply, 7 lbs. . . **29.95***

Kit HWA-202-3, Mobile 2-Meter Antenna, 2 lbs. **17.95***

Kit HWA-202-4, Fixed Station 2-Meter Antenna, 4 lbs. **15.95***

HW-202 SPECIFICATIONS — RECEIVER — Sensitivity: 12 dB SINAD* (or 15 dB of quieting) at .5μv or less. **Squelch threshold:** 3 μv or less. **Audio output:** 2 W at less than 10% total harmonic distortion (THD). **Operating frequency stability:** Better than ±.0015%. **Image rejection:** Greater than 55 dB. **Spurious rejection:** Greater than 60 dB. **IF rejection:** Greater than 75 dB. **First IF frequency:** 10.7 MHz ±2 kHz. **Second IF frequency:** 455 kHz (adjustable). **Receiver bandwidth:** 22 kHz nominal. **De-emphasis:** −6 dB per octave from 300 to 3000 Hz nominal. **Modulation acceptance:** 7.5 kHz minimum. **TRANSMITTER — Power output:** 10 watts minimum. **Spurious output:** Below −45 dB from carrier. **Stability:** Better than ±.0015%. **Oscillator frequency:** 6 MHz, approximately. **Multiplier factor:** X 24. **Modulation:** Phase, adjustable 0-7.5 kHz, with instantaneous limiting. **Duty cycle:** 100% with ∞ VSWR. **High VSWR shutdown:** None. **GENERAL — Speaker impedance:** 4 ohms. **Operating frequency range:** 143.9 to 148.3 MHz. **Current consumption: Receiver** (squelched): Less than 200 mA. Transmitter: Less than 2.2 amperes. **Operating temperature range:** −10° to 122° F (−30° to + 50° C). **Operating voltage range:** 12.6 to 16.0 VDC (13.8 VDC nominal). **Dimensions:** 2¾" H x 8¼" W x 9⅞" D.

$$\text{*SINAD} = \frac{\text{Signal + noise + distortion}}{\text{Noise + distortion}}$$

More Details? CHECK—OFF Page 126

...and here!

NEW Heathkit 2-Meter Amplifier for cleaner FM copy on the fringe... 69⁹⁵*

***40 watts nominal out for 10 watts in** — requires only 12 VDC supply.*

***Fully automatic operation** — with any 2-meter exciter delivering 5-15 watts drive.*

***Solid-state design** — all components mount on single board for fast, easy assembly.*

If you're regularly working from a fringe area, the new Heathkit HA-202 can boost your mobile output to 40 watts (nominal), while pulling a meager 7 amps from your car's 12-volt battery.

Install it anywhere... in the trunk, under the hood or dashboard. Use it with any 2-meter exciter delivering 5-15 watts drive. Features fully automatic operation. An internal relay automatically switches the antenna from transmit to receiver mode when you release the mike button.

All solid-state design features rugged, emitter-ballasted transistors, combined with a highly efficient heat sink, permitting high VSWR loads. Tuned input-output circuits offer low spurious output to cover the 1.5 MHz segment of the 2-meter band without periodic readjustment. All components mount on a single printed circuit board for easy, 4-hour assembly. Manual shows exact alignment procedures using either a VOM or VTVM. And installation is just as simple.

Kit includes transceiver connecting cable, antenna connector. Operates from any 12 VDC system — additional power supplies are not required. Add HA-202 power to your mobile 2-meter rig, and boom out of the fringe. **Kit HA-202,** 4 lbs.

HA-202 SPECIFICATIONS — Frequency range: 143-149 MHz. **Power output:** 20W @ 5 W in, 30W @ 7.5W in, 40W @ 10 W in, 50W @ 15 W in. **Power input (rf drive):** 5 to 15W. **Input/output impedance:** 50 ohms, nominal. **Input VSWR:** 1.5:1 max. **Load VSWR:** 3:1 max. **Power supply requirements:** 12 to 16 VDC, 7 amps max. **Operating temperature range:** −30° F. to +140° F. **Dimensions:** 3″ H x 4¼″ W x 5½″ D.

...and here!

New Heathkit VHF Wattmeter/SWR Bridge . . . 29.95*

Perfect tune-up tool for your 2-meter gear. Tests transmitter output in power ranges of 1 to 25 watts and 10 to 250 watts ±10% of full scale. 50 ohm nominal impedance permits placement in transmission line permanently with little or no loss. Built-in SWR bridge for tuning 2-meter antenna for proper match, has less than 10-watt sensitivity. **Kit HM-2102,** 4 lbs.

HM-2102 SPECIFICATIONS — Frequency range: 50 MHz to 160 MHz. **Wattmeter accuracy:** ±10% of full-scale reading.* **Power capability:** To 250 W. **SWR sensitivity:** less than 10 W. **Impedance:** 50 ohms nominal. **SWR bridge:** Continuous to 250 W. **Connectors:** UHF type SO-239. **Dimensions:** 5¼″ W, 5$\frac{5}{16}$″ H and 6½″ D, assembled as one unit.
*Using a 50 Ω noninductive load.

See them at your Heathkit Electronic Center — or fill out coupon for FREE Heathkit catalog

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ARIZ.: Phoenix, 2727 W. Indian School Rd.; **CALIF.: Anaheim,** 330 E. Ball Rd.; **El Cerrito,** 6000 Potrero Ave.; **Los Angeles,** 2309 S. Flower St.; **Pomona,** 1555 Orange Grove Ave. N.; **Redwood City,** 2001 Middlefield Rd.; **San Diego (La Mesa),** 8363 Center Dr.; **Woodland Hills,** 22504 Ventura Blvd.; **COLO.: Denver,** 5940 W. 38th Ave.; **CONN.: Hartford (Avon),** 395 W. Main St. (Rte. 44); **FLA.: Miami (Hialeah),** 4705 W. 16th Ave.; **GA.: Atlanta,** 5285 Roswell Rd.; **ILL.: Chicago,** 3462-66 W. Devon Ave.; **Downers Grove,** 224 Ogden Ave.; **IND.: Indianapolis,** 2112 E. 62nd Ave.; **KANSAS: Kansas City (Mission),** 5960 Lamar Ave.; **MD.: Baltimore,** 1713 E. Joppa Rd.; **Rockville,** 5542 Nicholson Lane; **MASS.: Boston (Wellesley),** 165 Worcester St.; **MICH.: Detroit,** 18645 W. Eight Mile Rd. & 18149 E. Eight Mile Rd.; **MINN.: Minneapolis (Hopkins),** 101 Shady Oak Rd.; **MO.: St. Louis,** 9296 Gravois Ave.; **N.J.: Fair Lawn,** 35-07 Broadway (Rte. 4); **N.Y.: Buffalo (Amherst),** 3476 Sheridan Dr.; **New York City,** 35 W. 45th St.; **Jericho, L.I.,** 15 Jericho Turnpike; **Rochester,** Long Ridge Plaza; **OHIO: Cincinnati (Woodlawn),** 10133 Springfield Pike; **Cleveland,** 5444 Pearl Rd.; **PA.: Philadelphia,** 6318 Roosevelt Blvd.; **Pittsburgh,** 3482 Wm. Penn Hwy.; **TEXAS: Dallas,** 2715 Ross Ave.; **Houston,** 3705 Westheimer; **WASH.: Seattle,** 221 Third Ave.; **WIS.: Milwaukee,** 5215 Fond du Lac.

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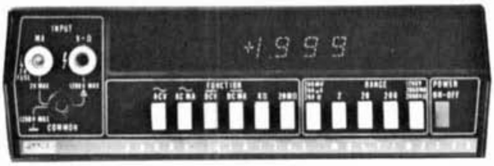
*Mail order prices; F.O.B. factory AM-282

More Details? CHECK—OFF Page 126



New digital V.O.M. works well in near field environment. Only $299.

Here's the best low cost digital voltmeter ever made for broadcast and communication use. It's got all the resistance range, voltage resolution, high ac accuracy you'll ever need plus 30 second warm-up to full accuracy. Fluke's new Model 8000A measures in 26 ranges ac/dc volts, amps and resistance from 100 μV to 1200 V, 0.1 μA to 2 A, and 100 milliΩ to 20 megΩ. Basic dc accuracy, 0.1%. Full year guarantee. Option choice includes rechargeable battery pack, printer output, deluxe test leads, HV probe, RF probe, 600-amp ac current probe, carrying case, dust cover and rack mount. Unique self-zero eliminates offset uncertainty. Electronics are securely mounted in high-impact case. Service centers throughout U.S., Canada, Europe and Far East for 48-hour turnaround repair.

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100′ 22 ga. twisted pair — good for intercom, telephone, etc. .... $1.50 ppd.
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Vidicon 7735A	$150.00	$ 50.00
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4X150A	$ 23.15	$ 11.00
2BP1	$ 24.00	$ 12.00
829B	$ 20.00	$ 10.00
8252/4PR60B	$115.00	$ 37.00
8187/4PR65A	$ 50.00	$ 16.00

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communications microphone

Turner's new amplified *Super Sidekick,* a base station communications microphone, has two gain controls: one on the top for normal volume adjustments and another on the bottom for matching the Turner *Super Sidekick* to various transceivers. This microphone has been designed specifically for the amateur, business band and communications field. It uses a dynamic interior for extreme ruggedness and durability and is unaffected by temperature and humidity. It has a built-in IC amplifier which provides a perfect impedance match with all a-m/ssb transceivers.

The amplifier gain control on the bottom of the Turner *Super Sidekick* uses a rugged die cast case. The base and neck are black with a polished bright chrome head. The cable is a three-conductor coiled cord. The microphone is activated by pressing down on the touch bar and can be locked on by moving the slide lock forward. The Turner *Super Sidekick* has a list price of $80 and is available from the Turner Division of Conrac Corporation, 909 17th Street N.E., Cedar Rapids, Iowa 52402. For more information use *check-off* on page 126.

More Details? CHECK–OFF Page 126

tone encoders

Powered directly by any 12-Vdc 2-meter fm transceiver, the new Ross and White tone-burst encoders allow automatic entry into tone access repeaters. Keyed by closing the transmitter microphone switch from the 12-Vdc keyed source, the encoder generates a half second tone burst which modulates the transceiver and activates the repeater.

Two models are available. The two tone model TE-2 sells for $39.95, and the five tone model TE-5 sells for $49.95 postage paid. Both are sold on a 10-day trial, money-back guarantee basis. Installation is simple with the complete instructions provided for your make and model of transceiver. The battery powered models will continue to be available for hams preferring that arrangement.

For full data including specifications, write direct to the Ross and White Company, 50 West Dundee Road, Wheeling, Illinois 60090 and ask about tone burst encoders. You can get the same information by using *check-off* on page 126.

solid-state general-coverage receiver

A new and improved version of its popular S-120 series a-m and short-wave table radios has been introduced by Hallicrafters. The new model S-125, called *Star-Quest II*, provides the user with an all-transistor, completely self-contained

INCREASE YOUR TALK POWER!

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MODEL ACA-1
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MODEL ACP-1
$24.95 KIT
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MODEL ACP-1 COMPRESSOR-PREAMP has 30 DB compression range ■ Flat 20-20,000 Hz response and low distortion ■ Designed for high-impedance mikes ■ Easily installed in mike line ■ 9-volt battery operation ■ Only 4″ W x 2½″ H x 3½″ D.

IDEAL FOR TAPE RECORDERS!

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3-CHANNEL WWV RECEIVER
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$99.95

0.25 microvolt sensitivity ■ Crystal controlled ■ 110-volt a.c. or 12-volt d.c. operation ■ Compact size only 4½″ W x 2½″ H x 5½″ D.

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2 METER FM

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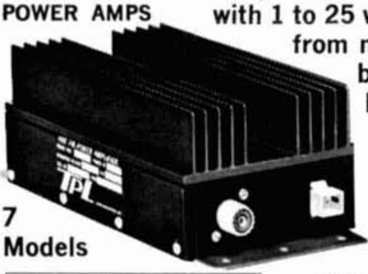

7 Models

Solid State Micro-Strip Circuit

MODEL	POWER (in/out)	PRICE
252	1W/25W	$ 85.00
502	10W/50W	105.00
502B	1W/50W	130.00
802	10W/85+W	180.00
802B	1W/85+W	195.00
1002-3	10W/120+W	220.00
1002-3B	1W/120+W	235.00

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a-m broadcast and general-coverage short-wave receiver.

Features include agc, bfo, illuminated slide-rule dial, logging scale, 1-watt audio output, bandspread, built-in speaker and provision for direct operation from 12 Vdc for portable use. The UL approved unit comes with an external antenna and offers continuous coverage from 550 kHz to 30 MHz in four bands.

The *Star-Quest II* is designed for the novice, beginner swl, hobbyist and world traveler. With built-in 117 Vac supply it is priced at $59.95. More information is available by using *check-off* on page 126 or by writing to The Hallicrafters Company, 600 Hicks Road, Rolling Meadows, Illinois 60008.

dry desoldering tool

Solder removal is fast, economical, and convenient with the new "Soder-Wick," dry desoldering tool. Used in conjunction with an ordinary soldering iron, it quickly removes solder from all sizes of electronic joints and connectors.

Used in the computer, aerospace, telephone and communications industries, "Soder-Wick" is useful for initial building, repairing, or rewiring of circuits or for salvaging parts from bargain computer boards or surplus chassis.

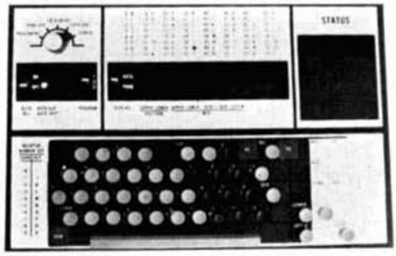
No special equipment is needed to remove solder from integrated circuits, printed circuits or telephone connections. Simply touch "Soder-Wick" to the heated joint and solder is drawn up immediately. Flux contamination is eliminated, and residue if any, is non-corrosive and non-conductive. In just one second, solder can be removed for as little as half a cent per connection.

Rolls of "Soder-Wick" fit conveniently into tool box or pocket, and are available in four sizes to match the joint and quantity of solder to be removed. Each roll contains five feet of wick and sells for $1.49 per roll.

For further information, contact Jensen Tools and Alloys, 4117 North 44th Street, Phoenix, Arizona 85018, or use *check-off* on page 126.

More Details? CHECK—OFF Page 126

USASCI-II ALPHA-NUMERIC KEYBOARD Brand new from a leading video terminal manufacturer. Beautiful, well made with the look and feel of an expensive electric typewriter. Sixty five keys + space bar. All alpha + 10 numerals + 28 control keys + 1 locking "shift" key. Diode matrix for ASCII is easily converted to use as morse or TTY keyer.. Attractive slanted tier.. Tri-color key scheme-replaceable keys. Stock # K10066....POSTPAID...$39.50



ALPHA-NUMERIC KEYBOARD AND CONTROL PANEL. Has a 44 key keyboard plus space bar, character lamp panel, function control switches and built-in audio tone generator. All mounted in an attractive molded sloping front enclosure with rubber feet and removable bottom plate. Keys are replaceable and can be relocated. Make your own format!........Stock Number K10152.........POSTPAID..... **$22.50**

2N1542 Hi-Rel PNP power in TO-3. 75v, 5 amp, 106 watts. User coded...$ .50 3/$1.00
OPTICAL COUPLERS. Infra-red LED + Phototransistor - MOC-1002....$2.00 2/$3.00
MINIATURE INCANDESCENT LAMPS. 4v-40 mA. Long flex leads..10¢, 11/$1, 100/$8
1000v-10A STUD RECTIFIER on heat sink. Removed from equipment..............2/$1
RUNNING TIME INDICATORS. CURTIS INDICHRON 120-LC mercury tube
mounted on P.C. board with zener regulator. NEW..Stock # RTM-120A1..... $2.50
CURTIS 120-LC indicator only.....NEW..............Stock # RTM-0120...... $1.50
MAGNETIC REED BOARD. 15 to 20 heavy duty magnetic reeds rated 250v/1A.... $1.00
TRANSISTOR SEATS. Plastic mounting pad for TO-5..........................100/$1
I.C. SOCKET. 10 pin round for TO-5 size I.C.s...............................3/$1
FEED THRU CAPS. Miniature 1300pf, silver plated. #8-32 thread............. 10/$1

NEW - GUARANTEED R.F. TRANSISTORS. FACTORY MARKED

TYPE	CHARACTERIZED AT		Po/Gp	Ft	PRICE	2 FOR
2N2857	6.0V	450MHz	12.5db	1.6GHz	$ 1.20	$ 2.20
2N2947	25.0V	50MHz	12.0W		$10.00	$16.00
2N3866	28.0V	400MHz	1.0W	500MHz	$ .75	$ 1.40
2N3924	13.6V	175MHz	4.0W	350MHz	$ 1.75	$ 3.00
2N3925	13.6V	175MHz	5.0W	350MHz	$ 2.25	$ 4.00
2N3927	13.6V	175MHz	12.0W	350MHz	$ 6.50	$10.00
2N3950	28.0V	50MHz	50.0W	150MHz	$13.30	$25.00
2N4072	13.6V	175MHz	.25w/10db		$ 1.00	$ 1.75
2N4073	13.6V	175MHz	.50w/10db		$ 1.10	$ 2.00
2N5109	15.0V	200MHz		1200MHz	$ 1.50	$ 2.50
2N5583	10.0V			1300MHz	$ 4.00	$ 6.00
2N5589	13.6V	175MHz	3w/8.2db		$ 4.00	$ 6.00
2N5590	13.6V	175MHz	10w/5.2db		$ 6.00	$10.00
2N5591	13.6V	175MHz	25w/4.4db		$10.00	$16.00
2N5862	27.0V	150MHz	90w/7.0db		$28.00	$40.00
2N5942	28.0V	30MHz	80w/13db	50MHz	$28.00	$40.00
2N6082	12.5V	175MHz	25w/6.2db		$12.00	$20.00
2N6084	12.5V	175MHz	40w/4.5db		$23.00	$40.00
MM1500	20.0V	1500MHz	250mW		$ 7.50	$14.00
MM8006	6.0V	450MHz	14db		$ 2.00	$ 3.50
MM1607	10.0V	1.7GHz	350mW		$ 3.00	$ 5.00
MM1620	12.5V	50MHz	50W		$20.00	$30.00

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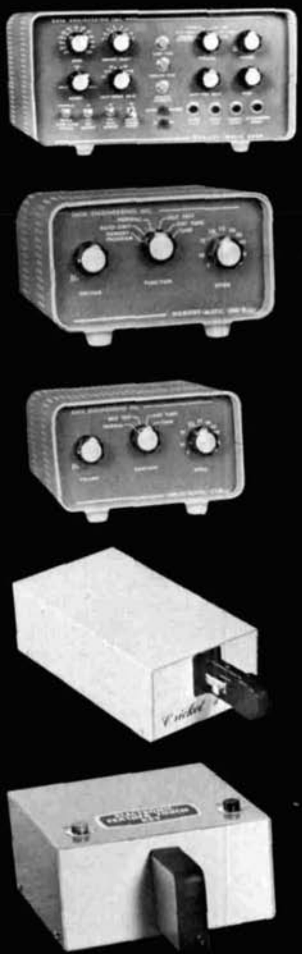
PHOENIX, ARIZONA 85063

More Details? CHECK—OFF Page 126



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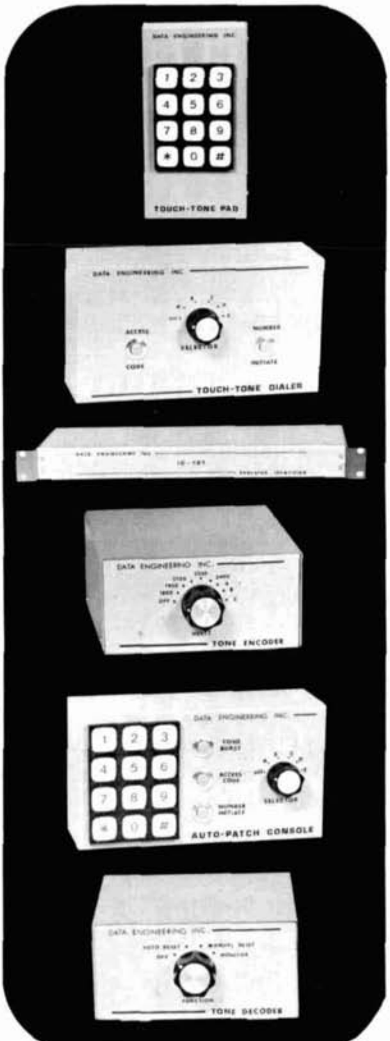

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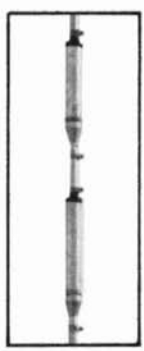

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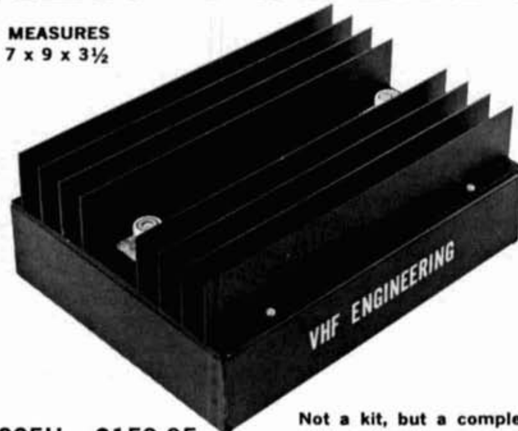

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WITH 10.7 CRYSTAL FILTER

- **Low cross modulation front end**
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VHF ENGINEERING

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6-channel Adapter kit with predrilled pcb and all components **$12.95**

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5-watt Speaker Driver Amplifier, wired and tested (Sept. 72 HR article) **NOW $14.95**

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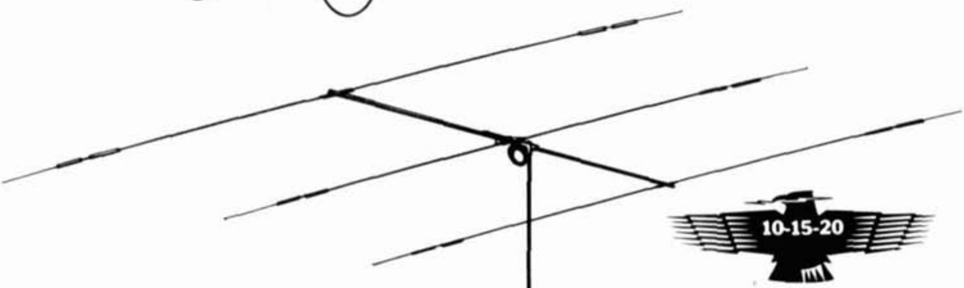
hy-gain TH3Mk3



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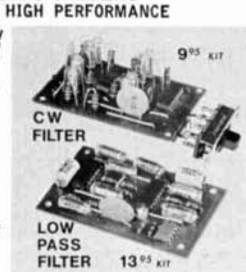

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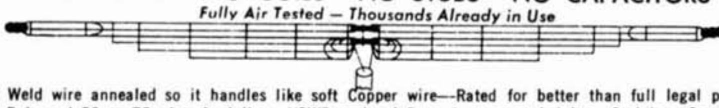

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7405	.36	.34	.32	.30
7406	.56	.53	.50	.47
7407	.56	.53	.50	.47
7408	.38	.36	.34	.32
7409	.38	.36	.34	.32
7410	.34	.32	.30	.28
7411	.34	.32	.30	.28
7413	.60	.57	.54	.51
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7418	.38	.36	.34	.32
7420	.34	.32	.30	.28
7421	.34	.32	.30	.28
7423	.84	.80	.76	.72
7425	.54	.51	.48	.45
7426	.40	.37	.34	.31
7430	.34	.32	.30	.28
7437	.56	.53	.50	.47
7438	.56	.53	.50	.47
7440	.34	.32	.30	.28
7441	1.73	1.64	1.55	1.46
7442	1.34	1.27	1.20	1.13
7443	1.34	1.27	1.20	1.13
7444	1.34	1.27	1.20	1.13
7445	1.71	1.62	1.53	1.44
7446	1.34	1.27	1.20	1.13
7447	1.30	1.23	1.16	1.09
7448	1.44	1.37	1.29	1.22
7450	.34	.32	.30	.28
7451	.34	.32	.30	.28
7453	.34	.32	.30	.28
7454	.34	.32	.30	.28
*7459	.34	.32	.30	.28
7460	.34	.32	.30	.28
7470	.46	.43	.40	.37
7472	.40	.38	.36	.34
7473	.52	.49	.46	.43
7474	.52	.49	.46	.43
7475	.80	.76	.72	.68
7476	.58	.55	.52	.49
7480	.80	.76	.72	.68
7482	1.10	1.05	1.00	.95
7483	1.72	1.64	1.56	1.48
7485	1.58	1.51	1.44	1.37
7486	.60	.57	.54	.51
7490	.85	.80	.75	.70
7491	1.48	1.41	1.34	1.27
7492	.85	.80	.75	.70
7493	.85	.80	.75	.70
7494	1.32	1.26	1.20	1.14
7495	1.32	1.26	1.20	1.14
7496	1.32	1.26	1.20	1.14
74100	1.80	1.70	1.60	1.50
74104	.70	.67	.64	.61
74105	.70	.67	.64	.61
74107	.54	.51	.48	.45
74121	.60	.57	.54	.51
74122	.74	.71	.68	.65
74123	1.30	1.20	1.10	1.00
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74150	2.00	1.85	1.70	1.55
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74155	1.56	1.49	1.42	1.35
74156	1.46	1.39	1.31	1.23
74157	1.56	1.48	1.39	1.31
74158	1.56	1.48	1.39	1.31
74160	2.20	2.10	2.00	1.90
74161	2.20	2.10	2.00	1.90
74162	2.20	2.10	2.00	1.90
74163	2.20	2.10	2.00	1.90
74164	2.20	2.10	2.00	1.90
74166	2.30	2.20	2.10	2.00

	Any Quantity Per Item (Mix)			*Multiples of 10 Per Item (Mix)*
Catalog Number	1-99	100-999	1000 up	100-990
74175	2.00	1.90	1.80	1.70
74180	1.30	1.23	1.16	1.09
74181	5.20	4.90	4.60	4.30
74182	1.26	1.19	1.12	1.05
74192	2.10	2.00	1.90	1.80
74193	2.10	2.00	1.90	1.80
74198	3.10	2.95	2.80	2.65
74199	3.10	2.95	2.80	2.65
SCHOTTKY TTL				
74S00	.88	.84	.79	.75
74S01	.88	.84	.79	.75
74S03	.88	.84	.79	.75
74S04	1.00	.95	.90	.85
74S05	1.00	.95	.90	.85
74S08	.88	.84	.79	.75
74S09	.88	.84	.79	.75
74S10	.88	.84	.79	.75
74S15	.88	.84	.79	.75
74S20	.88	.84	.79	.75
74S21	.88	.84	.79	.75
74S22	.88	.84	.79	.75
74S40	1.00	.95	.90	.85
74S50	.88	.84	.79	.75
74S51	.88	.84	.79	.75
74S60	.88	.84	.79	.75
74S64	.88	.84	.79	.75
74S65	.88	.84	.79	.75
74S73	1.82	1.73	1.63	1.54
74S74	1.82	1.73	1.63	1.54
74S107	1.82	1.73	1.63	1.54
74S112	1.82	1.73	1.63	1.54
74S114	1.82	1.73	1.63	1.54
74S140	1.00	.95	.90	.85
LINEAR IC'S				
NE501A	2.99	2.82	2.66	2.49
NE526A	3.59	3.38	3.17	2.95
NE531V	3.81	3.58	3.36	3.14
NE536T	7.31	6.88	6.45	6.02
NE540T	2.40	2.25	2.10	1.95
SE540T	4.48	4.20	3.92	3.64
NE550A	1.30	1.23	1.16	1.09
NE555V	1.10	1.05	1.00	.95
N5556V	2.10	1.95	1.80	1.65
N5558V	1.00	.95	.90	.85
NE560B	3.57	3.36	3.15	2.94
NE561B	3.57	3.36	3.15	2.94
NE562B	3.57	3.36	3.15	2.94
NE565A	3.57	3.36	3.15	2.94
NE566V	3.57	3.36	3.15	2.94
NE567V	3.57	3.36	3.15	2.94
N5111A	.90	.86	.82	.78
N5595A	3.40	3.20	3.00	2.80
N5596A	1.87	1.77	1.66	1.56
709V	.50	.47	.44	.41
710A	.50	.47	.44	.41
711A	.55	.52	.49	.46
723A	1.00	.95	.90	.85
733A	1.90	1.80	1.70	1.60
741V	.55	.52	.49	.46
747A	1.10	1.04	.98	.92
748V	.60	.57	.54	.51
LM335	2.85	2.72	2.64	2.55
LM336	3.85	3.66	3.46	3.27
LM337	4.05	3.70	3.51	3.31
TRANSISTORS AND DIODES				
1N270	.15	.14	.13	.12
1N914	.10	.09	.08	.07
1N4001	.10	.09	.08	.07
1N4002	.11	.10	.09	.08
1N4003	.13	.12	.11	.10
1N4006	.15	.14	.13	.12
1N747A - thru 1N758A	.25	.22	.19	.16
2N3860	.25	.23	.21	.19

All IC's are supplied in 8–, 14–, or 24–pin DIP (Dual-in-line) plastic or ceramic package except for NE536, NE540, and SE540 which come in TO–5 package. Voltage Regulators LM335, LM336 and LM337 are supplied in TO–3 (Diamond) package.

We give FREE data sheets upon request, so ask for those data sheets that you NEED, even for those listed IC's that you are not buying.

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Solid State Systems has now expanded it's line of LED Displays and also reduced their cost. The following are now available from us at these prices.

	1–49	50–99	100–499	500–999	1,000 up
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SSS-1C	4.75	4.50	4.00	3.65	3.25
SSS-2	4.50	4.25	3.75	3.40	3.00
SSS-3	7.75	7.50	7.00	6.75	6.50
SSS-4	7.75	7.50	7.00	6.75	6.50
SSS-7	3.50	3.25	3.00	2.75	2.50
SSS-9	3.50	3.25	3.00	2.75	2.50
Minitrons*	3.00	2.75	2.50	2.25	1.90

The SSS-7 and SSS-9 are the common .33 in character height 7-Segment and overflow display respectively, with decimal point on the left and wide angle viewing. The SSS-1 and SSS-2 have the same physical dimensions as the SSS-7 and SSS-9 with increased life and slightly lower current requirement. The SSS-1C is the same as the SSS-1 except it has a colon instead of a decimal point, making it ideal for use in a digital clock. The SSS-3 and SSS-4 are the new giant .77 in character height 7-Segment and overflow display respectively, with decimal point on the right and readability up to 40 feet. *Also included above is a new reduced price on our Incandescent 7-Segment Display.

Package of 8, 1/4 watt current limiting resistors .... $0.30.

MOLEX IC SOCKET PINS: Use these economical pins instead of soldering your IC's to PC boards. Sold in continuous strips in multiples of 100 pins only.

100 for $1.00	200 for $1.80	300 for $2.60	400 for $3.40
500 for $4.20	600 for $5.00	700 for $5.80	800 for $6.60
900 for $7.40	1000 for $8.20	each additional 1,000 $7.50	

Dual-in-line SOCKETS. Brand new with gold plated pins.

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14 Pin	Solder	.50	.45	.40	.35	.25
16 Pin	Solder	.55	.50	.45	.40	.30
14 Pin	Wire Wrap	.55	.50	.45	.40	.30
16 Pin	Wire Wrap	.60	.55	.50	.45	.35
14 Pin	Closed-Entry Cap	.05	.05	.04	.04	.03
16 Pin	Closed-Entry Cap	.05	.05	.04	.04	.03

STANCOR TRANSFORMERS: Ideal for use with LM series.

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P-6134, 6.3VCT, 1.2 amp $2.75

HEAT SINKS: Wakefield series 680 circuit board coolers. 1¼" high with a dissipation up to 20 watts. Designed for use with TO–3 package.

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Type 680–1.25A	1.20	1.10	1.00	.90	.80

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0.01μF. EACH .... $.11 0.02μF. EACH .... $.12

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10μF, 15V	$.10	30μF, 35V	$.20	5μF, 50V	$.10
30μF, 15V	$.10	50μF, 35V	$.20	10μF, 50V	$.15
50μF, 15V	$.10	100μF, 35V	$.20	20μF, 50V	$.20
100μF, 15V	$.10	500μF, 35V	$.40	50μF, 50V	$.20
220μF, 15V	$.15	1000μF, 35V	$.50	100μF, 50V	$.20
500μF, 15V	$.20	1μF, 50V	$.10	200μF, 50V	$.40
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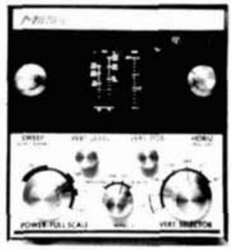

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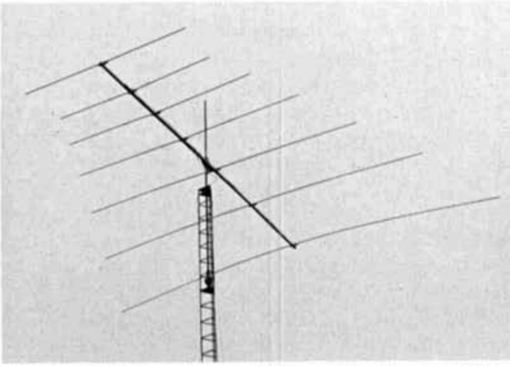

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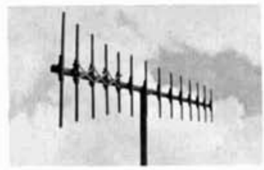

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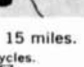

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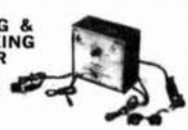

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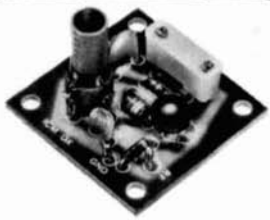

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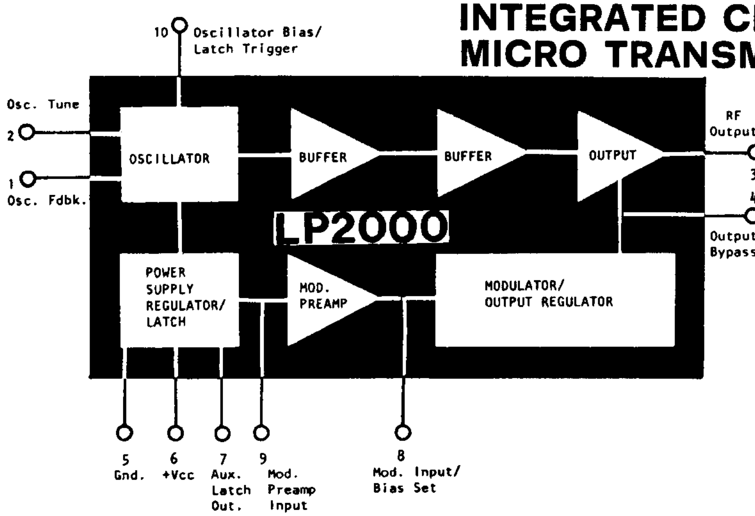

SOMETHING NEW FOR THE HAM LITHIC SYSTEM'S MICRO-TRANSMITTER. A COMPLETE AM TRANSMITTER INTEGRATED CIRCUIT IN A TO-5 CAN

With just a few external components you can build a minimitter for 10 or 6 meters. Works with fundamental or overtone xtals.

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LA3046 (Replaces CA3046) **$1.60**
LS370 (Replaces LM370) **$4.00**
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9258 Dual "D" FF toggles beyond 160 MHz **$4.65**
9582 Multi-function gate & amplifier **$3.15**
95H90 300 MHz decade counter **$16.00**
A 95H90 & 9582 makes an excellent prescaler to extend low frequency counters to VHF — or use two 9528s for a 160 MHz prescaler.

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MPF102	JFET	**.60**
MPF105/2N5459	JFET	**.96**
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MPF121	Low-cost dual gate VHF RF	**.85**
MFE3007	Dual-gate	**$1.98**
40673	Dual-gate	**$1.75**
3N140	Dual-gate	**$1.95**
3N141	Dual-gate	**$1.85**

POPULAR IC's

MC1550	Motorola RF amp	**$1.80**
CA3020	RCA ½ W audio	**$3.07**
CA3020A	RCA 1 audio	**$3.92**
CA3028A	RCA RF amp	**$1.77**
CA3001	RCA	**$6.66**
MC1306P	Motorola ½ W audio	**$1.10**
MC1350P	High gain RF amp/IF amp	**$1.15**
MC1357P	FM IF amp Quadrature det	**$2.25**
MC1496	Hard to find Bal. Mod.	**$3.25**
MFC9020	Motorola 2-Watt audio	**$2.50**
MFC4010	Multi-purpose wide band amp	**$1.25**
MFC8040	Low noise preamp	**$1.50**
MC1303P	Dual Stereo preamp	**$2.75**
MC1304P	FM multiplexer stereo demod	**$4.95**

CORES AND BEADS

T200-2 .... **$2.00**
KW Balun kit only **$3.50**
T68-2 3 cores **$1.00**
T50-2 3 cores **$1.00**
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BEAD SPECIAL

Ferrite Beads 1 doz. **$1.00**

Please add 35¢ for shipping

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FACTORY AUTHORIZED DISTRIBUTOR FOR MOTOROLA HEP — CIRCUIT-STICK — PLESSEY ALL DEVICES ARE FIRST QUALITY AND ARE FULLY GUARANTEED.

More Details? CHECK—OFF Page 126

flea market

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■ **COPY** No special layout or arrangements available. Material should be typewritten or clearly printed and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** can not check out each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue. Deadline is 15th of second preceding month.

■ **SEND MATERIAL TO:** Flea Market, Ham Radio, Greenville, N. H. 03048.

G5LK, TRANSMITTERS FOR THE BLIND, memorial fund. To supply on a loan basis ham equipment for financially restricted blind amateurs. Funds for this worthwhile cause gratefully accepted by G2DYM, The Old Saw Mills, White Ball, Wellington, Somerset, England.

TENNESSEE QSO PARTY, between 2200 GMT, May 19th and 2200 GMT, May 20. No time or power restrictions. All amateur bands. Amateurs outside Tennessee will attempt to contact as many amateurs in Tennessee as possible. Tennessee amateurs will attempt to contact as many amateurs as possible in Tennessee and the world. The exchange will consist of a signal report and QTH (Non Tennessee participants will give their State or Country. Tennessee participants will give their county only). Logs must include date, time in GMT, station worked, exchange, band, mode and multiplier. Stations may be worked on each band/mode. Portables and mobiles may be reworked if they change counties. Only those portions of the bands licensed to Generals may be used. Logs must be postmarked no later than June 22, 1973. Send logs to: Mel Wardell K4PJ, Box 489, Oak Ridge, Tenn. 37830. Full details from K4PJ.

WORLD QSL — See ad page 125.

BARGAIN HUNTERS! *Don't miss out. Closeout of* 18th Edition of W6SAI's Radio Handbook, list $13.50, only $7.95 ppd. while they last. Comtec, Greenville, N. H. 03048.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines in assembled or kit forms, plus many other suppression accessories. Free literature. Estes Engineering, 543-H West 184th, Gardena, California 90248.

TOROIDS, iron "E" powder 80-10 meters. .500" — 8/$1.00, .680" — 5/$1.00, .940" — 4/$1.00, 1.437" — 75¢ each or 3/$2.00, 2.310" — $1.50 or 3/$4.00. Please include 50¢ postage, slightly more on large orders. Fred Barken, WA2BLE, 274 E. Mt. Pleasant Ave., Livingston, N. J. 07039.

THE NAVAL RESEARCH LAB Amateur Radio Club, W3NKF, will sponsor a 2-meter tune-up clinic on Sat., May 19, from 9:00 a.m. to 12:00 noon. All amateurs are invited to bring in their rigs for calibration using the latest test equipment. Club personnel will provide assistance with transmitter checks and adjustments for frequency, deviation and power output. Autopatch frequencies will also be checked. Can test either indoors or directly from mobile so that removal of permanently mounted installations will not be necessary. There will be no charge. Also many NRL scientific displays of interest will be on exhibit including SSTV, color television, moon bounce and automatic morse code-to-typewriter conversion. Coffee and donuts will be served. The event will be held in Bldg. 222 of the Naval Research Laboratory located in S.E. Washington, D. C. just off Route 295. Talk-in on 146.94 MHz.

BOUND VOLUMES. The deluxe answer to a perfect Ham Radio Magazine collection. 1970, 1971 & 1972 now available. $14.95 postpaid. Ham Radio, Greenville, NH 03048.

ILLINOIS REPEATER COUNCIL meeting May 20 at Dixon, Ill. Meeting open to all representatives of active or planned repeaters. Those planning new repeaters especially urged to attend. Here is the place we can all get together and resolve our mutual problems. For details please contact Gil Kowols, W9BUB.

VERY in-ter-est-ing! Next 6 big issues $1. "The Ham Trader," Sycamore IL 60178

NEW SCANNER BOOK from Sams, includes comprehensive servicing data for 30 popular UHF and VHF Scanner-Monitor receivers including models by B & K, Browning, Johnson, Midland, Pace, Pearce-Simpson, Penney's, Realistic, Sonar and Teubury. Just $4.95 postpaid from Comtec, Greenville, N. H. 03048.

FOR YOUR FUTURE ROBYN RADIOS send your order to, Two Way Radio Sales, 1501 Monroe Street, Bogalusa, La. 70427 or 202 Farrell Street, Picayune, Miss. 39466.

WANTED: tubes, transistors, equipment what have you? Bernard Goldstein, W2MNP, Box 257, Canal Station, New York, N. Y. 10013.

WARREN HAMFEST, Largest family style Hamfest in East. Sunday, August 19th, at famous Yankee Lake Park. Giant Fleamarket, swimming, picnicing — All free. QSL W8VTD, Box 809, Warren, Ohio 44482.

COLLINS KWM-2 #13775 with new 516F2 power supply $750. 75S-3B #30283 with 500 Hz filter and 312B-3 speaker — mint $700. S. R. Eisenbarth, P. O. Box 5037, Dyess AFB, Tx. 79607.

WANTED — Hammarlund SP-600JX21 receivers — Need 20 or more. P. O. Box 4039, Foster City, California 94404.

MANUALS for most ham gear made 45/65, some earlier. Send SASE for copy quote. Hobby Industry, W0JJK, Box 864, Council Bluffs, Iowa 51501.

WANT OLD RADIO SHOW TRANSCRIPTION discs. Any size or speed. Send details to, Larry Kiner, W7FIZ, 7554 132nd Ave. N.E., Kirkland, Wa. 98033.

QSL'S. Second to none. Same day service. Samples 25¢. Ray, K7HLR, Box 331, Clearfield, Utah 84015.

CAPE COD'S *fabulous Hyannis! N. E. ARRL Con*vention, September 29 & 30. Flea market, seminars, FM, SSTV, AMSAT, YL trips, 2 pools, golf, beaches, sailing. Early bird registration $3. W1KCO, 572 Berkley Street, Taunton, MA. 02780.

DES MOINES HAWKEYE HAMFEST will be held on Sunday, June 17, 1973 at the Iowa State Fairgrounds. Plenty of free parking. Flea market, covered display booths available, small charge; open arena — no extra charge. Dealer displays, prizes, and XYL activities. Saturday night auto races and camping — extra. Registration $1.50 advance/$2.00 at gate. Write Des Moines Radio Amateur Association, Box 88, Des Moines, Iowa 50301.

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50	☐ $.69	☐ $.88
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Code: 2 amp TO-5 case
6 Amp ½ x ½ x 3/16 sq

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0-9 plus letters, Snaps in 14-pin DIP socket. ¾" x ¼" x ⅜". 5V 10ma, with decimal point. Like MAN-1
☐ Socket for above, 50c

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COUNTING SYSTEM

Includes SN7490, decade counter, SN7475 latch, SN7441 BCD decoder driver. 0-to-9 Nixie tube, instructions.

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• Factory Marked!

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☐ 14-Pin, dual in line .. $.45
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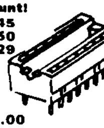

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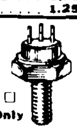

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☐ 747C	Dual 741C (A)	1.25
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☐ 748CV	Freq. adj. 741C (mini DIP)	.49
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(A) TO-5 or DIP dual in line pak

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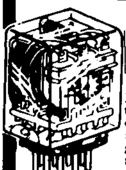

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☐ 12 VDC

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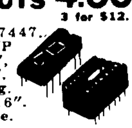
☐ Sockets .50 ea.



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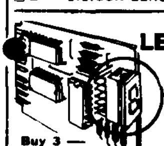
This display is excellent for small portable electronics, such as DVM's, calculators, etc. Equivalent to Monsanto MAN 3A. Operates from 5V, 20 milliamperes, with 47 ohm dropping resistor.



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Only Poly Paks can do it!

Will outperform any other DCM on the market today, not gaseous, not incandescent, but a device that will READ almost for life. MAN-4, Monsanto equal.
Kit includes: 3 x 2" printed ckt board, with fingers too! Side-mounting MAN-4 socket, resistors, 7448, 7475, 7490, booklet.

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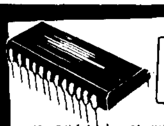
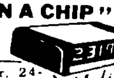


"DIGITAL CLOCK ON A CHIP"

☐ Only **$14.95**



SD-5314 direct substitute to famous U.S. maker. 24-Pin DIP — IMAGINE! ONE CHIP ELIMINATING 15 IC & other parts. Space Saver! Money saver! Latest in clock design. Features 12 or 24-hr. operation. 4 or 6 digits. 40 or 60 Hz operation. Internal digit multiplex oscillator, leading zero blanking, high output current for simple readout interface. Single power supply operation. Digit blanking for reduced current drain. 11 thru 19 volt range. Full MOS LSI. Spec sheets included.

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More Details? CHECK-OFF Page 126

FRESNO AMATEUR RADIO CLUB announces the Annual Fresno Hamfest including a Home-Brew Contest and events of particular interest to the FM crowd. The Hamfest will be held May 4, 5 & 6, 1973, at the Sheraton Inn, Highway 99 & Clinton Ave., Fresno, Calif. Pre-registration at $10.50 prior to April 27th, and querys may be sent to F.A.R.C., P. O. Box 783, Rresno, Ca. 93712.

MOTOROLA: P33DEN-1100A PT-300's with nicad low split $165. U43HHT-3100A Motracs with acc. $175. Robert Anderson, WA3PVO, 10314 Pierce Drive, Silver Spring, Md. 20901. 301-593-6993.

SAN FRANCISCO BAY AREA — T/T gear. 26 & 14 printers/MXD sender w. tables/serv. manuals, $239. J. P. Neil, K6PNW, 13150 Diericx Dr., Mt. View, Ca. 94040.

GONSET AIRCRAFT TUNER (108-128 M.C.); Topaz 250 watt mobile power supply, C10WDG. #2E, 1301 Estes, Chicago, Ill. 60626.

BEAM, TOWER SPRING SPECIAL: Triex W51 386.00; MW50 250.75; MW65 331.50; Ham-M 99.00; TR44 59.95; AR22R 31.95; Hygain TH6DXX 139.00; 204BA 129.00; TH3MK3 114.00; Mosley CL36 149.00; CL33 124.00; TA33 114.00; MCQ3B 91.00; S402 143.00; 8214 RG8 foam Belden 16¢/ft.; 8448 8-wire rotor cable 10¢/ft.; 3/16" cable clamps 18¢; Mallory 2.5A/1000PIV epoxy diode 29¢; Polygon fiberglas spreader arms 7.50; 6V/600MA transformer 1.95; KY65 code ider 5.95; Write quote Clegg FM27B; Hallicrafters FPM300A; Drake TR72; B & W; SBE; Standard; Eimac; Collins, CDE replacement parts; Prices FOB Houston, Warranty guaranteed. Mastercharge, BAC. Write list. Madison Electronics, 1508 McKinney, Houston, Texas 77002. (713) 224-2668.

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

RTTY SPEED CONVERTER. A drilled 4" x 6½" PCB and all components except input output jacks, power supply and chassis. See Dec. '71 and Oct. '72 issue of Ham Radio. $40.00 postpaid. PCB only $6.00. P & M Electronics, Inc., 519 South Austin, Seattle, Washington 98108.

GIVE ME FIVE MINUTES OF YOUR TIME: And I'll show you how to crack the computer code on those utility and charge card bills. Rush name, address and $1.95 to Data Guide, P. O. Box 1205, Garland, Texas. 75040.

KWM-1 FOR SALE — Good condition with power supply and manuals. $225.00 certified check to: W. Underwood, Box 527, N. Bradley, Mich. 48648.

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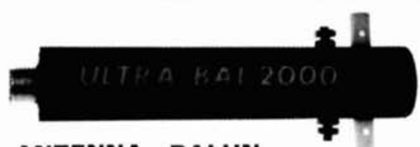

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FEATURING: Solid-state single-band SSB transceiver, External-anode tetrodes, FM communications receiver, RTTY tuning unit, Top-loaded vertical.

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FEATURING: Homebrew Parabolic Reflector, Solid-state Q-5er, Frequency calibrator with mos IC's, New multiband quad antenna, *Troubleshooting with a scope*.

September 1969
FEATURING: FM techniques and practices, IC power supplies, 1296-MHz varactor tripler, Tunable bandpass filters, *Amateur microwave standards*.

October 1969
FEATURING: Hot Carrier Diodes, Low-cost linear IC's, Diversity antennas, solid-state 432-MHz exciter, Tropospheric-duct communications.

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FEATURING: Op Amps . . . theory, selection & application, WWV receiver, Multiband antenna, Electronic key, Six-meter collinear.

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FEATURING: Communications experiments with light emitting diodes, FM modulation standards, Designing phase-shift networks, Transistor frequency multipliers, RTTY frequency-shift meter.

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FEATURING: Inductively tuned high frequency tank circuit, Solid-state receiver, Digital frequency counter, Two-meter kilowatt, SCR-regulated power supplies, High-frequency hybrids and couplers.

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December 1970
FEATURING: SSB generator, RF interference, Antenna bridge, QRP transmitter, AFSK oscillator.

April 1971
FEATURING: Inductors, VHF and UHF coil-winding data, Using ferrite and powdered cores, *FM control head, Power fets, Five-band linear amplifier.*

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FEATURING: A practical approach to 432-MHz SSB, FM carrier-operated relay, Audio agc systems, Practical IC's, Low-noise 1296-MHz preamp.

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FEATURING: Practical Photofabrication of Printed-circuit boards, Injection lasers, FM sequential encoder, Multimode i-f system, RTTY afc, IC phase-locked loops.

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FEATURING: Remotely switched broadband HF linear, 2300 MHz converter, FM i-f filter, reciprocating detector, digital integrated circuits.

April 1972
FEATURING: 2 meter FM transmitter, SSB two-tone tester, direct conversion receiver, audio-actuated squelch, tuning toroidal inductors.

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FEATURING: 5 Band solid-state communications receiver, FM repeater control, SSTV synch generator, microwave experimenting.

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FEATURING: Frequency synthesizer for Drake R-4, 2304 MHz preamp, audio filters, RTTY Monitor scope, mobile touch-tone.

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☐ April 1971
☐ June 1971
☐ September 1971
☐ March 1972
☐ April 1972
☐ June 1972
☐ August 1972
☐ September 1972
☐ October 1972
☐ December 1972

More Details? CHECK—OFF Page 126

WANTED: Members for Ham Flying Club being formed in Morristown, N. J. area. For details contact M. Kovar, W2ZN, 3 Puddingstone Ct., Morristown, N. J. 07960 (201) 267-2921.

CW OPS. 30 Hz SELECTIVITY *eliminates QRM.* Adjustable, lossless filter plugs into headphone jack. Drives phones (1000 ohms or more). $17.95. Send for literature. Autek, Box 1494H, Canoga Park, Cal. 91304.

CLEAN OUT — ton of parts. Too old to build. SASE for bargain list. K. A. Trites, 1918 E. 12th St., Des Moines, Iowa 50316.

THE EGYPTIAN RADIO CLUB Inc. will hold its Ham-Picnic Sunday, June 24, 1973 at 700 Chouteau Slough Rd., Granite City, Illinois. Something for everyone — prizes — games for the children — food at the club house — parking for swaps — etc. Details from K9KXP.

STELMAN #TA-1 TELEPHONE ADAPTER, $125. Heavy duty equipment slides $15 ea. Components, equipment, etc. Inquiries invited, catalog available. B. F. Williams Co., P. O. #7057, Norfolk, Va. 23509.

WANTED: Magnetics specialist or college professor thoroughly familiar with conventional magnetic theory to assist the editor in evaluating a new concept in explaining magnetism. Write to Jim Fisk, W1DTY, editor, Ham Radio Magazine, Greenville, N. H. 03048.

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THE MADISON COUNTY (Indiana) Amateur Radio Club presents their spring Hamfest Sunday, May 6, 1973 from 10 a.m till 5 p.m., 4 miles north of Anderson (west of state road 9) at the Madison *County Civil Defense building (old Linwood school).* The Talk-In frequencies are 146.94 and 146.22/146.82 MHz FM and 3.92 MHz SSB. All buyers, sellers, and visitors are welcome. Plenty of refreshments and prizes.

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WANTED: Lafayette HA46, Bob, K6GEV, 11 Wool, San Francisco 94110.

FIGHT TVI with the RSO Low Pass Filter — p115 March 73 — write for brochure — Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada.

SALE: DRAKE TR-4, RV-4, AC-4, mint condition, $500. WA3QNS, J. Reed, 1031 W. Lafayette St., Norristown, Pa. 19401, 215-279-1517.

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KANSAS — The Central Kansas ARC will hold *their Annual Hamfest, Sunday, June 3,* at the 4-H Complex, Kenwood Park, Salina. Also a dinner Saturday evening. Registration Sunday at 9:00 a.m., with a program for the OM, YL, XYL, and harmonic. Covered-dish lunch supplied by the club. *Talk-in on 146.34-94 and 3920kHz. For information* write WN0DEQ, William Peck, 1028 W. Ash, Salina, Kansas 67401.

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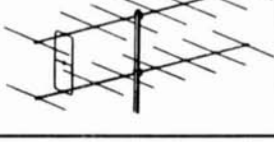

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VIDEO ADAPTER converts oscilloscope into flexible 1024 letter RTTY readout for under $400. High-performance H.F. frequency synthesizer replaces VFO and delivers clean R.F. output with calibration accuracy, stability, and resolution 100 times better than today's best amateur rigs. Write for full information. Petit Logic Systems, Box 51, Oak Harbor, WA. 98277.

THE BURLINGTON AMATEUR RADIO CLUB VE3RAB is celebrating the centennial of the Town of Burlington, Ontario by operating a centennial station for the duration of 1973. The special call sign of VA3RAB will be used and acknowlegement of contacts will be with a colourful QSL card. Operation during all major contests.

STOLEN IN WISCONSIN RAPIDS, Wisconsin on February 12, 1973: Regency HR-2A, serial number 04-07148 with Topeka FM 6-channel add-on transmit deck. Please contact Police, Wisconsin Rapids, Wisconsin 54494 or Edward W. Voigtman, W9GSS, 4050 Crestwood Court, Wisconsin Rapids, Wisconsin 54494.

THE ROYAL CANADIAN MOUNTED POLICE will be operating an amateur station at Ottawa, Ontario, to commemorate their 100th anniversary, from 23 May 1973 to 30 August 1973 from 1200 hours GMT to 0400 hours GMT daily, on 80 through 2 meters, using CW, SSB and FM. A special call VE3RCMP has been approved. A commemorative QSL card will be sent to all stations worked. Amateurs visiting Ottawa during this period may visit this station which will be in a large exhibit in the R. C. M. P. Training Center, on St. Laurent Blvd., Ottawa, Ontario. For further information please write to the Commissioner, R. C. M. Police, 1200 Alta Vista Drive, Ottawa, Canada. KIA OR2. Attention: Telecommunications Branch.

FOR SALE, KWS-1, $375; 75A4, $250; ZEUS, $225; 52S1, $350; Swan 250, $200; TX-62, $60; Model 15 TTY, $40; G.E. Progress line transistorized supply with 4 channel deck, $160. WB2PMF, Grantham, 808 Brook Ave., Union Beach, N. J. 07735. 201-264-7631.

THE F.M. DIVISION of CVT, Inc. (Poughkeepsie Amateur Radio Club) will hold a Ham-fest and Auction on Saturday, May 5th, 1973, between 11:00 a.m. and 7:00 p.m. at Gerring Park, Fishkill, N. Y. — near routes 52 and 84 intersection. Talk-in on W2CVT rpt. 37-97 as well as 94 and 52. Refreshments and door prizes — rain date is May 12th, 1973. Donations per person are $1.00 admittance, $3.00 for tables, with children under 12 and XYL's admitted free. CVT, Inc., c/o R. W. Perry, RD 1, Glen Ave., Fishkill, N. Y. 12524.

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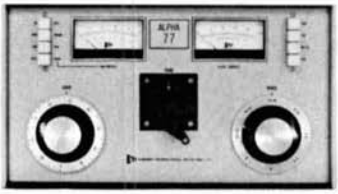

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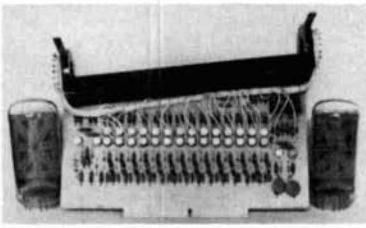

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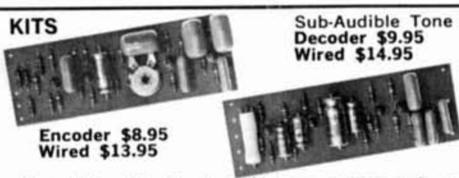

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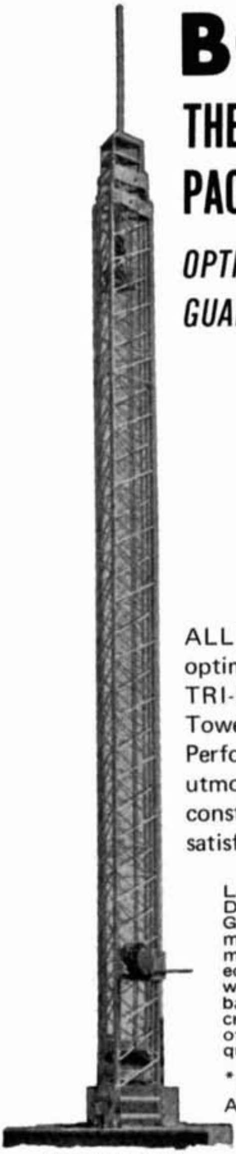

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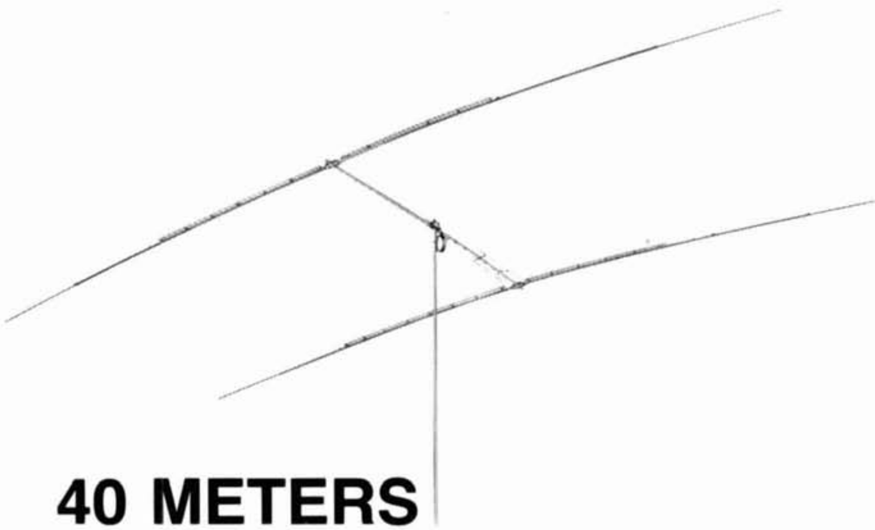

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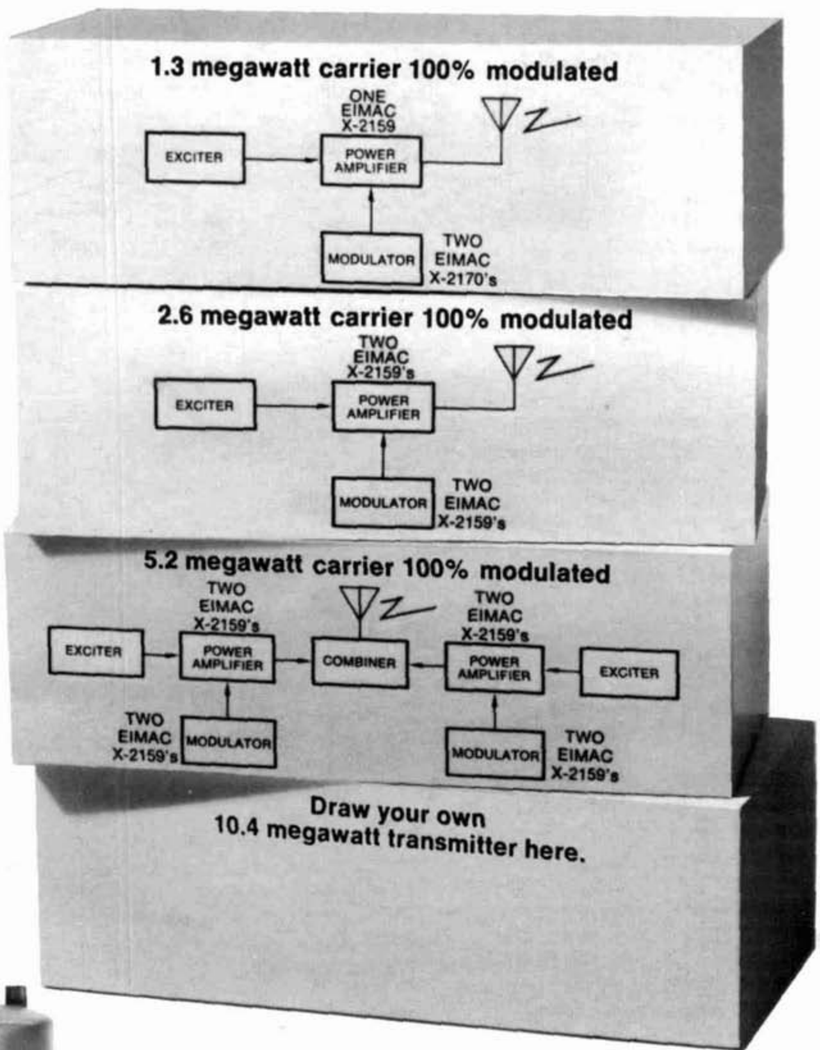

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