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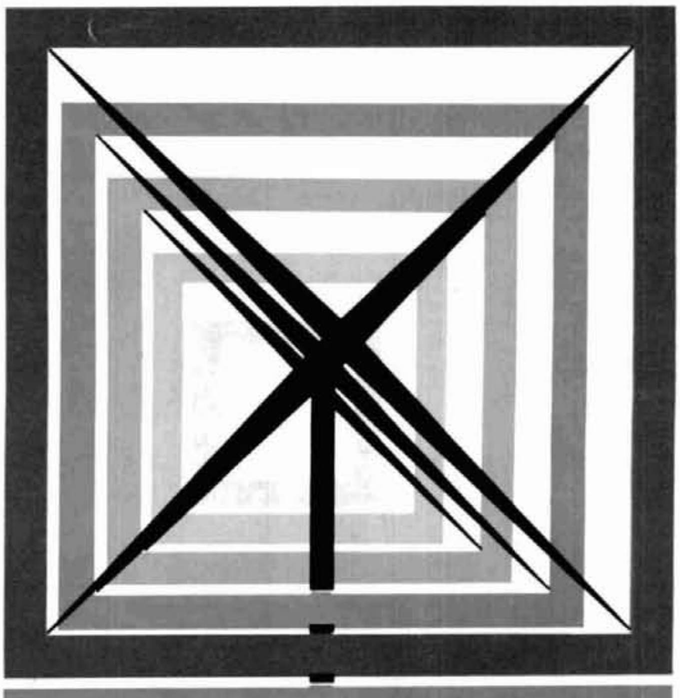
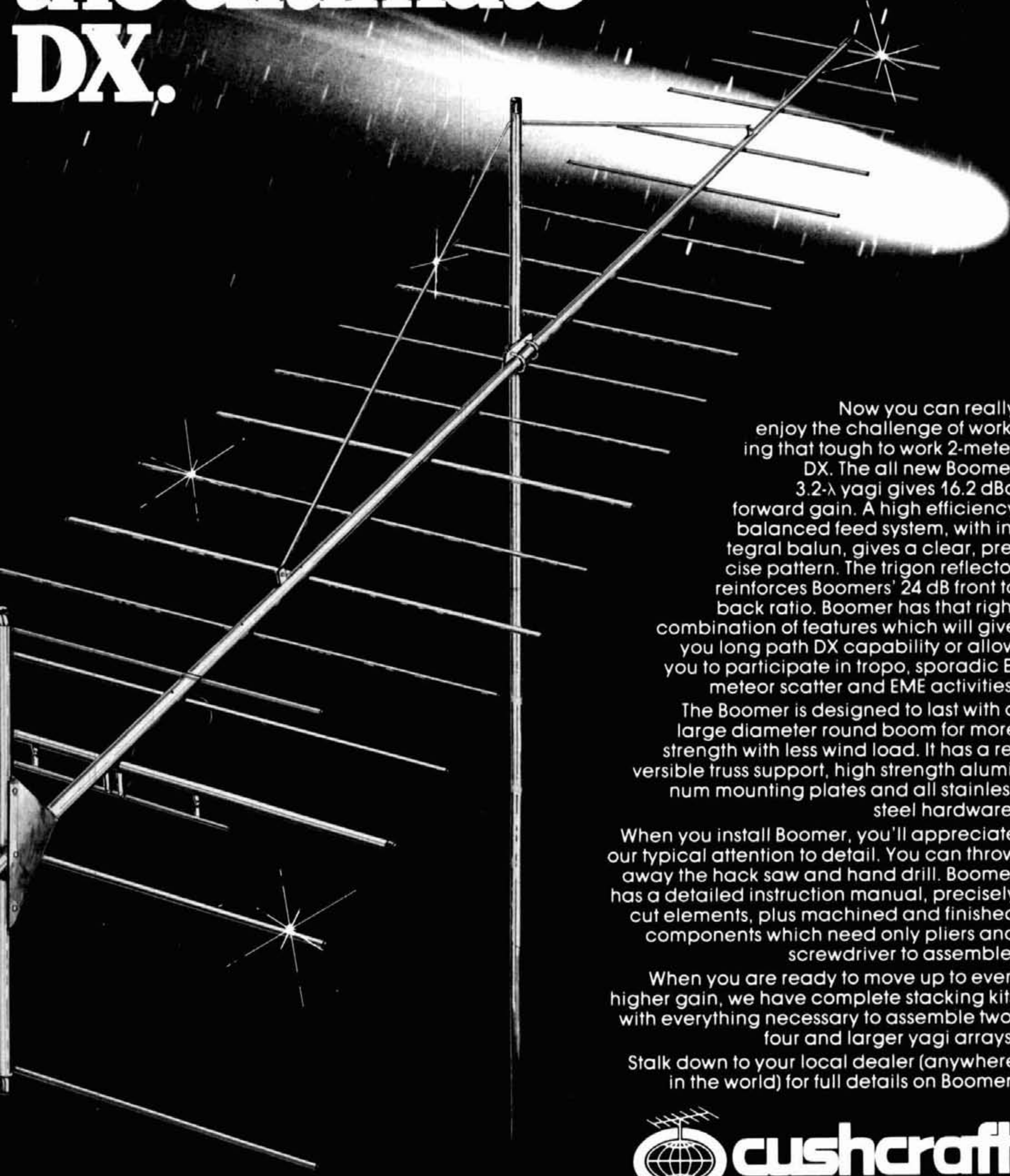
MAY 1979

10th annual ANTENNA ISSUE



emphasis: quads

Stalking the Ultimate DX.



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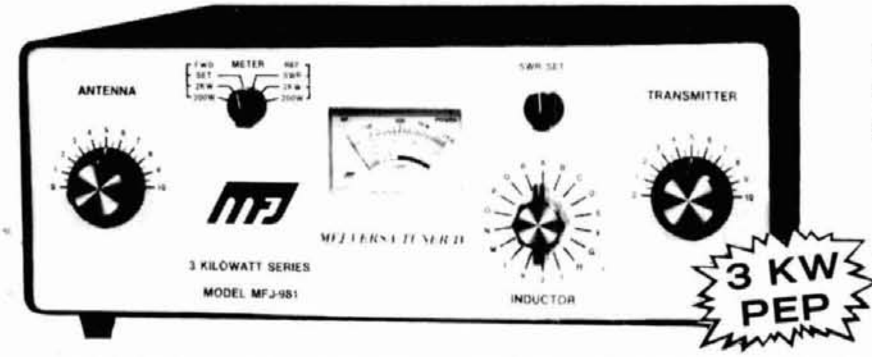

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More Details? CHECK—OFF Page 118

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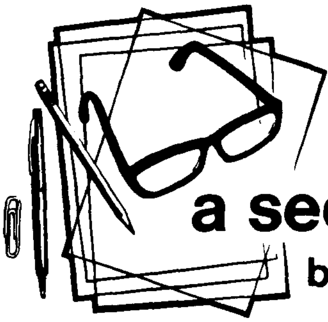


a second look

by Jim Fisk

Whether on or off the air, there's probably no Amateur Radio subject discussed more, scrutinized more carefully, or analyzed more qualitatively than antennas — the engineers analyze, the DX operators scrutinize, and the rest of us simply talk. And with the coming of spring and summer, interest in antennas peaks as Amateurs start working on their antenna systems for the coming DX season. If you have been thinking about updating your station antenna, you may find a useful design in this, our annual antenna issue. If you don't plan to install a new antenna this year, this is a good time to take a close look at your existing system to make sure it's operating up to par. Now that the ravages of winter are over, check all the electrical connections for oxidation, inspect the feedline for damage, and if your system SWR is not as low as it used to be, now's a good time to find out why.

If you look at the record, there have been few important breakthroughs in Amateur antenna design since the delta-loop beam and the quagi, and many readers would argue that both of these antennas are actually extensions of existing antenna theory (quads and Yagis). Many specialized antennas have been developed for military and space communications in recent years, but most have little or no application in Amateur Radio. One example is the log periodic or LP, first designed as a microwave antenna, later as a high-frequency wire beam, and finally, for TV reception. The LP has never been especially popular with Amateurs, probably because we operate on segmented bands and the LP is a broadband device. However, there is renewed interest in the LP for DX work on 80 and 40 meters, and if Amateurs are allocated any new high-frequency bands at WARC 79, it's a sure bet that a good many three-band beams will be replaced by rotatable log periodics.

Unlike other areas of electronics and radio communications, where there have been occasional quantum leaps forward, improvements in basic antenna design have been slow and evolutionary, beginning in 1887 with Hertz' classical center-driven dipole. Marconi's first successful wireless experiments used essentially the same antenna: Two large copper plates excited by a spark gap. To increase the distance of his transmissions, Marconi put up larger and larger quantities of wire. Early Amateurs did the same — because of the low frequencies then in use, the DX performance of a station was proportional to the size and height of the station antenna. In fact, many of the radio engineering textbooks of the early 1900s included a mathematical equation attributed to Marconi which showed that communications distance was directly proportional to the square root of antenna height.

The first advances in gain antennas were the result of experiments by commercial radio companies which wanted to improve the reliability of their overseas service. First came the long wire, the vee, and the rhombic; then the lazy-H, Sterba curtain, and Bruce array, followed closely by the Yagi beam and the 8JK flat-top; W9LZX's cubical quad was introduced a few years later. Each new antenna design was eagerly tested by Amateurs who were trying to improve the performance of their stations.

The perpetual need to improve station performance has become something of a tradition in Amateur Radio, and whether it's the result of ever greater band crowding or the competitive Amateur spirit, I don't know, but it certainly is a fact. Single-sideband provided the needed improvement in the early 1960s, and compact kilowatt linears made their contribution in the late 1960s; that left the antenna system. The fact that there were no antenna breakthroughs did not dilute the compelling urge to enhance station performance — if you couldn't improve basic antenna layout and design, you could certainly increase antenna size, and hence, antenna gain.

As an example of this trend, consider the great interest in phased arrays for 40 and 80 meters, sparked primarily by W1CF's *QST* articles and his big signal on 75 meters. It wasn't too many years ago that most of us were content with a ground-plane antenna on 7 MHz and a dipole (usually not too high) on 3.5 MHz. In those days some of the more serious 40-meter buffs had two element-vertical arrays, and you might have read in one of the magazines about a few daring souls who had 40-meter Yagi beams, but you almost certainly had never actually seen one. In recent years, however, big low-frequency arrays and full-sized beams have become relatively commonplace, and the same rationale for greater antenna height and size has begun to permeate 10, 15, and 20 meters. As the late Sam Harris, W1FZJ, used to say when talking about *vhf* antennas, "If it lasted through the winter, it wasn't big enough." Based on the large number of antennas which came tumbling down this past winter, perhaps we've hit the practical limit!

Jim Fisk, W1HR
editor-in-chief

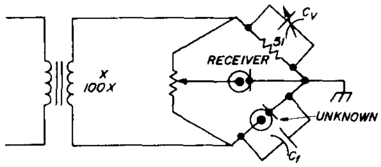
comments

RX noise bridge

Dear HR:

I found Ted Hart's letter in the August 1978, issue of *ham radio* both interesting and informative. I believe Pappot was the first to describe the R-X Noise Bridge (*ham radio*, January 1973), but he did not reference the source for the original, resistance-only noise bridge which he improved.

Hart's design, which is marketed as the Model TE 702, is technically interesting but would have an awkward capacity readout range if modified as indicated. Using the resistance values



he suggested, calling the fixed and variable capacitors C_f and C_v, and letting X represent the resistance from the pot wiper to the upper corner of the bridge, the conditions for balance become:

$$R_u = \frac{51(100-X)}{X}$$

$$C_u = \frac{X \cdot C_v}{100-X} - C_f$$

where R_u and C_u are, respectively, the parallel resistance and capacitance of the unknown impedance. As Mr. Hart stated, the resistance range is zero to infinity. Furthermore, with a linear taper pot, the low end of the resistance scale would be spread out and the upper end compressed. For many applications, that would be more desirable than the linear and finite range of the Pappot design.

Conversely, the reactance or capacitance range of Hart's proposed reactance bridge would be awkward or unusable. Note that the estimated value of the unknown capacitance is affected both by the setting of the 100-ohm pot *and* the variable capacitor. The effective capacitance range is thus dependent upon the resistance measured. Suppose, for instance, that C_v is a standard broadcast variable with a range 20-365 pF. With C_f a 180 pF capacitor, the range for capacitance balance with $R_u = 51$ ohms would be $-160\ pF \leq C_u \leq 185\ pF$, which is similar to Pappot's R-X bridge as modified by Gehrke (*ham radio*, March 1975). But suppose R_u were 5 ohms. Because of the interaction between pot setting and reactance balance, the capacitance range would now be $20\ pF \leq C_u \leq 3470\ pF$. One could not even measure a pure resistance! Similarly, with R_u equal to 250 ohms, the capacitance range becomes $-176\ pF \leq C_u \leq -107\ pF$ and again does not include a purely resistive impedance. Of course, other values could be chosen for the capacitors, but the effect described above would still cause the reactance range to be severely distorted for R_u values away from 50 ohms.

Mr. Hart also makes the point that his model TE 702 works to over 250 MHz and that the reactance measuring version thereof would yield "a lot more accuracy — over a wider frequency range." It is well known that, with careful design, resistance-only noise bridges can be made to work well up into the vhf range. Adding the fixed and variable capacitors, however, severely reduces the upper frequency limit. The R-X noise bridge Doting and I described works accurately to 30 MHz, and data to substantiate this claim have been published (*ham radio*, February 1977). The two commercial R-X noise bridges claim upper frequency limits of 100 MHz. However the manual for one of these units suggests it may require recalibration for use at the higher frequencies; neither makes any claim for accuracy.

Quite independently of how the transformer may be wound, the upper frequency range of the R-X bridge is limited by residual errors in the bridge components themselves. The pot has stray capacitance to ground which changes with the pot setting, and the interconnection wires have reactances which cannot be ignored; most important of all, the variable capacitor has residual series inductance. 250 MHz is well above the series resonant frequency of any reasonable-size variable capacitor. Severe resistance and reactance measurement errors would start to appear well *below* the resonant frequency. These constraints are recognized by commercial equipment designers; where accuracy is required in vhf impedance-measuring equipment, bridge techniques using discrete components are typically abandoned.

I congratulate Mr. Hart for his invention, the Antenna Noise Bridge. The R-X Noise Bridge pioneered by Pappot was certainly inspired by this invention. Refinements to the Pappot unit which allow calibration and compensation without access to lab standards make the R-X bridge a very useful device for accurate measurements in the high-frequency range.

R. A. Hubbs, W6BXI
Orange, California

presstop

"RESTRUCTURING," DOCKET 20282, was terminated by an FCC order released late March. The Commissioners left the door open for further action on the unresolved portions of the Docket. Noting that previous Report and Orders on 20282 had tightened up licensing procedures, but expanded Novice and Technician privileges, the Commission reaffirmed its support for some form of no-code entry level "Communicator Class" license despite its rejection by the Amateur community when proposed four years ago.

"We Hope To Revisit this matter later this year in a new Rule Making proceeding," the Commission continued, noting that Amateur Radio had grown by almost 50 per cent (much of that from CB ranks) in the past four years, so Amateur attitudes toward "no-code" may have changed. Continued Commission endorsement for "no-code" is well evidenced by their inclusion of relaxed code requirements in the proposals for WARC.

The Proposal To Base Power Limits on output measurements is also still high in Commission interest. However, that subject is also being shelved for the time being while encouraging "Amateurs, in the interim, to develop and disseminate data which could be used as a basis for a workable and state-of-the-art measurement technique."

431-433 MHz Will Remain "off-limits" to ATV repeaters, the FCC decided at another March meeting. Responding to two Petitions for Reconsideration on Docket 21033, the Commissioners noted that protection for weak signal and satellite operation was appropriate, but ATV repeater operators would always have the option of requesting a waiver. If the operator could establish a need for repeater operation in the protected segment, while showing his operation would not interfere with weak signal work there, such a request for waiver would be granted.

EFFECTS OF CB-ANTENNA RADIATION on the bodies of nearby people is being investigated by the Department of Health, Education and Welfare. The first study, published in a 24-page booklet titled "Measurement of Electromagnetic Fields in Close Proximity of CB Antennas," discusses bumper, trunk lid and rooftop-mounted mobile antennas as well as those on hand-held units. Near field radiation distribution of each type is presented graphically, in an attempt to determine what hazard, if any, radiation presents.

The Study Concludes: "The health implications (of CB-antenna radiation) are not clear at this time. The Bureau of Radiological Health is continuing to investigate this matter." HEW is obviously quite concerned with the effects of RF on the population, and with Amateurs running 200 times the power of CBers on frequencies from 1.8 MHz through millimeter wavelengths, our operations are sure to come under careful scrutiny as well — if they haven't already.

A 900-MHZ AMATEUR BAND will be enjoyed by Canadian Amateurs sometime later this year, possibly as early as this summer. An announcement by the Department of Communications of the reassignment of 420-430 MHz to another service is considered imminent, and at the same time the granting of 902-928 to the Amateur Service on a shared basis should also be announced.

The Movement of that as yet unspecified "other service" to the presently Amateur 420-430 MHz slot is expected to take place rather quickly. When Canadian Amateurs will be permitted into their new frequencies is less certain.

INTERNATIONAL SUPPORT for new Amateur HF bands at 10, 18, or 24 MHz seems to be building, with formal submissions supporting one or more of the new slots now confirmed from all three ITU regions. Don't be in too much of a hurry to swap off your present five or six band radios, however. Even if the WARC does authorize new bands for the Amateur Service next summer, it will likely be a number of years before present users can be moved out and Amateurs will be permitted to move in.

"UOSAT" — THE UNIVERSITY OF SURREY SATELLITE — will include a voice synthesizer to provide telemetry transmissions in plain English, a 4,000 character datascore capability, and a slow-scan TV camera for live cloud-cover pictures. Educators who've heard about the sophisticated bird are reported very enthused about its classroom possibilities.

PROHIBITION OF RADIO TRANSMISSIONS in residential areas is being considered by the Oregon State Senate. Senate Bill 423, sponsored by Senator Ted Hallock of Portland, proposes sharply restricting all electromagnetic emissions in residential areas.

In Testimony Favoring the bill Merrie Buel, government affairs coordinator for the Oregon Environmental Council, said that medical studies "have found that persons living next to electromagnetic sources often experience serious health effects, including rashes, headaches, dizziness, and tingling sensations."

Power Transformers and transmission lines as well as radio and TV transmitters would be curtailed under the bill's provisions, though Senator Hallock and members of the Senate Committee on Environment and Energy have been discussing removing transmission lines from its coverage.

FIRST WORKED ALL CONTINENTS ON 2 meters was completed January 31 by GW4CQT, when he succeeded in working VK5MC via moonbounce at 1132Z.

A New 6-Meter DX Record of 12,059 miles was set in early March when LU8AHW and HL9TG made contact at 0000Z. The same evening several VK4s worked WA4TNV/KL7, while ZB2BL heard the Brazilian beacons but was unable to make himself heard through JA/LU QRM!

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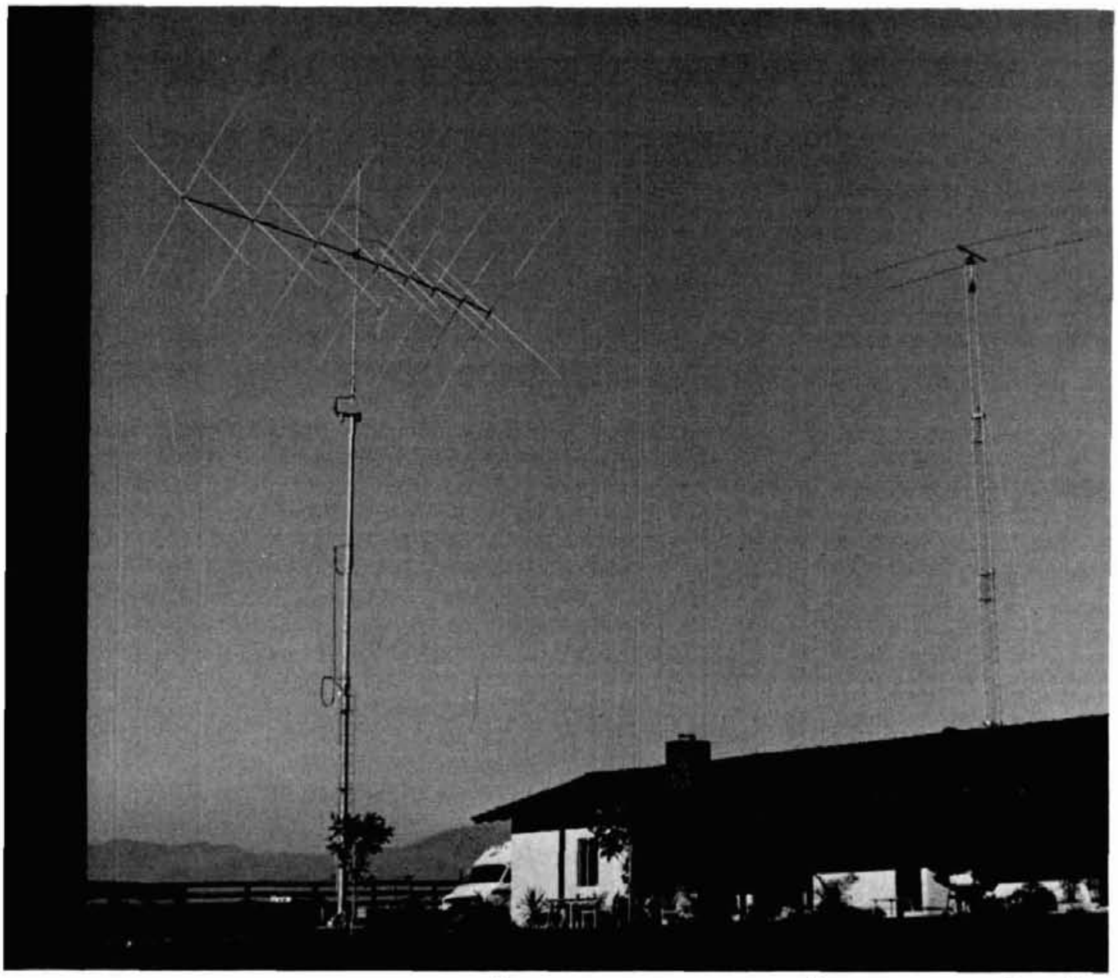


quads *vs* yagis revisited

The author attacks an old question in a new way by actually measuring the relative gain of high-frequency quads and Yagis

Which is the better antenna — a cubical quad or a Yagi? That question has aroused Radio Amateurs' emotions for more than thirty years now, and remains controversial in spite of the great volume of published research and analysis.

It has been a decade since Jim Lindsay published his classic work on quads and Yagis,[1,2] presenting both theoretical and empirical data to support his conclusion that the quad was in many ways the better antenna. He concluded that a quad of any length would outperform a similar size Yagi by 2 dB in forward gain. Basing his findings on model quads and Yagis operating at 440 MHz, Dr. Lindsay said that it was necessary for the Yagi to have 1.8 times the boom length of a quad to equal its forward gain.

At the time of its publication, Lindsay's study seemed conclusive, but in the years since the issue has refused to die. The question has now been subjected to computer modeling, which produced data

By Wayne Overbeck, N6NB, Pepperdine University, Malibu, California 90265

supporting Lindsay;[3] this was followed by a rejoinder from the owner of a highly successful Yagi-based contest station who pointed out sigificant errors in the modeling techniques.[4] That was followed immediately by a reply from the authors of the computer modeling study in which they conceded their errors, but stood by other parts of their work.

Meanwhile, Hardy Landskov, an antenna experimenter with a very pragmatic goal (to build a cubical quad that would be truly competitive in radio contests), spent many hours experimenting on antenna range owned by the United States Navy.[5] He came up with a design that the first user rated "good" on 20 meters and "excellent" on 15 and 10, in comparison to Yagis with which he'd "slugged it out" in pile-ups. During his antenna range work, Landskov built one 336-MHz Yagi and tested it against his quad design. He found the two equal in gain, although the Yagi was 1.65 times the quad's length.

popularity contests

The quad-versus-Yagi question has been argued with anecdotes, testimonials, and hunches, as well as with theory and quantification. Intuitively, some quad builders have concluded that their antennas were just not 2 dB better than similar-size Yagis. Others have reached the opposite conclusion by trusting the same intuitive sixth sense.

Moreover, one need only survey the antennas used by the consistent DX contest winners to see that Lindsay's conclusions remain controversial. Although there are notable exceptions, the great majority of big winners in DX contests today are using Yagis, not quads. If a quad is equal to a Yagi nearly twice its size, how could this be? Obviously, anecdotes, testimonials, and popularity contests, taken alone, prove nothing about the merits of the two antennas. But they do suggest that the issue is unresolved and deserves further study.

In an attempt to resolve this issue, I've spend hundreds of hours measuring the performance of quads and Yagis in both the high frequency and vhf spectrum and have encountered considerable evidence that the cubical quad is *not* inherently superior to the Yagi.

This seems to be particularly true below 100 MHz. However, there are potential variables that may sometimes bias the results of uhf modeling in favor of the cubical quad.

what happens at uhf?

My quads-and-Yagis project really began as an attempt to develop an efficient antenna for the 432-MHz Amateur band. In 1970, I bought a 432-MHz Yagi of the only brand then commercially available, and optimistically took it to an antenna gain measuring session at the West Coast VHF Conference. The gain was measured at 6.4 dBd (dB over a dipole) — a shocking figure compared with the manufacturer's claim of 13+ dBd. What was wrong?

The element lengths and spacing seemed acceptable, if not optimum, and the SWR was below 1.5:1. Nevertheless, I finally replaced the driven dipole with a quad-type full-wave loop. The gain improved to almost 10 dBd (as measured at the next West Coast VHF Conference).

That led to the next logical step. I set up a backyard antenna range and set out to design a good 432-MHz cubical quad. After many frustrating hours, I decided I couldn't come up with a combination of element lengths and spacing that would beat the hybrid quad-driven Yagi at 432 MHz. Up to four elements, the quads were competitive, but beyond that the quad-driven Yagi was better.

Note that I said I couldn't design a quad that would beat the *hybrid*. A mere 4-element quad was superior to the original 11-element Yagi with its "stock" driven element on 423 MHz, even though the quad was less than half the Yagi's length!

Finally, of course, I gave up on the quad and set out to optimize the quad-driven Yagi. Many hours and many designs later, the design that has come to be known as the *Quagi* emerged. Since the original publication of that design,[6,7] the Quagi has been duplicated all over the world, with the design published in Amateur journals in such diverse countries as the Soviet Union, South Africa, and India!

At about the same time, a Danish scientist working in an anechoic chamber also observed the phenomenon that led to the Quagi antenna. He was working with antennas that combined loop driven elements and reflectors with three types of parasitic directors — loops, Yagi-type rods, and flat plates.[8] He reported that for long-boom arrays (over two wavelengths), the loops were the *least effective* directors, although the difference was never greater than 1 dB.

free dB?

When the Quagi design was published, many Amateurs assumed its main advantage was a "free" 2 dB of extra "loop gain," and that the gain of any Yagi could be improved 2 dB by replacing the driven element with a full-wave loop. This is not the case, unless the original dipole is less than adequate.

For instance, while the gain of the 432-MHz Yagi previously mentioned increases dramatically when the dipole is replaced by a loop, the same is *not* true of the 144-MHz version of that antenna. Replacing the two-meter model's dipole with a loop results in almost no change in gain. At that frequency, it would appear the gamma-matched dipole is still a reason-

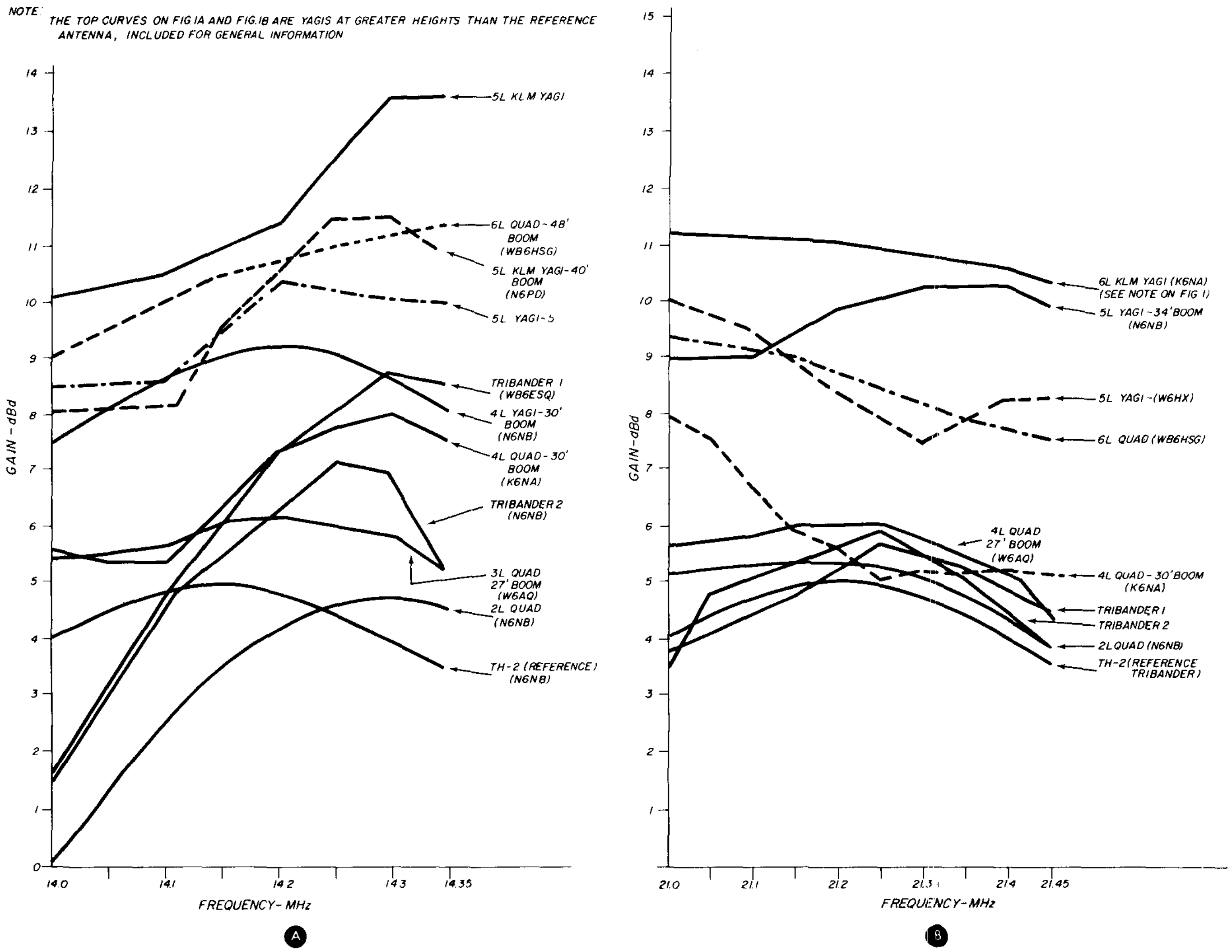


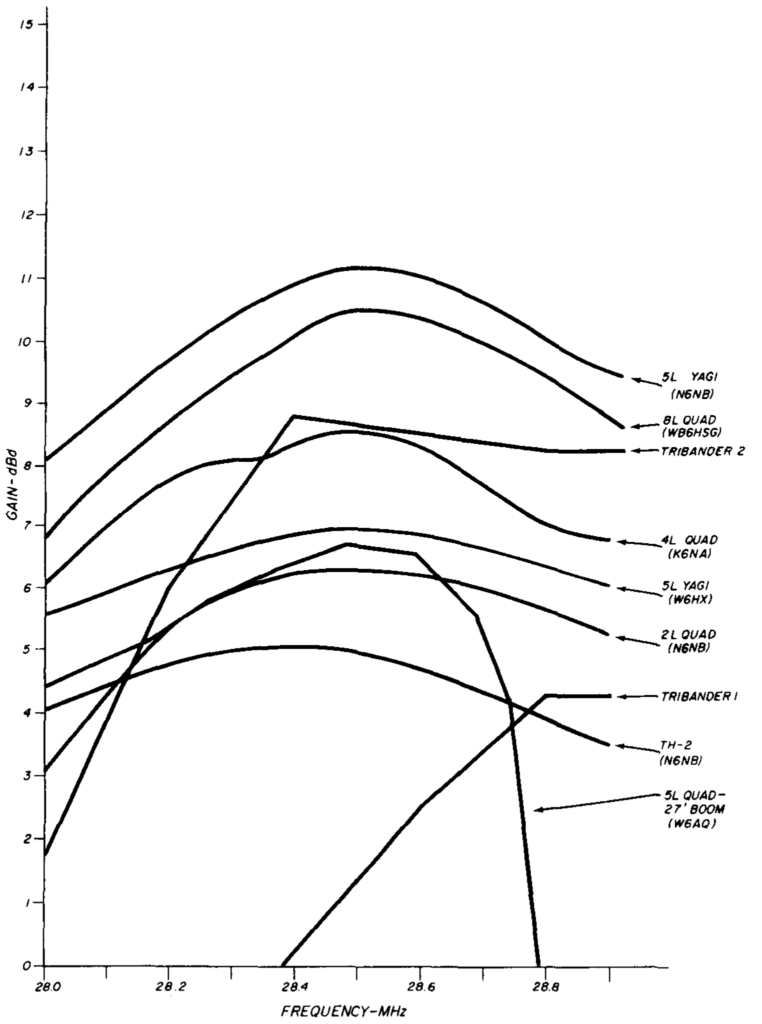
fig. 1. Relative gain measurements for 20, 15, and 10 meters. (A) shows 20 meters, (B) 15 meters, and (C) 10 meters. The top curves on 20 and 15 meters are for a Yagi which is at a greater height than the reference antenna. They were included only for general information, not for direct comparison.

ably efficient driven element. Nor does the Quagi's driven loop automatically ensure it 2 dB more gain than similar-size Yagis that have solved the feed problem in other ways. At 432 MHz, two of the 15-element Quagi's toughest competitors in antenna gain competitions are the KLM 16-element *log-periodic-driven Yagi*, and the F9FT 21-element array, which has a large oval-shaped folded dipole sometimes called a "flattened quad." What the vhf Quagi offers is the gain of a long-boom Yagi with an *efficient driven element* that can be easily duplicated using tools and materials readily available to Amateurs. It *does not* offer 2 "free" dB.

When most Radio Amateurs, and some commercial antenna builders, set out to build a conventional Yagi for uhf, the result may well be disappointing. Anyone who has attended a few antenna gain measuring sessions at vhf conferences has seen seemingly well-built 432-MHz Yagis measure very low gains, despite all indications that they should work well (*i.e.*, good SWR, good E- and H-plane patterns, and so forth).

At 1296 MHz, building an efficient Yagi is even more difficult, and no commercial manufacturer currently attempts to do so for the Amateur market. But there is a commercial "loop-Yagi" available, an effective antenna of quad-type full-wave loops. For whatever reasons, quads seem to retain near-high-frequency efficiencies at higher frequencies than do conventional Yagis.

Nevertheless, in previous comparisons of quads and Yagis, much has been made of the results of uhf modeling, with authors sometimes citing the sophistication of their antenna ranges as evidence of the validity of their results. Now no one would question the principle of uhf modeling for designing antennas.



C

All of my antennas were experimentally optimized that way. One can derive good element spacings and lengths, and scale those values to lower frequencies, as long as frequency-related variables such as changing length-to-diameter ratios are not overlooked.

However, quad-versus-Yagi studies are a little different. Here someone is generalizing about the *comparative* performance of *two different antennas* at high frequencies on the basis of the comparative performance of uhf models of those antennas.

You can not consider it good engineering practice to compare two power transistors, for instance, at one frequency and then generalize about their relative performance at another frequency an order of magnitude removed. But our assumptions about quads and Yagis have been based largely on just such extrapolations! Those assumptions would be valid if quads and Yagis were equally efficient at high frequency and uhf (or declined in efficiency at the same rates). However, with antennas that exist in the real world, as with other rf-handling components, there may well be frequency-related variations in efficiency.

All one can really say, after a series of uhf experiments comparing quads and Yagis, is something like this: "These particular quads outperform these particular Yagis (or vice versa) in this frequency range." The fact that uhf modeling (including mine) tends to produce pro-quad results does not necessarily settle the matter on the 10- 15-, and 20-meter bands.

high frequency experiments

With these questions about comparative antenna data from 400 to 14 MHz in mind, I felt it was time to attack the quad-versus-Yagi question in a new way, by actually measuring the gain of quads and Yagis in operational high frequency installations.

Using the measuring techniques described in a previous article,[9] I have rated the gain of several large 20-, 15-, and 10-meter antenna systems in **fig. 1.** Briefly, the technique involves placing a directional reference antenna alongside each antenna to be tested (at the same height) and reading the strength (in dB) of a nearby signal as received by each antenna. The signal source is a directional antenna of the same polarization as the test and reference antennas, located at least 40 wavelengths, but not more than about 5 km distant. The receiver agc is disabled and its audio feeds a Hewlett-Packard 400L audio voltmeter.

How do you place a reference antenna beside various antennas that may be 70 or 80 feet in the air? The answer, of course, is a self-supporting crankup tower on a trailer. I just happen to own not one but two such monsters; they were built for portable contest operating.

As a reference antenna, I selected a 2-element triband Yagi (Hy-Gain TH-2) because reference dipoles sometimes "see" reflections that can produce misleading results when a more directional antenna will not. All results are relative to the 2-element tribander. Its gain was assumed to be 5.0 dBd at its center frequency on each band. If that gain rating is too high (or low), all the other numbers will be incorrect on an absolute scale, but *correct in relation to each other*, which is what really matters for our purposes.

20-meter results

If the cubical quad antenna was to look good anywhere, 14-MHz turned out to be the place. Among the antennas I measured was the 6-element quad (8 elements on 28 MHz) at WB6HSG. It has a 14.6-meter (48-foot) boom. Patterned after Landskov's design but with a second reflector (added because quad pioneer C.C. Moore advised WB6HSG that a second reflector would surely provide more coupling, and hence more gain and front-to-back

A 5-element, log-periodic-style, KLM 20-meter monobander. The author's reference tribander is positioned beside the antenna, which is owned by N6PD. This KLM monobander had the highest measured gain of any 20-meter antenna (tested at the same height as the reference) over much of the phone band, but trailed the larger WB6HSG quad on CW.

ratio, than another director), the antenna is impressive in both appearance and performance.

As **fig. 1** shows, this quad outperformed any Yagi tested (except a much higher one) over much of the 20-meter band. (The higher antenna is K6NA's 5-element log-periodic Yagi at 32.3 meters (106 feet). It was included for general information, but not considered a part of the study. Note how it compares with an identical Yagi owned by N6PD which was at the same height as the reference antenna.)

It should be pointed out that only one Yagi, an array surrounded by wires and other towers at W6HX, was as big as the quad at WB6HSG. If Lindsay's thesis were correct, WB6HSG's quad would be expected to beat all of these Yagis by at least 2 dB. In fact, the 12.2-meter (40-foot) log-periodic Yagi that was 21.3 meters (70 feet) high topped the bigger quad in much of the phone band.

Aside from the performance of WB6HSG's quad on 20 meters, these tests consistently produced data favoring the Yagi design. In no other case did the long-boom quads even equal the gain of comparable size Yagis, let along exceed their gain by anything like 2 dB.

An interesting example is the 4-element quad at K6NA, which has a 9.1-meter (30-foot) boom and uses Lindsay's spacing. K6NA (ex-W6MAR) has long been concerned about the quad's seemingly poor performance. In fact, its apparent mediocrity provided inspiration for Landskov's attempt to optimize the quad design. This is the quad Landskov specifically cited as an example of a poor performer in his article.

After Landskov's research was completed, K6NA took the quad down and moved to a new home. When put back up, the quad retained the original spacing but used Landskov's dimensions for the elements (which differ from Lindsay's mainly in that the percentage differences between the driven and parasitic elements are greater). For whatever reason, the data in **fig. 1** show that it still performs poorly. Both Landskov's larger quad design (as adapted by WB6HSG) and a number of Yagis proved to be substantially better than this quad.

On 20, even my 2-element quad was disappointing, comparing unfavorably with the 2-element trap tribander (on a 2-meter [6-foot] boom) used as a reference!

15-meter results

On 15 meters (**fig. 1B**), the results were much the same, except that my 2-element quad squeaked past the reference tribander by 0.25 dB across most of the band. Neither big quad matched my 5-element Yagi on a 10.4-meter (34-foot) boom. At one embarrassing point (21.250 MHz), K6NA's 4-element quad fell to within 0.1 dB of the gain of the 2-element trap tribander.

Both WB6HSG's and K6NA's quads appeared to be resonant below the bottom of the band. Since both were cut to Landskov's dimensions and also provided their best SWR at 21.0 MHz, it appears his dimensions are too long on this band. WB6HSG has since shortened all his 15-meter elements and reports a much better SWR and front-to-back ratio in the phone band.

As on 20 meters, K6NA's higher Yagi was tested and plotted on 15, but the results are not considered comparable. Still, an antenna like that helps to explain K6NA's success in contests, doesn't it?

10-meter results

On 10 meters (**fig. 1C**), my 2-element quad finally behaved like an antenna without traps, topping the little tribander by up to 1.5 dB. Nevertheless, **fig. 1C** could not be used to support Lindsay's thesis. The top curve is a commercial 5-element Yagi on a 7.9-meter (26-foot) boom, little more than half the boom length of WB6HSG's big quad. Incidentally, this Yagi was measured directly against the big quad. After I compared the quad against the reference tribander, I lowered the portable tower and put up the 10-meter Yagi. The Yagi had the edge at every point in the band where we took a reading (each 100 kHz).

K6NA's quad was consistently 2 to 2.5 dB down from the smaller Yagi. It did, however, outperform a 5-element Yagi at W6HX, but that antenna was known to be defective before my measurements, perhaps due to driven element problems. For contest work W6HX uses another 10-meter Yagi considered to be "1 to 2 S-units better," but that antenna could not be measured due to logistics problems.

front-to-back ratios

Another claim often made for the cubical quad is a superior front-to-back ratio. The emphasis in the previous tests was on forward gain. We did measure the front-to-back ratio of WB6HSG's long quad on 10 meters, since he felt it was particularly good on that band. It varied from 18.2 dB at 28.4 MHz to an excellent 28.1 dB at 28.8 MHz. For comparison, the source antenna for those tests, a Hy-Gain TH-6 tribander at N6MB, was rotated. Its front-to-back ratio varied from 19 to 25 dB across 10 meters.

While this test did not show the long quad to be dramatically superior to a tribander in front-to-back ratio, comparing my 2-element quad against the reference 2-element tribander did reveal a substantial edge for the quad. On all three bands, the quad exhibited in excess of 20 dB while the tribander never exceeded 14 dB.

high and low quads

When this data was first presented at a meeting of the Southern California DX Club, two questions were raised that led to additional research. First, someone pointed out that virtually everything I had done was at a height of about 21.3 meters (70 feet). "A quad really comes into its own is at low heights," someone suggested.

table 1. Test results for different 50-MHz monoband quads vs a 5-element Yagi.

antenna	gain over reference
4-element long-boom quad, 5.3-meter (17.5-foot) boom	−0.65 dB
4-element Machin "optimum" quad, 4.5-meter (14.75-foot) boom	−0.85 dB
5-element quad, Landskov design, 2.7-meter (9-foot) boom	−0.90 dB
3-element quad, 0.21λ spacing, 2.5-meter (8.33-foot) boom	−1.05 dB
4-element quad, Lindsay design, 2.6-meter (8.5-foot) boom	−1.55 dB

antenna height — 1.5 wavelengths

source — 3-element Yagi at various points on a nearby hill, with vertical angles ranging from 0 to 9 degrees up from the site

reference — 5-element Yagi on a 4.3-meter (14-foot) boom, rated at 0 dB reference

relative strength variation from 0 to 9 degrees vertical angle — ±0.3 dB

relative strength variation when reference and test antennas are placed on opposite towers — <0.15 dB

Almost everyone who has written about quads has denied that a quad provides a lower angle of radiation than a Yagi.[10] Nevertheless, I set up two 21.3-meter (70-foot) towers side by side near a body of salt water (at the Ventura marina) to test the relative performance of a quad and a Yagi at high and low heights. The over-salt-water site was selected to eliminate the possibility of actual ground being so far below the earth's surface as to invalidate the experiment.

The result was conclusive; the relative performance of the quad and Yagi was exactly the same at both 7.6 meters (25 feet) and at 21.3 meters (70 feet)! This was true on zero-angle line-of-sight signals, high-angle "short skip," and on long-haul DX signals. There was no height at which the quad's relationship to the Yagi changed. The curves rating the two antennas could have been derived at any height between 7.6 and 21.7 meters (25 and 70 feet).

main-lobe centered tests

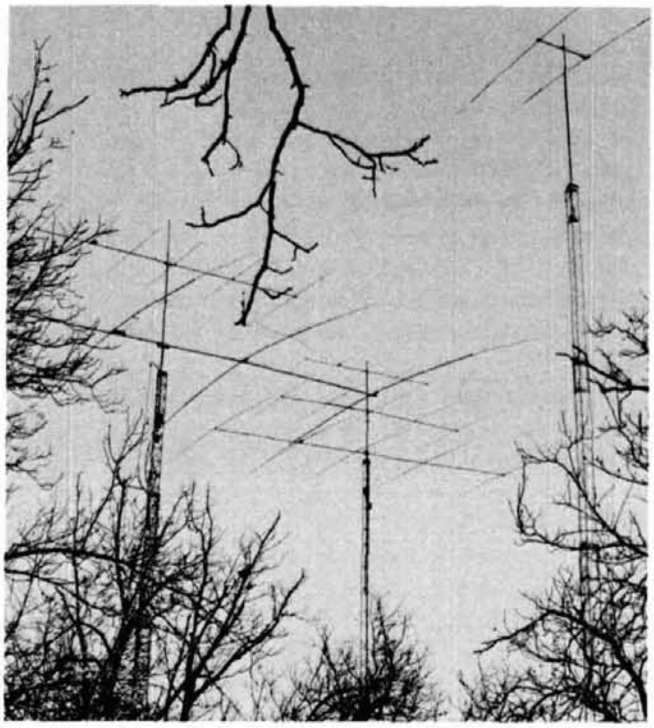
The other major question raised by the SCDXC members was really twofold: 1) my results might be invalid because I had been testing triband quads against monoband Yagis; and 2) my antenna ranges were, in effect, "ground-reflection" ranges, but I was measuring signals at zero degree angles rather than up in the middle of the main lobe.

To determine if these factors were significant in my research, I set up another experiment. I selected a cleared construction site where the soil had just been leveled, a site on flat land about 500 meters from the foot of a hill. The vertical angle to the hilltop was about nine degrees, according to AA6DD's transit. Roads traversed the hill at several elevations, permitting tests at other radiation angles between zero and nine degrees.

I chose 50 MHz for these tests in a tradeoff between the desire for results applicable to the high frequency spectrum and the desire to work with antennas having manageable dimensions. Since the construction methods, element and boom diameters, and wire sizes were essentially the same as those used at 14 MHz (as a percentage of the respective wavelengths), the results here would be expected to be similar to those in the upper high frequency bands.

I prevailed upon AA6DD and K6LPF to spend an afternoon and evening on the hilltop. Then AA6DD spent another day moving up and down the hillside, always with a 3-element, 50-MHz Yagi mounted on his car as a signal source.

These 50-MHz tests were interesting in several



Leafless trees give this photo of the antenna farm at W6HX an eerie feeling. At the upper right is the reference tribander positioned to match the height of one of the W6HX antennas for the gain comparisons.

respects. First, there was virtually no difference (±0.3 dB) in the comparative performance of the quads and Yagis tested at the various vertical angles from zero to nine degrees. In view of what has been previously written (and what I found) about the similarity of the vertical angle produced by quads and Yagis at any given height above ground, this result would be expected. It indicates that measurements can indeed be made with a local signal source (arriving at or near zero degrees) to produce results valid at higher angles, as long as the test and reference antennas are at the same height.

Perhaps the most interesting thing about the 50-MHz tests was the opportunity to compare a variety of well-known quad designs in a monoband configuration with a good 5-element Yagi as an on-site reference.

The results are summarized in **table 1**. The Lindsay and Landskov designs are those described in the articles already cited. The Machin "optimum" quad is a design recently published with the claim that it represents the true optimum spacing for quad arrays.[11] The Machin spacing is 0.15 λ reflector to driven element, 0.30λ driven to first detector, and 0.30λ driven to second director. The longest 4-element quad is an outgrowth of my 432-MHz experiments. Its spacing is conventional (about 0.21λ) except between the first and second directors, where it is 0.49λ! I used Landskov's element dimensions for this antenna. The 3-element quad is spaced 0.21λ and uses Landskov's dimensions.

In all cases, the element lengths were scaled from the original designs by determining the percentage differences from the driven elements and then applying those percentages to an experimentally derived correct length for a 50.1-MHz driven loop.

50-MHz summary

In these tests, monoband quads with short booms (up to about 0.5 wavelength) did indeed approach (but not equal) the gain of a longer Yagi. However, increasing the boom length still did not produce any quad that equaled the reference Yagi.

Neither Machin's long-boom quad nor mine delivered enough gain to justify its size. For all practical purposes, Machin's quad is identical in gain to the far smaller Landskov design, casting doubts on his claim that he has discovered the unique optimum design for a multi-element quads.

In fact, for an Amateur who could not accommodate a long-boom Yagi on his real estate, the Landskov quad design would seem to offer an excellent compromise. In this monoband version, it fell only 0.9 dB short of the 5-element Yagi. For comparison, a 20-meter Landskov quad is 9.75 meters (32 feet) long, while the Yagi would be 15.85 meters (52 feet) long.

Another good design appears to be the relatively wide-spaced 3-element quad shown in **table 1**. On 14 MHz it would fit on a 9.1-meter (30-foot) boom; it delivers excellent gain for its size and boom length.

It should be emphasized again, however, that these are monoband quads. The high frequency study indicated that the same results are difficult to attain in multiband configurations. And given the mechanical problems inherent in stacking monoband quads for several bands (with an acceptable stacking distance between the top of one quad and the bottom of the next higher one), stacked monoband Yagis still look pretty good for high performance on a variety of high-frequency bands.

about trap tribanders

If this field research suggests that long Yagis are the most consistent high-performance antennas for serious DXers and contest operators, where does that leave the thousands of Amateurs who use trap tribanders? How good are these multiband Yagis?

To find out, I set up two manufacturers' top-of-the-line tribanders side by side. Using the same test procedures as in the other high-frequency experiments, I ran gain curves on the two big tribanders. Then I replaced one tribander with the original reference TH-2 and repeated the experiment so the gain of the two big tribanders could be plotted on the same chart as the other antennas tested.

Perhaps the most notable conclusion, and the least controversial, was that these big tribanders sacrifice bandwidth for multiband coverage. Both were adjusted for phone band operation, using the factory-specified dimensions, and both exhibited drastic gain fall-off in the CW bands.

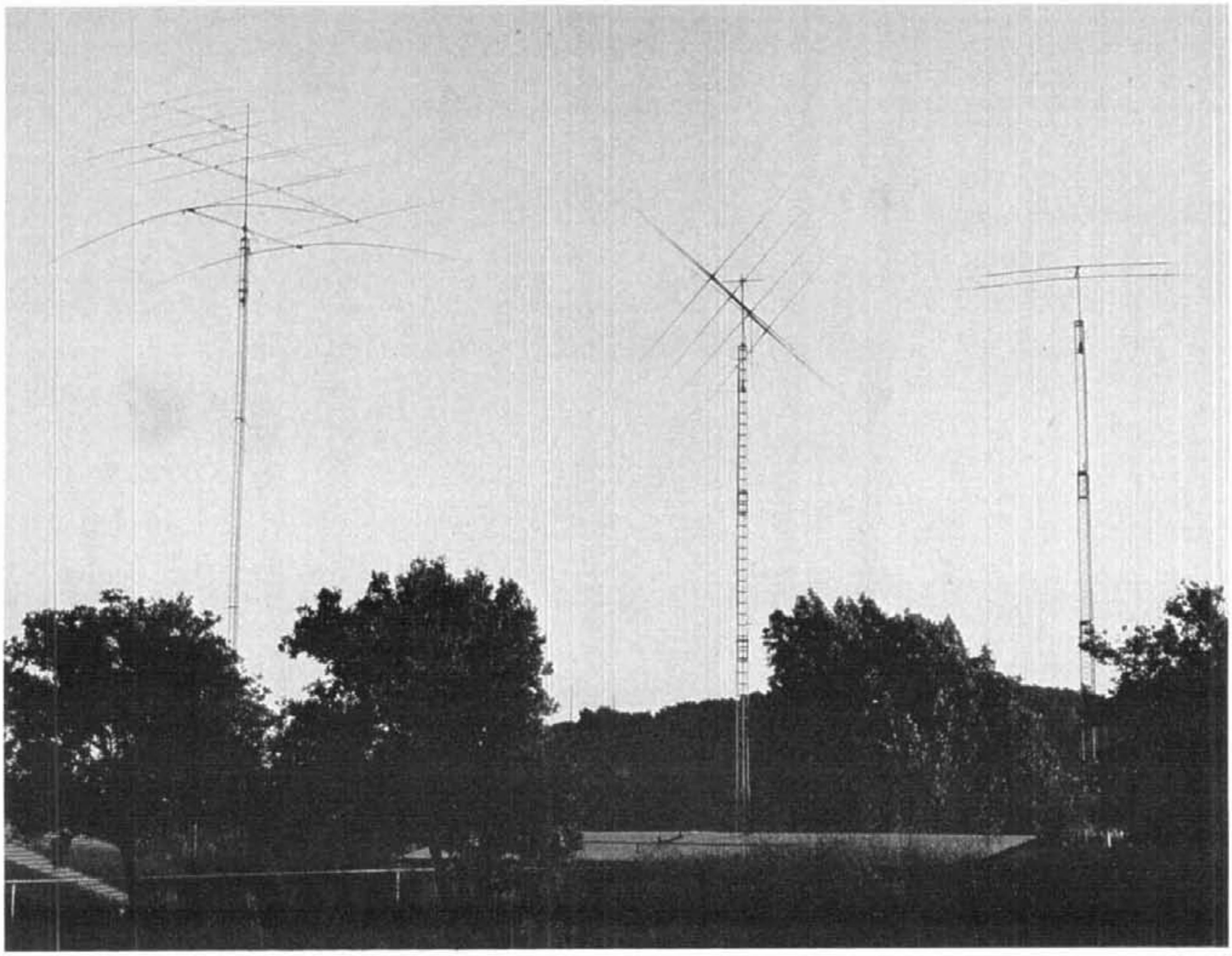
The results of the comparison produced no clear-cut answer for the Amateur who asks, "Which should I buy?" Tribander number 1 was much better on 20 meters, but slightly inferior on 15 and very inferior on 10. The poor showing on 10 can be explained in part by the owner's choice of the "high phone" length settings, but even at 29.4 MHz it was only 1.4 dB better than the reference TH-2, which was tuned much lower in the band! In fact, except for a couple of instances, the big tribanders exhibited very little gain above the two-element reference tribander! And both tribanders were markedly inferior to the monoband antennas, even in that very narrow range of frequencies where the tribanders hit their peak performance on each band.

None of this is new or surprising information, of course. But a look at the antenna gain charts could provide a dramatic illustration of the compromises involved in trap tribanders! If your goal is to keep in touch with friends and do some casual DXing, a tribander is fine. But if you want a first-rate signal, a trap tribander isn't the answer!

conclusions

These field experiments are by no means the last

Another source of big signals, N6NA (ex-W6MAR). At the left is the stack of Yagis which look as good on the gain plots as they do in the air. The 20- and 15-meter Yagis are considerably higher than the reference tribander, rendering the gain figures on these big beams invalid for comparison purposes. In the center is the 4-element quad, a source of much head scratching because of its questionable performance.



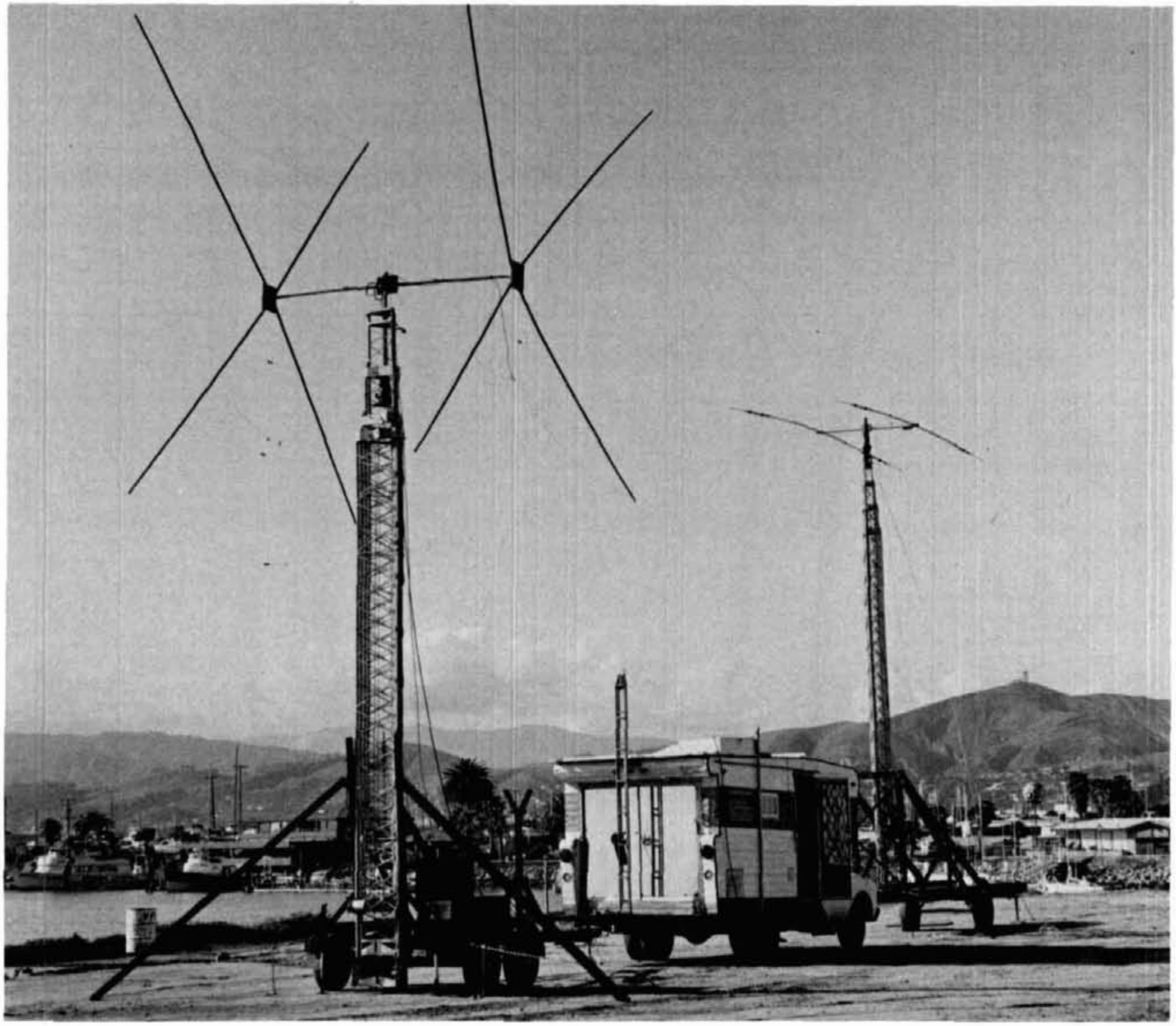
ones I'll undertake to compare working quads and Yagis on the high-frequency bands. Any judgement at this point is necessarily tentative, subject to revision as more data is produced, but the following conclusions are justified:

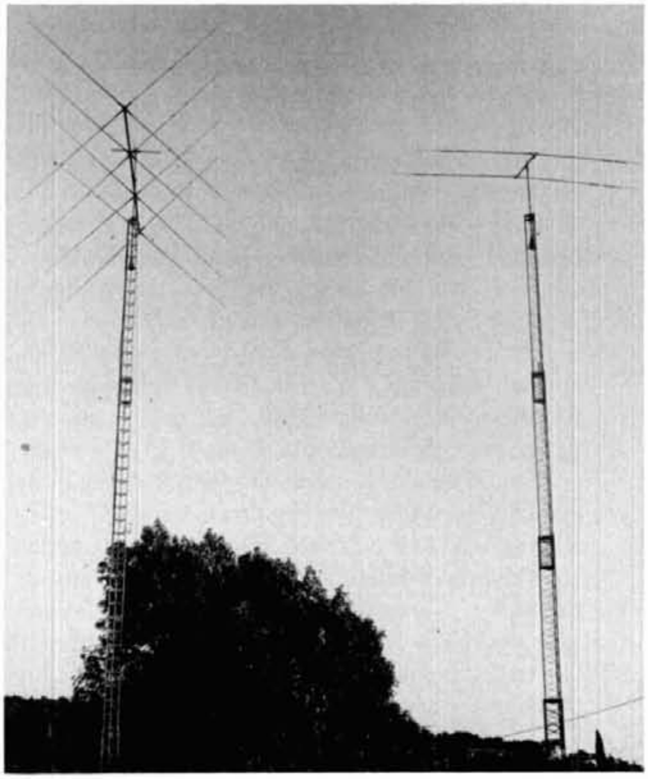
1. Cubical quads do *not* "come into their own" at low heights. At any given height, the vertical angle of radiation of quads and Yagis is virtually identical. The old idea that quads are better low-height performers *than Yagis should be recognized as the myth that* it is.

2. As the frequency is increased into the uhf region, the performance of cubical quads and Yagis may not deteriorate at exactly the same rate, given the mechanical differences between the two designs, particularly their driven-element configuration. This creates difficulties that must be accounted for if you wish to generalize about the relative performance of the two antennas at the high frequencies on the basis of uhf modeling.

3. While it may be possible to design a high-frequency cubical quad with a long boom that will outperform a similar size Yagi by 2 dB as Lindsay suggested, no quad I tested approached that level of performance. In few cases did a quad of more than two elements even equal a comparable-size Yagi. The 50-MHz tests illustrate the difficulties of achieving gain increases, when a quad's boom is lengthened, that equal the gain increases normally found when a Yagi's boom is increased. In fact, the quad

High and low antennas by the sea. Each antenna is on a trailer-mounted crankup tower beside a salt-water marina, ensuring an electrical ground near the surface. Regardless of the height, the relative performance was identical.





The enigmatic quad. This 4-element quad at K6NA, because of its mediocre performance, inspired Landskov's efforts to develop a competitive long quad. Now modified to Landskov's dimensions, it remains so marginal that the reference 2-element tribander nearly topped its gain midway across 15 meters. Were the reference beam a 3-element trap tribander, it would have probably matched or beaten this quad across all three bands.

seems to be at its best in two- and three-element designs.

The data presented here would support a conclusion not far afield from the assessment of quads versus Yagis in Bill Orr's original work on the subject some 15 years ago.[12] In that first edition, Orr said that a 2-element quad was superior to a 2-element Yagi, but that larger quads were inferior to comparable-size Yagis.

In his 1970 edition, Orr qualified that conclusion considerably, and his latest antenna book, published in 1978,[13] says flatly that quads are 2 dB better than Yagis. The new work has a "truth table" that simply rates the 4-element quad at 12 dBd and the 3-element quad at 10, with the corresponding Yagis 2 dB lower!

Neither our tests at 50 MHz, nor the 10-, 15-, and 20-meter tests at K6NA (both tests involving quads almost identical to the 4-element design in Orr's new book), would support that conclusion. I have yet to see a 4-element quad deliver 12 dBd gain or anything close to it on any frequency, or to outperform a well-designed 3-element quad by 2 dB, for that matter.

Perhaps there really is a high-frequency cubical quad out there somewhere that delivers 2 dB more forward gain than a well-designed Yagi of the same boom length, a quad that does what Orr, Lindsay, and others say a quad will do. Perhaps, but I tested quads built to the most popular published dimensions by respected Radio Amateurs and none of their antennas came close to beating a comparable-size Yagi by 2 dB. In many instances, even trap tribanders were comparable to quads of similar boom lengths, with full-size Yagis far better than either!

To those who still believe in the superiority of the quad antenna, I offer a challenge — bring me a high-frequency quad of four or more elements that you believe outperforms a comparable-length Yagi. I'll provide two towers in an open field for the side-by-side tests. If your quad really delivers 2 dB more than my Yagi, I'll publicly recant the conclusions presented in this article.

acknowledgments

Many Amateurs cooperated in the time-consuming process of gathering data for this report. In particular, I would like to thank W6AQ, K6AV, WA6BTX, W6CG, AA6DD, WB6ESQ, WA6FVR, WB6HSG, W6HX, WA6IJZ, K6LPF, N6MA, N6MB, K6NA, N6NT, W6OXY, and N6RS for their help. Without their field work, the charts and tables would be blank.

references

1. J. E. Lindsay, WØHTH, "Quads and Yagis," *QST*, May, 1968, page 11.
2. J. E. Lindsay, "A Parasitic End-Fire Array of Circular Loop Elements," IEEE *Transactions on Antennas and Propagation*, volume AP-15, Number 5, page 697, September, 1967.
3. D. K. Belcher, WA4JVE, and P. W. Casper, K4HKX, "Loops vs Dipoles — Analysis and Discussion," *QST*, April, 1976, page 34.
4. James L. Lawson, W2PV, Technical Correspondence, *QST*, August, 1976, page 51.
5. Hardy Landskov, W7KAR, "Evolution of a Quad Array," *QST*, March, 1977, page 34.
6. Wayne Overbeck, K6YNB, "The VHF Quagi," *QST*, April, 1977, page 11.
7. Wayne Overbeck, N6NB, "The Long Boom Quagi," *QST*, February, 1978, page 20.
8. J. Appel-Hansen, "The Loop Antenna with Director Arrays of Loops and Rods," IEEE *Transactions on Antennas and Propagation*, July, 1972, page 516.
9. Wayne Overbeck, N6NB, "Measuring Antenna Gain with Amateur Methods," *QST*, October, 1977, page 11.
10. See, for example, W. R. Hillard, K6OPZ, "Quad Antenna Design Parameters," *ham radio*, August, 1970, page 55.
11. See an unsigned article entitled, "Optimum Gain Element Spacing Found for the Quad Antenna," *Worldradio News*, March, 1978.
12. William I. Orr, W6SAI, *All About Cubical Quad Antennas*, 1st edition, Radio Publications, Wilton, Connecticut.
13. William I. Orr, W6SAI, and Stuart D. Cowan, W2LX, *The Radio Amateur Antenna Handbook*, Radio Publication, Wilton, Connecticut, 1978.

ham radio

rf impedance bridge measurement errors and corrections

How to determine the effects of stray reactance in rf impedance measurements and how to compensate for them

The current interest in various commercial and homemade impedance-measuring devices which measure both the real and imaginary components of impedance certainly represents progress toward higher-performance antenna systems. To attain the level of accuracy that these devices can deliver, however, it is necessary to appreciate the sources of error than can creep into a test setup and then correct for these errors. Unfortunately, few Amateurs seem aware of these problems, and consequently they accept their bridge readings as gospel.

Basically, there are two sources of error: those external to the measuring device (usually stray capacitance, which will cause any impedance-measuring device to read low), and those within the measuring device itself. Even the prestigious General Radio 916/1606 family of rf bridges has systematic errors which must be corrected for if accurate results are to be obtained. I was unpleasantly surprised when I finally got around to working out the predictable errors in my measurements.

benefits of bridge corrections

A user of an impedance-measuring device may ask, "Why go to all the trouble of calculating correction factors?" First of all, it does not take that much additional effort. If you want accurate measurements, you are going to spend a fair amount of time and effort putting together a good test setup; the additional time and effort to punch numbers into a calculator is minor.

In addition, you can get a great deal of personal satisfaction when your measured data falls right where the textbooks say it should. When this happens to me, I feel as though I really understand whatever I am working on and am really the master of it. This feeling of accomplishment is probably why I experiment in the first place — that and curiosity. Finally, when you are sure of your measurements and then get unexpected results, you can explore the device with a lot more confidence.

In the material that follows, I will discuss in detail the error caused by stray capacitance and give a calculator program to correct this error. I will briefly discuss instrumentation errors and give a procedure for calibrating a measuring instrument; discussions of calibration will necessarily be in outline form since the many types of instruments in general use will each require slightly different calibration procedures.

stray capacitance errors

The effect of any stray reactance, either capacitive or inductive, shunted across an impedance is to lower the apparent value of that impedance. Consider the impedance $Z_x = R_x + jX_x$ in **fig. 1** with a reactance jX_a shunted across it. In the discussion that follows, I will assume that all reactances are inductive (positive), as this simplifies the problem of algebraic signs. When a conclusion is reached, I will explain the changes, actually very minor, which are necessary for negative reactances.

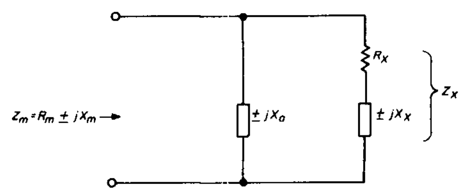


fig. 1. Diagram showing the stray reactance $\pm X_a$ shunted across an unknown impedance $Z_x = R_x \pm jX_x$. The text presents equations for compensating for the effects of $\pm X_a$.

In **fig. 1**, R_x and X_x are the real and imaginary parts of the unknown impedance. The shunt reactance is represented by jX_a and is presumably known, or at least estimated. The resulting impedance formed by $Z_x \| jX_a$ (the parallel bars | | should

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be read "in parallel with") is given mathematically by the well-known "the product divided by the sum" rule:

$$Z_m = \frac{jX_a(R_x + jX_x)}{R_x + j(X_a + X_x)}$$

After rationalizing the denominator by multiplying both numerator and denominator by the conjugate of the denominator, the separation of the results into real and imaginary parts followed by equating the real and imaginary parts gives

$$R_m = \frac{R_x X_a^2}{R_x^2 + (X_a + X_x)^2} \qquad (1)$$

$$X_m = \frac{X_a[R_x^2 - X_x(X_a + X_x)]}{R_x^2 + (X_a + X_x)^2} \qquad (2)$$

In actual practice, R_m and X_m will be read from the bridge, so will be known. The stray reactance will also be known, or at least estimated. R_x and X_x are the unknown quantities. It will therefore be desirable to solve **eqs. 1** and **2** for R_x and X_x. The algebra is rather involved, so I will just give the results:

$$R_x = \frac{R_m}{\left(1 - \frac{X_m}{X_a}\right)^2 + \left(\frac{R_m}{X_a}\right)^2} \qquad (3)$$

$$X_x = \frac{X_m - \frac{R_m^2}{X_a} - \frac{X_m^2}{X_a}}{\left(1 - \frac{X_m}{X_a}\right)^2 + \left(\frac{R_m}{X_a}\right)^2} \qquad (4)$$

If the stray reactance is capacitive, X_a will be negative, so that a negative sign should be used in the above equations with X_a; the same holds true for X_m. If there were no stray capacitance, X_a would be infinite, so that $R_x = R_m$ and $X_x = X_m$.

Eqs. 3 and **4** do not require great mathematical ability to solve, but the algebra is tedious when done by hand, even with a pocket calculator. A program can be written for a programmable calculator, however, that eliminates much of the burden (and many chances for mistakes). An HP-25 program to solve these equations is shown in **fig. 2.**

It will be seen that while the external corrections may be minor when working with low-impedance networks at low frequencies, the errors increase at higher impedances and higher frequencies. The illustrative example given in the HP-25 program shows that a correction of about 5 per cent in resistance and the correction of the reactance term completely changes sign from negative to positive. This example is based on an actual measurement I made on an experimental balun. If I had tried to correct a negative reactance in the balun when the reactance was actually positive, it is obvious I would have been wasting my time! A situation like this can be very misleading.

Two final comments are in order: First, while shunt reactance has been portrayed as a source of error, the same shunting effect can also be used to advantage to measure an equivalent series impedance that is above the range of the bridge. The unknown impedance is shunted down by placing a reactance, usually capacitive, in parallel with it. The unknown impedance is then calculated by **eqs. 3** and **4**, preferably using the calculator program. Capacitors between 35 and 200 pF are usually satisfactory; the value should be no larger than necessary to bring the unknown impedance within range of the bridge.

The second comment is that **eqs. 3** and **4** should be used only with impedance-measuring devices which measure unknown impedance in terms of its series equivalent impedance; *i.e.*, $Z_x = R_x \pm jX_x$. If the measuring device gives results in terms of admittance, as does the GR-821, or as parallel resistance and reactance, as does the Hewlett-Packard RX meter, **eqs. 3** and **4** are not applicable.

HP-25 Program

SWITCH TO PRGM MODE, PRESS [f] [PRGM], THEN KEY IN THE PROGRAM

DISPLAY LINE	DISPLAY CODE	KEY ENTRY	X	Y	Z	T	REMARKS
00							
01	23 02	STO 2					
02	21	x ↔ y					
03	24 00	RCL Ø					
04	61	X					
05	15 22	1/X					
06	23 03	STO 3					
07	71	÷					
08	24 01	RCL 1					
09	21	x ↔ y					
10	41	−					
11	23 04	STO 4					
12	15 02	X^2					
13	21	x ↔ y					
14	24 03	RCL 3					
15	71	÷					
16	23 05	STO 5					
17	15 02	X^2					
18	51	+					
19	23 06	STO 6					
20	71	÷					
21	74	R/S					Display Rx
22	34	CLR X					
23	24 05	RCL 5					
24	61	X					
25	24 02	RCL 2					
26	24 04	RCL 4					
27	61	X					
28	41	−					
29	32	CHS					
30	24 06	RCL 6					
31	71	÷					
32	74	R/S					Display Xx
33	13 01	GTO 01					
34							
35							
36							
37			SAMPLE CALCULATION:				
38				Ca =	6 pF		
39				Rm =	106 ohms		
40				f =	30 MHz		
41				Xm =	-1.7 ohms		
42							
43			ANSWER:	Rx =	104.895	ohms	
44				Xx =	10.896	ohms	
45							
46							
47							
48							
49							

MEMORY REGISTERS	
R0	$-2\pi C_a \cdot 10^{-6}$
R1	1
R2	+Xm
R3	Xa
R4	1-Xm/Xa
R5	Rm/Xa
R6	denominator
R7	

fig. 2. H-P 25 program for solving the stray reactance effects given by *eqs. 3* and *4*. The program also calculates the shunt reactance for a fixed value of stray capacitance and the variable parameter, frequency (see STO Ø and steps 3, 4, 5, and 6). Note that the sign STO Ø must be negative because the stray reactance is capacitive. Before running the program store $-2\pi C_a \cdot 10^{-6}$ in STO Ø and in 1 in STO 1. To run program, key in R_m (ohms), press ENTER, key in frequency (MHz), press ENTER, key in X_m (ohms with proper sign), and press R/S. Calculator displays R_x at step 21, and X_x at step 31.

instrumentation errors

The shunt reactance error discussed above is external to and independent of the impedance-measuring device. This error will occur whether you use a laboratory-type instrument costing several thousand dollars or a homemade device, built with parts from the station junkbox.

I will now discuss in a very general way errors that occur within the measuring instrument itself. The GR-916/1606 instruments will be used as a vehicle, but I will try to present the material in a manner that makes it applicable to any similar instrument, commercial or homemade.

All impedance-measuring devices (that I am aware of) have internal errors, especially at the extreme ends of their frequency or impedance ranges. The sources of these errors can be very subtle. For example, in the GR-916/1606 family, the principal error at high frequencies is caused by the changing effective series inductance of the RESISTANCE capacitor; *i.e.*, the variable capacitor connected to the resistance dial. This inductance causes the effective capacitance to increase as the frequency increases, thereby causing the resistance dial reading for a given resistance value to read low. For the GR-916, this error alone can be as large as 30 per cent at 60 MHz and 100 ohms, for a typical instrument.

At the low-frequency end, the dielectric loss in the REACTANCE capacitor causes an effective series resistance that increases with higher REACTANCE dial settings and low frequencies, again causing the resistance dial to read low under some conditions.

Both these errors are predictable, systematic errors which exist in addition to any random, unknown errors caused by manufacturing variations or operator error. Graphs for correcting both types of errors in the GR-916/1606 are given in the instruction manuals and should be used if you want good accuracy. In addition, an equation for correcting the high-frequency error in a typical instrument is provided along with a procedure for obtaining the fudge factor for any particular instrument. I have programmed this equation on an HP-25 pocket calculator, but am not including the program here because of its limited interest. However, I will be glad to provide a copy to interested readers on receipt of a large, self-addressed, stamped envelope.

I feel certain that all impedance-measuring instruments have some systematic error. Just because the instruction manual for an instrument does not mention internal errors does not mean that there are none; it just means either that the manufacturer did not know how to determine it or he could not afford to work it out for the price at which he is selling the instrument. Actually, working out the instrument correction factors is not too difficult — and it is absolutely essential if you want to obtain accurate measurements.

In calibrating an impedance-measuring instrument, the most important item is a known value of impedance. For this, I use a Hewlett-Packard 906-A 50-ohm termination. This termination is an accurate 50-ohm resistor with negligible reactance well into the GHz region. This model uses a type-N connector; the cost is in the $25-30 range. Though this may seem expensive for a 1-watt resistor, the cost is small compared with what you already have invested in a commercial bridge. If your bridge is homemade, you may need a precision 50-ohm resistor more than you realize!

A second reason for using this type of calibrated load is that since the load has negligible reactance itself, you can accurately determine the stray reactance which must be known before accurate test data can be obtained.

If you want to avoid the expense of a laboratory-type termination, I suggest the use of the RN-55 family of Mil-spec resistors. These seem to have the lowest reactance of any family I have tried. They also have the advantage of being available in values other than 50 ohms.

The calibration procedure for a typical instrument is very simple; although it does not apply to the GR-916, it can be used with a GR-1606. Measure the impedance of the termination at various frequencies through your range of interest. Since it is necessary to know precisely the resistance and reactance presented to the bridge terminals, it is necessary to make corrections using **eqs. 1** and **2**. To do this, you must estimate the shunt capacitance, and this is where a reactance-free load comes in handy. Use **eq. 2** first; assume values of X_a corresponding to shunt capacitances of, say, 1, 2, 3 . . . pF, *etc.* at your highest test frequency. Set $R_x = 50$ *ohms* or whatever resistance value you are using, $X_x = 0$, and calculate the values of X_m for each capacitance. Compare these values of X_m with the X_m you measure, and when your calculated values of X_m have bracketed the measured values of X_m, you have also bracketed the actual value of C_a. Now back up, say, 0.5 pF, and determine C_a as accurately as you wish. Remember that since X_a is capacitive, a negative sign should be used in all of the correction equations.

When you accurately know X_a, solve **eq. 1** to calculate the resistive component of impedance appearing at your bridge terminals at each frequency; compare these against the measured resistance of the load and determine the correction factor for your instrument at each frequency. These corrections can then be plotted.

One difficulty in using a chart is that a chart cannot be programmed into a computer. It would be convenient to determine the equation of the correction curve so that it could be programmed into a calcula-

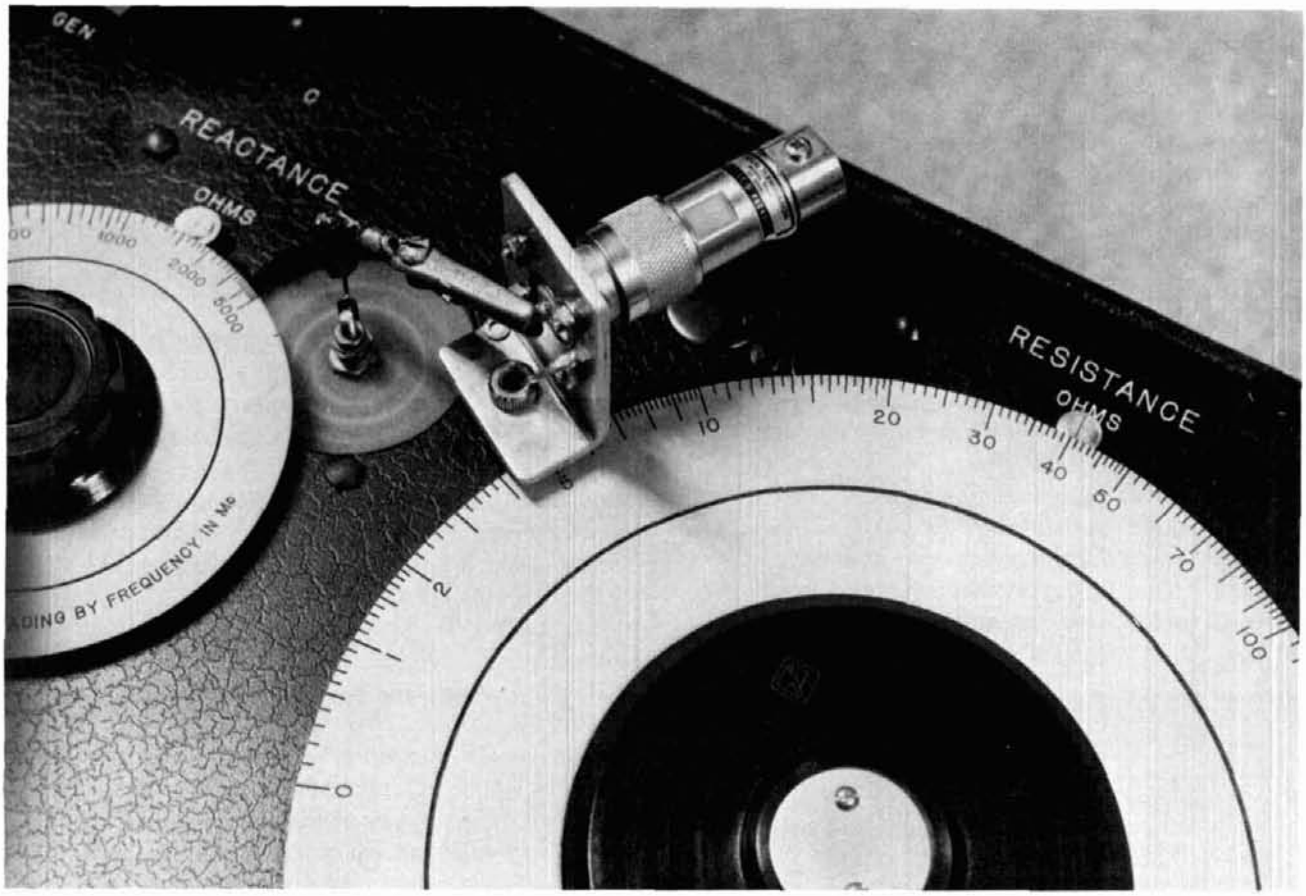


fig. 3. Photograph of K4KJ's test setup for calibrating a GR-916 rf impedance bridge using a precision 50-ohm termination.

tor. It should be possible to do this and those interested may refer to a textbook on the subject.[1] Thus both the bridge correction and the shunt reactance correction can be worked out in one calculation.

The advantage of having a reactance-free resistance can be seen. Your impedance-measuring device can only measure the reactance across its terminals; it cannot distinguish between stray reactance or a reactive component in the unknown impedance.

A note of caution concerning the order in which the corrections are made: when measuring an unknown impedance, the usual application, the bridge correction *must* be calculated *first*. **Eqs. 3** and **4**, which are used to calculate the stray capacitance correction, assume that the measured values are accurately known. On the other hand, when calibrating the bridge using a known value of resistance, the stray capacitance correction *must* usually be made first because you are trying to determine the actual impedance across the bridge terminals. The GR-916 appears to be an exception; I do not know why.

examples

At this point some examples should help clear up the details. The first example will demonstrate the use of a reactance-free termination to determine the shunt capacitance and show how this capacitance can differ from the measured value.

I was in the process of calibrating my GR-916 using an H-P 50-ohm termination. A photograph of my setup is shown in **fig. 3**. The stray capacitance to ground of the test lead and type-N coax connector measured 2.95 pF using a GR-821 admittance bridge.

At 54 MHz the impedance of the 50-ohm termination measured 40.3-j3.333 ohms on the GR-916 bridge. For a high quality termination, this appears way off, but let's correct it. Start with **eq. 2**. Set $R_x = 50\ ohms$; assuming the stray capacitance to be 2.95 pF as measured, then at 54 MHz, X_a will equal −990.894 ohms. Solving **eq. 2** gives $X_m = -2.49603$ as compared with −3.3333 ohms measured. Hence the stray capacitance must be more than 2.95 pF.

Next try, say, $C_a = 4.0\ pF$, and calculate $X_m = -3.3774\ ohms$, again compared with $X_m = -3.3333\ ohms$ measured. Back up a little and let $C_a = 3.95\ pF$ and calculate $X_m = -3.3355$, which is very close. Since the test fixture measured 2.95 pF, the stray capacitance in the bridge must be 1 pF.

Assuming the stray capacitance is 3.95 pF, it is interesting to calculate the equivalent impedance looking into **fig. 1**. Use **eqs. 1** and **2** and obtain $R_m = 49.776$ *ohms*. The difference between this value and the 40.3 ohms measured by the bridge is the bridge error. The reason why the shunting effect is so small is that the shunt capacitance and resistance level are both relatively low.

I am not going to pursue this example further because the remainder is unique to the GR-916 and would have relatively limited interest, but I did want to demonstrate the value of having a high quality termination and how to use it in estimating stray capacitance.

My second example should be of special interest to users of baluns, particularly W2AU balun users. In this case I was measuring the input impedance of a W2AU 1:1 balun at the unbalanced end with various values of resistance connected across the balanced terminals. **Table 1** gives the uncorrected bridge readings, the impedance with bridge corrections only, and finally bridge and stray capacitance corrections. A photograph of this test setup is shown in **fig. 4**.

fig. 4. Photograph of K4KJ's test setup for measuring the input impedance of a W2AU 1:1 balun with various resistance values across the balanced terminals.

table 1. Measured performance of a W2AU 1:1 balun with various values of load resistance across the balanced terminals.

load resistance ohms	original bridge reading	with bridge corrections only	with bridge and capacitance corrections
54.0	70 - j14.00	74.64 - j14.00	76.56 - j7.34
68.0	56 - j22.07	59.61 - j22.07	62.53 - j18.12
102.9	47.1 - j43.33	50.09 - j43.33	55.45 - j42.20
201.0	25 - j54.17	26.52 - j54.17	30.26 - j56.88

The stray capacitance of the test fixture with a type-UHF connector and a male-to-male adapter measured at 5.3 pF; adding 1 pF for the bridge capacitance gives 6.3 pF. I am giving only the 30-MHz measurements.

Comparing the original bridge reading with the fully corrected data shows as much as 10 per cent correction, approximately equally divided between instrumentation and stray capacitance effects.

Comparison of the load resistance and final data columns will be of interest to those using 1:1 baluns. It shows the necessity of matching the balun impedance to that of the load and transmission line. This is a need that is just beginning to be recognized. I believe this data is typical of ferrite-rod baluns, but that's another story.

conclusion

Impedance-measuring devices can be very useful for matching antennas as well as in many other applications around the ham shack. Their results, however, must be treated with caution because even the best instruments and test setups are subject to errors. The most predictable source of error caused by the test setup is stray capacitance; this effect can only be minimized, not eliminated. Equations have been presented for calculating the true impedance in the presence of stray capacitance. Possible instrument errors have been discussed in a general way, and a possible method described for correcting these errors as well.

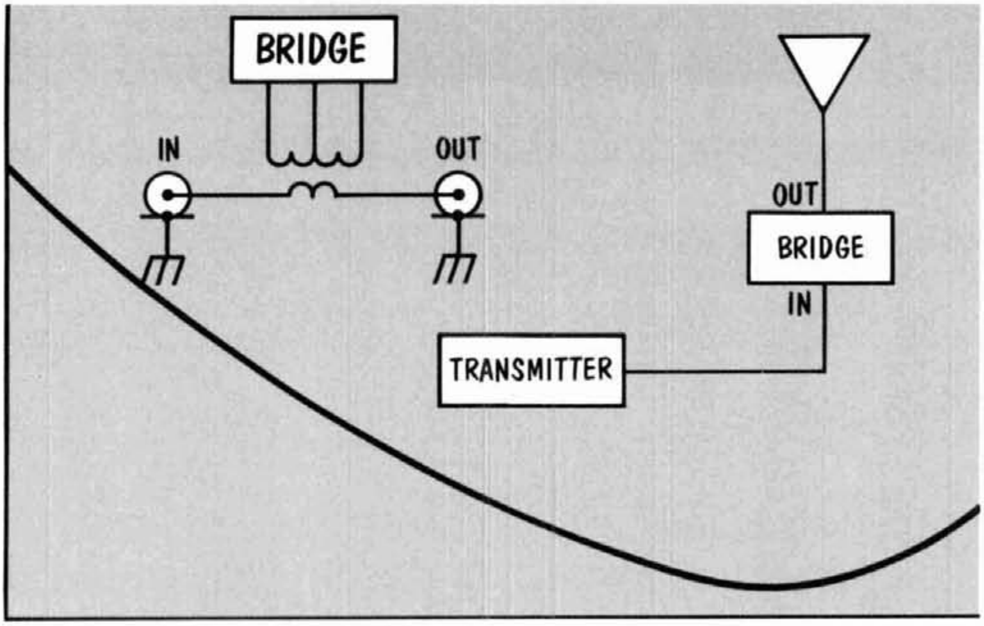
The program for computing the true impedance in the presence of stray capacitance on an H-P 25 programmable calculator is probably usable on other H-P calculators, although the keystroke numbers may be different. I do not have programs for calculators of other manufacturers.

reference

1. C. R. Wylie, Jr., *Advanced Engineering Mathematics*, second edition, McGraw-Hill, New York, 1960, Chapter 5, "Finite Differences," pages 130-193.

ham radio

More Details? CHECK—OFF Page 118



broadband reflectometer

and power meter

Construction details for a combination peak-reading power meter and broadband SWR bridge

The reflectometer design described in this article uses a coupler technique that has not received attention in the Amateur literature worthy of its versatility, simplicity, and useful characteristics. Apart from being easy to construct, this design covers a three-decade frequency range, from 100 kHz to 100 MHz, and can be constructed with a power sensitivity as low as 500 mW or as high as 500 watts.

The problem with most high-frequency reflectometer designs, in the experience of the authors, is that they generally cover only a frequency range of a decade or less — usually 3 to 30 MHz. Many are quoted as covering well into the vhf range (usually to 150 MHz), but, in practice, they suffer from rather extreme errors in accuracy due to construction discontinuities as well as from large sensitivity excursions across the range.

The predominant technique employed in most published Amateur designs, and in many commercial designs, is to have one or more secondary "coupling" lines inserted into a short length of coaxial transmission line. The well-known *Monimatch* uses this principle. Two insulated wires are simply slipped under the braid of a short length of coax to form

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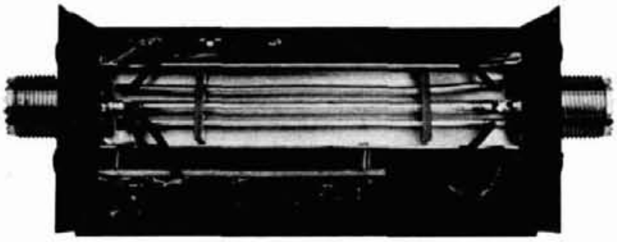
coupling lines which sense the forward and reflected components of standing waves on the transmission line.

A similar method, popularly used in commercial designs, is to construct a section of coaxial transmission line from a sheet metal trough with two short coupling lines supported parallel to the center conductor.



Apart from construction discontinuities, the technique suffers from two serious drawbacks. The coupling coefficient of the secondary lines varies with frequency, being least at the low frequencies and rapidly increasing as the length of the coupling lines becomes a significant fraction of a wavelength. Secondly, the technique suffers from ever-decreasing accuracy at the higher frequencies for similar reasons, and poor sensitivity at the lower frequencies reduces the accuracy at low standing-wave ratios.

Properly engineered and constructed, reflectometers using this technique can have excellent characteristics and accuracy across a bandwidth of as much as several octaves. Getting them to perform consistently across a decade or more is tantamount to magic — you rapidly run into the law of diminishing returns.

design points

Although the technique employed in the coupler of this reflectometer has been around for a number of years, it has received inadequate attention in the literature. The basic requirement for a reflectometer is that it generates two voltages which are proportional to the forward and reflected voltages or currents existing in the transmission line under measurement. Techniques employed to fulfill this requirement use either voltage or current deflectors coupled to the transmission line to produce two out-of-phase signals, since the forward and reflected components on the transmission line are 180 degrees out of phase.

This reflectometer employs a current transformer constructed as follows. A short length of coaxial cable is passed through a ferrite toroid forming the primary. The braid, or outer conductor of the coax, is connected to form an electrostatic shield. The secondary consists of a winding around the circumference of the toroid which couples to the magnetic component of the leakage field of the short length of coax cable.

The load on the current transformer secondary is center-tapped so that out-of-phase signals appear at each end of the secondary. The load center-tap is returned to a voltage divider which samples the rf signal on the transmission line to perform the addition and subtraction across the load, yielding the forward and reflected components.

From this, the SWR may be computed from the following equation:

$$SWR = \frac{E_f + E_r}{E_f - E_r}$$

where

E_f = forward voltage components
E_r = reflected voltage components

Although a current transformer is employed, for

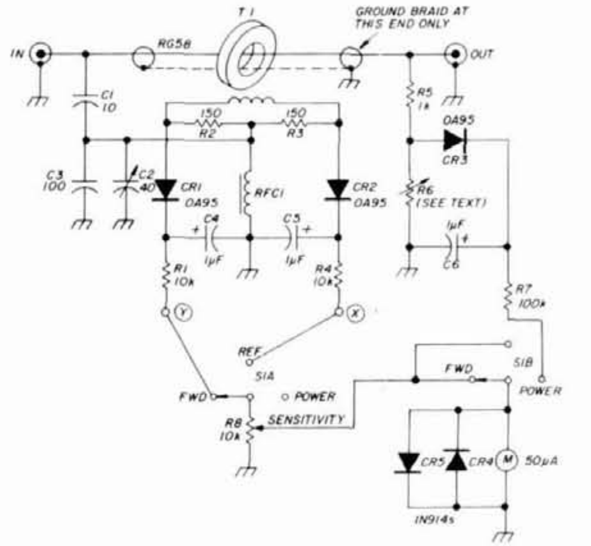


fig. 1. Schematic diagram of the broadband reflectometer and power meter. A specially configured switch was used for S1 (C&K type 7211); otherwise a double-pole, triple-throw switch will be necessary. The meter has a basic scale of 50 µA, with an internal resistance of 2000 ohms. The sensitivity pot (R8) should have a logarithmic taper. Transformer T1 is wound with 40 turns of number 35 AWG (0.14 mm) enameled wire over a Neosid type 28-511-31,F14 material toroidal core (initial permeability of 220). The measurements (outside diameter, inside diameter, thickness) of this toroid are 12.7 × 6.35 × 3.18 mm (0.5 × 0.25 × 0.125 inch). It is available from Neosid Limited, 10 Vansco Road, Toronto, Ontario, M8Z 5J4, Canada. C2 is a small mica compression trimmer.

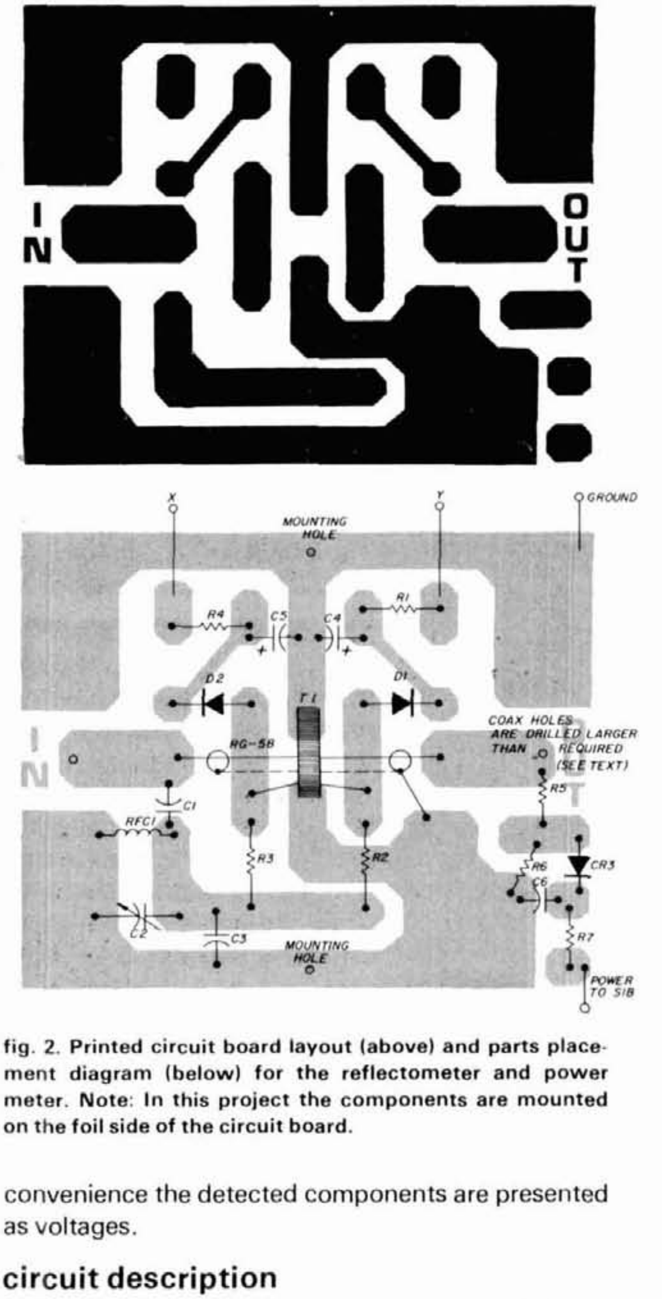


fig. 2. Printed circuit board layout (above) and parts placement diagram (below) for the reflectometer and power meter. Note: In this project the components are mounted on the foil side of the circuit board.

convenience the detected components are presented as voltages.

circuit description

The secondary of the current transformer drives a center-tapped resistive load (R2, R3) connected to a voltage-sampling network *(C1-C2/C3) across the rf* input such that sum and difference voltages will appear across the ends of the transformer (see **fig. 1**). The two diodes, CR1 and CR2, rectify the sum and difference voltages, with rf and audio bypassing being provided by C4 and C5. A dc return for the diodes is provided by RFC1.

Power measurement is made by rectifying a portion of the rf voltage tapped off the line by the resistive divider, R5, R6. CR3 and C6 form a peak detector, as the load, R7 and the meter, is very light. CR4 and CR5 provide protection for the meter.

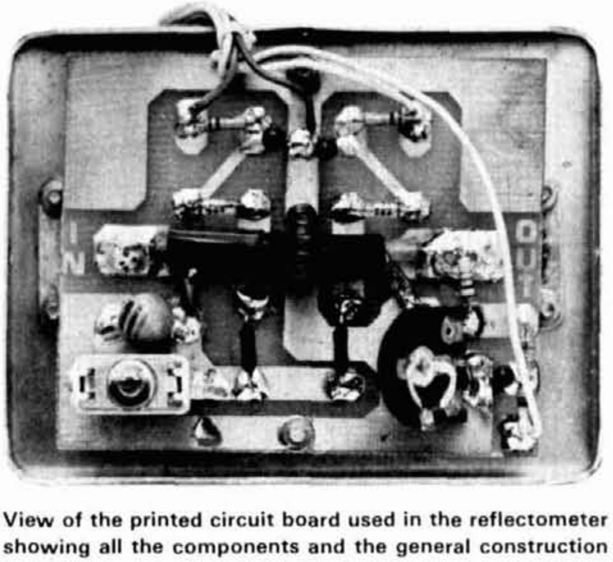
Some published designs use a resistive tap across the line to sample the rf for the current transformer load. At low powers, however, the low-resistance dc return of RFC1 provides better sensitivity.

The power rating is limited principally by the voltage breakdown characteristics of the coax line through T1. Standing-wave ratios greater than 3:1 generate substantial voltages across the transmission line, and any high-power operation with high SWR values should take this into account.

The sensitivity bandwidth is limited by the permeability of the toroid and the number of turns on the secondary winding. If this reflectometer is constructed for use at higher power levels, the sensitivity bandwidth is considerably improved.

Construction is very straightforward. The printed circuit board design shown in **fig. 2A** is recommended; otherwise, variations in construction may *affect performance, particularly at the higher fre*quencies. As can be seen from **fig. 2B**, the components are mounted on the *copper side* of the board. Once all the components are soldered into position, the board is attached to the coax sockets and mounting bolts.

The toroid current transformer's secondary should be wound first. Following that, the coax primary should be assembled. Cut a 45-mm (1-3/4 inch) length of RG-58/U (single shielded), stripping back the braid and insulation as illustrated in **fig. 3**. Refer also to the component overlay and photographs. This operation is not all that critical, but it is advisable *to follow the diagrams. Slip the toroid over the short* length of coax and solder the coax and T1 leads to the printed circuit board as illustrated in **fig. 2**. Position the toroid centrally and attach it to the coax and board with a small amount of pliable rubber cement. Follow this by mounting all the other components.



View of the printed circuit board used in the reflectometer showing all the components and the general construction technique.

The printed circuit board is mounted in a metal box on which two suitable coax connectors have been mounted. The printed circuit board is soldered to the center pins prior to securing the assembly with the two mounting bolts. To avoid undue stress, which can cause problems following assembly, coaxial plugs (assembled with cables) should be inserted into the two coax sockets when soldering the board to the center pins. Make sure that a good fillet of solder secures the pins to the printed circuit board IN and OUT pads.

The board is mechanically secured by two mounting bolts (shown in **fig. 2** and the photos). A nut is placed under the board on each mounting bolt and a second on top of the board. This also serves to ground the board groundplane. Solder the top nuts.

The drawings show mountings for two SO239 sockets, although any of the other popular series of connectors may be used. However, center-to-center spacing of the sockets should be maintained at 60 mm (2-3/8 inches). The reflectometer was mounted in a 100 × 75 × 50 mm (4 × 3 × 2 inch) aluminum box. The meter used has a 50 × 50 mm (2 × 2 inch) face, but a larger unit, offering better accuracy, may be used, although this would necessitate a larger box.

calibration

A suitable rf source, a dummy load, and an rf voltmeter or an accurate rf power meter will be required for calibration.

SWR Scale. The instrument is connected between the rf source and the dummy load, the rf to the IN socket and the dummy load to the OUT socket. The sensitivity control should be set fully counterclockwise. The switch should be set to read forward power.

With the rf source on, rotate the sensitivity control clockwise until the meter reads full scale. Now, switch to read reverse power; adjust the trimmer, C2, to obtain minimum meter reading, increasing the sensitivity as the meter reading decreases. You should be able to reduce the meter reading to zero or very near.

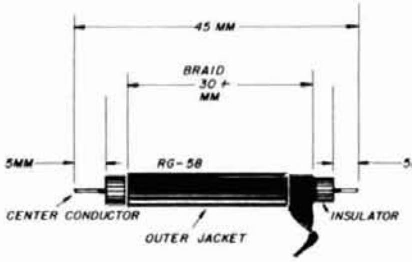
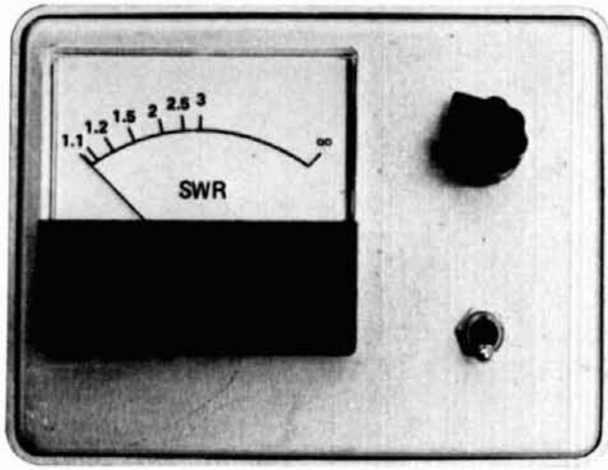


fig. 3. Dimensions for the section RG-58 of coaxial cable used as the primary of the transformer.

Once this operation is completed, the reflectometer section is calibrated. The photo shows the calibrated meter scale we attached to the meter face.



Any meter scale can be calibrated by using **table 1** or the SWR equation.

table 1. Meter readings to calibrate the new SWR scale.

SWR	scale reading
3.0:1	0.5 full scale
2.5:1	0.42 full scale
2.0:1	0.34 full scale
.5:1	0.2 full scale
1.2:1	0.1 full scale
1.1:1	0.005 full scale

Power. Fig. 1 shows a divider network which samples the rf voltage on the transmission line. The lower divider resistor is shown as a trimpot. A deposited-carbon type was used, but a fixed resistor may be substituted. The trimpot was set so that the full-scale meter reading corresponds to a particular peak power measured by another method (a borrowed power meter or rf voltmeter across the dummy load).

R6 values for particular full-scale power readings are given in **table 2.** The power scale should be calibrated to suit the individual instrument, as it will be nonlinear, the nonlinearity depending on the particular diode used for CR3.

table 2. Resistance value for R6 to change full-scale power reading.

peak power watts	R6 value
500	6.8 ohms
200	two 33 ohms in parallel
100	33 ohms
50	68 ohms
20	two 330 ohms in parallel
10	330 ohms
5	680 ohms
3	1k and 100 ohms in series (linearity suffers)

performance

The current transformer response is essentially aperiodic, with the −6 dB points (compared with midband) from 200 kHz to 40 MHz (see **fig. 4**). This unit has a midband full-scale sensitivity of 500 mW (sensitivity control at maximum). At 50 MHz less than 5 watts is required to carry out measurements, even with low SWR values.

The inherent impedance of the unit was measured using a 5-watt TEK dummy load and a Hewlett-Packard vector impedance voltmeter. The results are illustrated in **fig. 5**. The impedance discontinuities displayed are well within the accuracy limitations of the meter movement. The real (or resistive) component of the reflectometer's impedance is within 5 per cent of the nominal 50 ohms — most of this variance probably is due to connector and construction discontinuities.

The variation in the real part of the impedance is within ±1 ohm across the frequency range and can be essentially ignored. The reactive component is negligible up to 30 MHz, at which point it begins to become slightly capacitive. This is largely immaterial. The overall impedance decreases rapidly above 100 MHz.

The short length of coax through T1 is "short" compared with the wavelength at 100 MHz, and it is physical discontinuities that contribute to the inaccuracies measured, becoming significant around 100 MHz. The SO239s used aren't constant-impedance connectors, and they probably contribute as much as construction to the upper-frequency limitation.

possible modifications

For higher powers, the sensitivity of the reflectometer may be varied by one or several of the following methods. For power around 20 to 50 watts, R2 and R3 should be reduced to 47 ohms. For powers above this, the number of turns on the toroid should be reduced. As a guide, twenty turns on T1 with R2 and R3 down to 47 ohms should prove adequate for powers in excess of 150 watts.

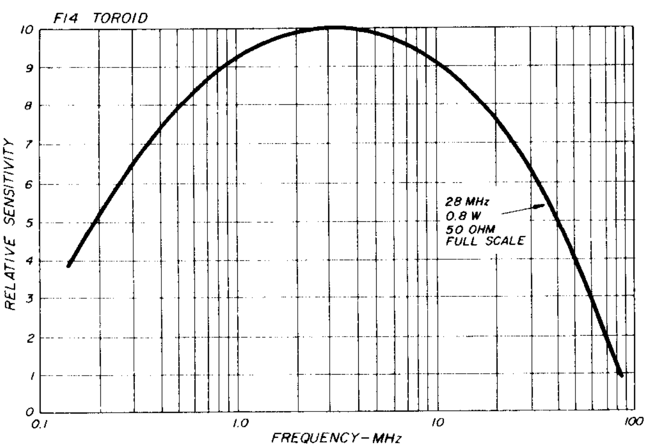


fig. 4. Relative sensitivity of the reflectometer portion of the meter. It takes 0.8 watt across 50 ohms to produce a full-scale reading at 28 MHz.

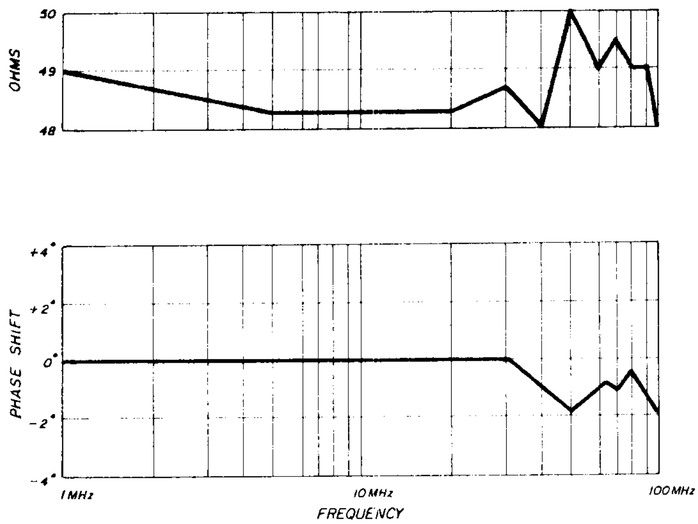


fig. 5. Impedance characteristics of the broadband reflectometer, as measured with a Hewlett-Packard vector voltmeter while terminated with a 50-ohm load.

The basic reflectometer construction is so simple and inexpensive that several could be built to provide remote monitoring of individual antenna installations. Protection circuitry for transceivers and power amplifiers may be simply implemented using the basic reflectometer circuit driving protection circuitry from the outputs of CR1 and CR2. It is possible to use the reflectometer for swept VSWR measurements by using the differential output of CR1 and CR2.

Accurate measurement of VSWR values below 2:1 can be made by driving an expanded-scale differential voltmeter circuit as described in reference 2. This type of measurement is useful when measuring the VSWR performance of an antenna over a narrow bandwidth, particularly narrow-band loaded whips used for mobile applications.

The basic sensitivity bandwidth may be shifted up in frequency by a decade or more such that it rolls off around 1 MHz at the low end and above 50 MHz at the high end by using a toroid having a permeability of 50 rather than 220.

references

1. P.G. Martin, "Frequency Independent Directional Wattmeters," *Radio Communications*, (England), July, 1972.
2. H.C. Gibson, G8GCA, "Test Equipment for the Radio Amateur," Radio Society of Great Britain, London, 1974.

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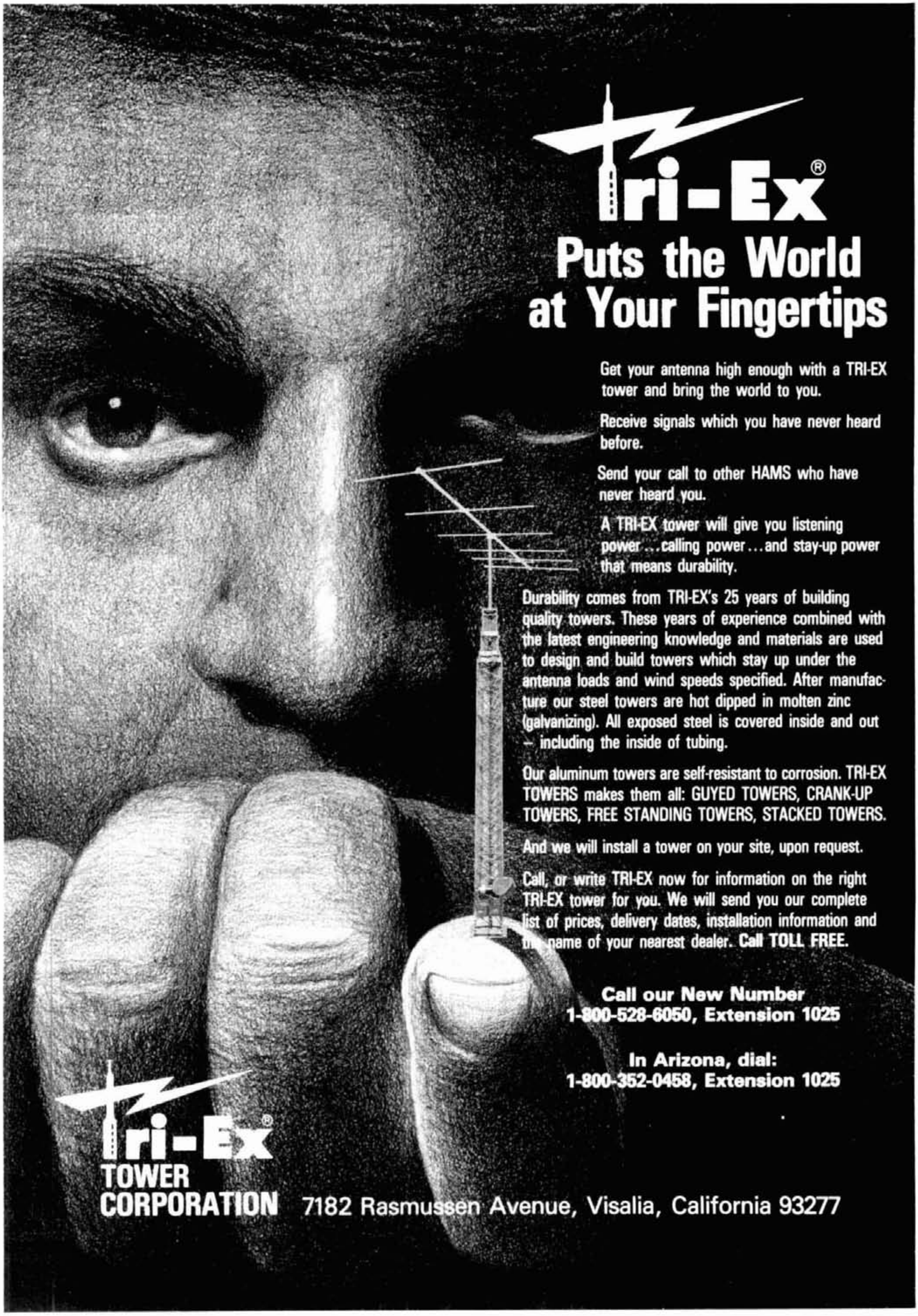
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new approach to measuring SWR at high frequencies

A new type of sampling bridge for measuring power and SWR provides linear response and high directivity

In the past, VSWR measurements were made mainly to check antenna matching characteristics. Therefore, these measurements were performed at fairly high levels, with a directivity of 26 dB being sufficient. The new circuit design in this article provides low-level VSWR measurements between 30 watts and 30 mW incident or reflected power with a directivity of 40 dB.

applications

After the introduction of highly linearized transistors, wideband transformer techniques to cover 1.5 to 30 MHz became increasingly important. Wideband power stages, with exceptionally low intermodulation distortions, are required in test instruments, antenna distribution amplifiers, and ssb transmitters. Because there is higher feedback in transistor circuits than in vacuum tube designs, the return loss of the matching transformer plays an important role. Slight matching changes will degrade the intermodulation distortion performance. Therefore, it has become vital to measure the properties of wideband transformers over a large frequency, power, and directivity range. So far, no instrument has become available that will easily measure these parameters.

circuit description

The initial bridge arrangement for measuring the forward and reflected voltages (power) on a transmission line was invented in Germany by Dr. Buschbeck more than 30 years ago (see **fig. 1**). The obvious disadvantage of this circuit is that the two output ports have a fairly high impedance and are very sensitive to loads. Resistive loads below 10 kilohms will significantly disturb the directivity as well as the frequency response. This requires special diodes for high resolution. Also, this type of power meter suffers from the disadvantage that the power reading is highly nonlinear and depends very much on the mechanical configuration. The other disadvantage caused by the high impedance is that there is always fairly high cross-talk between both output ports, which effectively limits the directivity to about 26-30 dB.

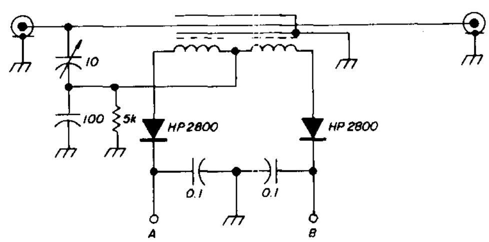

fig. 1. Schematic diagram of a conventional bridge arrangement for measuring SWR. The load across points A and B, if sufficiently low, will significantly affect the directivity as well as frequency response.

In an effort to overcome the rectification nonlinearity, a special version of the tunnel diode, called a

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"backward diode," was used. Backward diodes* have virtually no threshold voltage and exhibit an extremely good approximation to a square law characteristic between a few μV and several mV. However, back diodes used as rectifiers have an extremely low impedance and therefore will load the circuit.

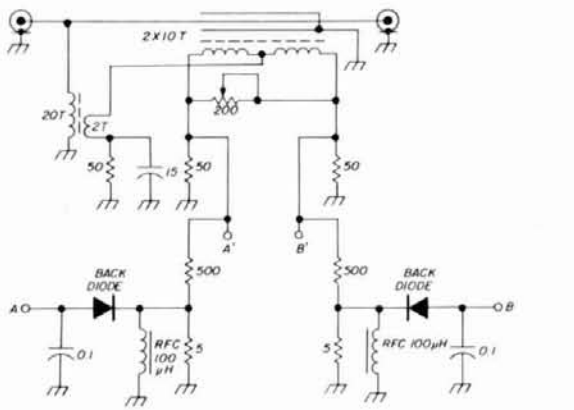

fig. 2. Diagram of a new bridge arrangement that employs back diodes and a transformer voltage divider. This configuration provides wide frequency response and high directivity. The transformers are wound on TC9-type ferrite cores. This is the circuit used in the Rohde & Schwarz NAUS 80 rf power meter.

Because of this loading effect, an attempt was made to use a compensated RC voltage divider, as used in oscilloscopes. This was not successful, however, since the required flatness of output voltage tracking and frequency could not be achieved.

Analyzing Dr. Buschbeck's circuit, it is obvious that the primary limitation is a result of the capacitive voltage divider, which, as a side effect, limits the cutoff frequency at the lower end of the frequency range. To overcome this limitation, a transformer was employed as a voltage divider, which led to the circuit shown in **fig. 2**.

The advantage of **fig. 2** is that both outputs are now terminated in 50 ohms, providing the necessary low impedance for the back diode rectifier. The inductive voltage divider provides a significantly flatter frequency response. In addition, since all impedances are now 50 ohms, the cross-talk is also reduced, allowing directivity of 40 dB.

This new technique can be used effectively to measure the characteristics of wideband transformers and power amplifiers under actual operating conditions. Network analyzers presently on the market are not capable of measuring at this low frequency range and high power level.

*Another description of the back diode can be found in the Hints and Kinks section of *QST* for April, 1978.

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folded umbrella antenna

An effective, easy-to-build, all-band amateur antenna based on the principles of the folded unipole used in the broadcast service

A survey of amateur antennas would probably show that 95 per cent of them fall into one of four general categories:

1. Horizontal dipole (including inverted vee)
2. Vertical (ground mounted and ground plane)
3. Yagi (multiband and monoband)
4. Quad (multiband and monoband)

The folded umbrella falls into none of these groups — yet, when you see what it can do you'll wonder, "Why not?" This article describes a versatile antenna that is:

1. Broadband on all frequencies, 1.8 through 30 MHz
2. Easily tuned
3. Fully effective without ground radials
4. Without critical dimensions
5. Simple, inexpensive, and easily erected by one man
6. Space saving
7. DC grounded
8. Adaptable to your tower

It seems that most homes lack the space required for a 3.5-4 MHz dipole, or for the ground radials needed to operate a conventional series-fed vertical antenna efficiently. The folded umbrella has evolved from the effort to overcome these space problems.

The first step was to consider an antenna used in the commercial-broadcast field and known as a folded unipole. Shown in **fig. 1**, it is a *grounded* broadcast antenna tower, with steel arms across the top which are connected electrically to the tower. Wires are connected to the ends of these arms and dropped to the bottom, forming a cage around the tower that is insulated from the tower at all points except the top. The cage wires are tied together at the bottom and fed directly at that point with 50-ohm coaxial cable. The advantages claimed for this antenna are as follows:

1. Broadband performance
2. Low radiation-angle
3. Elimination of expensive base insulator
4. Elimination of approximately 6100 meters (20,000 feet) of copper wire
5. Elimination of expensive matching network and weatherproof housing

These features are important to the operator who's trying to put a broadcast station on the air with limited funds.

the result

The folded umbrella is simply the result of several approaches to the development of an antenna which is, roughly, the *electrical equivalent* of the folded unipole. The outcome of the evolution process is shown in **fig. 2**.

design considerations

In the interest of simplicity and economy, this antenna was built around a 12-meter (40-foot), four

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section, telescopic or pushup TV receiving-antenna mast. In the development process, it soon became evident that the cage wires could best be supported by the nylon guys. Thus, the wires were pulled much farther away from the center mast — a fortunate accident as will be seen later.

Also, a 4.6-meter (15-foot) aluminum top-loading whip was added at the 12-meter (40-foot) level, making the antenna 16.8 meters (55 feet) high. The antenna will work well enough without the top loading, but the whip lowers the radiation angle and improves efficiency, especially at frequencies below 7 MHz.

Note that this antenna is *not* to be confused with the conical monopole or the discone. It is not within the scope of this article to discuss the differences, but they are well covered in reference 1.

tuning and matching

The commercial broadcast version of the folded unipole requires no variable tuning or matching arrangement, since it's designed for a single frequency. However, to match the folded umbrella on any frequency across all six high frequency amateur bands, a tuned open-wire line and transmatch unit are used. **Fig. 3** shows four different transmatch and feedline combinations. **Fig. 3A** is the basic combination, using an unbalanced transmatch. In this configuration, be sure that the side of the feedline grounded at the antenna is the *same side* that's connected to the ground terminal on the transmatch.

Fig. 3B illustrates the use of a balanced transmatch. In this case, a 4:1 balun is used at the antenna to maintain a balanced condition on the feedline.

Fig. 3C shows an arrangement which, theoretically, should unbalance things and bring unwanted rf fields into the shack. However, it has been tried and found successful in some cases. As a matter of fact the experimental antenna, which has drawn so much favorable mail, is operated in this manner. Note the *balanced* transmatch, and *no balun* at the antenna.

Fig. 3D shows the use of a short length of coax when it's inconvenient to bring open-wire line into the station. Keep this coax *as short as possible*. The open-wire part of the feedline should be, ideally, about 20 meters (65 feet) long (or a multiple thereof). When using other lengths it may be difficult to obtain a 1:1 swr on some frequencies, especially the higher frequencies. If this happens, experiment with slightly different line lengths of plus or minus 0.9-3 meters (3-10 feet) until it becomes easy to obtain 1:1 swr on virtually any frequency.

performance

Performance of the folded umbrella is quite gratifying. When operated properly, the swr should be 1:1, and your rig should see a 50-ohm resistive load on all hf amateur frequencies. On 1.8 MHz, the folded umbrella substantially outperforms a half-wave inverted vee, whose apex is 15 meters (50 feet) above ground. For all other bands, the comparison antenna is a multiband inverted vee, 40 meters (130 feet) long, 15 meters (50 feet) above the ground, with tuned feeders and transmatch.

From 3.5-4 MHz, the inverted vee is generally better up to 805 km (500 miles) because of the high radiation angle of the inverted vee or the low radiation angle of the folded umbrella. Between 805-1610 km (500-1000 miles) the superiority of the two antennas alternates depending on propagation conditions. Beyond 1610 km (1000 miles) the folded umbrella takes over, its superiority improving with increasing distance.

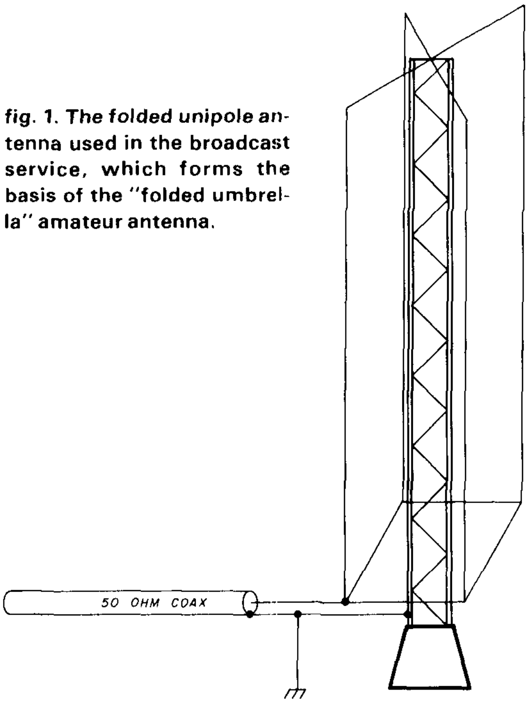


fig. 1. The folded unipole antenna used in the broadcast service, which forms the basis of the "folded umbrella" amateur antenna.

From 7-7.3 MHz, the folded umbrella definitely outperforms the inverted vee at any distance. It appears that the diamond shape of the wire cage begins to provide a measure of cross-polarization from 7 MHz up resulting in the following:

1. A diversity effect, which minimizes fading on the transmitted signal
2. A much better snr on receive because of the closed-loop design and because the antenna is dc grounded
3. Broadband performance. For example, if the folded umbrella is tuned for a 1:1 swr at 7.150 MHz and the transmatch is left untouched thereafter, the maximum swr observed at either 7.000 or 7.300 MHz is 1.2:1

The experimental model was not used much between 14 and 30 MHz since a quad is generally used on these bands, but performance is comparable to that of a dipole on these frequencies. Other builders have reported excellent DX results on the upper bands.

operation without transmatch

The folded umbrella is basically a 3.5-4 MHz antenna. If it is fed directly with coax and no transmatch, the swr is less than 2:1 at both 3.5 and 4 MHz. From 1.8 to 2 MHz the coax-fed antenna shows an swr of approximately 2:1. On the 7-MHz band, swr is in the 2.5:1 range. At 14.2 MHz, swr is 5:1, at 21.3 MHz, swr drops back to 1.5:1, and on 30 MHz, swr is about 3:1.

Since none of these swr numbers is really high, a transmatch and tuned feedline can easily subdue them, resulting in *1:1 swr* across all six bands.

using your tower

By applying unipole principles, you can use your tower. Just start by connecting one wire at some arbitrary point on the tower, say 12 meters (40 feet)

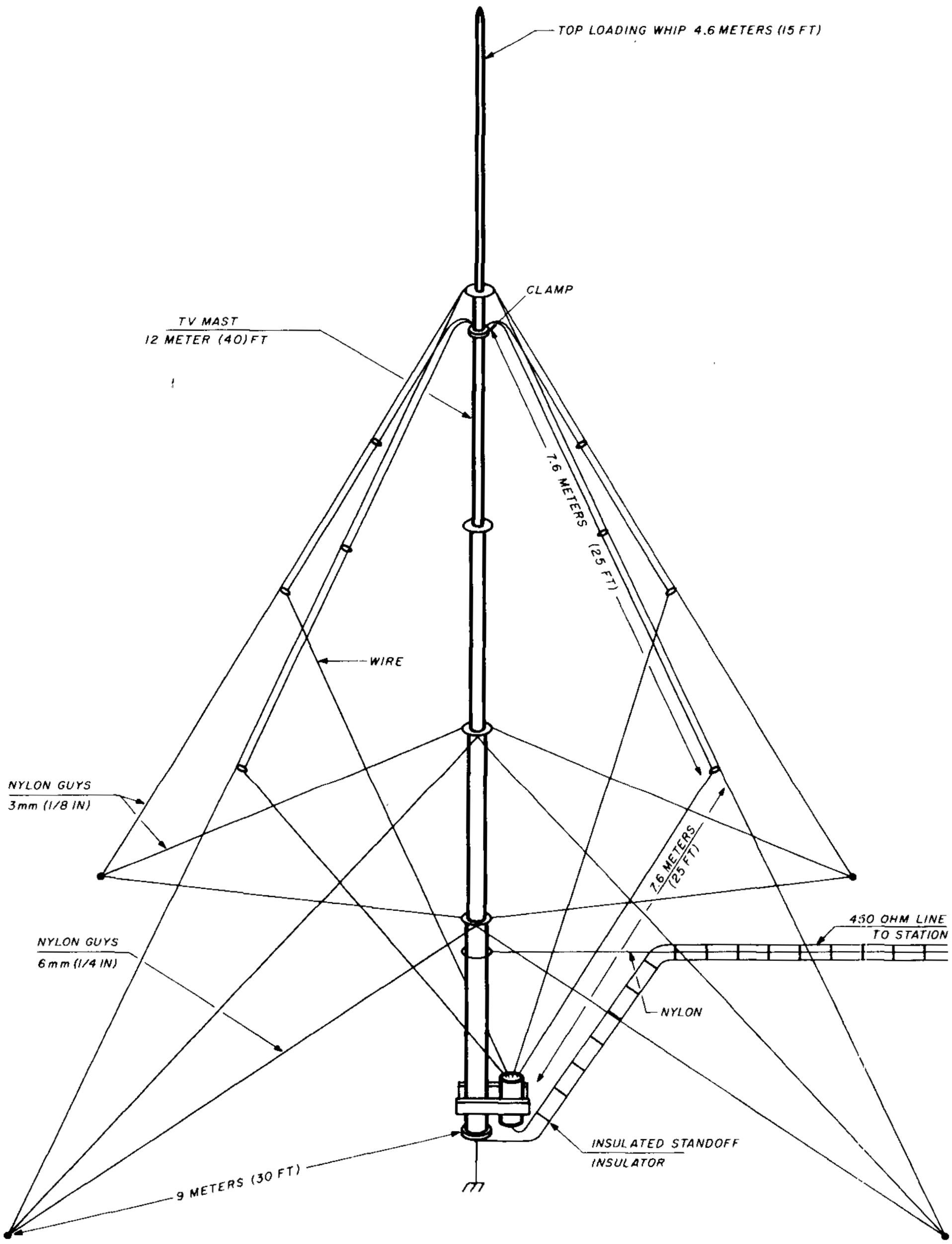


fig. 2. Construction details of the folded umbrella antenna, which is, roughly, the electrical equivalent of the folded unipole. Dimensions are approximate and are not critical.

above the ground. Use nylon line to pull the wire away from the tower. Then, bring the wire back to the bottom of the tower, as shown in **fig. 4**.

Use an exciter/vswr meter and a bridge or a grid dipper to check the resonant frequency. If it falls within the 3.5-4 MHz range, add the other three wires and proceed as with the folded umbrella. Your beam should provide adequate top loading. Be sure to ground the tower well.

construction

1. Set up the collapsed pushup mast, using 6-mm (1/4-inch) nylon guys on all four sides. Use the closely woven nylon, not the loosely braided type. The former is much stronger and will not unravel. Do not

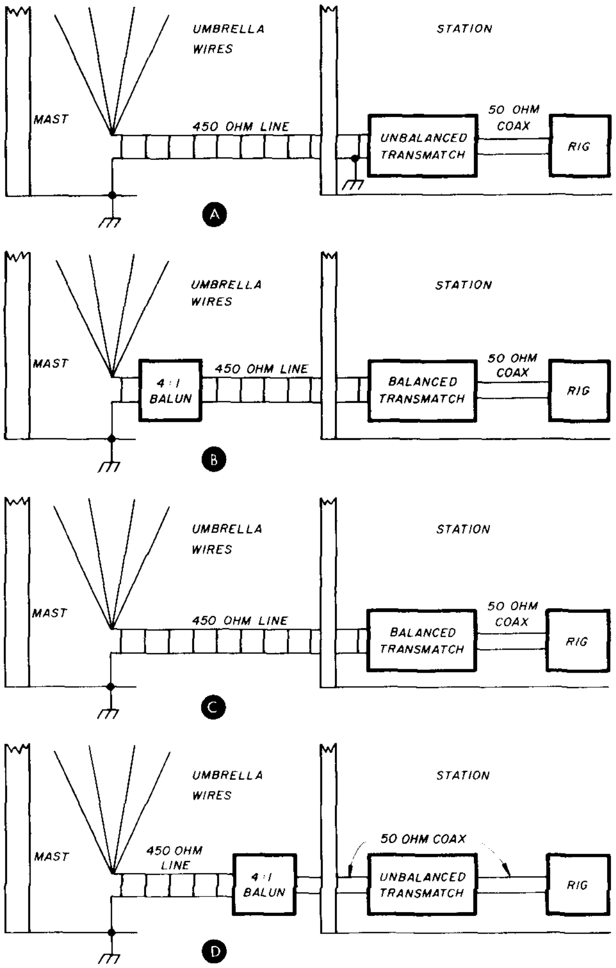
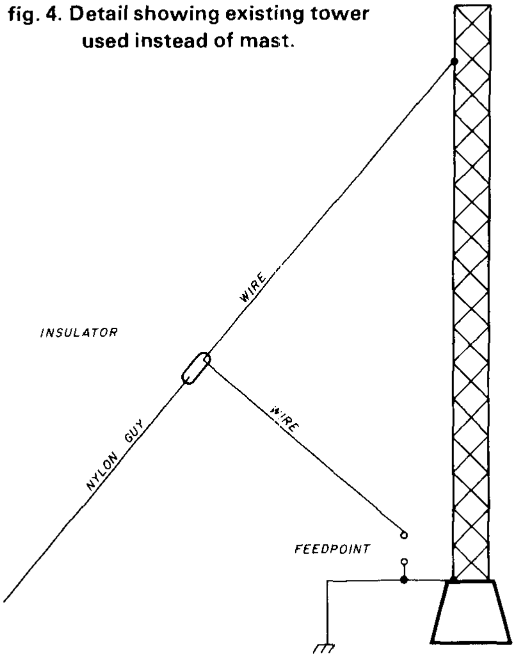


fig. 3. Transmatch and feedline configurations for the antenna. Sketch (A) shows the basic arrangement using an unbalanced transmatch. Note grounding. In (B) a balanced transmatch is used. A 4:1 balun is required. Sketch (C) shows an arrangement as in (B), but without the 4:1 balun. Transmatch is balanced (no ground). Sketch (D) shows how to use a short length of coax cable between the open-wire line and the station. The coax cable length should be as short as possible.

fig. 4. Detail showing existing tower used instead of mast.



use other synthetic line. Some of the other kinds of line become brittle with exposure to sunlight and will eventually break, while nylon retains its strength indefinitely. Nylon will stretch, but the close-woven type requires tightening only a few times initially.

2. Place the guy anchors at least 9 meters (30 feet) from the base of the mast (or use the house or trees where possible). Tighten the bottom guys firmly and place your ladder against the mast for further work.

3. Metal rings are supplied on the TV mast for attachment of guys. Be sure these rings are now in place before proceeding.

4. Insert 4.6 meters (15 feet) of aluminum tubing into the top of the pushup mast. This tubing can be made up of two or three telescoping pieces, if desired, just so long as the bottom (largest) piece fits snugly inside the top section of the pushup mast. The tubing can be secured by drilling through and bolting or by slotting the pushup mast and using a clamp (see **fig. 5**).

5. Attach four nylon (close-woven) guys to the top guy connection ring (**fig. 5**).

6. Pull the top section up out of the collapsed mast assembly about 0.6 meter (2 feet) to facilitate connection of the umbrella wires.

7. Tie two small loops in each of the four top nylon guys as shown in **fig. 2**. These loops should be about 4 and 8 meters (12.5 and 25 feet) from their attachment points on the mast.

8. Install umbrella wires.* Use approximately 16.8 meters (55 feet) of wire for each of the four elements. Clean and tin about 5 cm (2 inches) at one end of each wire. Clean and sand the mast just under the guy attachment ring. Using a stainless-steel hose clamp, attach the umbrella wires, spacing them equally around all four sides of the mast (**fig. 5**). Smear silicone rubber cement (GE or Dow-Corning)

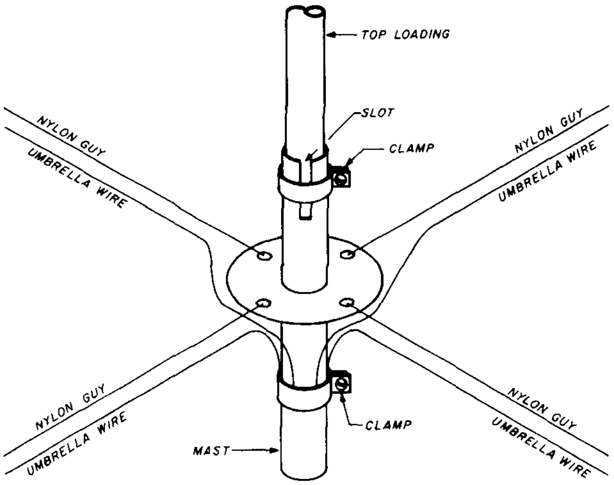


fig. 5. Detail showing attachment of top guys, "umbrella" wires and top loading whip.

liberally over the hose clamp and bare wire ends to prevent corrosion of the electrical connection.

9. Thread one of the antenna wires through the two loops on each of the guys. You are now ready to begin raising the mast.

10. Use heavy leather gloves and be very careful when pushing the mast up. Whenever you stop the mast part way up, be sure to tighten the locking bolt very firmly, using pliers or a sufficiently large crescent wrench. If the mast should slip unexpectedly, it can pinch and cut your hand most painfully. This is the reason for the heavy leather gloves.

11. As you raise the mast, temporarily secure the bottom ends of the umbrella wires to their respective guys with tape. Then, keep these four wire/guy assemblies tied away from the mast as you raise it. This prevents the wires and guys from becoming tangled during the erection of the mast.

12. Now, push the top section up to its full length. There will be a hole at the top of the next section below. When the bottom of the top section is pushed high enough to clear this hole, push a large cotter pin (provided in the mast hardware) through this hole. Spread the ends of the cotter pin only enough to secure it, which will make it easy to remove at some later time. Now, tighten the locking bolt firmly. Repeat this process on the other sections.

13. Push the next section up and secure as above.

14. Attach four more 3-mm (1/8-inch) nylon guys to the ring at the top of the section just above the bottom section. This set of guys will end up, on full erection, 6 meters (20 feet) above the ground (**fig. 2**).

15. *Push this last section up and secure, as above,* and temporarily secure all guys.

16. Now, provide a bracket at the base of the mast for the purpose of connecting the four umbrella wires together while insulating them from the mast. This is the feedpoint for the antenna. One suggested method of anchoring and insulating the feedpoint is shown in **figs. 2** and **6**. However, as with other parts of this project, there are many different mechanical arrangements which will produce the same electrical results. Use your ingenuity. Remember, none of the dimensions are really critical, since the tuned feeders compensate for physical variations. If you're following **fig. 6**, however, pull the umbrella wires through the PVC tubing, tighten the clamp below the tubing, and trim off excess wire, leaving several cm of wire below the clamp. Now, bare the wires below the clamp and solder them together.

17. Drive three or four 2.4-meter (8-foot) ground rods around the base of the mast and connect them

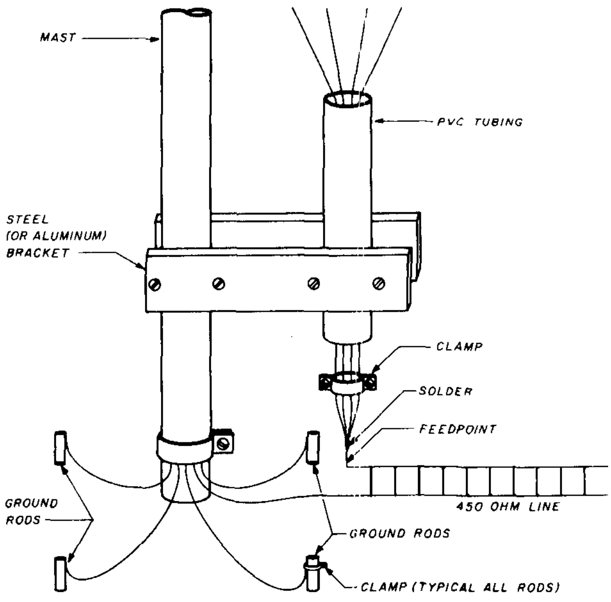


fig. 6. Mechanical details at the bottom end of the TV mast. The ground rods are essential for good performance.

*Any available type of copper wire up to 2 mm (no. 12 AWG), solid or stranded. The experimental model uses surplus 1.3 mm (no. 16 AWG) stranded, insulated wire.

securely to the mast with heavy copper wire, tubing or strap (**fig. 6**).

18. Attach feedline, soldering one side to the feedpoint and connecting the other side to ground. The most practical line to use is the 450-ohm plastic ladder line made by Saxton. It is strong, flexible, and much easier to use than bare open wire while just as effective. Furthermore, it's affected very little by ice, snow, or rain, as far as tuning is concerned. **Figs. 2** and **7** show a simple, practical way of supporting the line. For the experimental model, it was necessary to run the line 18 meters (60 feet) to the house, keeping it at least 3 meters (10 feet) above ground. To relieve tension on the line, 3-mm (1/8-inch) nylon was threaded through the holes in the line and stretched from the mast to the house, serving as a "messenger" cable. Here again, use your own ingenuity to fit your situation.

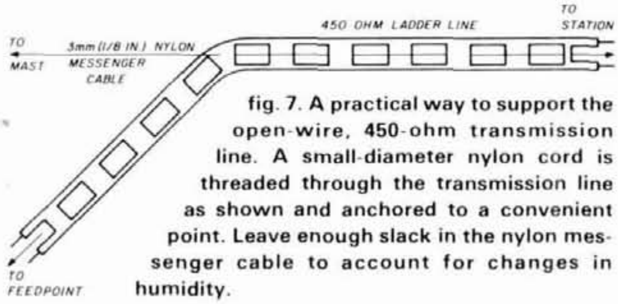


fig. 7. A practical way to support the open-wire, 450-ohm transmission line. A small-diameter nylon cord is threaded through the transmission line as shown and anchored to a convenient point. Leave enough slack in the nylon messenger cable to account for changes in humidity.

19. After tuning and testing, tighten and secure the guys, using a plumb level to be sure the mast is vertical.

closing remarks

Here is an antenna that can do many things for you. Don't expect it to perform like a beam — but it will more than hold its own against conventional dipoles and trapped verticals at all frequencies and on all high frequency amateur bands.

I have received literally hundreds of inquiries from people who were impressed with what they heard when I was using the umbrella antenna. All inquiries have been answered, and those who have built the antenna report equally gratifying results.

The writing of this article was deliberately delayed pending receipt of data from others to provide the reader with authentic, reliable information.

reference

1. Paul H. Lee, K6TS, "The Amateur Radio Vertical Antenna Handbook," Cowan Publishing Company, 1974, pages 49-52 (discones and monopoles); pages 75-80 (folded unipoles).

ham radio

80-meter broadband antennas

A discussion of different approaches to broadbanding 80-meter antennas, including theoretical calculations and actual model measurements

Judging by the horrendous congestion that can be found on the 80-meter band almost any evening, it is certainly one of the most popular bands. But all of its users share the same problem with antennas. The ratio of the upper limit of the band to the lower limit is 1.143:1, larger than that of any other high-frequency Amateur band. Building an antenna which has adequate bandwidth for the entire 500 kHz may seem like an impossibility.

Years ago, transmitters had a very large range of matching capability. This luxury disappeared when the compact transceiver appeared on the scene over ten years ago. The problem has been compounded by the introduction of transmitters with solid-state power amplifiers requiring a load very close to 50 ohms. Protection circuits are normally employed to reduce the driving power to avoid damage to the output transistors. The use of a transmatch will eliminate the mismatch problems, but takes away the convenience of frequency changes without retuning.

The antennas shown in this article exhibit acceptable impedance matches over much more than the usual bandwidth. Although these designs may not be the perfect solution in every installation, they should provide starting points for further experimentation.

current designs in use

One of the classic ways to increase the bandwidth of a simple dipole is to enlarge the effective diameter of the conductors in the radiating elements. The cage antenna is one example of this, in which each half of the dipole is made of several conductors. The multiple conductors are suspended on spreaders at two or more places. This simulates a conductor of roughly the diameter of the spreader. The fan dipole, or bow-tie, antenna is a simplification of the cage arrangement. In this design, each half is composed of two wires joined at the feedpoint. The wires fan out from this point and are held apart by a single spreader at the far end.[1] Antennas of this type provide a noticeable increase in the bandwidth over which a transmitter may be adjusted for a conjugate match, but they have apparently not enjoyed much popularity. Perhaps it is because these antennas are considered somewhat unsightly. The antennas I'll discuss have wider bandwidths for the same level of complexity (and lack of beauty).

antenna models

To provide a more convenient means of attacking the problems associated with broadband antennas, two types of antenna models were used to test the designs. Simple mathematical models were used to

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allow prediction of the approximate antenna impedance match vs frequency, before they were constructed, whenever possible. An equivalent circuit for a simple wire dipole appears in **fig. 1**. This model accounts for the change in reactance at the feedpoint as the frequency is changed, but it does not allow for the normal tendency of the resistive component of the feed impedance to rise with increasing frequency. This tends to be a second-order effect and doesn't seriously affect the results. It does, however, greatly simplify the calculations.

If the resonant frequency of this mathematical model is checked, it will be found to be 3742 kHz. It is not 3750 kHz, which is the arithmetic center of the band. Like all resonant circuits, the model exhibits *geometric symmetry*. The resulting effective center of the band is $\sqrt{3500\ kHz \times 4000\ kHz} = 3742\ kHz.$ This frequency is used as the band center throughout the calculations to maintain band-edge symmetry when plotting the SWR. In real antennas, the many other variables involved make the 8-kHz distinction unimportant.

The plot of the calculated impedance for this mathematical model is shown on the Smith chart in **fig. 2**. The accompanying SWR plot is given in **fig. 3**.

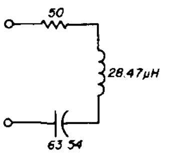

fig. 1. Approximate equivalent circuit of a standard wire dipole antenna.

This is typical of several antennas I have used in the past. These antennas were mostly inverted vees with center heights of about 12 meters (40 feet) and the ends about 3 meters (10 feet) high. A 5:1 SWR is considered intolerable by many Amateurs and much worse than a typical antenna would measure. This is probably because many SWR meters read closer to 3.5:1 for such an antenna. Close inspection with a noise bridge or other impedance-measuring equipment will show a typical SWR meter to be an incurable optimist. This defect is especially obvious when attempting to read fairly high mismatches at lower power levels.

Calculations of predicted antenna impedances and matches were facilitated by the use of programmable scientific calculators (HP-55 and TI-59) and an IBM 370 running the SPICE circuit analysis program written at the University of California, Berkeley. The antennas were also physically modeled by scaling them up in frequency and down in size by a factor of almost nineteen. This moves the resonant frequency to 70 MHz, which is the center of the i-f passband used in most microwave equipment designed for telecommunications service. Microwave link analyzers cover the range from 50 to 90 MHz and include the capability of accurately measuring return loss. Return loss is just 20 times the logarithm of the reflection coefficient, expressed in dB. Although the Hewlett-Packard 3702B/3710A and its companion return loss hybrid are designed for 75-ohm measurements, the use of a minimum-loss resistive matching pad permits its use with nominal 50-ohm loads. The loss of this pad was accounted for in the measurements made.

The scaled antennas were suspended from the ceiling inside a laboratory for the measurements. There were many reflections from the metal framework of the building, but they were probably on a par with those one could expect from power lines and the exteriors of buildings in the vicinity of an 80-meter antenna. All of the plots in this article show the equivalent scaled-down frequencies corresponding to the measurements made on the scale models. All of the necessary corrections have been made.

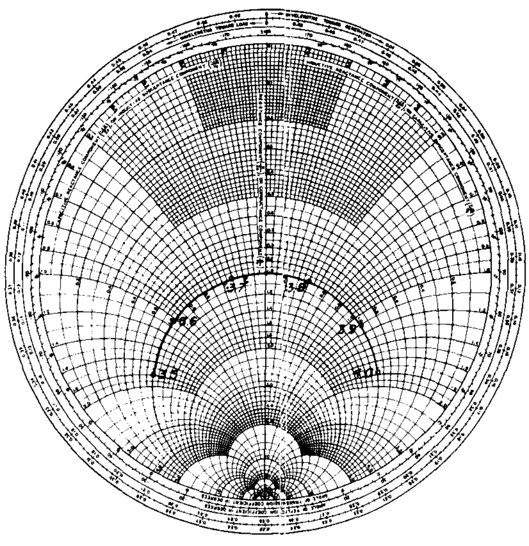

fig. 2. Calculated input impedance of the dipole equivalent circuit, normalized to 50 ohms.

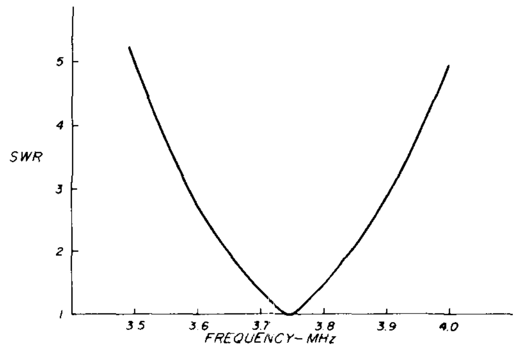

fig. 3. Calculated SWR of the dipole equivalent circuit.

parallel antennas

This antenna configuration was suggested by the common use of paralleled dipoles for several bands. Others have apparently tried paralleling two antennas cut for different parts of the same band to widen the overall bandwidth with little success. The secret for

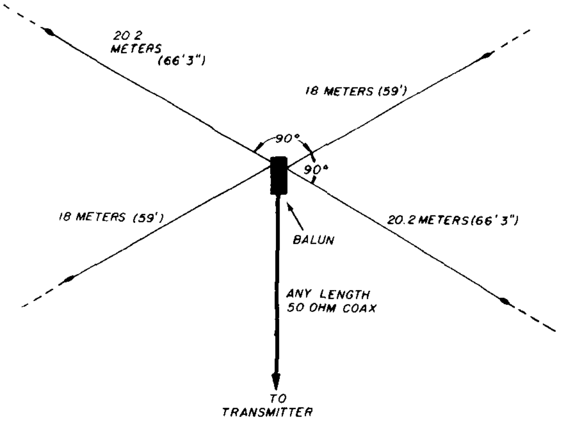

fig. 4. The parallel antenna is formed by two stagger-tuned dipoles, mounted at right angles to each other and fed at a common feedpoint.

proper operation is to mount the two antennas in such a way that they do not couple to each other. This can be done by mounting them at right angles as shown in **fig. 4**.

One of the two dipoles is cut for 3530 kHz and the other to 3966 kHz. The higher frequency is 1.06 times the geometric center of the band (3742 kHz). The

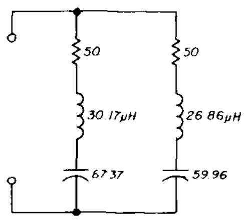

fig. 5. Approximate equivalent circuit of the parallel antenna. Individual resonances are at 3530 and 3966 kHz.

lower frequency is the center frequency divided by 1.06. The equivalent circuit of this arrangement is given in **fig. 5**. It is just the parallel combination of two dipole equivalent circuits which have been adjusted up and down in frequency by multiplying and dividing the reactance values by the 1.06 factor.

It is recommended that this antenna, and the others shown as well, be fed through a balun. Currents flowing on the outer conductor (shield) of the coaxial feedline can cause undesired coupling between the antennas, which can restrict the bandwidth.

The calculated impedance of the antenna is shown in **fig. 6**. The loop in the curve is interesting. The

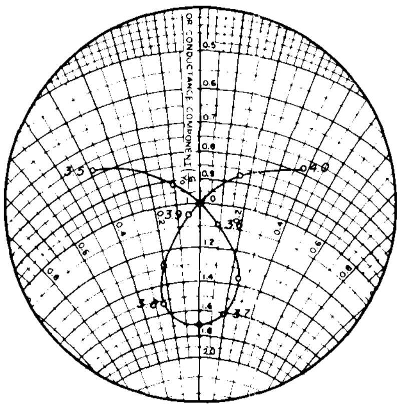

fig. 6. Impedance calculated for the parallel antenna equivalent circuit, normalized to 50 ohms.

antenna impedance is capacitive at low frequencies just like the single dipole, crosses over through a perfect match, then becomes inductive. The impedance then becomes capacitive again as the frequency increases, goes through perfect match once again, and finally becomes inductive once more at the top of the band. The calculated SWR is shown by the solid line in **fig. 7**. Measurements on the scale model of the antenna are also shown on the same plot by the dashed line. The measurements show good agreement with the calculations (most of the discrepancy between the two curves results from the individual dipoles never having a perfect match to 50 ohms). Despite this, the SWR is better than 2:1 across the entire band. If you can make dipoles that have a wider bandwidth than the ones assumed here, your antenna could be even better than this.

One of the interesting features of the parallel antenna is its tendency to be omnidirectional. Like the turnstile antenna, the currents in the two dipoles are out of phase. Over the middle of the band, at least, the currents in the two dipoles are roughly equal. **Fig. 8** shows the calculated phase difference between the two dipoles as a function of frequency. The ratio of the two currents, given in dB, is plotted in **fig. 9**. Even though the currents can differ by more than 10 dB at the band edges, the normal nulls in the

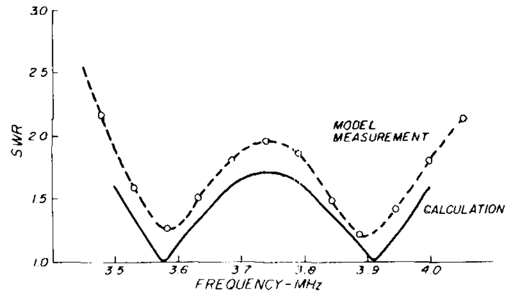

fig. 7. Calculated and measured SWR of the parallel antenna.

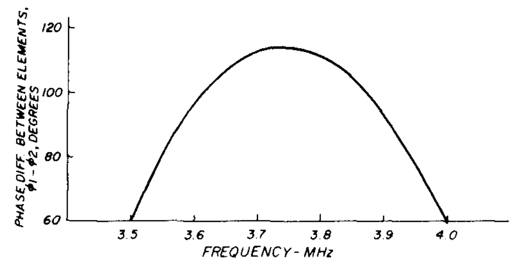

fig. 8. Calculated phase angle between the currents in the two stagger-tuned dipoles of the parallel antenna.

radiation pattern of a dipole will be filled to a large extent. Signals radiated at a high angle will be elliptically polarized. This is of some benefit when receiving. The antenna will respond fairly well to linearly polarized signals which arrive parallel to either antenna from high elevation angles. Since many of the signals received on the 80-meter band arrive at high angles, the elliptical polarization is probably of much more value than the omnidirectional characteristics observed toward the horizon.

It is worth noting what happens when the resonant frequencies of the two dipoles are separated by a different ratio. Calculations were made at two other pairs of resonant frequencies. When the ratio is 1.05 instead of 1.06, the SWR at the band edges is about 2.5 to 1 and the midband SWR is about 1.4 to 1. If the ratio is reduced to 1.04, the SWR at the middle of the band barely rises to 1.05 to 1, yet the SWR remains about 3.1 to 1 at the band edges. The loop in the impedance plot on the Smith chart shrinks, but it does not disappear until the two dipoles are tuned to the same frequency.

Most Amateurs probably don't have a house lot of the right shape to permit placing two such antennas at right angles to each other. It may be desirable to erect the antennas as inverted vees instead of as conventional dipoles. Increasing the coupling between the antennas will reduce the bandwidth of the system, but the use of inverted vees has a minimal effect

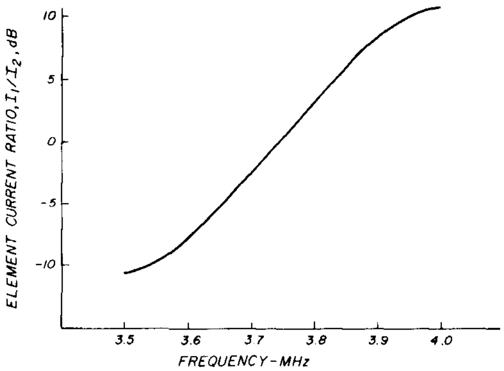

fig. 9. Calculated current ratio between the two dipoles of the parallel antenna.

on the coupling. The angle between the dipoles may deviate from 90 degrees by about 15 degrees without significant degradation. If the angle decreases below 60 degrees, the match at the high end of the band will deteriorate. As the angle is decreased even more, the lower frequency antenna seems to dominate, and the tuning of the higher frequency dipole has less

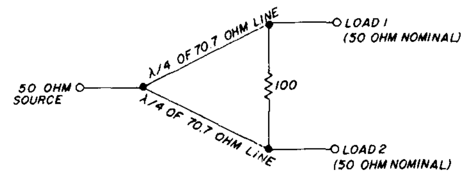

fig. 10. Schematic representation of the two-way Wilkinson hybrid with the ideal transmission line impedance.

and less effect on system operation. When the antennas are nearly parallel, the SWR curve appears to be that of the lower frequency antenna alone.

Wilkinson hybrids

Before looking at the next antenna configuration, a discussion of a very interesting circuit is in order. The Wilkinson hybrid is very commonly used as a

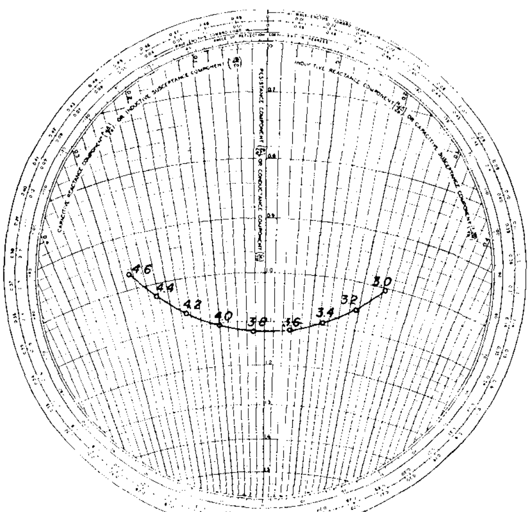

fig. 11. Calculated input impedance of the Wilkinson hybrid terminated by two 50-ohm loads. The quarter-wavelength lines are assumed to be 75 ohms. Data are normalized to 50 ohms.

power divider or combiner at microwave frequencies.[2] The arrangement of the circuit is shown in **fig. 10**. This is the simplest form of the circuit. Other variations allow driving more than two loads. Modifications providing very wide bandwidths have also been developed.[3]

Fig. 11 shows the calculated impedance of a Wilkinson hybrid terminated with 50-ohm loads. The

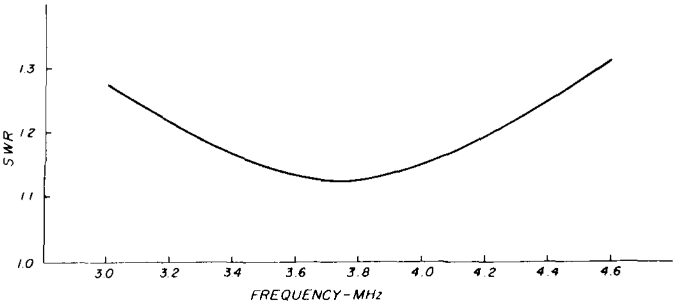

fig. 12. Calculated SWR at the input of the Wilkinson hybrid using 75-ohm cables. Each leg was terminated in a 50-ohm resistive load.

quarter-wavelength lines are assumed to be 75 ohms instead of 70.7 ohms to indicate the performance to be expected with available cables. For this reason, the input impedance is never exactly 50 ohms. The corresponding SWR is shown in **fig. 12**.

Like other hybrid circuits, the Wilkinson provides isolation between the two loads, This occurs because a signal entering the *Load 1* port can travel to the *Load 2* port by two paths. One path is directly through the 100-ohm resistor; the other path is through one of the quarter-wavelength lines to the source and then back up the other quarter-wavelength line. Because the second path totals one half-wavelength, the signal traveling this route is 180 degrees out of phase with the signal through the resistor. As it happens, the amplitudes of the two signals are equal, and complete cancellation occurs.

No circuit is perfect, however, and several imperfections can cause a reduction in the isolation obtained between the two load ports. It should be obvious

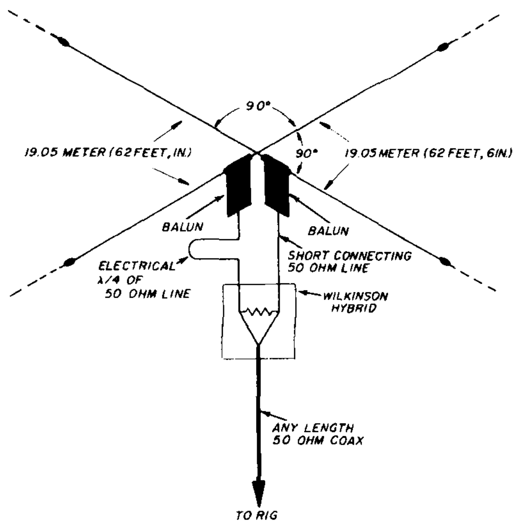

fig. 13. Diagram of the turnstile antenna driven with a Wilkinson hybrid. **Both dipoles are tuned to the band center and are mounted at right angles to each other.**

that the rejection is perfect only at the design frequency, since the transmission lines give the right phase shift only at that frequency. Even so, the isolation will be better than 20 dB over the whole 80-meter band. The other major source of less-than-ideal performance is the possibility that the driving source is other than 50 ohms. Most Amateurs fail to realize that the output impedance of a power amplifier designed to drive 50-ohm loads is seldom 50 ohms. This effect could easily cause a 10-dB degradation of the isolation between the output ports.

One clever use of the Wilkinson hybrid with Amateur antennas has been in driving phased vertical arrays.[4] The isolation of the hybrid is useful in preventing interaction of the antennas via the phasing

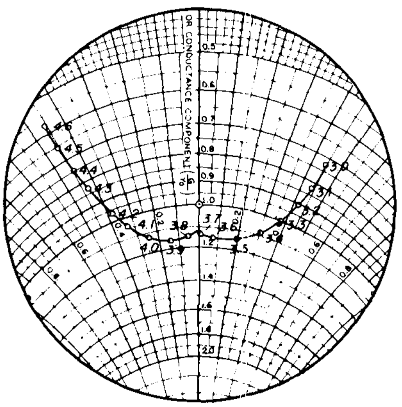

fig. 14. Input impedance, calculated using SPICE program, of the turnstile antenna driven by a Wilkinson hybrid with 75-ohm lines. Data are normalized to 50 ohms.

harness, which makes designing and adjusting such an array much easier.

Since the power from the input of the hybrid is equally split, the loss is 3 dB between the input and each output. Power coming in either of the two load ports is attenuated by 3 dB because half of the power goes back into the source port and the other half is dissipated in the 100-ohm balancing resistor. This has an interesting effect on the reflected power — it is cut in half! Unfortunately, when the reflected power is burned up in the load, it cannot be re-reflected and travel again out to the antenna or other load where the power is wanted. This causes a drop in system efficiency.

A special case occurs when two identical loads are driven by the hybrid: one load driven directly from the hybrid output and the other load driven through a quarter-wavelength of 50-ohm cable. If the loads are not 50 ohms, there will be a reflection at the load back toward the source. Since one of the loads is 90 degrees farther away, the reflection coming back will be a total of 180 degrees out of phase with the reflection from the directly connected load. The reflected waves are thus equal and out of phase. The power summing action of the Wilkinson hybrid will cause them to cancel out. Where did the power go? It is all dissipated in the 100-ohm balancing resistor. None of the reflected power will arrive back at the source, and the apparent match is perfect. This leads directly to the next antenna system.

turnstile plus Wilkinson

A turnstile omnidirectional antenna is shown in **fig. 13**. The Wilkinson hybrid is used to drive the two antennas with equal power. An extra electrical quarter-wavelength of 50 ohm coax is connected

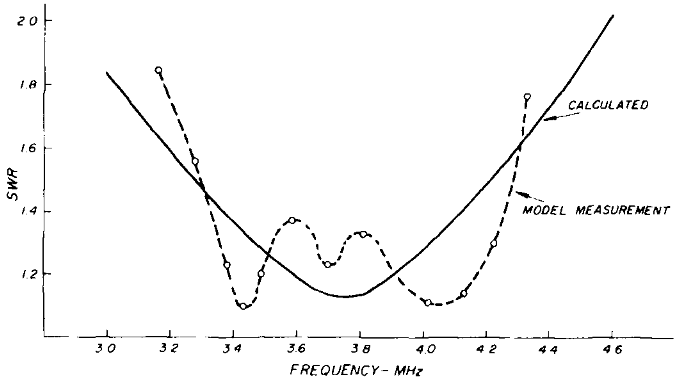

fig. 15. Calculated and measured SWR of the turnstile antenna driven with a Wilkinson hybrid.

between the hybrid and one of the antennas. The hybrid is made of two electrical quarter-wavelengths of 75-ohm coax and a high power noninductive 100-ohm resistor. The bandwidth of this antenna system is unbelievable! See **fig. 14** for the calculated impedance of the system. The calculated and measured values of SWR appear in **fig. 15**. Many dummy loads don't match this well. It is perhaps an apt comparison, unfortunately; the bad news is in **fig. 16**. This plot shows the equivalent loss as a function of frequency. At the edges of the 80-meter band, about 2.5 dB of transmitter output is turned to heat in the 100-ohm resistor. If your kilowatt power amplifier has 65 per cent efficiency, almost 285 watts must be dissipated at 3.5 or 4 MHz, leaving only 365 watts to be radiated.

These calculations are still based on the original dipole equivalent circuit with the 5:1 SWR at each band edge. The amount of loss in the resistor is reduced if the antennas fed by the hybrid are wide in bandwidth.

Baluns are almost mandatory for this antenna configuration. The cables in the phasing line and the

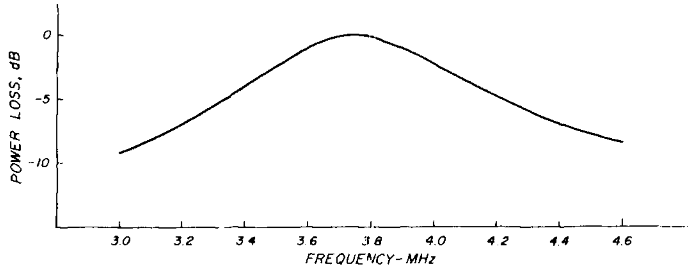

fig. 16. Calculated equivalent loss in the balancing resistor for the turnstile antenna driven by a Wilkinson hybrid.

hybrid will cause undesirable resonances to affect the impedances of the two dipoles if currents are allowed to flow on the cable sheaths. Whether a balun is used or not, the connections at the feedpoints *must* be insulated from each other. If no balun is used, this means the two shields of the coaxial cables at the feedpoints cannot be allowed to make contact, since these points are *not* at zero potential with respect to each other.

If a solid-state transmitter is in use and a transmatch is considered undesirable, an antenna of this type might be a good compromise. The power lost in the balancing resistor in the hybrid might be less than you would lose when the automatic drive reduction circuit is activated by another antenna with a poorer match.

conventional turnstile

An obvious question occurs immediately. Why not remove the 100-ohm resistor? This would transform the antenna into a conventional turnstile antenna. The Smith chart in **fig. 17** shows what happens

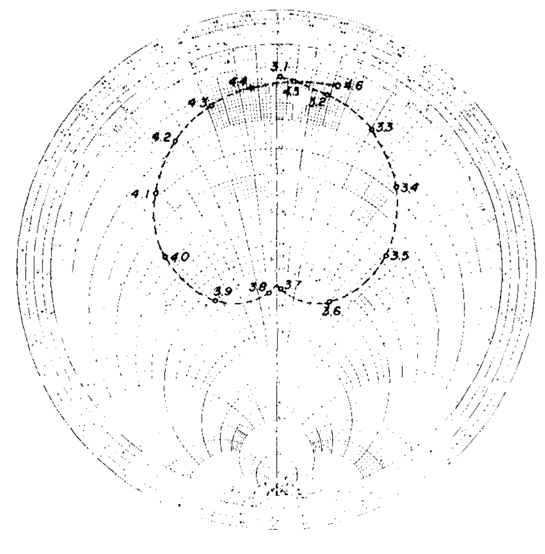

fig. 17. Impedance calculated for a conventional turnstile antenna (no 100-ohm balancing resistor), normalized to 50 ohms.

when this is done. The corresponding SWR curves are shown in **fig. 18**. The results are not that impressive, but are included here to satisfy possible curiosities. If the necessary space for all of the wire is available, a better choice would be the parallel antenna. This would eliminate all of the coaxial transformers and provide an increase in bandwidth.

coaxial trap antenna

When the wondrous claims about the "double bazooka" antenna came forth, it was hard to resist trying one. Even if only 10 per cent of the claims were true, it still had to be amazing. After the disillusion-

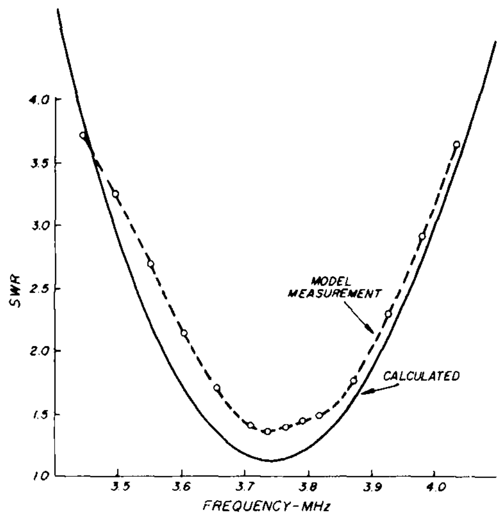

fig. 18. Calculated and measured SWR of the conventional turnstile antenna.

ment,[5] those strange lengths of RG-58/U cable cried for use in an antenna. The resulting design is sketched in **fig. 19**.

The shorted quarter-wavelength sections of coax look like parallel resonant traps that decouple the short end-sections at the high end of the band and make the antenna think it is shorter. At the lower end of the band, the shorted pieces of coax look inductive, slightly loading the antenna and allowing the antenna to be somewhat shorter physically than would otherwise be required. The larger diameter of the coaxial traps also contributes to the increased bandwidth.

The synthesis of a mathematical model for this antenna was not attempted. However, both full-size and scale models of the design were built. The full-size antenna used RG-58/U and the scale model used RG-174/U, a miniature 50-ohm coax. The scaling of the conductor diameters is not in proportion to the frequency ratio, which certainly results in some errors.

A Boonton model 250-A RX meter was used

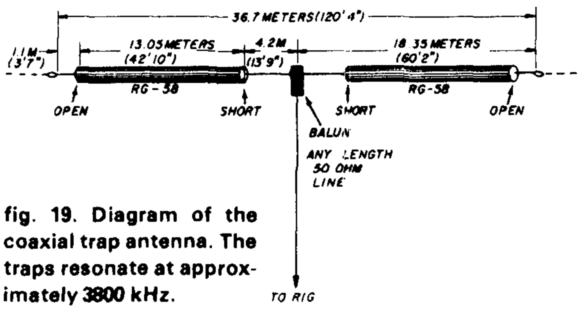

fig. 19. Diagram of the coaxial trap antenna. The traps resonate at approximately 3800 kHz.

through a known length of 50-ohm cable to measure the impedance of the scale model. The scaled down frequencies and impedances are plotted in **fig. 20**. The equivalent SWR curve is shown in **fig. 21**. Notice that the shape of both plots is similar to those of the previously mentioned parallel antenna, although the overall match is not as good. This antenna is worth consideration when the necessary acreage is not available for two full-size dipoles.

Tuning the coaxial trap antenna can be difficult. The first thing to do is to grid-dip the traps as shorted half-wavelength sections at about 7.6 MHz. A noise bridge could be used to look for a zero impedance at this frequency instead. When this is done, the traps will be quarter-wavelength at about 3.8 MHz. If a noise bridge or grid-dipper is not available, cutting to the specified length shown may be close enough.

If the coaxial cable used for the traps has foam-polyethylene insulation, the traps must be lengthened to approximately 15.85 meters (52 feet) and the inner wires shortened to about 1.4 meters (4 feet, 7 inches). For Teflon-insulated cables, the appropriate dimensions are 13.75 meters (45 feet, 1 inch) and 3.5 meters (11 feet, 6 inches).

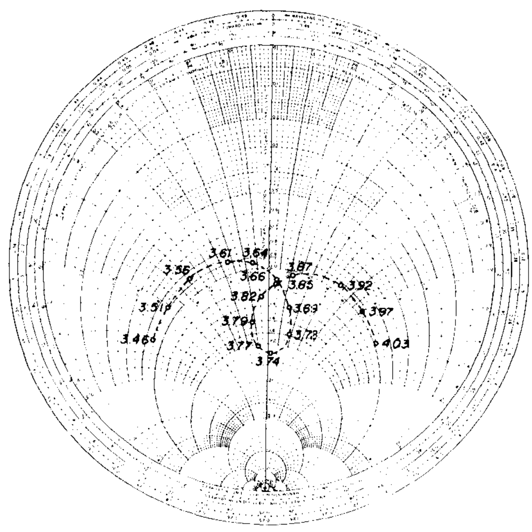

fig. 20. Measured impedance of the scale model of the coaxial trap antenna normalized to 50 ohms. Frequencies are scaled down to 80-meter equivalents.

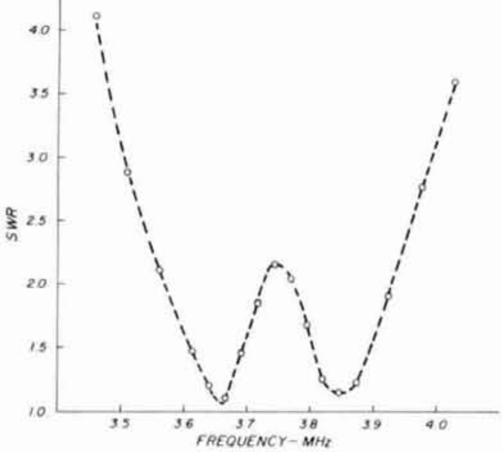

fig. 21. Measured SWR of the scale model coaxial trap antenna.

Once the coaxial traps are cut, connect the wires to them that go from the shorted end of the traps to the feedpoint. Leave these pieces of wire about 30 cm (1 foot) longer than indicated to allow for trimming. Hoist the antenna into position without the end wire stubs connected. Adjust the length of the inner wire sections to obtain resonance around 3800 kHz. Then connect the end stubs to the center conductor at the open-circuited end of the coaxial traps. Trim their length to optimize the match at the low end of the band.

It may be necessary to go back and make minor adjustments to the lengths of the wires at both ends of the coaxial traps to center the SWR curve as desired. Remember to keep the lengths of all sections the same on both sides of the antenna. It is quite possible that your dimensions may come out quite different from those shown, due to effects from the surroundings.

comments please

I hope that some of the ideas presented here have been thought provoking. I would be interested in hearing of any productive modifications to the designs presented in this article. Comments on both successes and failures in working with these antennas are also welcome.

references

1. Charles C. Camillo, W9GZJ, and Richard M. Purinton, W1SX, "A Broadband Antenna for 75 Meters," *QST*, June, 1955, page 11.

2. Ernest J. Wilkinson, "An N-Way Hybrid Power Divider," *IRE Transactions on Microwave Theory and Techniques*, January, 1960, page 116.

3. Seymour B. Cohn, "A Class of Broadband Three-Port TEM-Mode Hybrids," *IEEE Transactions on Microwave Theory and Techniques*, February, 1968, page 110.

4. Dana W. Atchley, Jr., W1CF, "Updating Phased-Array Technology," *QST*, August, 1978, page 22.

5. Walt Maxwell, W2DU, "A Revealing Analysis of the Coaxial Dipole Antenna," *ham radio*, August, 1976, page 46.

ham radio

matching complex antenna loads

to coaxial transmission lines

A simple method for determining the correct length and stub position when stub-matching antenna systems

Matching problems in vhf coax systems can be a stumbling block for the Amateur interested in advanced or large-scale antenna arrays. Commercial antennas match closely to a 50-ohm system and provide little challenge. When several antennas are stacked, however, the matching or feed system becomes more complex. If the antenna is homebrew, even one antenna can cause matching problems by providing other than a 50-ohm nonreactive load.

There are two simple methods of matching a 50-ohm system to a load of another impedance: the quarter-wavelength transformer section and the matching stub. Each method has its good and bad points; each is perfect for some applications and much less than perfect for others.

The quarter-wavelength transformer section is well described; it is simply a quarter-wavelength section of coaxial cable used between the load and the rest of the feedline. The Z_o, or characteristic impedance, of this section is an interim value between the load and the feedline impedances. It is this impedance value and the quarter wavelength that are critical to proper transformer function. Since the formula for transformer section Z_o requires the desired impedance at both ends of the section, these values must be known.

The stubbing method involves a physically short, open-circuited section of coaxial cable connected into the feed line with a T connector (see **fig. 1**). The

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positioning piece places the stub at a point on the line where the resistive component of the impedance is equal to Z_o and the reactive component is inductive. The stub itself is simply a capacitor which is adjusted to cancel the inductance. This makes the stub attachment point appear to be resistive and equal to Z_o; in effect, it becomes a perfect load. To use a stub assembly you must know the following:

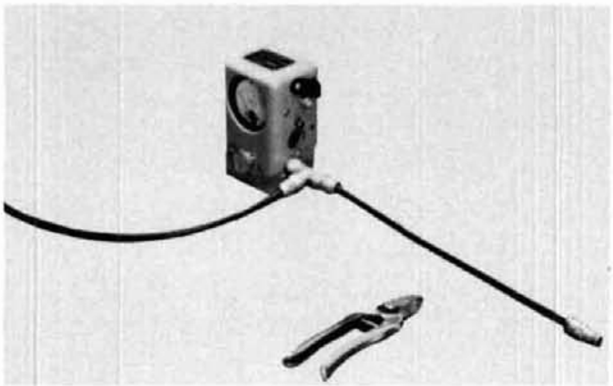
1. VSWR of the unstubbed system (measured at the antenna)

2. Wavelength in the line

3. Actual position of the standing wave voltage minimum point nearest the load

which system?

The strong points of the systems dictate their best uses. When the load impedance is unknown (and



Basic stubbing assembly. The load attaches to the connector at the right. The shears are used to trim the stub for the lowest reflected power.

probably complex), the stub is the easiest choice. When paralleling antennas of known impedance, the quarter-wavelength section is perfect for the impedance conversion, since the impedance values for both the antenna and transmission line are known. If multiple homebrew antennas are used, of course, each antenna is stubbed to 50-ohms and paralleled with quarter-wavelength sections.

In general terms, however, unknown complex impedances can easily be reduced to a purely resistive load which is equal to the feedline Z_o with a stub, while transformations from one known impedance to another are more easily done with transformer sections because the construction is easier.

stub system

When using a stub matching system, I use a capacitive stub because the end of the stub is left electri-

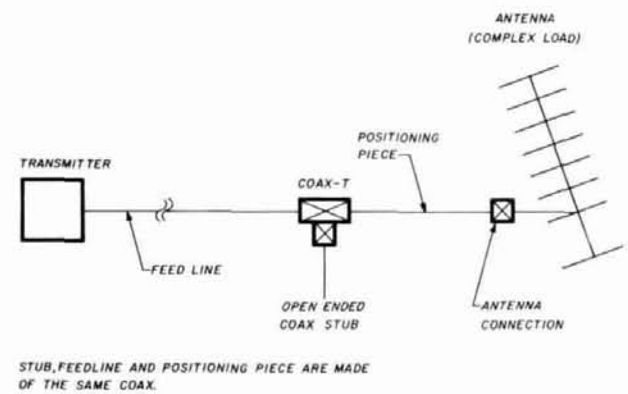


fig. 1. Diagram of a stub-matching system to match the complex load present by the antenna and the fixed output impedance of the transmitter. In this example, the feedline, positioning piece, and stub are made from the same coax.

cally open. This allows easy adjustment of length and permits the whole feed system to be checked occasionally with a leakage meter to check dielectric condition.

The stub is installed in the inductive region of the feedline at a point within 90 degrees toward the generator from the voltage minimum nearest the load (see **fig. 2**). The distance from the load to the first voltage minimum point is part **A** of the positioning piece length and should be found by direct measurement. A slotted line may be used if its velocity constant is identical to that of the cable in use. Details of its use may be found in **reference 1**.

If an appropriate slotted line can't be found, a simple fluted line may be constructed from a 60-cm (2-foot) length of coaxial cable. The cable is marked every 2.5 cm (1 inch). A small (1-cm, or 3/8-inch)

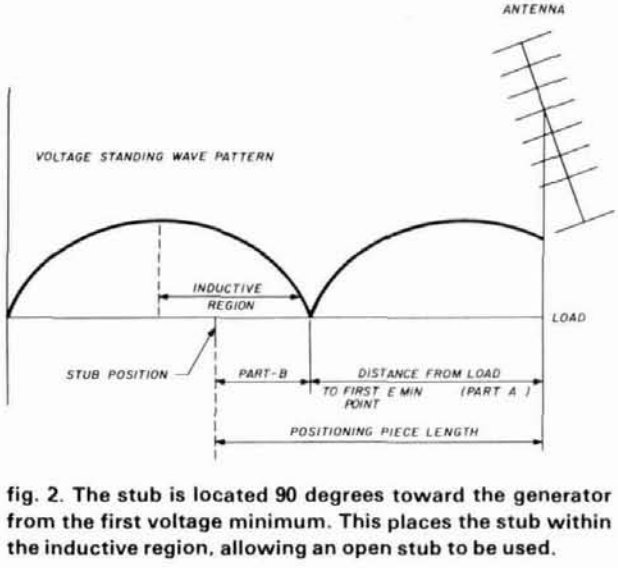


fig. 2. The stub is located 90 degrees toward the generator from the first voltage minimum. This places the stub within the inductive region, allowing an open stub to be used.

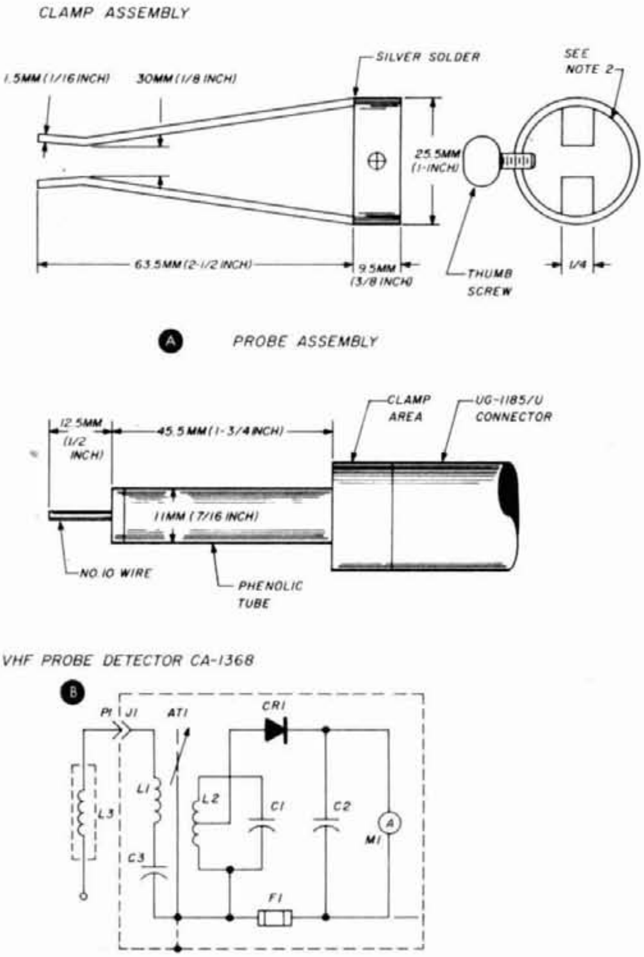


fig. 3. Detailed diagram of a detector assembly which can be used with a homemade fluted line (A). The clamp assembly slides over the probe assembly and is secured with a thumb screw in the clamp area. The schematic diagram shown in (B) is suitable for use with the probe. This detector has the capability, by use of the attenuator, of determining the VSWR on the line. If other means of measuring VSWR are available, the attenuator can be deleted. The tuned-circuit can be changed to measure the desired frequency, acting as a simple rf voltmeter.

area around each mark is stripped of outer insulation and the braid is quickly tinned with a large soldering gun. Using a drill press and V block, drill a small hole through the tinned shield and inner insulation to expose the inner conductor as shown in the photograph. A suitable detector probe is shown in **fig. 3**.

This arrangement allows rf voltage measurements along the line every 2.5 cm (1 inch). By using interpolation the voltage minimum can be located quite accurately between holes.

When part **A** of the positioning piece length has been determined, part **B** is calculated with

$$\theta(\text{electrical degrees}) = Tan^{-1}\frac{1}{\sqrt{VSWR}} \quad \textbf{(1)}$$

To convert θ in electrical degrees into part **B** in cm, first measure the distance between the voltage minimum points on your fluted line. Multiply this figure by two to find the line wavelength. Then

$$\text{part } B\ (cm) = \frac{\theta \times \text{line wavelength (in cm)}}{360} \quad \textbf{(2)}$$

If you're working with inch dimensions, simply substitute those dimensions at the appropriate places in the above formula.

Line wavelength can also be calculated from

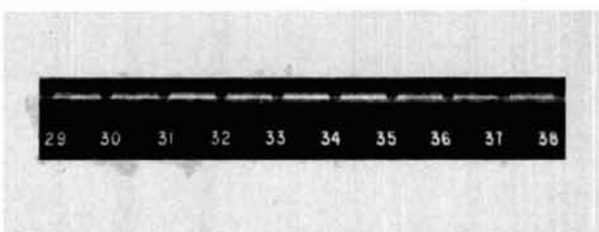
$$\text{Line wavelength} = \frac{29980\, v_p}{f_{MHz}}\ (cm) = \frac{11803\, v_p}{f_{MHz}}\ (inches)$$

where

v_p = velocity factor of the line (0.686 is typical for coax with polyethylene dielectric)
f_{MHz} = operating frequency
part **B** = the distance from the voltage minimum to the stub location
VSWR = the standing wave ratio of the unstubbed system measured at the antenna
θ = part **B** expressed in electrical degrees
Line wavelength = wavelength measured on the fluted line in cm (or inches) or computed.

The total length of the positioning piece is part **A** (the measured part) plus part **B** (the computed part). A section of feedline cut to that length (including connectors) is connected as shown in **fig. 4** with a variable capacitor substituted for the stub.

As the capacitor is adjusted, the reverse power indicated on a VSWR meter will dip to a minimum. If the positioning piece is the correct length, the minimum will be zero. If you don't obtain a zero reading, loosen the connector on the stub end of the positioning piece as shown in **fig. 4** to slightly lengthen the piece (don't take it off). If the reflected power dimin-



A commercial fluted line section.

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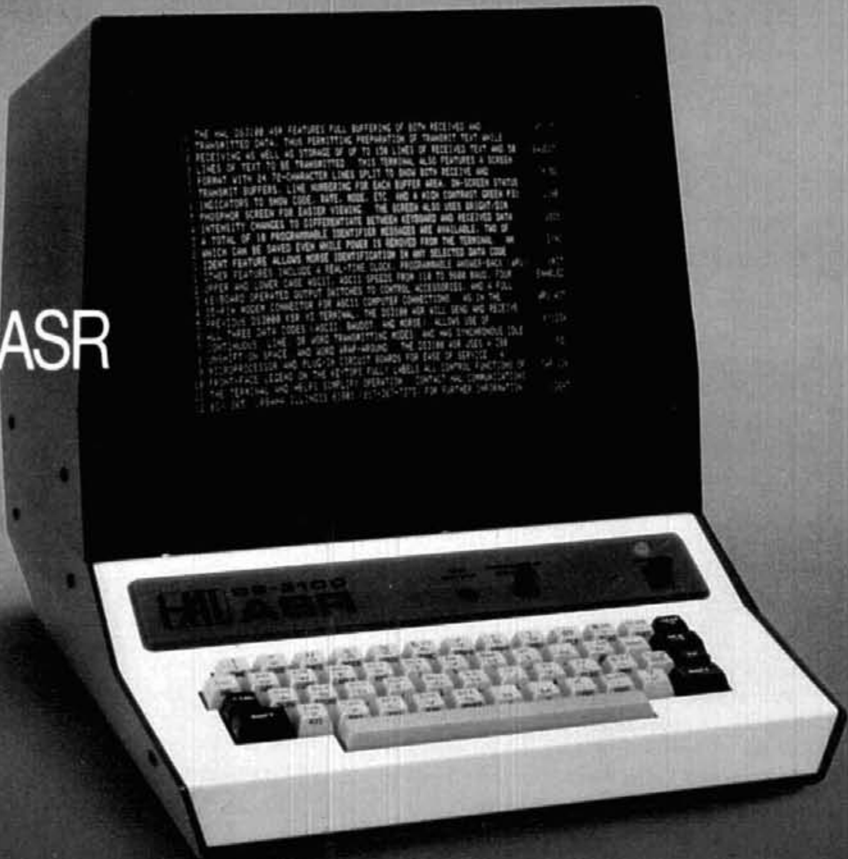

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ishes as the connector is loosened, the positioning piece is too short and should be lengthened in 1-cm (3/8-inch) increments until a minimum is obtained (representing a VSWR of 1.1 or less). If loosening the connector increases the reflected power, the piece is too long and should be shortened in 1-cm (3/8-inch) increments.

When the positioning piece is the correct length, the minimum reflected power should be noted and an open-circuited coaxial stub with a connector on only one end should be substituted for the capacitor

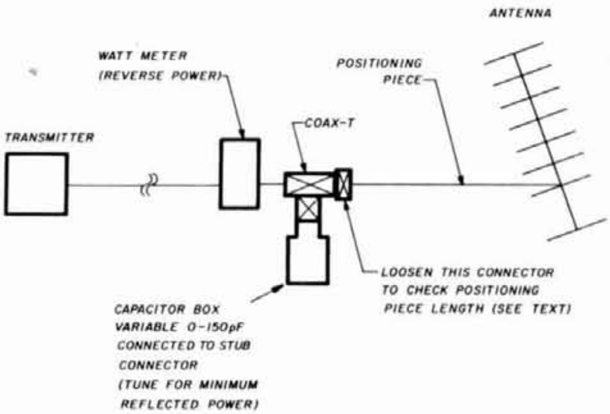


fig. 4. After the exact length of the positioning piece has been determined, a capacitor box can be substituted for the coaxial stub. Varying the capacitor should reduce the reverse power to a very small value. If not, the length of the positioning piece will have to be adjusted until the reverse power is negligible. Once the value of the capacitor has been determined, the equations in the text can be used to find the physical length of the coax.

box. The stub length in electrical degrees is determined with the following formula

$$\phi = tan^{-1} \frac{VSWR - 1}{\sqrt{VSWR}} \quad \textbf{(3)}$$

where

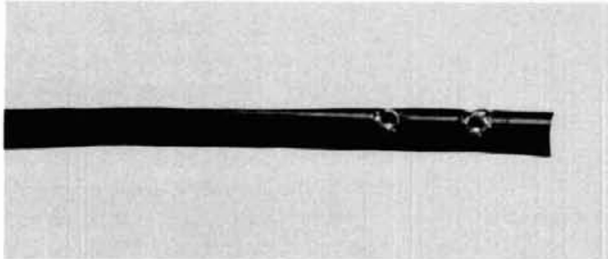
ϕ = electrical length of the stub in degrees

This is converted to stub length in cm by this formula:

$$stub\ length = \frac{\phi(line\ wavelength,\ cm)}{360}$$

The stub should be cut at least 2.5 cm (1 inch) too long. After it is in place use garden pruning shears to cut off first 1 cm sections, then smaller ones as the reflected power approaches the previously noted minimum; try not to cut off one section too many!

When the stub is properly installed and pruned, your antenna will show a virtually perfect 50-ohm load to the feed system and the VSWR on the feedline will be nearly 1:1.



Sample section of a homemade fluted line.

quarter-wavelength matching system

When using a quarter-wavelength transformer section there are only two computations to make. First the quarter-wavelength length is found either by direct measurement with a fluted or slotted line section or by the following formula

transformer section length =

$$\frac{29980\ v_p}{4f_{MHz}}\ (cm) = \frac{11803\ v_p}{4f_{MHz}}\ (inches)$$

Next, the characteristic impedance of the transformer section is determined from

$$Zo = \sqrt{Zs \cdot Zr}$$

where

Zo = impedance of the matching section
Zs = impedance at one end of section
Zr = impedance at the other end of the section

A section of the appropriate cable is then chosen, cut to the computed length, equipped with connectors, and installed in the system (see **fig. 5**).

The real problem with this method is finding the appropriate impedance cable, of course. Referring to the example, how far would you have to look to find commercial 61-ohm cable? The problem can be alleviated if the system is designed so the required characteristic impedance is near commercially available

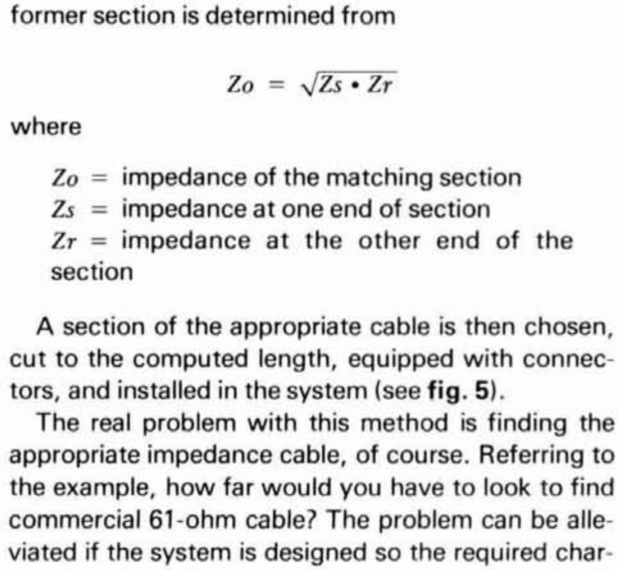


fig. 5. Example of a quarter-wavelength matching transformer. To match between 50 and 75 ohms requires a coaxial section with a characteristic impedance of 61.24 ohms.

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However, the use of this or any vertical assumes you have a good ground or radial system for efficient operation. If you do not have enough room or do not wish to install such a radial system, performance may suffer. And if you do have radials, you still have to change the feeder connections each time you operate on 160 meters.

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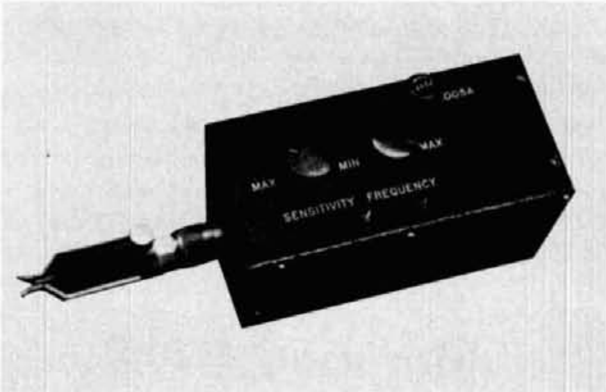

Complete fluted line detector showing the probe and detector.

values, but this isn't always possible. You can also construct the cable yourself in rigid form, or forget it.

quarter-wavelength sections as power dividers

If careful attention is paid to the values of impedance available for conversion at different points in a proposed antenna system, some natural combinations can be found. One example is the parallel combination of 50-ohm antennas with 75-ohm matching sections as shown in **fig. 6**.

In this example 50-ohm loads are connected to 71-ohm matching sections which transform the impedance to 100 ohms. The feedline then sees two 100-ohm loads in parallel, or a total load impedance of 50 ohms. In addition, since the input points to the 100-ohm section are equal, the current (and power) will split evenly between the antennas.

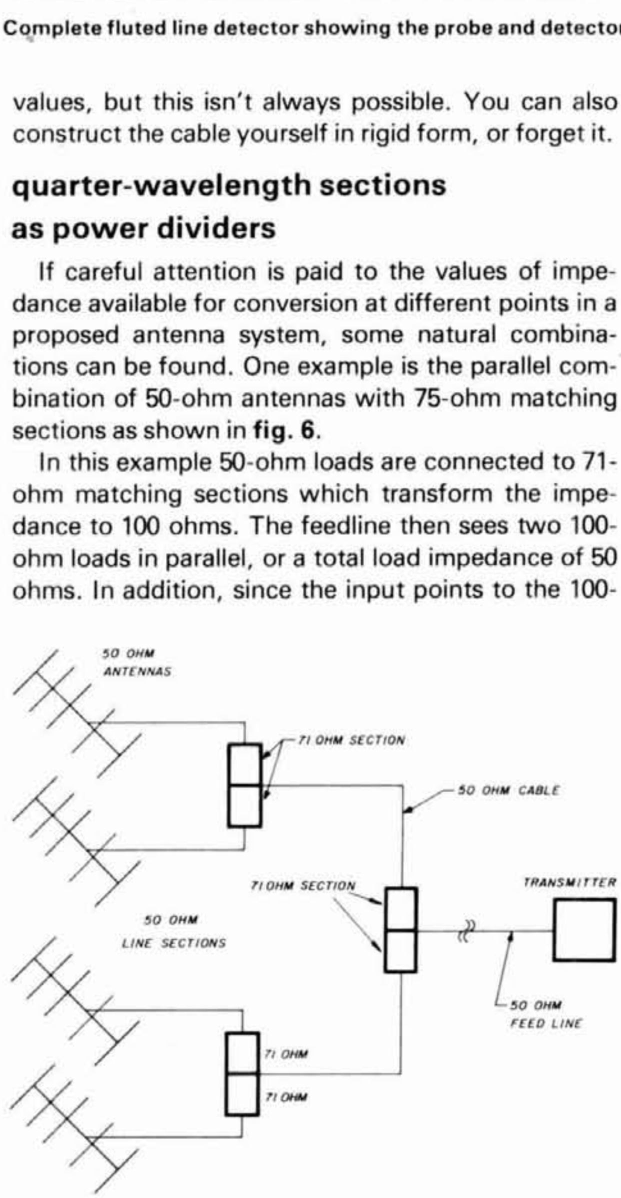

fig. 6. As seen in this diagram, four antennas can be matched to the transmitter by using quarter-wavelength sections of 70-ohm coax. Each antenna's impedance is transformed to 100 ohms and combined with another antenna to get back to 50 ohms.

Further, loads with the same impedance can be fed with different power levels by using different cable values in the sections (although this brings back the problem of noncommercial impedance values). In this case the desired power levels are converted to currents. The input impedances to the transformer sections are then selected to obtain the desired currents as shown in **fig. 7**.

phasing

Another factor to remember when operating multiple antennas is phasing, or timing the arrival of rf energy at each antenna. Generally, if the antennas are simply stacked together, you want them to operate in phase; all feedlines from the antennas to the matching transformers must be equal length.

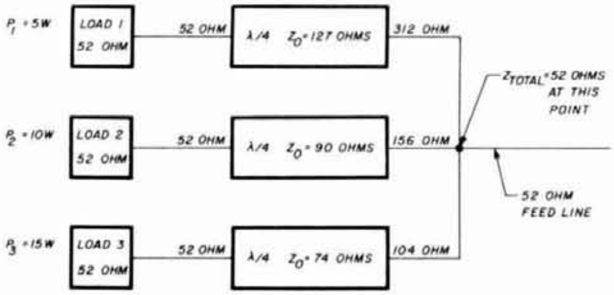

fig. 7. By selecting the impedance of the matching sections, an unequal power division can be obtained. This procedure is useful when trying to create a particular radiation pattern from a group of antennas.

If the antennas are not to be in phase, the appropriate delays can be easily obtained by adding additional cable in the indicated antenna feedlines. Added cable length increases the phase delay; the amount of delay can be computed from

$$\text{degrees of delay per cm of cable} = \frac{360}{\text{line wavelength, cm}}$$

Stubbing and matching sections are not really the bugaboo that they may seem. A good stubbing job can be done easily in an hour; a matching transformer takes less time. The frequency changes over the two-meter band, for example, have negligible effect. These matching tricks can be a big help in making efficient, custom-tailored Amateur arrays.

reference

1. Robert S. Stein, W6NBI, "How to Use the Slotted Line for Transmission-Line Measurements," *ham radio*, May, 1977, page 58.

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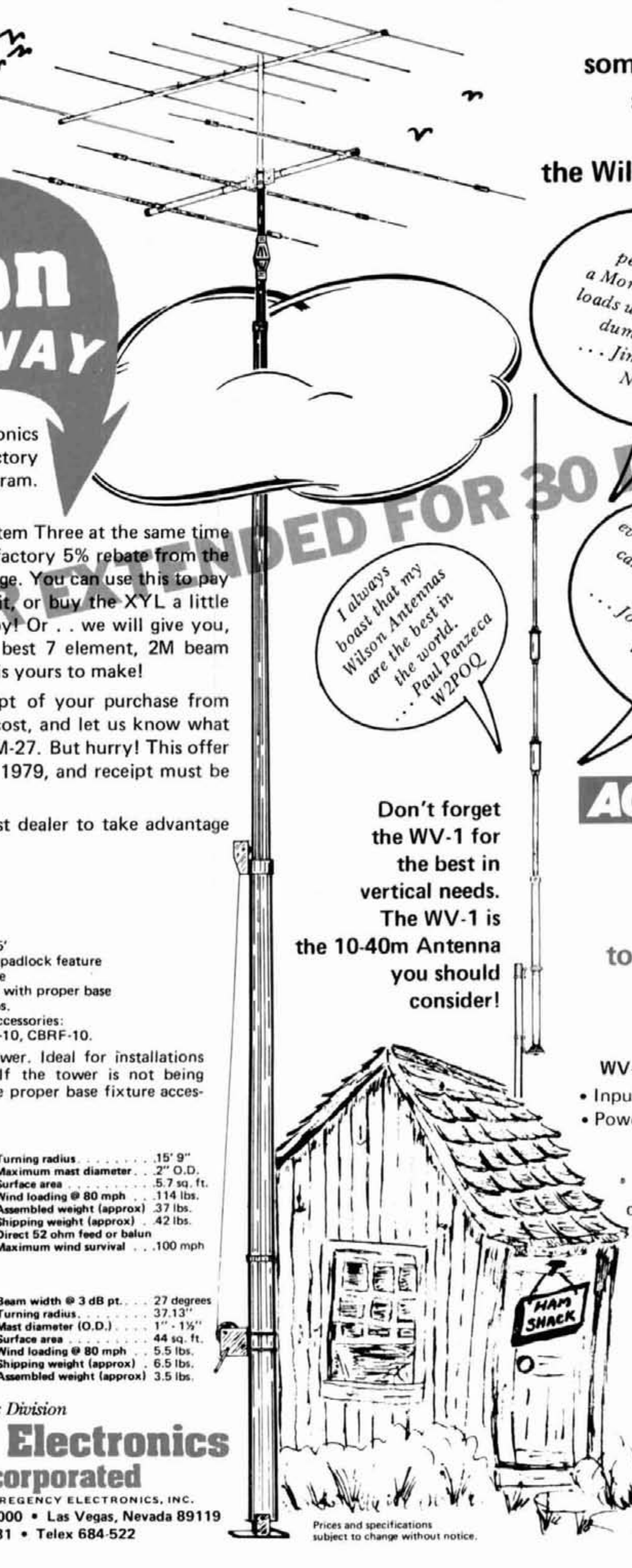

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VSWR at resonance	1.3:1	Wind loading @ 80 mph	114 lbs.
Impedance	50 ohms	Assembled weight (approx)	37 lbs.
F/B Ratio	20 dB	Shipping weight (approx)	42 lbs.
Boom (O.D. x length)	2" x 14' 4"	Direct 52 ohm feed or balun	
No. of elements	3	Maximum wind survival	100 mph
Longest element	27' 4"		

M-27 - 7 ELEMENT 2M BEAM

Band MHz	144-148 MHz	Beam width @ 3 dB pt.	27 degrees
Gain	11 dB	Turning radius	37.13"
VSWR	1.2:1	Mast diameter (O.D.)	1" - 1½"
Impedance	50 ohms	Surface area	44 sq. ft.
Boom (O.D. x length)	1" x 64"	Wind loading @ 80 mph	5.5 lbs.
Number of elements	7	Shipping weight (approx)	6.5 lbs.
Longest element	40"	Assembled weight (approx)	3.5 lbs.

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multiband antenna system

A different approach to triband-beam design results in performance comparable to that of large, single-band, multielement Yagis

Until the early 1950s, *a person interested in serious* DX had to resort to stacked Yagis, fittingly called a Christmas tree, when faced with the limitation of a single rotor and mast. For most of us, however, it is difficult enough to build and tune a single Yagi beam, much less three stacked beams. During the record sunspot peak of 1956-58, several Amateurs tried to solve the multiband antenna problem, resulting in a number of new beams, especially mini types.

Most people are familiar with the W3DZZ trap antenna either as a dipole, ground plane, or Yagi tribander. The disadvantages and difficulties of this antenna, compared with a single-band, full-size Yagi, are that at 14 and 21 MHz the element is less than full size, causing reduced gain and bandwidth (both SWR and F/B ratio bandwidth). It is a major problem to seal the traps (tuned circuits) so that moisture and the polluted atmosphere do not cause corrosion at element, coil, and capacitor contacts, especially if dissimilar metals are used. In addition, a compromise between trap Q and bandwidth had to be chosen. For a triband element, four traps are required per element, with the contact resistance in the traps causing losses. This form of the triband Yagi is now the most widely used Amateur DX antenna, and it is manufactured in several countries.

G4ZU tribanding

Substantial initial interest, except in the U.S., earned G4ZU British patent number 790,576 (12-2-1958) for his multibanding method. Here are some claims and rebuttals for his version:

1. A beam element that was self-resonated near 21 MHz was made to resonate near 14 MHz by inserting a loading coil or twin boom hairpin loop in the middle of the element.

Fact. *The coil actually used had only about half the* inductance a coil would need to act as claimed.

2. An "automatic-switching stub" in the form of a piece of open-ended twin lead or coaxial cable was connected in parallel with the loading coil. The stub was to act as an electrical short when the antenna was used near 21 MHz. This was because the stub alone resonated at this frequency, electrically eliminating the tuning effect of the loading coil at 21 MHz.

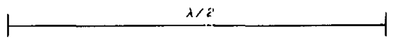
Fact. An open quarter-wavelength stub acts, under matched conditions, like a near short, but G4ZU had a different case and insisted that the stub cable had to have a very special "velocity factor" (*i.e.*, capacitance per unit of length). It appeared to me that the cable capacitance, in conjunction with the parallel inductor, performed the two-band tuning — and not the stub, as claimed.

3. The 28-MHz tuning was not explained by G4ZU. In private correspondence, the inventor stated that the coil-to-mounting-channel capacitance did the trick together with a part of the stub.

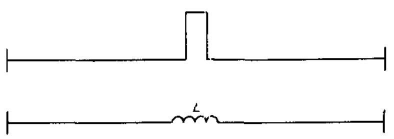
Fact. By placing the stub cable inside the element or double-boom tubing, the resultant coupling of distributed L and C caused the 28-MHz resonance to occur, along with others.

The experiments which demonstrate these facts can easily be repeated. Start with a dipole resonating at

$$f_{MHz} = \frac{300}{\lambda(meters)} \text{ or } \frac{492}{\lambda(feet)}$$



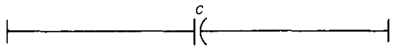
A dipole can be tuned to a lower frequency by inserting a loading inductance, L.



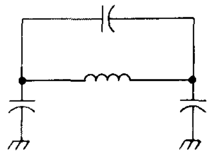
By Hans F. Ruckert, VK2AOU, 25 Berrille Road, Beverly Hills, 2209 Australia

This article first appeared in *Amateur Radio*, the journal of The Wireless Institute of Australia, in April, 1978.

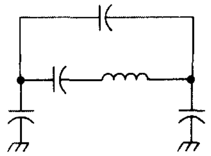
Or, to a higher frequency with a capacitance, C.



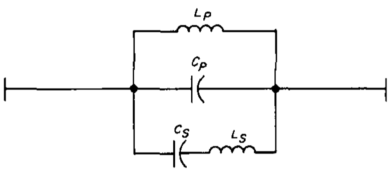
By looking at the distributed L and C components, the antenna can be reduced to a parallel-tuned circuit,



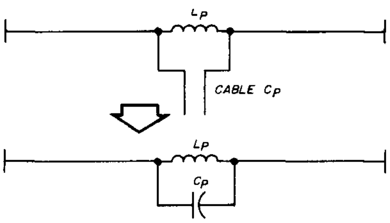
with the dipole itself acting as a series-tuned circuit,



resulting in the combination looking like two resonant circuits.

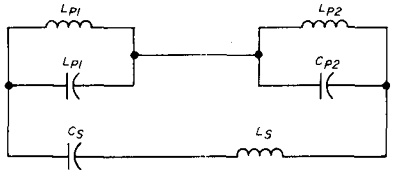


The paralleled parallel-($L_p + C_p$) and series-tuned circuits ($L_s + L_s$) form the "multiband tank" used in transmitters to cover 3.5 to 30 MHz without coil switching. There are always two resonances occurring at the same time, 3.5 to 8 MHz (L_p and C_p) and 7 to 30 MHz (L_s and C_s), depending on the values of C_p and C_s



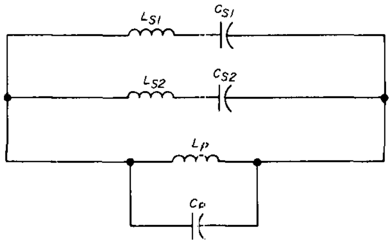
By replacing the series-tuned circuit (L_s and C_s) with the dipole half-elements, and the cable capacitance by a lumped capacitor of the same value, you obtain (in either case) a two-band element (for example 14 and 21 MHz, 21 and 28 MHz, or even 70 and 180 MHz). The cable (stub) resonance and the velocity factor of the cable used are of no consequence — only the cable capacitance matters. L_p may be a coil, a hairpin loop, or a double boom with shortening bar. Bringing the cable (C_p) near the element creates more resonances, due to the distributed L. This form was too difficult to tune, and unwanted resonances occurred as well.

After understanding what made the G4ZU beam work on three bands, I looked for a three-frequency circuit that was tunable (and controllable) and could be converted into a triband antenna element. To obtain resonance on three different frequencies (14.15, 21.25, and 28.6 MHz) at the same time without switching inductors or changing capacitors, you need three inductors and three capacitors arranged as follows:



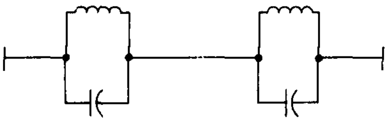
A

OR

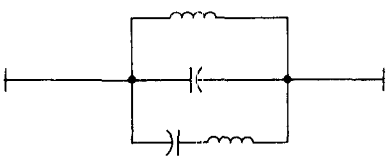


B

These two circuit versions fulfill this requirement. By adjusting the three L and C values, the three simultaneous resonances can be moved over a wide range.

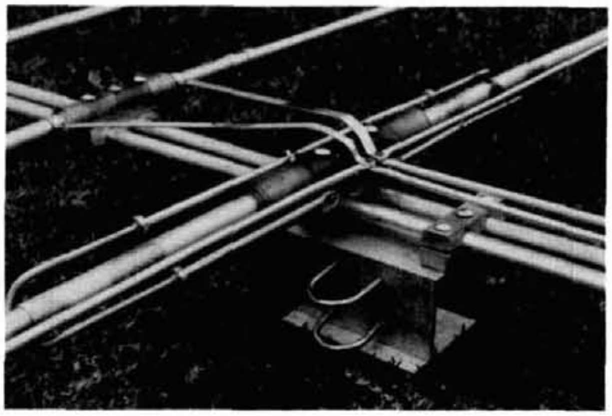


A



B

As previously described, one series-tuned circuit can again be replaced by a dipole to obtain a triband element. In **A** above, you then have two differently tuned, parallel-tuned circuits in series; in **B**, a series and a differently tuned parallel-circuit in parallel in the middle of the element. This "triband element" may be any Yagi-type radiator, director, or reflector, the groundplane radiator, or a cubical quad element.



Close-up view of the center element showing the hairpin loops and interconnecting straps. Note that a double boom is used in this antenna.

The dipole may have any length, from one quarter wavelength to a full wavelength. The resonant circuits are not tuned to the antenna operating frequencies, and should not be confused with dipole traps (W3DZZ type).

Since 1960, the **A** version has been built in Yagi, groundplane, and quad form by Amateurs in several countries. I've described these antennas in VK, ZL, DL and W-land Amateur literature. Other Amateurs (JA, ZS, DM, OK) have also described their experiences with this system. Unfortunately, antenna manufacturers showed no interest. This is a true triband-antenna element, where the full element is used on all three frequency bands, unlike the unused dipole ends of the W3DZZ system.

DJ2UT version

DJ2UT was particularly successful in using this triband-tuning system, and he asked the writer for permission to produce this antenna and to call it the VK2AOU beam (see **fig. 1**). He had continued the antenna's development, later extending the 14-MHz elements to full size to be competitive with other full-size Yagis. On 21 MHz, the element is 0.75 wavelength and on 28 MHz a full wavelength long (collinear), resulting in excellent gain and bandwidth on the 15- and 10-meter bands. The front-to-back ratio, and so the reflector gain and bandwidth, were improved by feeding the reflector via a crossed-phasing line. This resulted in more concentrated radiation in the vertical plane. Mechanically, the reflector to driven element and driven element to director spacing is only 2 meters (6 feet), producing a short beam. For strength, a twin boom (25 × 3 mm [1 × 1/8 inch] Al-Mg-Si corrosion-resisting tubing) is used. All clamps are cast from an aluminum alloy. Only stainless-steel screws, bolts, and nuts are used, to avoid electrolysis and corrosion at contacts between dissimilar metals.

feed system

Feeding with a single coaxial cable presented a number of problems because of the large impedance and phase changes, especially at 21 MHz, A T-match connected to both the driven element and reflector finally gave the desired, and easy to control, results. The 28-MHz match is improved by selecting a suitable L/C ratio for the tuned circuits. By placing proximity, or matching elements, for 21 MHz and 28 MHz in front of and near the driven element, the impedance at the T-match is also suitable for 21- and 28-MHz operation. At 21 MHz, the resonant frequencies of the 21-MHz match element and the radiator are above and below 21.25 MHz respectively, much like a band filter. At 28 MHz, the match element also acts like an additional director.

construction

The centers of the long elements and the 21-MHz match element have a polycarbonate center that seals and holds the coaxial cable capacitors (about 75

director	8.6 meters
28-MHz match element	4.9 meters
21-MHz match element	6.7 meters
radiator	10 meters
reflector	10.6 meters
radiator T-match	each side 1 meter long
reflector T-match	each side 1.4 meters long
radiator to 21-MHz match element spacing	0.4 meters
28-MHz match element to 21-MHz match element spacing	0.4 meters
director to radiator to reflector spacing	2 meters each

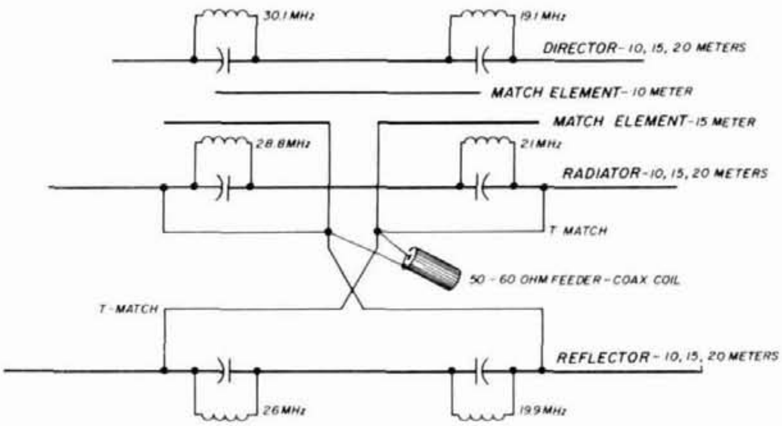
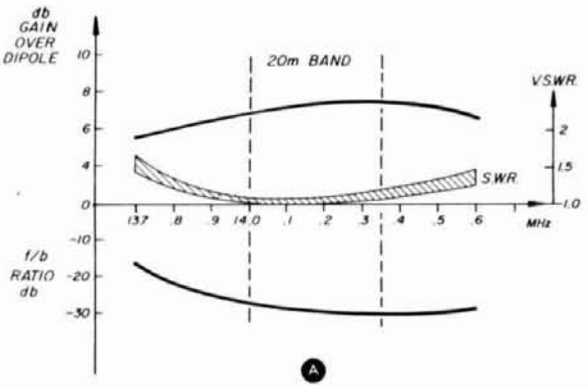


fig. 1. Physical layout of the VK2AOU multiband beam as manufactured by DJ2UT. The capacitors are formed by short lengths of coax inserted in the center of the element, while the inductances are small hairpin loops.



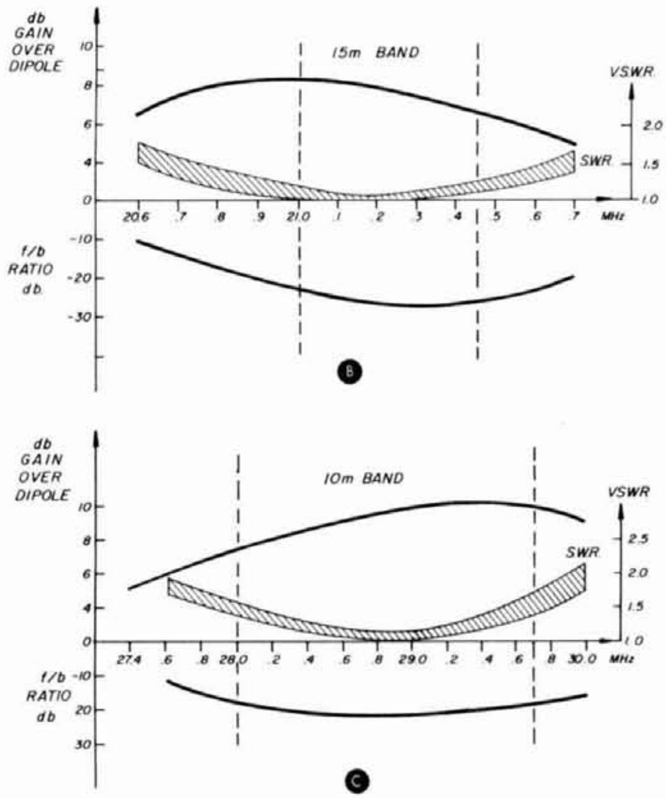
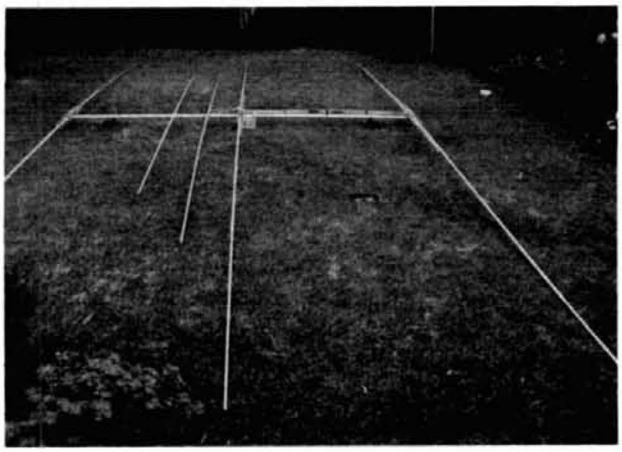


fig. 2. Performance characteristics of the VK2AOU beam. The test dipole was located at the same height, though ten wavelengths distant.

and 100 pF), the stubs for the hairpin loops, and the pieces of 30 × 2 mm element tubing. Two-part clamps and three bolts hold each of the five elements to the boom, and also the boom to the mast-mounting bracket. An insulated wire and clamp for the mast extension are used to support the boom and avoid sagging. The weight with the original tubing amounts to 23 kg (50 pounds). The turning radius is 5.8 meters (19 feet) and the antenna area is 0.65 square meters (7 square feet).

The antenna can handle a continuous rf power of 2.5 kW. The tuning elements are not at high rf voltage points as in trap beams. Galvanized copper solder lugs are used to attach the RG8U coax. The use of the popular 1:1 ferrite balun is not recommended for obtaining symmetrical feeding of the beam halves because it was discovered that the same degree of coupling was achieved without this core. DJ2UT recommends using 3.5 meters (11.5 feet) of coaxial cable in the form of a closely wound, six-turn cylindrical coil near the beam feed point to achieve a balanced feed.



The complete triband beam prior to installation.

performance

When compared with a W3DZZ-type triband beam on a 7-8 meter boom, this antenna exhibits a superior forward gain and reflector bandwidth (see **fig. 2**). On 20 meters, the performance is better than that of a two-element quad or three-element, full-size Yagi. On 15 meters, due to the extended elements, performance is similar to that of a four-element, full-size Yagi. On 10 meters the performance is due to the collinear (double length) elements and the 10-meter match element, and is comparable to the performance of a five- or six-element Yagi.

The VSWR curves are shown as a band because nearby objects cause a change depending upon proximity.

bibliography

Grossman, Robert E., WAØUDJ, "Triband Delta-Loop Beam," *QST*, (Technical Correspondence), December, 1969, page 52.

Ruckert, Hans F., VK2AOU, "A Different Multi-band Aerial System," *Amateur Radio* (Australia), April, 1958.

Ruckert, Hans F., VK2AOU, "Tests with Multiband Beams," *Amateur Radio* (Australia), May, 1958.

Ruckert, Hans F., VK2AOU, "The Triband Beam at VK2AOU," *Amateur Radio* (Australia), June, 1958.

Ruckert, Hans F., VK2AOU, "A Triband One-Loop Cubical Quad Element," *QST*, March, 1969, page 50.

Ruckert, Hans F., VK2AOU, "More on the One-Loop Triband Quad Element," *QST*, (Technical Correspondence), May, 1969, page 49.

Ruckert, Hans F., VK2AOU, "The Mono-Loop Triband Cubical Quad," *CQ*, January, 1971, page 41.

ham radio

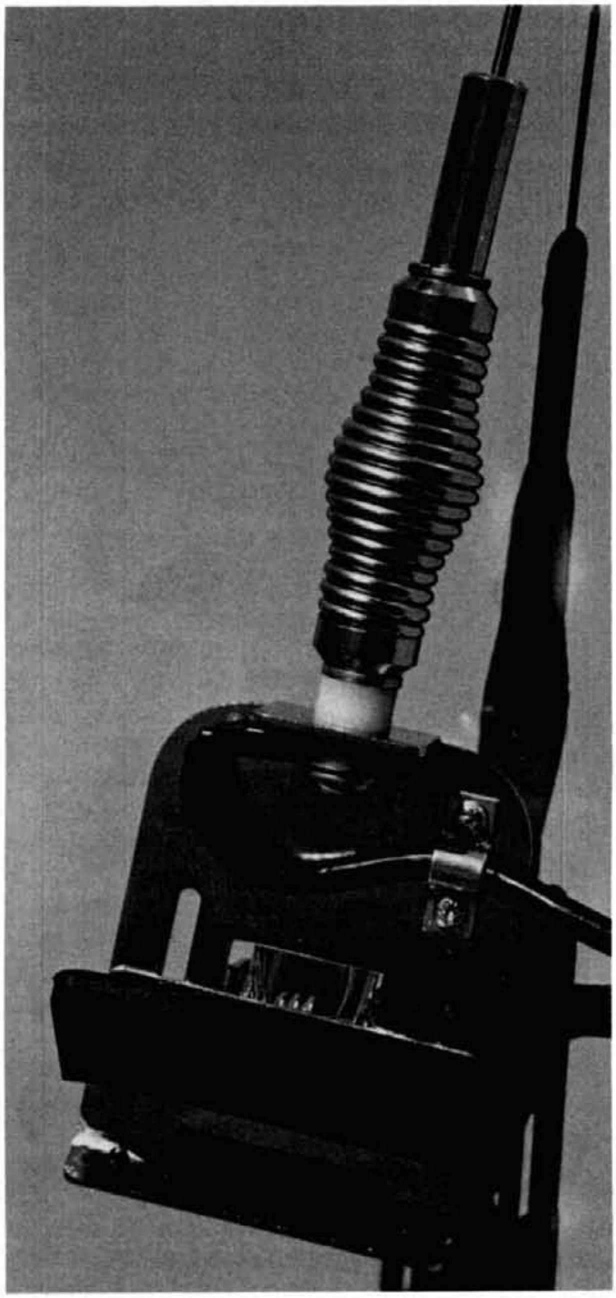
TS-1

TS-1JR

PE-2

SD-1

homebrew 2-meter mobile antenna



There's no doubt that the Citizen-Band boom is here. There are millions of CBers and millions more CB radios and accessories. Hams, always ready to make something out of nothing, are discovering many ways to use CB components for Amateur-Radio use. This article is about another use: a 2-meter, ¼-wavelength, mobile gutter-clip antenna made from CB antenna parts. Although I designed it for 2 meters, the same techniques could be used for any vhf or uhf band by making appropriate changes in antenna length for the desired frequency.

Starting at the base and working up, the parts used are these: a gutter-clip antenna mount (originally intended for use with a center-loaded CB antenna); a spring with an M6 (¼-20) threaded female base and a top that takes a whip (this is a part from a base-loaded CB antenna); and, finally, the whip itself, which is stainless steel. The whip can be a CB or Amateur Radio part.

construction

Here's how it all goes together. The gutter-clip mount that I found had RG-58/U coax and a PL-259 connector attached. If the clamp you find doesn't include the cable you'll have to make one. Obtain a 3-meter (10-foot) length of RG-58/U coax and solder a PL-259 connector (or the connector to fit your radio) to one end.

The other end of the coax goes to the antenna. Solder the coax center conductor to a solder lug large enough for a 6.4-mm (0.25-inch) bolt. Even if your clamp has coax with it, you may have to replace the solder lug with one that will fit. If you solder on a new lug, use heat-shrink tubing over the connection, part of the lug, and about 25 mm (1 inch) of the coax. This will help protect the connection and act as a cable strain relief.

Connect the coax outer conductor to the metal clamp. This is a little tricky. Make the ground connection at the U-shaped holddown clamp. To do this and still have shielding from there to the antenna base, carefully cut away a 3-mm (0.125-inch) piece of the outer insulation all the way around at the point where the coax will be under the holddown clamp. Be careful not to cut the braid. Then wrap a 25-mm (1-inch) length of bare wire around the coax braid. This wrap will protrude past the outer insulation to provide good contact with the clamp and bracket when tightened down.

You're now ready for the spring. The spring may have a 6.4-mm (0.25-inch) stud screwed into the bot-

By Joel Sampson, WD8QIB, 3009 Calumet Street, Weber Road and Calumet, Columbus, Ohio 43202

tom; if so, remove the stud. To attach the spring to the clamp, use an M6 (¼-20) by 25-mm (1-inch) round head bolt through the solder lug, an insulating washer, the clamp, an insulating washer, a lock washer, and the bottom of the spring in that order, bottom to top. Note that some of the gutter clamps have insulating washers smaller than 6.4 mm (0.25 inch); if so, drill them out before assembling. Tighten the bolt.

radiating element

You're now ready for the antenna whip. It can be almost any stiff wire, but stainless steel designed for

Construction of the 2-meter, quarter-wavelength, mobile whip antenna. Parts were scrounged from CB supply stores and the author's junk box. The antenna is easy to unclip and remove when you leave your car unattended.

this purpose looks good and won't rust. You may be able to find a broken piece large enough to work, or it can be purchased at any electronics store that sells CB or ham equipment. A CB whip for a bottom-loaded antenna can be used and should be long enough to make two 2-meter antenna whips.

The whip goes into the top of the spring and is held in place with a setscrew (which may take a hex key wrench for adjustment). Position the whip in the opening as far as it will go, then back it out about 12.7 mm (0.5 inch). In this way you can loosen the setscrew and make minor changes in whip length without having to cut the whip. Antenna length is measured from the top of the whip to the bottom of the lockwasher under the spring. How do you find the correct length? Use the following formula:

$$\text{length in mm} = \frac{74970}{\text{frequency in MHz}}$$

$$\text{length in inches} = \frac{2952}{\text{frequency in MHz}}$$

For example, the middle of the 2-meter repeater band is 147 MHz:

$$\text{length in mm} = \frac{74970}{147} = 510$$

$$\text{length in inches} = \frac{2952}{147} = 20$$

operation

After the antenna is cut to the correct length you're ready to try it out. Clamp it on to the gutter mount and feed the coax through a window. A vhf swr bridge can be used to adjust the whip length for the lowest reflected power. This shouldn't be necessary, however, if you calculated and measured accurately.

In using the antenna, I found it to be very effective and convenient. Its performance is more than adequate for repeater use, and it's easy to unclip and slip through the car window when the car is parked, which is an excellent security feature. The antenna is small and weighs much less than the CB antenna for which the gutter clamp was intended, so you should have no problems with the clamp coming loose.

My total cost came to around $4 for parts, which were purchased from a "junk box" at a local Olson electronics store. Antenna parts from damaged CB antennas or surplus parts should be available free or inexpensively from a CBer friend or a CB store. Even if the parts are purchased brand new, the cost is still considerably less than for most commercially made units.

ham radio

sloping antenna array

for 80-meter DX

An array using wire elements that has given a good account of itself during the pileups — it's the W2LU sloper

Anyone who has put in an evening trying to work DX on 80 meters will understand the frustration that results in a desire to develop a better antenna system for this band. With 80-meter DX you soon learn that the criteria by which a "better" antenna system is judged would weigh directivity nearly equal to gain: *i.e.*, "You can't work 'em if you can't hear 'em." An increasingly popular way of obtaining a reasonable amount of both has been with the sloping dipole system. The sloper, as must be expected, has both positive and negative aspects.

the sloper antenna

Probably the sloper's biggest drawback is that, to get good azimuth coverage, it's necessary to have at least two radiators directed 180 degrees apart, with three radiators at 120-degree intervals being preferable. This arrangement requires a good-sized piece of real estate, typically a 61 by 53 meter (200 by 175 foot) lot for a full three-radiator system with reflectors.

The second drawback is that a big tower is highly desirable. Although functional slopers have been erected with tower heights of only 15 meters (50 feet), heights of 24 meters (80 feet) or more are preferable, with 31-37 meters (100-120 feet) being ideal.

On the positive side we have a number of points. Perhaps first is the sloper's excellent operating characteristics. The complete system as outlined in this article demonstrates a front-to-back ratio of 20-25 dB on signal paths on the order of 3200 km (2000 miles) or more. The gain of the system is estimated to be between 2 and 5 dB over a dipole, depending on the direction relative to the radiator.

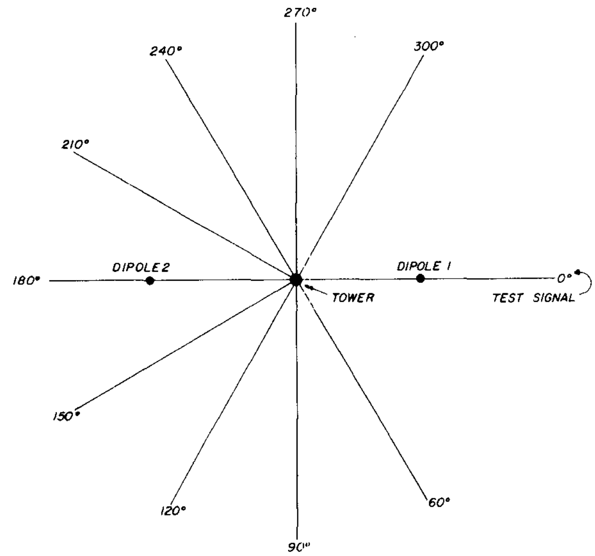


fig. 1. Plan view of the experimental sloper antenna. Two sloping dipoles were used. One was pointed directly at a vertically polarized test signal; the second was pointed 180 degrees away.

The other major advantage of the system, once the cost of the real estate and tower have been discounted, is its basic simplicity and its cost and effort effectiveness. The radiators are ordinary dipoles, and the reflectors are either plain wire or inductively loaded wires. Furthermore, the radiators, being dipoles, present approximately balanced feedpoints and don't require an extensive ground system for efficient operation. A system of radials tied in with a grounded tower would probably reduce ground reflection losses.

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experimental system

While developing this system, I performed experiments to determine the ideal angular spacing between the radiators and radial reflectors. The configuration used for these experiments consisted of two slopers; one was pointed directly at a vertically polarized test signal source approximately 0.8 km (0.5 mile away, and a second was pointed 180 degrees away. Two reflector wires were then placed radially, one to each side, so that the included angles between the radiators and reflectors could be varied in a symmetrical fashion as shown in **fig. 1**.

The tests were repeated several times and the results appeared to be consistent. **Table 1** indicates representative values.

Several conclusions were drawn from these tests. First, by comparing signals from the two dipoles, I found that an included angle of 60 degrees between the reflectors and the further dipole represented the best front-to-back ratio — 20 dB. An angle much smaller than this resulted in degredation. An angle of 60 degrees between the reflectors and the near dipole resulted in a forward gain of about 5 dB over a dipole. Therefore a system of three dipoles and three reflectors optimized both front-to-back ratio and forward gain. A four-dipole, four-reflector system would probably perform satisfactorily; however it's doubtful whether the added complexity would produce meaningful improvement in performance. On the other hand, dropping back to a two-dipole, two-reflector system would definitely result in degraded performance.

table 1. Test results from experiments to determine ideal angular spacing between radiators and reflectors in the experimental sloper antenna system.

reflector position (degrees)	dipole 1 (dB)	dipole 2 (dB)	f/b (dB)	gain (dB)
no reflectors	38	28	10	0
60-300	43	32	11	5
90-270	41	28	13	3
120-240	41	21	20	3
150-210	40	27	13	2

A system was then installed using a three-dipole, three-reflector configuration with 60-degree spacing as shown in **fig. 2**. All reflectors were cut to 43 meters (140 feet) and all dipoles were made resonant at 3.8 MHz. Although direct 180-degree, front-to-back checks were no longer possible, a large number of on-the-air checks confirmed the expected results.

As a further refinement to the system, I decided to try adding additional parallel reflectors under each dipole as shown in **fig. 3**. In this installation the dipole and radial reflectors are supported by a 30.5-meter (100-foot) tower. The added reflectors were hung from the 21-meter (70-foot) point on the tower, resulting in approximately 0.1-wavelength spacing from the dipole. Each reflector was 26 meters (85 feet) long and resonated at 3.5 MHz, with about 30 turns of B&W 3905-1 inductance. Obviously, higher towers would allow one to take greater advantage of this concept by making possible greater spacing and less inductive loading. Although I made no direct comparative measurements with and without these reflectors, it seemed that front-to-back ratio improved by about 5 dB, and the theory seemed valid.

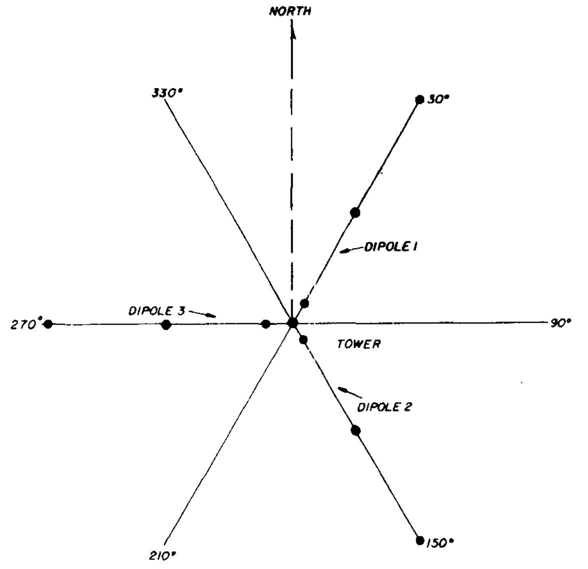

fig. 2. Sloper system using three dipoles and three reflectors with 60-degree azimuth spacing.

Tuning of the parallel reflectors was accomplished by grid dipping and noting the amount of rf energy in the element. With power fed to the radiator, I could

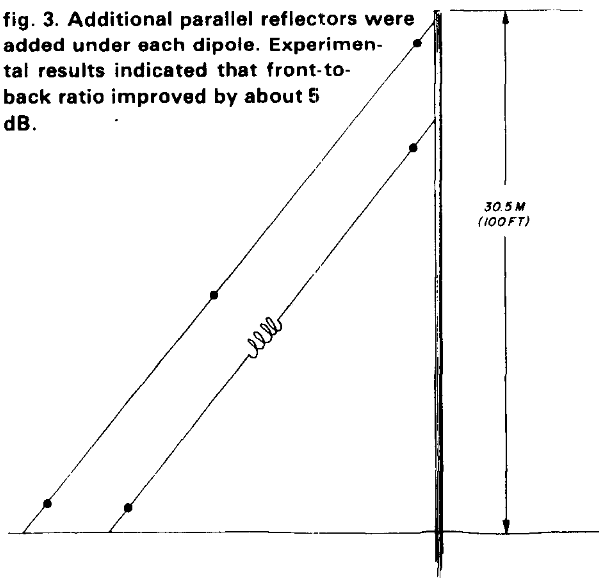

fig. 3. Additional parallel reflectors were added under each dipole. Experimental results indicated that front-to-back ratio improved by about 5 dB.

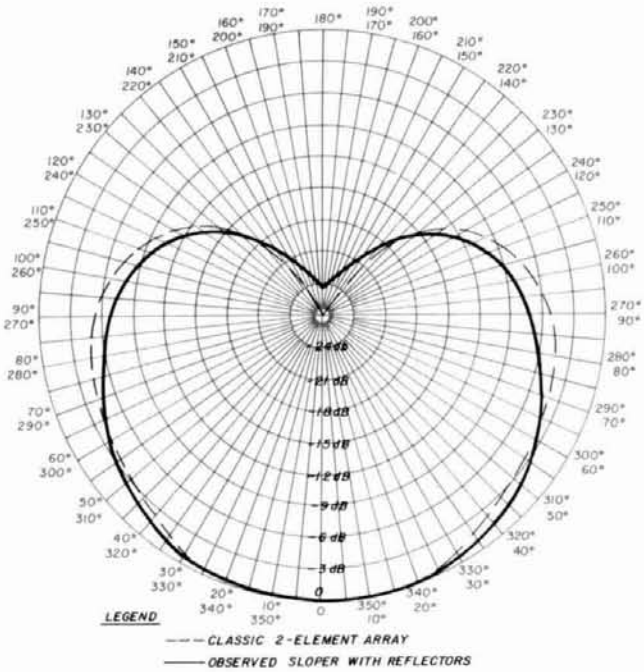

fig. 4. Beam pattern of the sloper using three radiators, three radially oriented reflectors, and three parallel reflectors. The data indicates response in the horizontal plane; that is, directivity, not gain.

draw an arc with a pencil from the low end of the reflector.* I assumed that this arcing was greatest when the element was self-resonant. The element was then made to resonate about 10 per cent lower in frequency, or at 3.5 MHz.

Thus the system was complete — using three radiators, three radial reflectors, and three parallel reflectors. With the aid of a large number of comparative signal-strength readings — taken in the receive mode (using a Drake R-4A receiver) to eliminate the S-meter variable — a beam pattern was developed, as shown in **fig. 4**. Also shown in **fig. 4** is the ideal pattern for a two-element vertical array using quarter wavelength spacing. It can be seen that the sloper pattern compares quite favorably in horizontal directivity. Remember that this data indicates a comparison only in the horizontal plane, not vertical, and that it indicates directivity, not gain — gain being a function of directivity and efficiency.

The system has been used for several years and has provided excellent, consistent, and reliable performance. It's been a great asset in digging DX out of the QRM and has always given an excellent account of itself in the pileups.

ham radio

*Not a very good test from an engineering standpoint, but one used by hams for years. Use caution and make certain you are insulated from ground. **Editor**

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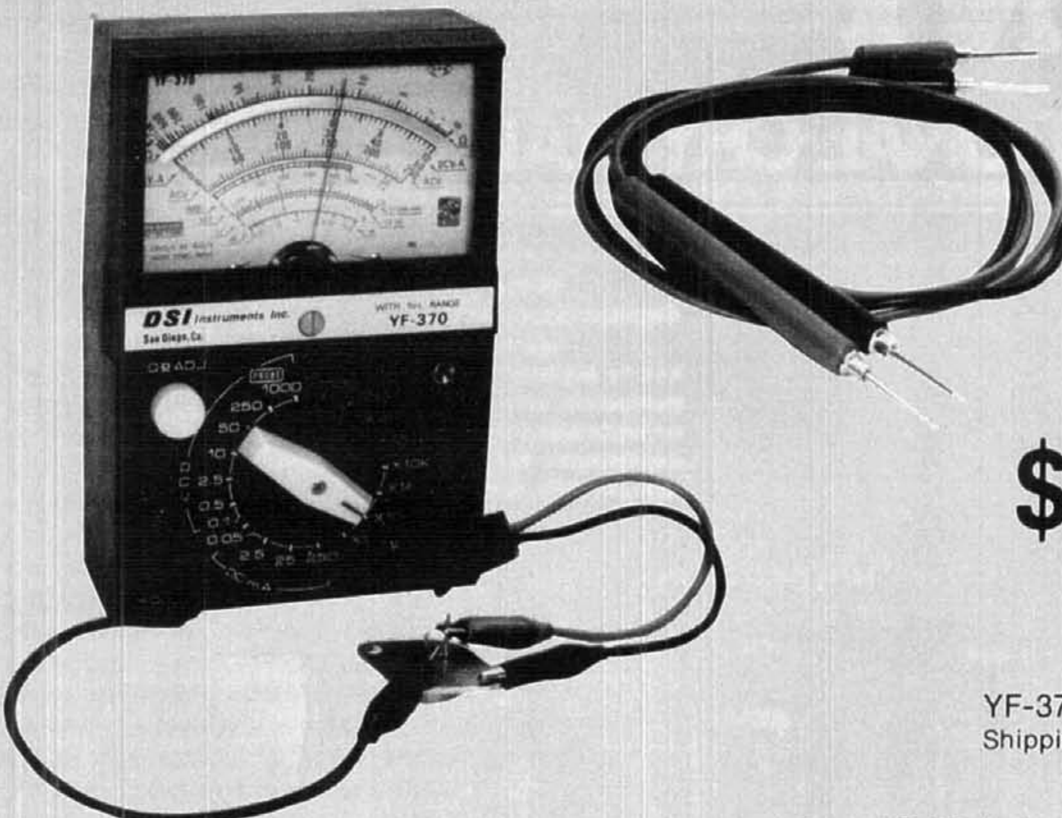

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antenna-performance measurements using celestial sources

A simple procedure for measuring the receiving figure of merit of large vhf and uhf arrays using celestial bodies as noise sources

High-performance vhf and uhf arrays for moonbounce, meteor, and tropo scatter are proliferating in the Amateur Radio ranks. This article describes a simple procedure for measuring the receiving figure of merit of large vhf and uhf arrays using radio stars, the moon, or the sun as a source. I developed the technique from the references and recently used it to measure the performance of the 25.6-meter (84-foot) moonbounce dish at K3NSS.

The method derives the ratio of the antenna gain, G, to the receiving system noise temperature, T, or G/T. G/T is a measure of system receiving sensitivity and applies directly in link calculations and serves as a standard for performance comparison. Knowing G/T and either the antenna gain (G) or the system noise temperature (T), the unknown parameter can be derived.

measurement procedure

G/T is measured from celestial sources by taking the ratio of the received signal* noise power to the noise power received from the cold sky. This ratio, called the Y factor, is compared with the known radiation flux density, S, of the source (**table 1**) to determine the receiving system figure of merit, G/T (**eq. 1**). Units of G/T are decibels per degree Kelvin, dB/°K.

The advantages of this technique are simplicity

*The signal of these celestial sources has noise characteristics.

By **William H. Curry, Jr., W5CQ/W4RXY**, 11003 Blue Roan Road, Oakton, Virginia 22124

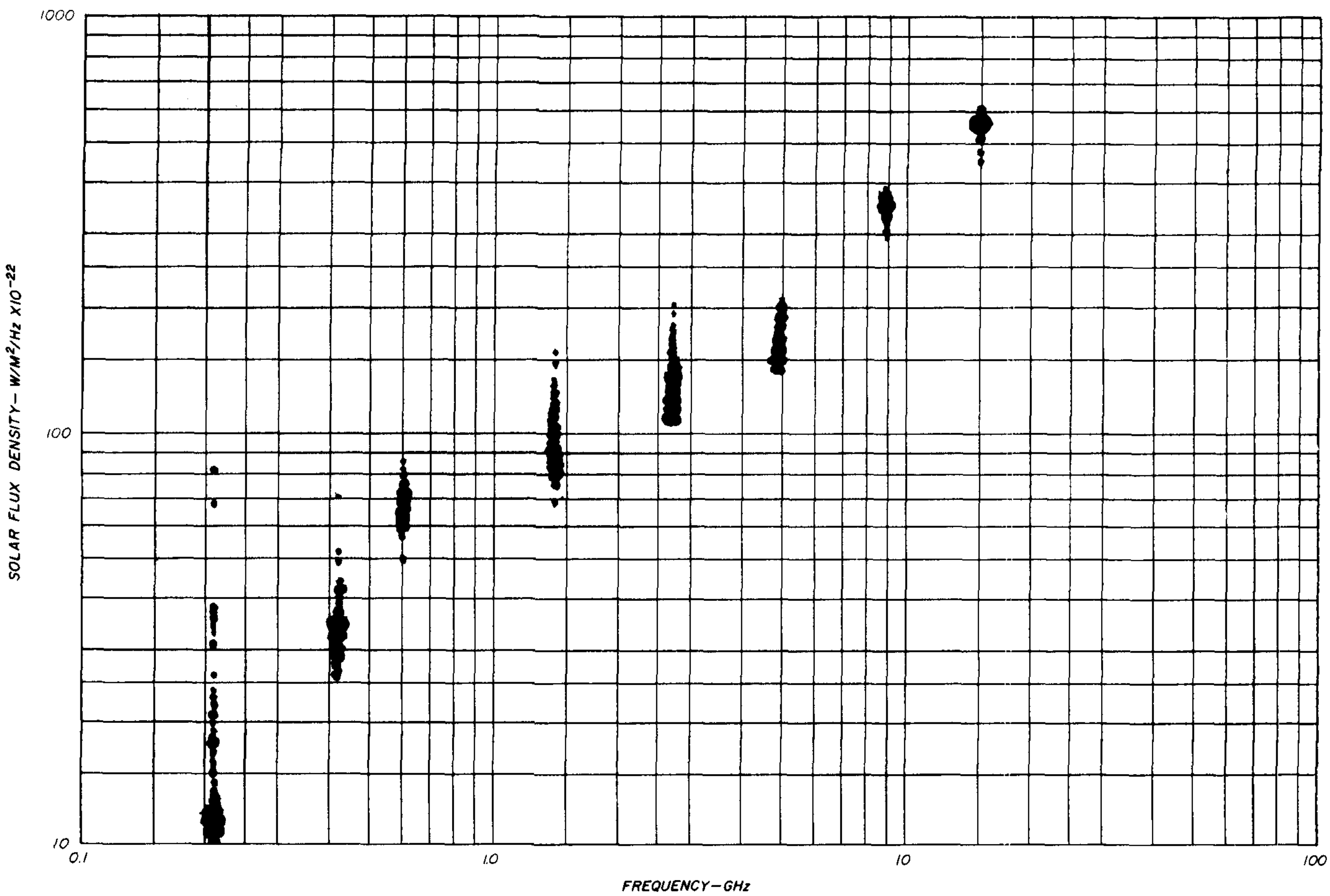


fig. 1. Solar flux density *vs.* frequency for July through December, 1978.

and accuracy. The technique is elegant because it requires no knowledge of either antenna gain, G, or system noise temperature, T. The critical measurement, Y, is calculated as a ratio so that measurement units and biases cancel. Finally, no special equipment beyond that for normal station operation is necessary. Only a suitable measure of receiver output power is required. This could be from the receiver S-meter, although better accuracy will result if a simple diode noise detector is used, as described in reference 1.

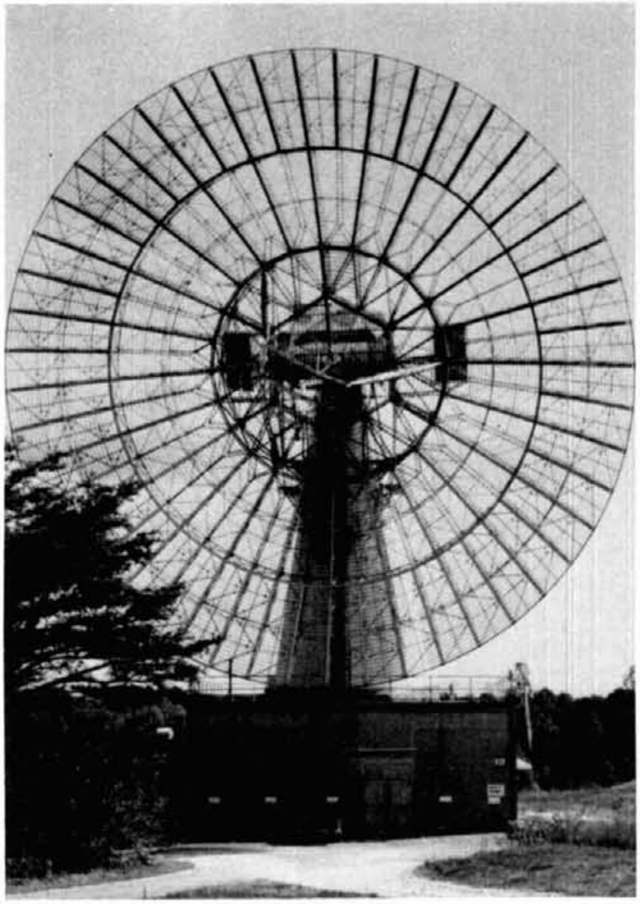
The qualifying minimum performance necessary to use this procedure is that the system must be able to detect sun noise, which is the strongest source. Measurement accuracy depends on the following factors:

1. Source used. The flux density, S, of the sun varies randomly by a factor of two or more. Therefore measurements from the sun may not be accurate within 3 dB unless corrected for actual solar flux at the time of observation (see **table 1** and **fig. 1**). If G/T is large enough to permit radio star measurements, accuracies to within 0.5 dB are attainable under favorable reception conditions.

2. Atmospheric/ionospheric attenuation. Source attenuation varies inversely with frequency and elevation angle. Observations at 144 MHz near the horizon may not be accurate within 3 dB. Observations of Cassiopeia A or Cygnus A at 1296 MHz, at elevation angles greater than 45 degrees, can be accurate to ±0.5 dB. The references contain additional information for those interested in corrections to obtain the greatest possible accuracy.

3. Number of measurements. Averaging a large number of observations, or applying linear regression analysis, will result in improved accuracy.

4. System noise floor. The more sensitive the system, the bigger will be the difference between signal noise power and cold sky noise power; *i.e.*, a larger Y factor. Reference 2 has an excellent chart of sky noise. It illustrates the relatively high noise characteristic of the galactic equator and the relatively low sky noise at the galactic poles. The more sensitive the system, the more attention must be paid to cold sky



The K3NSS 25.6-meter (84-foot) parabolic reflector in the stow position. A small group from the Southern Maryland Amateur Radio Club, including the author, restored the antenna to 432-MHz moonbounce. All rf systems, including the feedlines and feed antenna, were missing. The 432-MHz system was built and installed from individual and club assets. The restoration began in the fall of 1976, and the first contact was completed with LX1DB in April, 1977.

temperature. For example, to take readings from the moon, which has a very weak S, care would have to be taken to ensure that the cold sky reading was from a low noise area. This isn't as important for sun measurements. The objective is to get large Y factor measurements.

measurements

The algebraic relationship of G/T to the Y factor and source intensity, $I(s)$, is given by:

$$G/T = \frac{Y-1}{I(s)} \quad (1)$$

where:

$$Y = \frac{\text{signal noise power (source)}}{\text{cold sky noise power}}$$

$$I(s) = \frac{\lambda^2 S}{8\pi K} \quad (2)$$

λ = wavelength (meters)

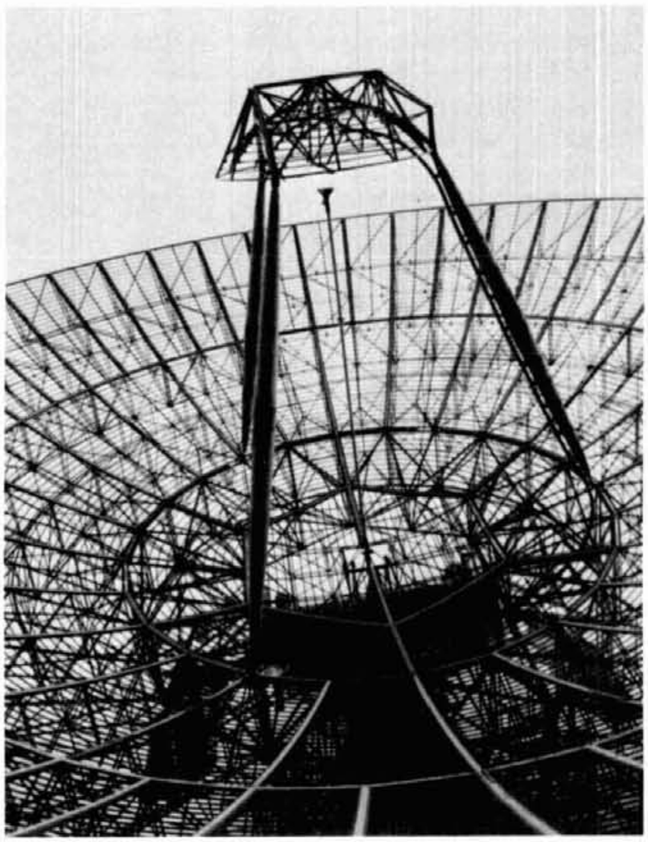
S = source flux density from **table 1** (watts per square meter per Hertz)

K = Boltzmann's constant
= 1.38×10^{-23} joules per degree Kelvin

Eq. 2 translates the source flux density, S, to units of equivalent temperature, T. It includes a factor (1/2) to account for the unavoidable loss resulting from the interception of a randomly polarized signal by an antenna sensitive to a single polarization. The factor $\lambda^2/4\pi$ accounts for the antenna gain relationship to wavelength (area factor).

The Y factor used here differs from that described by K2LMG and W2YBP in reference 1, but the principle is the same. WAØIQN, reference 3, describes a sun-noise measurement procedure using an estimate of antenna gain by use of horizontal and vertical

A view showing the antenna feed supporting the radiating element (dipole) covered by a polyethylene bag at the focus. The Gregorian reflector, supported by the 5.5-meter (18-foot) fiberglass tripod, was not usable in the restoration. Instead, the dipole feed was mounted on a feed tower, clamped at the base to a rotator for polarization control. The coaxial feed tower was made from 7.6-cm (3-inch) diameter aluminum irrigation pipe with a 3.5-cm (1-3/8-inch) diameter copper water pipe as a center conductor. The focal length of the dish is 7.6 meters (25 feet).



beamwidths, θh and θv. The procedure described here will yield better accuracy.

Eq. 1 is an algebraic ratio. The G/T value is more useful in logarithmic (decibel) units. Therefore the following conversion applies to the G/T ratio from **eq. 1**:

$$G/T\ (dB/^{\circ}K) = 10\log_{10}[G/T \text{ ratio from } \textbf{eq. 1}] \quad (3)$$

Remember that algebraic ratios usually result from, or are used in, equations with multiplication and/or division terms. Equations employing or yielding logarithmic values usually have addition and/or subtraction terms. **Eq. 1** written for logarithms is:

$$G/T\ (dB/^{\circ}K) = 10\log_{10}(Y-1) - 10\log_{10}[I(s)] \quad (4)$$

Typical G/T values for Amateur arrays range between -10 and $+15$ dB/°K.

Those interested in the derivation and further explanation concerning radio astronomical measurements of antenna performance should consult references 4 through 8. Wait (reference 4) presents a clear derivation of **eq. 1**, and the remaining references contain extensive information dealing with every aspect of radio astronomy measurements.

measurement techniques

The ease and accuracy of measurements depend greatly on your ingenuity. The following observations are submitted as food for thought:

1. Receiver linearity. The receiver chain must be operated *linearly* over the dynamic range of the measurements. As a starter, the receiver agc must be defeated.

2. Receiver bandwidth. The i-f should be operated at the widest possible bandwidth, since noise-power measurements are involved.

Close-up of the feed dipole. The dipole is covered with a polyethylene bag to keep rain water out of the assembly. The feed tower is guyed by use of a slip-ring collar, visible as the bulge half-way down the feed-tower. Since this photo was taken, a reflecting element has been added to the feed dipole, giving a cardioid feed pattern.

3. Measuring the Y factor. An accurate measurement technique is to note the cold sky power, then acquire the source; then, by use of a precision variable attenuator, reduce the source signal to equal the previous cold-sky reading. The required attenuation is the Y factor. **Caution**: remember to convert decibel readings to algebraic ratios and *vice versa* as applicable.

table 1. Source flux density, S, as a function of frequency for selected celestial bodies. The data were derived from references 5 through 7. Values are in watts per square meter per $Hz \times 10^{-23}$.

frequency (MHz)	sun ($\times 10^{-23}$) note 1	moon ($\times 10^{-23}$) note 2	Cassiopeia A ($\times 10^{-23}$) note 3	Cygnus A ($\times 10^{-23}$)	Taurus A ($\times 10^{-23}$)
144 note 4	52	0.01	15.0	10.0	1.80
432	280	0.08	5.55	4.00	1.25
1296	525	0.80	2.05	1.40	0.92

Notes: 1. The value for sun S varies randomly by a factor of two or more. The value listed is typical for a quiet sun.

2. Calculated by the author from the relationship: $S = (2KTm/\lambda^2)\ \Omega m$ where Ωm = solid angle subtended by the moon viewed from earth. See reference 7.

3. S decreases approximately 1 per cent per year. Value corrected by the author to 1978. See references 5 and 6.

4. 144 MHz values extrapolated by the author. Expect large measurement variations because of atmospheric and ionospheric effects.

5. Daily solar radiation measurements are available from the Space Environmental Laboratory, 325 Broadway, Boulder, Colorado 80302. Data is available to remote computer terminals by contacting J. D. Schroeder at (303) 499-1000, extension 3780.

4. Power *vs* voltage measurements. Be sure to measure the Y factor as a *power* ratio. Most meters and chart recorders respond to voltage or current, not to power. Squaring a voltage or current ratio yields the corresponding power ratio.

5. Acquiring the source. Locating a source in the sky is a matter of determining its Greenwich hour angle, GHA, and declination for the time of observation. **Table 2** lists celestial coordinates (right ascension and declination) for stellar sources. Reference (9) gives GHA and declination directly by hour for the sun and moon, as well as procedures for finding stellar GHA from right ascension.

Polar antenna mounts are usually calibrated directly in GHA (or the equivalent measure, LHA) and declination, since these are used for the mounting axes. To use azimuth/elevation antenna mounts, conversion formulas, calculator, and computer programs are published in reference (10) and other sources.

6. More information. The Eimac compendium, reference (10), contains a wealth of information for anyone with a serious interest in large vhf/uhf arrays. It's free from Eimac.

measurement refinements

There's much more to be said regarding measurements of high-performance antenna systems using celestial sources. For example, the determination of antenna gain, G, by measuring the equivalent system noise temperature, T, is not yet adequately addressed in Amateur Radio literature. Several rather esoteric correction factors not covered in this article are available. These include corrections for propagation attenuation and source polarization assymetry (stellar sources). Those who strive for absolute precision may be interested in the more detailed discussions on factors affecting measurement accuracy contained in references 4 through 6.

table 2. Location, advantages, and disadvantages of celestial sources for antenna-performance measurements.

celestial source	position (see note 1) right ascension (hrs.-mins.)	declination (degrees)	advantages	disadvantages
Cassiopeia A	23-22	N 59	Strong stellar source. Observable 24 hrs/day north of 32° n latitude	S decreasing about 1 per cent per year / Poor visibility in Southern Hemisphere
Cygnus A	19-59	N 41	Observable over much of the earth for substantial period each day	Some polarization evident in very precise measurements
Taurus A	5-33	N 22	Visible for good portion of day over most of the earth	Third strongest stellar source
Sun	see reference 10		Strongest source; Easy to locate	Large, random variations in intensity
Moon	see reference 10		Easy to locate	Very weak source

Note 1. Right ascension and declination are coordinates on the celestial sphere. See references 9 and 10 to convert to antenna pointing coordinates for local time.

acknowledgments

I'd like to thank Ruth Phillips, K3AGR; Howard Eich, W3HE; Jim Erickson, K3LFO; Dave Phillips, W3JPM; and Willie Mank, W1ZX; all made major contributions to the restoration of the K3NSS 25.6-meter (84-foot) parabolic reflector at Cheltenham, Maryland, to moonbounce operation, including the measure of performance from Cassiopeia A. That effort was the inspiration for this article.

references

1. D. W. Bray, K2LMG, and P. H. Kirchner, W2YBP, "Antenna Patterns From the Sun," *QST*, July 1960.
2. Ralph E. Taylor, "136-MHz/400-MHz Radio-Sky Maps," *Proceedings of the IEEE*, April 1973, page 469.
3. Don Lund, WAØIQN, "Using Sun Noise," *QST*, April 1968. Don Lund, WAØIQN, (letter to the technical editor) *QST*, June 1968.
4. David F. Wait, "Satellite Earth Terminal G/T Measurements," *Microwave Journal*, April 1977.
5. J. W. M. Baars, "The Measurement of Large Antennas with Cosmic Radio Sources," *IEEE Transactions on Antennas and Propagation*, Vol. AP-21, July 1973.
6. Hiroshi Yokoi, Toshio Satoh, and Matsuichi Yamada, "Gain Measurements of Large-Aperture Antenna for Satellite Communication," *Electronics and Communications in Japan*, Vol. 51-B No. 4, 1968.
7. A. D. Kuz'Min and A. E. Salomonovich, "*Radioastronomical Methods of Antenna Measurement*," Academic Press, New York 1966.
8. J. D. Kraus, *Radio Astronomy*, McGraw-Hill, New York 1966.
9. *The Nautical Alamanac*, (current year), U.S. Government Printing Office, Washington, D.C. 20402. Order Stock No. 008-054-0069-0 (1978 price $8.30).
10. "Everything You Want To Know About EME," EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070.

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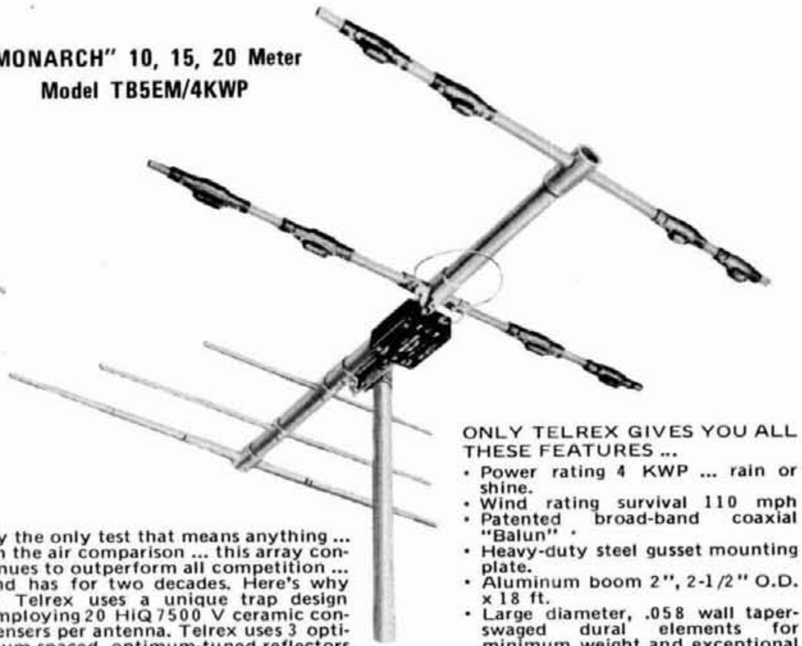

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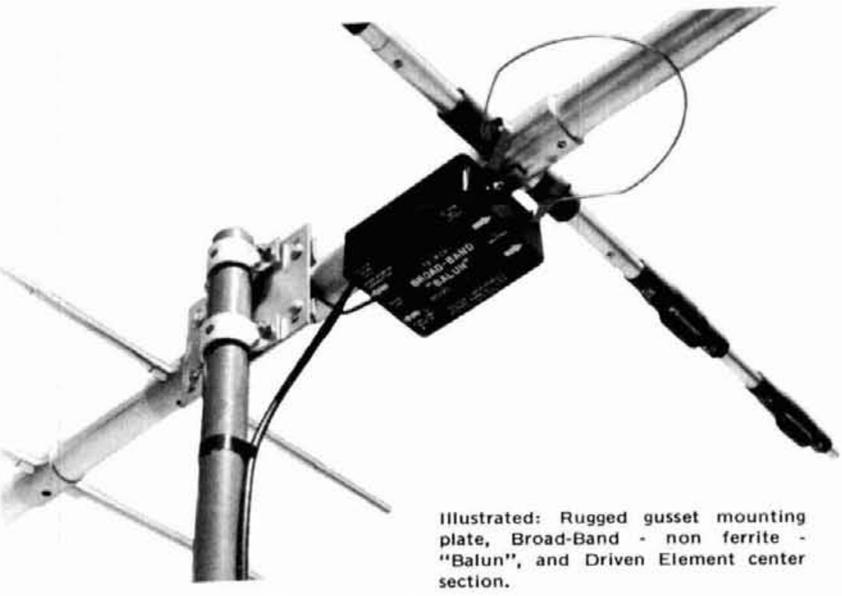

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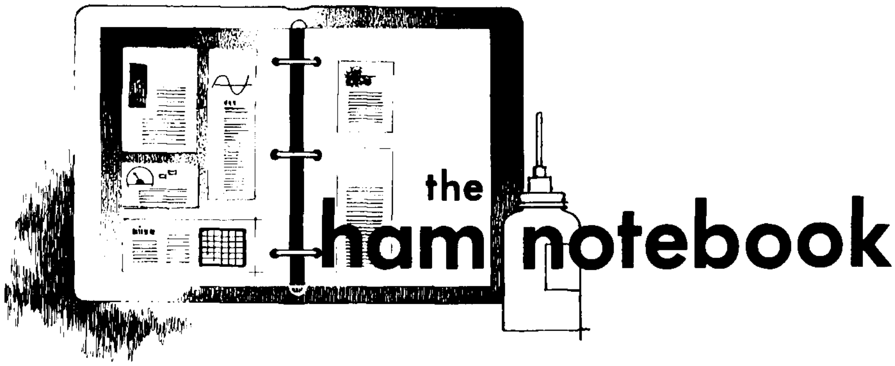

self-gating the 82S90/74S196 decade counter

In many typical counter circuits, the clock input to the first decade counter is logically combined with the count gate prior to being applied to the counter. In some cases, the limiting frequency factor is then the external gate and not the first decade counter. **Fig. 1** shows a method of using the internal circuitry of the 82S90/74S196 to perform the gating, thus allowing the IC to be used to its full 100-MHz capability without any degradation caused by external gating.

When the Count/Load line and the Rest line, pins 1 and 13 respectively, are high, the counter will operate in a normal clocked fashion. Since the count gate is connected to the Count/Load line, the counter will continue to function for the length of the gate. However, at the end of the counting time, the count gate goes low, shifting the IC into a mode where the counters actually act as latches fed from the Data Input lines. In addition, the counters also ignore any inputs on the clock lines. By tying the load lines to the output lines, the information is held, while it is processed through to the readouts. A negative reset pulse will reset all flip-flops to zero, ready for the next count period.

R. S. Naslund, W9LL

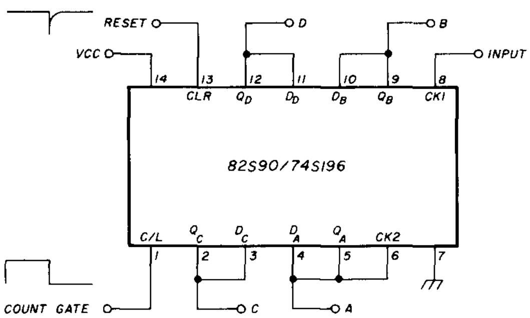

fig. 1. Schematic diagram of a method for using the internal gating in the 82S90/74S196 counter to eliminate any external clock gates. By using the count gate to control the Count/Load line, the IC will ignore any pulses on the clock line when the counters are used as latches.

metalized capacitors

Where the need exists for a very small size, low cost, stable, close tolerance capacitor in the range of 0.001 to 2.2 μF with good high-frequency characteristics, the Siemens MKM and MKH types are a good choice. They can be obtained in either metalized polycarbonate or metalized polyester, with 5 per cent tolerance, rated at 100, 250, or 400 volts. As an example of their compactness, the 0.47 μF, 100 volt capacitor measures a 1 × 1 × 0.5 cm. The feature that attracted me most was their very low parasitic inductance of 20 nH; this is due to the stacked foil construction and the package design which allows very short lead lengths. Several values were checked for series resonance with 3 mm leads; values for two popular ceramic values are included in the list below for comparison:

Ceramic	0.02 μF	12.0 MHz
Siemens	0.047 μF	10.0 MHz
Siemens	0.068 μF	8.0 MHz
Siemens	0.1 μF	6.5 MHz
Ceramic	0.1 μF	6.3 MHz
Siemens	0.47 μF	2.8 MHz
Siemens	0.68 μF	2.6 MHz

Stability of the Siemens capacitors, of course, is not as good as polystyrene or silver mica, but I find them very useful for timing circuits, active filters, and similar applications.

Bill Wildenhein, W8YFB

cure for the R4C backlash

Shortly after I received my new R4C, the dial started to develop a backlash problem. At first glance, it appeared that the clearance between the nylon gears was not correct. However, upon closer examination I determined that the backlash was caused by a binding of the outer edge of the plastic concentric dial closest to the front panel. In order to get a better look at the problem, I removed the white metal bracket that has the pilot lamp socket attached to it. This bracket is attached to the front panel by a machine screw on each end.

Each machine screw has a metal spacer between the bracket and panel. While removing the screw, hold the spacer with a long-nose plier or it will fall down into the bottom of the chassis necessitating the removal of the bottom cover in order to retrieve it.

After removal of the bracket, you will notice two felt pads on each end of the plastic index plate attached to the front panel. Remove these two pads completely. These pads were added by Drake to prevent the concentric dial from rubbing on the plastic index plate, which could warp with age.

Drake has since corrected the problem on their later production runs by relocating the index plate from the inside of the panel to the front of the panel. The felt pads have also been removed.

Bernard White, W3CVS

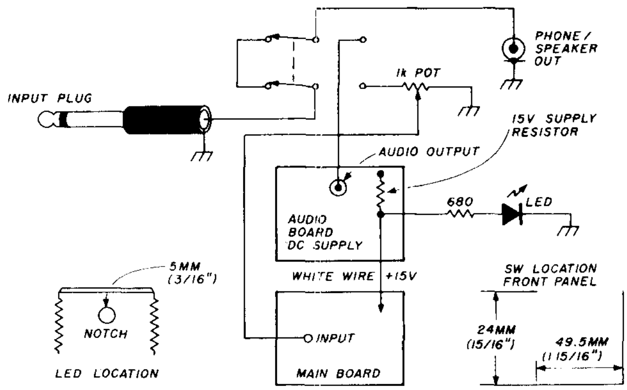

fig. 2. Diagram of the modifications to the QF1 audio filter. The power-indicating LED is mounted in a 5-mm hole just above the NOTCH. To allow the operator to switch the QF1 in and out of the circuit, a miniature double-pole, double-throw switch was installed in the indicated position.

autek filter

The Autek QF1 ssb/CW active filter has proven itself to be a very useful device. Like any other "black box" in the typical ham shack, on-the-air use indicates certain modifications would make it far more useful.

Since the QF1 operates from the ac line, a low-drain indicator light would show when the power is on. This is easily accomplished with an LED mounted just above the NOTCH control on the front panel. A 15-Vdc supply is available, with the appropriate series resistor, you have a light, color of your choice.

The second modification allows the operator to switch the filter in or out of the circuit. Thus, the headphone/speaker can monitor either the filter or the direct output from the receiver. This is very easily accomplished with a miniature double-pole, double-throw switch installed just to the left of the existing ac switch. An equalizing control was included to prevent overloading the Autek Amplifier. Thus, the phones will hear basically the same level in or out of the filter. Since the pot requires very little adjustment, it was mounted on the rear, just below the three-lug strip. This three-lug strip is the tie point for the filter input, making modification very simple.

Bill Long, K6EVQ
Bob Landgrave, WA6WZQ

improved stability for the 32S transmitter

While operating CW "split" with my Collins 32S-1/75S-3 combination, I noticed a definite frequency shift on the transmitter signal. This occurred only on the first dash or couple of dots when using VOX CW keying, being most noticeable on 10 meters. When PTT was used, the drift was completely unnoticeable.

My transmitter is a modified 32S-1 which has been up-dated to an S-3.[1] A zener diode provides regulation for the B-plus supply to the HFO and PTO. The stock 32S-3 also regulates the voltage to these oscillators, but it is supplied by an OA2. Examination of the circuit revealed that the voltage for the regulators is derived from the +275 volt input via a set of contacts on the VOX relay, K1 (see **fig. 3**). This means that during receive mode, there is no voltage applied to the HFO or PTO, with the transition from zero to full operating voltage (regulated or not) causing the oscillators to shift frequency slightly.

By changing the circuit to maintain voltage on the regulators, and hence the oscillators during receive, this anomaly is avoided. Simply move the lead connecting R17 to the VOX and connect it to C137 on the power amplifier cage wall. This capacitor has +275 volts applied continuously.

After this change is made, VOX keying will be just as good as with PTT, with no shift discernible. However, the effectiveness of this modification to an unmodified 32S-1 has not been determined.

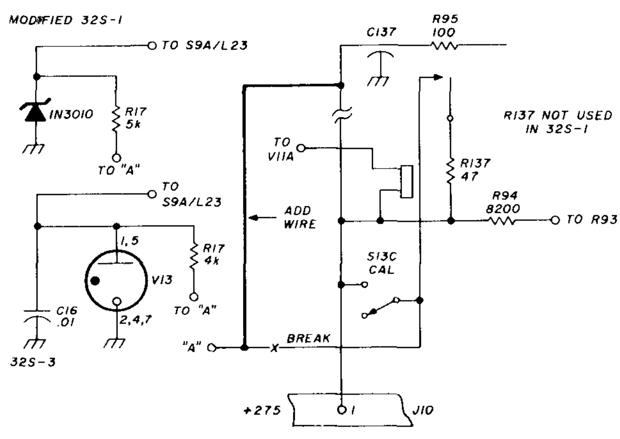

fig. 3. By changing the connection to R17, the oscillators are energized at all times. This eliminates the frequency shift caused by switching their plate voltage.

reference

1. Paul K. Pagel, N1FB, "Updating the Collins 32S-1," *ham radio*, December, 1978, page 50.

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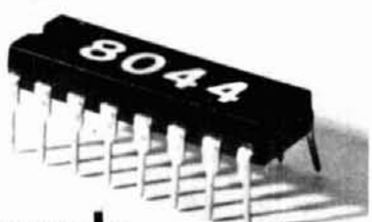

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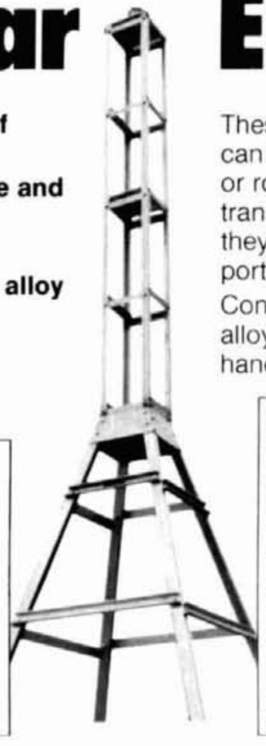

- Ideal for ground or roof mounts
- One man can assemble and erect
- Lightweight
- High quality aluminum alloy
- High stability
- Modular and portable
- Extremely rugged

These unique antenna towers can be installed on the ground or roof. Since they're easily transported and site erected, they're a natural for field and portable operations.

Constructed of sturdy aluminum alloy, they're sturdy enough to handle large size HF beams and EME arrays as well. Also available with optional stainless steel hardware for harsh environments.

Base is approximately 60" high and weighs 28 pounds. Tower sections are 72" high and weigh 21 pounds.

LUNAR'S NEW MODEL 2M 10-150 LINEARIZED AMP

Now ready and being shipped. We held off on announcing it until it was right...

Ready now. Order today from your Lunar dealer.

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LUNAR'S TRANSVERTER SYSTEMS

Individual modules and other accessories are available for up and down converter systems. Can be connected in any combination your system dictates. Write for complete list of modules and accessories.

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- FOLD-BACK CURRENT LIMITING Protects Power Supply from excessive current & continuous shorted output.
- CROWBAR OVER VOLTAGE PROTECTION on Models RS-7A, RS-12A, RS-20A, & RS-35A.
- MAINTAIN REGULATION & LOW RIPPLE at low line input Voltage.
- HEAVY DUTY HEAT SINK • CHASSIS MOUNT FUSE
- THREE CONDUCTOR POWER CORD
- ONE YEAR WARRANTY • MADE IN U.S.A.

PERFORMANCE SPECIFICATIONS

- INPUT VOLTAGE: 105 - 125 VAC
- OUTPUT VOLTAGE: 13.8 VDC ± 0.05 volts (Internally Adjustable: 11-15 VDC)
- RIPPLE: Less than 5mv peak to peak (full load & low line)
- REGULATION: ± .05 volts no load to full load & low line to high line

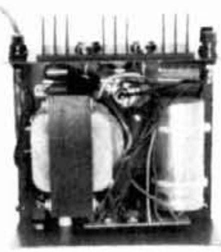
ASTRON 12 AMP REGULATED POWER SUPPLY Model RS-12A

9 Amps continuous
12 Amps ICS*
4" (H) × 8" (W) × 9" (D)
Shipping Weight 13 lbs.
Price. $72.95

Other popular POWER SUPPLIES also available: (Same features and specifications as above)

Model	Continuous Duty (amps)	ICS* (amps)	Size (in.) H × W × D	Shipping Wt. (lbs.)	Price
RS-35A	25	35	5 × 11 × 11	29	$136.95
RS-20A	16	20	5 × 9 × 10½	20	$94.95
RS-7A	5	7	3¼ × 6 × 7½	7½	$49.95
RS-4A	3	4	3¼ × 6 × 7½	5	$39.95

*ICS — Intermittent Communication Service (50% Duty Cycle)
If not available at your local dealer, please contact us directly.



Inside View — RS-12A

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- Audio Amplifier & Receiver Repair
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includes built-in Pre-Amp & Prescaler

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An unprecedented DSI VALUE . . . in a high quality, LSI Design, 50 HZ to 550 MHZ frequency counter kit. And, because it's a DSI innovation, you know it obsoletes all competitive makes, both in price & performance.

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FACT: Every 3550 QUIK-KIT® PC board is factory assembled and tested before shipment. FACT: The problems of bad LED's, IC's, and Capacitors are a thing of the past. FACT: No manufacturer except DSI offers a 550MHZ frequency counter with . . . 8 digits, .5 in. LED's, TCXO, 1HZ resolution and a one year warranty on parts for under $100.00. FACT: We do not know how long we can hold this low, low price. **GO WITH THE LEADER . . . BUY A DSI FREQUENCY COUNTER KIT TODAY. SAVE TIME & MONEY AND BE ASSURED IT WILL WORK THE FIRST TIME.**

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Time Base TCXO 1PPM 65° to 85°F
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Resolution 1HZ to 55MHZ, 10HZ to 550MHZ
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NEW products

For literature on any of the new products, use our *Check-Off* service on page 118.

loop antenna

A new receiving antenna for the 80- and 160-meter Amateur bands, the broadcast, and the VLF bands has been introduced by Palomar Engineers.

The loop rotates 360 degrees in azimuth and ±90 degrees in elevation with calibrated scales for both. The elevation or "tilt" of the loop is a new feature of the Palomar Engineers design and gives much deeper nulls than ordinary direction finder loops.

Loop nulls are very sharp on local and ground wave signals, but are broad or nonexistent on distant skywave signals. This allows local interference to be eliminated while DX stations can still be heard from all directions.

The loop picks up much less noise than the usual transmitting antenna. This, along with its ability to null out specific interfering signals, improves reception considerably.

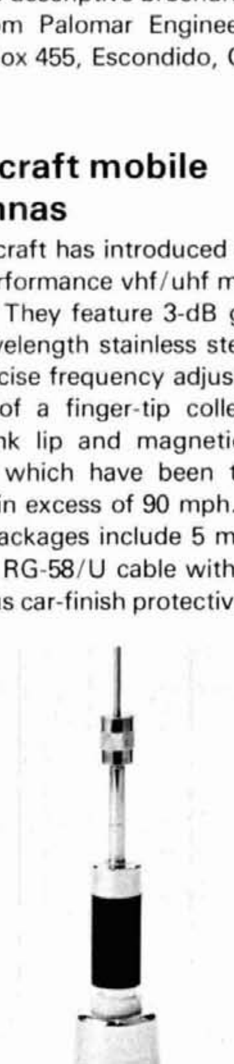
A Loop Amplifier serves as the mounting base for the antenna. It contains a tuning capacitor to resonate the loop and an amplifier to boost the signal and preserve the high Q of the loop. The Loop Antenna plugs into the amplifier.

Plug-in loops are available for 160/80 meters (1600-5000 kHz), broadcast band (550-1600 kHz), and VLF (150-550 kHz).

A free descriptive brochure is available from Palomar Engineers, Post Office Box 455, Escondido, California 92025.

Cushcraft mobile antennas

Cushcraft has introduced two new high-performance vhf/uhf mobile antennas. They feature 3-dB gain with 5/8-wavelength stainless steel whips and precise frequency adjustment by means of a finger-tip collet. There are trunk lip and magnetic mount models which have been tested to speeds in excess of 90 mph. The antenna packages include 5 meters (18 feet) of RG-58/U cable with connectors, plus car-finish protective pads.



The vhf models cover 144-174 MHz, including the 2-meter fm subband. The uhf model covers 220-225 MHz.

For more information write to Cushcraft Corporation, P.O. Box 4680, Manchester, New Hampshire 03108.

220-MHz fixed-station antenna

The all-new Hustler 220-MHz vertical fixed-station Amateur antenna, designated the Model G7-220, was recently introduced by New-Tronics Corporation of Brookpark, Ohio. The G7-220 marks New-Tronics' entry into the now-popular 220-MHz band and complements their existing base and mobile Amateur antenna line. The superior 7-dB gain of the antenna, for both transmitting and receiving, makes it the most powerful omnidirectional 1½-meter antenna available. The all-new rugged design of the Hustler G7-220 antenna keeps the signal radiation pattern at the lowest possible angle to the horizon for maximum efficiency and longest range.

The Model G7-220 has an SWR of 1.5:1 across its entire 5-MHz bandwidth, with SWR at resonance at 1.2:1 at the antenna. The radiating elements of the Hustler G7-220 are dc grounded for lightning protection and the antenna has a 50-ohm base impedance.

This new Hustler 220-MHz vertical combines the latest antenna technology and the best available corrosion-resistant materials for extra-long life. Only Hustler uses all stainless steel hardware in Amateur and professional products. Each component is precisely built for quick and easy assembly.

The all-new Hustler G7-220 (1¼-meter) Amateur vertical fixed-station antenna has a suggested list price of $119.95 and is available now. For fur-

More Details? CHECK—OFF Page 118

ther information on this or other Hustler products write Sales Department, New-Tronics Corporation, 15800 Commerce Park Drive, Brookpark, Ohio 44142.

mobile towers

Aluma Tower Company of Vero Beach, Florida, announces a new series of towers. Named "Mobile Van Towers," these towers are perfect for signal communications work, all types of test work (radio signals, air sampling), Civil Defense mobile communications, and Amateur Radio.

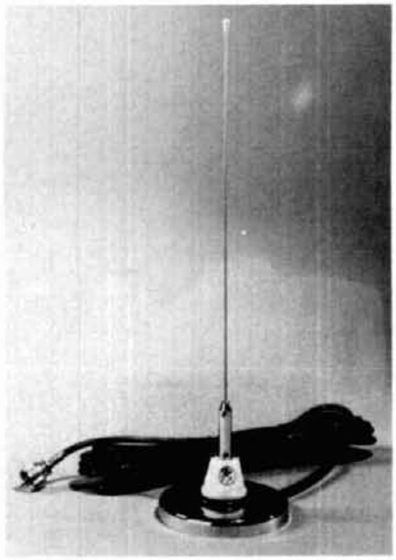
The tower is mounted on a standard ladder rack on top of a van. It is transported in a horizontal position, and, when at the selected site, is easily tilted to the vertical position and cranked up to the desired height. The feature that makes this tower different from the standard Aluma Tower is the unique sliding track design, which enables the operator to put the tower from the horizontal to the vertical position and back to horizontal with a minimum of effort.

The tower is made in three standard-duty models — 35, 50, and 60 feet — and two heavy-duty models for internally mounted rotors — 35 and 50 feet.

Aluma Tower Company plans to market this tower across the country through their network of dealers, concentrating on TV installation experts and Civil Defense units.

For more information, please contact Aluma Tower Company, 1639 Old Dixie Highway, Vero Beach, Florida 32960.

Antler 2-Meter antenna



A new quarter-wave, magnetic, roof or cowl-mount antenna has been announced by Antler Antennas. The new model covers 144 to 148 MHz and features a powerful, permanent base that firmly grips any flat, steel surface.

The magnet base is fitted with a wide, low-profile, chrome-plated base which allows the factory-wired coax to exit and lie flat against the vehicle's roof to reduce the wind whip and noise often encountered with this type of antenna system. Requiring no installation, the antenna is easily removed for storage to prevent theft.

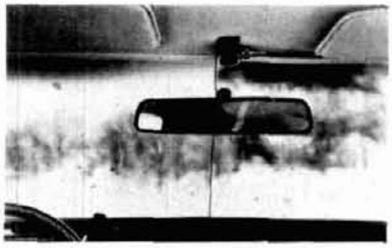
The unit is designed for in-city hams for whom overhanging obstructions, low garages, and parking facilities present problems.

The new antenna joins a complete

More Details? CHECK — OFF Page 118

line of quarter-wave and 5/8-wave 2-meter models produced by Antler Antennas and sold through distributors and dealers nationwide. For more information, write Antler Antennas, 6200 South Freeway, Fort Worth, Texas 76134.

invisible 10-meter mobile antenna



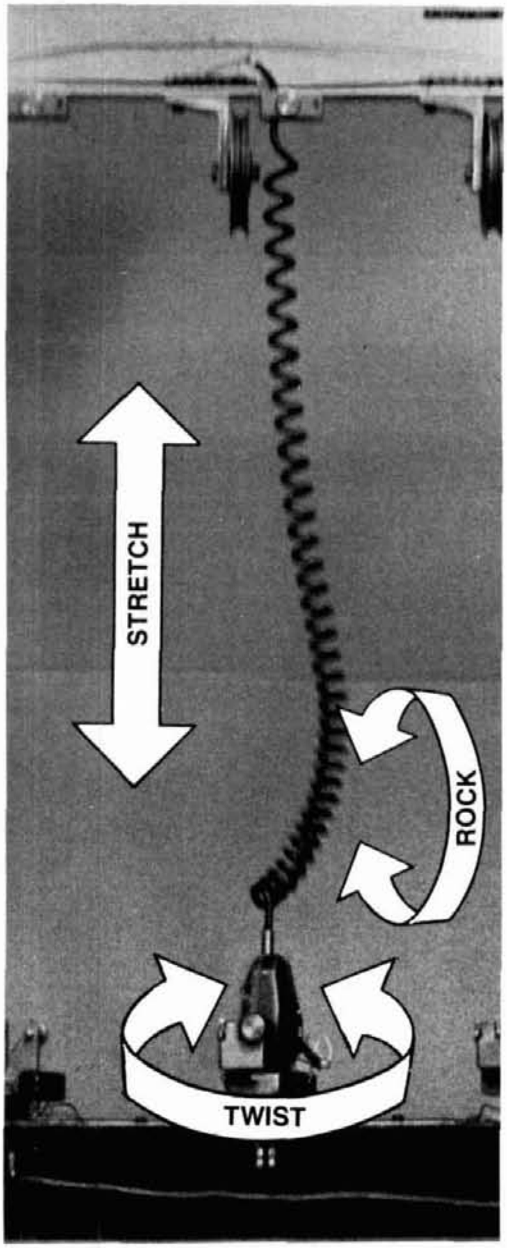
The "Ten/Tenna," for 10-meter and CB use, mounts inside metal-roofed vehicles and excites the car shell into radiation as a 10-meter or CB antenna. The complete kit includes matching network, coaxial cable, and all required mounting hardware. The matching network includes a tuning indicator which dims at low swr. The kit is priced at $27.40 postpaid. A complete report is available free, from Dept. HRR1, Microwave Filter Co., Inc., 6743 Kinne St., East Syracuse, New York 13057.

rf micro-volt meter

RMS Electronics recently introduced its new Model 10-500 RF μV Meter. This meter is ideal for bench or field use and offers, for the first time, a compact battery-operated meter with sensitivity of 10 μV over a bandwidth of 10 to 500 MHz and is usable from 1 through 800 MHz. The Model 10-500 RF μV Meter is perfectly suited for testing two-way radio receivers, antenna systems, CATV distribution amplifiers, and the like. The unique design of the instrument is such that it may be upgraded for wider bandwidth to 1000 MHz by the user if future needs demand this. For additional information, contact RMS Electronics, Inc., 2412 Crystal Drive, Ann Arbor, Michigan 48104.

More Details? CHECK — OFF Page 118

fact:
our quality assurance is your performance insurance.

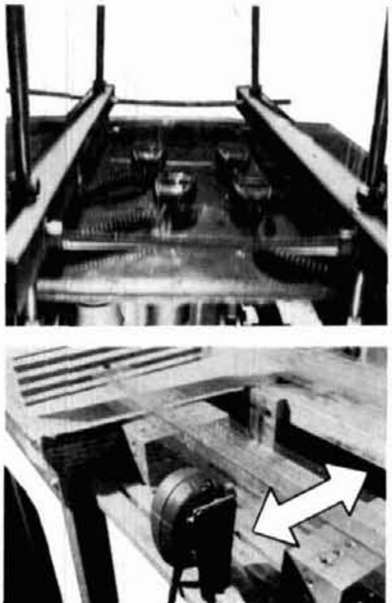


Originally designed for battlefield ruggedness, the microphone elements in Shure mobile and communications microphones offer unequaled reliability. Our quality control engineers anticipate the worst possible field conditions. These microphones have been subjected to the most rigorous tests in the industry, including six-foot drops onto hard floors; violent vibration tests; temperature variation tests ranging from a bitter -54°F. to a searing 185°F.; and 100% humidity tests. We've even dragged them behind automobiles on open roads and subjected them to a battery of corrosion tests. And yes, they really work after all that!

Exclusive Three-Way Flex Tester

Shure knows that the single most common cause of microphone malfunction is failure of the cord. An exclusive Shure-designed story-and-a-half tall microphone cord tester dishes out more abuse than the average microphone gets in a lifetime.

Stretch, rock, and twist: first, the cord tester stretches the microphone to the full length of the cord. Then it simultaneously rocks the microphone 270° at the end of the cord while it gives the microphone a violent 90° twist in two directions. And this goes on day after day!



3-D Shake Tester

A microphone that fails spells disaster for a mobile communications system. Every Shure microphone is designed to withstand hours in our brutal 3D Shake Tester — simulating years of driving over rough, bumpy roads.

Million-Cycle Switch Tester

Another abused microphone component is the switch. Shure-designed long-life leaf switches operate with a wiping action that resists the buildup of corrosion and dirt. And Shure's ongoing tests show that they continue to make contact reliably and positively after *one million switching operations.*

mobile communications microphones

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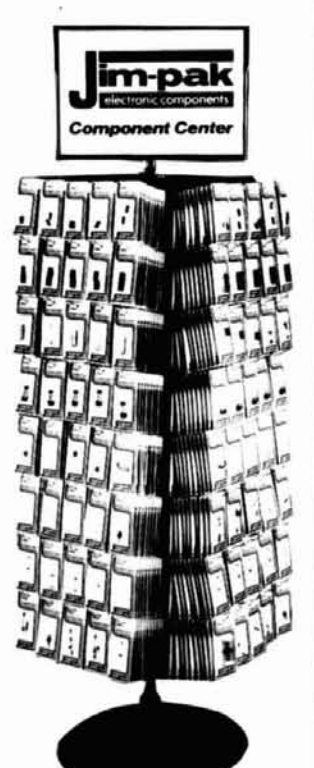

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- ★Dual Sensors — switching controls for indoor/outdoor or dual monitoring
- ★Continuous LED .8" ht. display
- ★Range. -40°F to 199°F / -40°C to 100°C
- ★Accuracy. ±1° nominal
- ★Set for Fahrenheit or Celsious reading
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Use your HF transceiver on the VHF/UHF bands with the addition of a transverter. Both the transmit up-converter and the receive down-converter are built into one package. Typical IFs available are 10M also 6M and 2M. Internal T/R switching eliminates need for external relays. Some models have VOX circuit. Typical output power 10 watts minimum. Typical receive NF 3.0 dB. 12 volt operation. Models available for CW, AM, FM, SSB, RTTY, OSCAR, ATV operation. Ask for detailed specifications.

Prices from $175.00 Shipping $3.50

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Post Office Box 1084
Concord, Mass. 01742, USA

ANTENNAS

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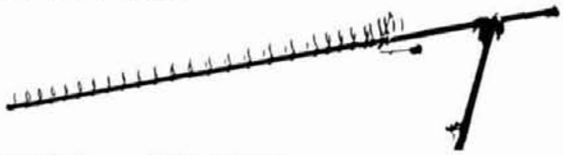

26 LOOPS	GAIN +20 dBi	
1250-1340 MHz	1296-LY	$56.95
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for OSCAR, TROPO and ATV Communications

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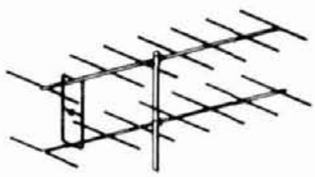

144-148 MHz J-SLOTS

8 OVER 8 J-SLOT +12.3 dBd	D8/2M	$50.65
8 BY 8 VERTICAL POL.	D8/2M-VERT.	$59.50
DOUBLE 8 TWIST	8XY/2M	$52.45

ANTENNAS
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Converters for all bands 50 MHz through 1691 MHz (*2304 MHz coming soon*). Twin crystal models at 432/435 for OSCAR work. Wideband ATV models and Low NF options at 70cms.

10M, 6M, 2M & TV IFs.
137.5 IF for GOES model

Prices from **$59.95**

Shipping $2.50

LINEAR AMPLIFIERS

EDL432 (illus.)	$154.95
EDL432P, incl's power supply & cabinet	$329.95

Both models 50W out for 10 W drive.

2M Models

2M10-80P	$199.95
2M10-150P	$289.95
2M25-150P	$269.95

Shipping, via UPS at cost.

Send 30¢ (2 stamps) for full details of KVG crystal products and all your VHF & UHF equipment requirements.

Pre-Selector Filters	Amplifiers	SSB Transverters
Varactor Triplers	Crystal Filters	FM Transverters
Decade Pre-Scalers	Frequency Filters	VHF Converters
Antennas	Oscillator Crystals	UHF Converters

More Details? CHECK—OFF Page 118

More Details? CHECK—OFF Page 118

FREQUENCY COUNTER KIT

Outstanding Performance

CT-50

Incredible Price $89.95

The CT-50 is a versatile and precision frequency counter which will measure frequencies to 60 mHz and up to 600 mHz with the CT-600 option. Large Scale Integration, CMOS circuitry and solid state display technology have enabled this counter to match performance found in units selling for over three times as much. Low power consumption (typically 300-400 ma) makes the CT-50 ideal for portable battery operation. Features of the CT-50 include: large 8 digit LED display, RF shielded all metal case, easy pushbutton operation, automatic decimal point, fully socketed IC chips and input protection to 50 volts to insure against accidental burnout or overload. And, the best feature of all is the easy assembly. Clear, step by step instructions guide you to a finished unit you can rely on.

Order your today!

SPECIFICATIONS:

Frequency range: 6 Hz to 65 mHz, 600 mHz with CT-600
Resolution: 10 Hz @ 0.1 sec gate, 1 Hz @ 1 sec gate
Readout: 8 digit 0.4" high LED, direct readout in mHz
Accuracy: adjustable to 0.5 ppm
Stability: 2.0 ppm over 10° to 40° C, temperature compensated
Input: BNC, 1 megohm, 20 pf direct, 50 ohm with CT-600
Overload: 50VAC maximum, all modes
Sensitivity: less than 25 mv to 65 mHz, 50-150 mv to 600 mHz
Power: 110 VAC 5 Watts or 12 VDC @ 400 ma
Size: 6" x 4" x 2", high quality aluminum case, 2 lbs
ICS: 13 units, all socketed

CT-50, 60 mHz counter kit	$89.95
CT-50WT, 60 mHz counter, wired and tested	159.95
CT-600, 600 mHz scaler option, add	29.95
CB-1, Color TV calibrator-stabilizer	$14.95
DP-1, DC probe, general purpose probe	12.95
HP-1, High impedance probe, non-loadir	15.95

CAR CLOCK

The UN-KIT, only 5 solder connections

Here's a super looking, rugged and accurate auto clock which is a snap to build and install. Clock movement is completely assembled—you only solder 3 wires and 2 switches, takes about 15 minutes! Display is bright green with automatic brightness control photocell—assures you of a highly readable display, day or night. Comes in a satin finish anodized aluminum case which can be attached 5 different ways using 2 sided tape. Choice of silver, black or gold case (specify).

DC-3 kit, 12 hour format	$22.95
DC-3 wired and tested	$29.95
110V AC adapter	$5.95

Under dash car clock

12/24 hour clock in a beautiful plastic case features 6 jumbo RED LEDS, high accuracy (1 min/mo.), easy 3 wire hookup, display blanks with ignition, and super instructions. Optional dimmer automatically adjusts display to ambient light level.

DC-11 clock with mtg. bracket	$27.95
DM-1 dimmer adapter	2.50

PRESCALER

Extend the range of your counter to 600 mHz. Works with any counter. Includes 2 transistor pre-amp to give super sens., typically 20 mv at 150 mHz. Specify ÷10 or ÷100 ratio

PS-1B, 600 mHz prescaler	$59.95
PS-1BK, 600 mHz prescaler kit	49.95

OP-AMP SPECIAL

741 mini dip	12/$2.00
B1-FET, mini dip, 741 type	10/$2.00

VIDEO TERMINAL

A completely self-contained, stand alone video terminal card. Requires only an ASCII keyboard and TV set to become a complete terminal unit. Two units available, common features are: single 5V supply, XTAL controlled sync and baud rates (to 9600), complete computer and keyboard control of cursor. Parity error control and display. Accepts and generates serial ASCII plus parallel keyboard input. The 3216 is 32 char. by 16 lines, 2 pages with memory dump feature. The 6416 is 64 char. by 16 lines, with scrolling, upper and lower case (optional) and has RS-232 and 20ma loop interfaces on board. Kits include sockets and complete documentation.

RE 3216, terminal card	$149.95
RE 6416, terminal card	189.95
Lower Case option, 6416 only	13.95
Power Supply Kit	14.95
Video/RF Modulator, VD-1	6.95
Assembled, tested units, add	60.00

CALENDAR ALARM CLOCK

The clock that's got it all. 6-.5" LEDs, 12/24 hour, snooze, 24 hour alarm, 4 year calendar, battery backup, and lots more. The super 7001 chip is used. Size: 5x4x2 inches.

Complete kit, less case (not available)

DC-9	$34.95

30 Watt 2 mtr PWR AMP

Simple Class C power amp features 8 times power gain: 1 W in for 8 out, 2 in for 15 out, 4 W in for 30 out. Max. output of 35 W, incredible value, complete with all parts, less case and T-R relay.

PA-1, 30 W pwr amp kit	$22.95
TR-1, RF sensed T-R relay kit	6.95

FM MINI MIKE KIT

A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality by means of its built in electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.

FM-3 kit	$12.95
FM-3 wired and tested	16.95

CLOCK KITS

our Best Seller your Best Deal

Try your hand at building the finest looking clock on the market. Its satin finish anodized aluminum case looks great anywhere, while six .4" LED digits provide a highly readable display. This is a complete kit, no extras needed, and it only takes 1-2 hours to assemble. Your choice of case colors: silver, gold, bronze, black, blue (specify).

Clock kit, 12/24 hour, DC-5	$22.95
Clock with 10 min. ID timer, 12/24 hour, DC-10	27.95
Alarm clock, 12 hour only, DC-8	24.95
12V DC car clock, DC-7	27.95

For wired and tested clocks add $10.00 to kit price.

Hard to find PARTS

LINEAR ICs		
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324		1.50
380		1.25
380-8		.75
555		.45
556		.85
566		1.15
567		1.25
1458		.50
3900		.50
CMOS ICs		
4011		.20
4013		.35
4046		1.85
4049		.40
4518		1.25
5369		1.75
TRANSISTORS		
2N3904 type	10	1.00
2N3906 type	10	1.00
NPN 30W Pwr	3	1.00
PNP 30W Pwr	3	1.00
2N3055		.60
UJT 2N2646 type	3	2.00
FET MPF102 type	3	2.00
UHF 2N5179 type	3	2.00
MRF-238 RF		11.95
SOCKETS		
8 pin	10	2.00
14 pin	10	2.00
16 pin	10	2.00
24 pin	4	2.00
28 pin	4	2.00
40 pin	3	2.00

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78MG		$1.25
723		.50
309K		.85
7805		.85
78L05		.25
7905		1.25
7812		.85
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With info. specs	15	1.00
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Ramsey's famous MINI-KITS

FM WIRELESS MIKE KIT

Transmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.

FM-1 kit **$2.95** FM-2 kit **$4.95**

COLOR ORGAN/MUSIC LIGHTS

See music come alive! 3 different lights flicker with music. One light for lows, one for the mid-range and one for the highs. Each channel individually adjustable, and drives up to 300W. Great for parties, band music, nite clubs and more.

Complete kit, ML-1 **$7.95**

LED BLINKY KIT

A great attention getter which alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights, anything! Runs on 3 to 15 volts.

Complete kit, BL-1 **$2.95**

VIDEO MODULATOR KIT

Converts any TV to video monitor. Super stable, tunable over ch. 4-6. Runs on 5-15V, accepts std. video signal. Best unit on the market!

Complete kit, VD-1 **$6.95**

TONE DECODER

A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone decoding, tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.

Complete kit, TD-1 **$5.95**

WHISPER LIGHT KIT

An interesting kit, small mike picks up sounds and converts them to light. The louder the sound, the brighter the light. Completely self-contained, includes mike, runs on 110VAC, controls up to 300 watts.

Complete kit, WL-1 **$6.95**

SUPER SLEUTH

A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2 W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.

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Produces upward and downward wail characteristic of a police siren. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.

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More Details? CHECK—OFF Page 118

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BULLET ELECTRONICS

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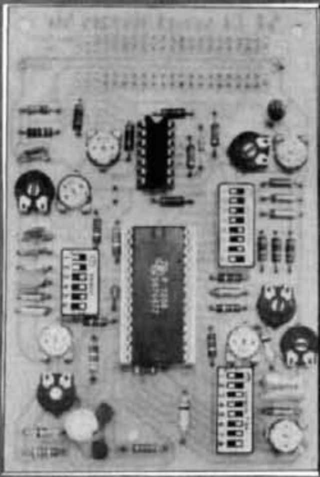
GARLAND TEXAS 75040

SOUND EFFECTS



OVERVOLTAGE PROTECTION KIT 6.95

WARBLE ALARM KIT 2.50

POWER SUPPLY KIT PS-14

REVIEWED IN 7/78 73 MAG

15A CONT. 20A INT. 42.95

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12.95 Set

MK-03A CLOCK/TIMER KIT 28.95

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490-T Ant. Tuning Unit
(Also known as CU1658 and CU1669)

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Highest price paid for these units. Parts purchased. Phone **Ted, W2KUW collect**. We will trade for new amateur gear. GRC106, ARC105, ARC112 and some aircraft units also required.

We stand on our long term offer to pay ~~5%~~ 25% more than any other bonafide offer.

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Any large piece of gear we sell you (average $300 or up) we will **double** your warranty period!

FOR EXAMPLE: A 3 month warranty = 6 months from date of purchase. 1 year = 2 years from date of purchase.

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Simply send your rig in a good shipping carton, postage prepaid, with a copy of your receipt showing date of purchase. We will repair promptly and return by best way.

NOTE: Manufacturers do not cover final in most cases, but we will try!

Try Our Competitive Prices, Too!

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STAR-TRONICS monthly picture flyer is full of parts and pieces for the builder. Cheap. Quality. U.S. only. Star-Tronics, Box 683, McMinnville, OR 97128.

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SELL HEATH HW-2021 H-T and HA-201A amp. With xtals for 07/67 16/76 22/82 28/88 34/94. All manuals and jumper coax included. $225.00. Steve Stout 6227 I-40 West #274 Amarillo, TX 79106..

RECONDITIONED TEST EQUIPMENT for sale. Catalog $.50. Walter, 2697 Nickel, San Pablo, Ca. 94806.

MOBILE HF ANTENNA, 3.5-30 MHz inclusive, 750 watts PEP, center loaded coil, tuned from the base, eliminating coil changing or removing from mount. Less than 1.5 to 1 VSWR on all ham bands. $119.95 each — contact your local dealer or order from Anteck, Inc., Box 415, Route 1, Hansen, ID 83334. (208) 423-4100. Master Charge and VISA cards accepted. Dealer inquiries invited.

ROHN TOWERS — Buy wholesale direct from distributor. 20G sections $28.82 each, 25G sections $37.62 each, 45G sections $57.20 each — 100 foot tower kit complete $646.02 — 40 foot free standing BX tower $179.45 — 48 foot 25G foldover, freight paid $565.00 — Hill Radio, 2503 G.E. Road, Bloomington, IL 61701, (309) 663-2141.

STODDARD NM20B complete with AC supply, cables, carrying cases. Swap or sell. VE4AI, Steve Chisholm, 551 Bruce Ave., Winnipeg, Manitoba.

QSL CARDS 500/$10. 400 illustrations, sample. Bowman Printing, Dept. HR, 743 Harvard, St. Louis, MO 63130.

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SPECTRUM ANALYZERS: Polarad SA-84 and Panoramic SPA-4A. Both units 10 MHz-44 GHz Reconditioned with books. Call Mort WB2GEU, (617) 665-1740 days. P.O. Box 412, Stoneham, MA 02180.

SUPER SHACK: Heath SB-104A, factory aligned, with SB-604 and HP-1144A matching speaker and power supply, plus SBA-104-1 Noise Blanker, SBA-104-3 CW Filter, SBA-104-2 Mobile Mount, HDP-121A Desk Mike, GH-12A Mobile Mike. All perfect: $650. SB-230 1 kW linear w/10 meters, $450. 2 kW Transmatch, $70. MFJ-484 Grandmaster Memory Keyer w/paddle, $95. MFJ-752 Dual Tunable SSB/CW Filter, $49. MFJ-LSP-520BXII Speech Processor, $39. All new. K2RHK, (212) 877-8539.

TRI-EX W-67 TOWER, motorized extension from 22 ft. (nested) to 67 feet. Also Drake remote antenna selector, Ham III rotator and Wilson 10/15 meter beam. Sell only complete package for $1995.00 or write and ask for details on complete QTH. Write: F. Moller, Cathedral Rd. Rindge, N. H. 03461.

COMPUTER FOR SALE: SWTP 6800 w/16 memory. Real-time multi-processing OS. Extra interface and memory boards, lots of software. AC-30 cassette interface included. $1200.00 takes all. May trace. KL7EWQ, Box 839, Wasilla, AK 99687.

RTTY AFSK Modulator PC board. See Feb. 79 Ham Radio. Drilled $5.00. F.E. Hinkle, 12412 Mossy Bark, Austin, TX 78750.

WANTED: Hilltop property near Pollock Pines, California. WA6COA, 4 Ajax Place, Berkeley, CA 94708.

FOR SALE: Drake 2B and 2-BQ $175. TX-62 w/VFO-621 $75. FTV-250 with Janel Pre-amp $195. W2NXC 1244-Crim Rd., Bridgewater, N. J. 08807. (201) 725-5093.

REPLACE RUSTED ANTENNA bolts with stainless steel. Small quantities, free catalog. Elwick, Dept. 332, 230 Woods Lane, Somerdale, N.J. 08083

SONY T.V. CAMERA CVC-100 works $60., Regency HR-440 UHF new $220, 70 item trade list. K6K2T 2255 Alexander, Los Osos, CA 93402.

1-GHz PRESCALER PARTS HR Sept. 1978. SASE AVTECHSERV 53130 Haddington, South Bend, IN 46635.

More Details? CHECK—OFF Page 118

EZ deals are the best! Try me and see for Yaesu, Drake, KLM, Swan, Cushcraft, DenTron, VHF Eng., ICOM, CDE, Hustler, Wilson and more. Call, see or write WØEZ, Bob Smith Electronics, RFD 3, Hwy 169 & 7, Fort Dodge, IA 50501. (515) 576-3886.

FERRITE BEADS: w/specification and application sheet - 12/$1.00. Assorted PC pots - 10/$1.00. Miniature mica trimmers, 3-40 pF. - 5/$1.00. Postpaid. Includes latest catalog. Stamp for catalog alone. CPO Surplus, Box 189, Braintree, MA 02184.

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WANTED: Motorola KXN 1024 and KXN 1052 channel elements. WA6COA, 4 Ajax Place, Berkeley, CA 94708.

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WANTED: GE MASTR ER-41C receiver, ET-58 transmitter. Fred Findling, P.O. Box 125, Littleton, N. H. 03561.

RTTY — Bandpass active filter 2125/2295 Hz. Kit $11.95, W/T $16.95 ppd. SASE for info. Nat Stinnette Electronics, Tavares, FL 32778.

REPEATERS — Factory Built VHF Engineering, 4 uhf, 1 with P.L. Two in unopened boxes. 1 220 MHz, 2K Takes all. WA6COA, 4 Ajax, Berkeley, CA 94708.

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TEST EQUIPMENT CATALOG listing used Tektronix, HP and GR equipment at bargain prices. PTI, Box 8699, White Bear Lake, MN 55110. Price $1.00 refundable with first order.

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Coming Events

KENTUCKY HAM-O-RAMA — Sunday, May 20, at Boone County Fairgrounds, Burlington, Kentucky. 10 miles South I-75 of Cincinnati, Ohio. Major and hourly door prizes included with $3.00 gate ticket. Info: N.K.A.R.C., Box 31, Ft. Mitchell, KY 41017.

MARYLAND: The Maryland Mobileers Amateur Radio Club's annual Hamfest, May 20, Camp Barrett, Crownsville, west of Annapolis. Prizes awarded. Tickets $3.00. Gates open 10:30 AM. Talk in 146.52, 146.10/.70. For info: MMARC, P.O. Box 784, Severna Park, MD 21146.

More Details? CHECK—OFF Page 118

7400 TTL

SN7400N	16	SN7470N	29	SN74160N	89
SN7401N	18	SN7472N	29	SN74161N	89
SN7402N	18	SN7473N	35	SN74162N	1.95
SN7403N	18	SN7474N	35	SN74163N	89
SN7404N	18	SN7475N	49	SN74164N	89
SN7405N	20	SN7476N	35	SN74165N	89
SN7406N	29	SN7479N	5.00	SN74166N	1.25
SN7407N	29	SN7480N	50	SN74167N	1.95
SN7408N	20	SN7482N	99	SN74170N	1.59
SN7409N	20	SN7483N	59	SN74172N	6.00
SN7410N	18	SN7485N	79	SN74173N	1.25
SN7411N	25	SN7486N	35	SN74174N	89
SN7412N	25	SN7489N	1.75	SN74175N	79
SN7413N	40	SN7490N	45	SN74176N	79
SN7414N	70	SN7491N	59	SN74177N	79
SN7416N	25	SN7492N	43	SN74179N	1.95
SN7417N	25	SN7493N	43	SN74180N	79
SN7420N	20	SN7494N	65	SN74181N	1.95
SN7421N	29	SN7495N	65	SN74182N	79
SN7422N	39	SN7496N	65	SN74184N	1.95
SN7423N	25	SN7497N	3.00	SN74185N	1.95
SN7425N	29	SN74100N	89	SN74186N	9.95
SN7426N	29	SN74107N	35	SN74188N	3.95
SN7427N	29	SN74109N	59	SN74190N	1.25
SN7429N	39	SN74116N	1.95	SN74191N	1.25
SN7430N	20	SN74121N	35	SN74192N	79
SN7432N	25	SN74122N	39	SN74193N	79
SN7437N	25	SN74123N	49	SN74194N	89
SN7438N	25	SN74125N	49	SN74195N	69
SN7439N	25	SN74126N	49	SN74196N	89
SN7440N	20	SN74132N	75	SN74197N	89
SN7441N	89	SN74136N	75	SN74198N	1.49
SN7442N	49	SN74141N	79	SN74199N	1.49
SN7443N	75	SN74142N	2.95	SN74S200	4.95
SN7444N	75	SN74143N	2.95	SN74251N	1.79
SN7445N	75	SN74144N	2.95	SN74279N	79
SN7446N	69	SN74145N	79	SN74283N	2.25
SN7447N	59	SN74147N	1.95	SN74284N	3.95
SN7448N	79	SN74148N	1.29	SN74285N	3.95
SN7450N	20	SN74150N	89	SN74365N	69
SN7451N	20	SN74151N	59	SN74366N	69
SN7453N	20	SN74152N	59	SN74367N	69
SN7454N	20	SN74153N	59	SN74368N	69
SN7459A	25	SN74154N	99	SN74390N	1.95
SN7460N	20	SN74155N	79	SN74393N	1.95
		SN74156N	79		
		SN74157N	65		

20% Discount 100 pcs combined order 25% -1000 pcs combined order

C/MOS

CD4000	23	CD4028	89	CD4070	55
CD4001	23	CD4029	1.19	CD4071	23
CD4002	23	CD4030	49	CD4072	49
CD4006	1.19	CD4035	99	CD4076	1.39
CD4007	25	CD4040	1.19	CD4081	23
CD4009	49	CD4041	1.25	CD4082	23
CD4010	49	CD4042	99	CD4093	99
CD4011	23	CD4043	89	CD4098	2.49
CD4012	25	CD4044	89	MC14409	14.95
CD4013	39	CD4046	1.79	MC14410	14.95
CD4014	1.39	CD4047	2.50	MC14411	14.95
CD4015	1.19	CD4048	1.35	MC14419	4.95
CD4016	49	CD4049	49	MC14433	19.95
CD4017	1.19	CD4050	49	MC14506	75
CD4018	99	CD4051	1.19	MC14507	99
CD4019	49	CD4053	1.19	MC14562	14.50
CD4020	1.19	CD4056	2.95	MC14583	3.50
CD4021	1.39	CD4059	9.95	CD4508	3.95
CD4022	1.19	CD4060	1.49	CD4510	1.39
CD4023	23	CD4066	79	CD4511	1.29
CD4024	79	CD4068	39	CD4515	2.95
CD4025	23	CD4069	45	CD4518	1.29
CD4026	2.25			CD4520	1.29
CD4027	69			CD4566	2.25

74C00

74C00	39	74C85	2.49	74C163	2.49
74C02	39	74C90	1.95	74C164	2.49
74C04	39	74C93	1.95	74C173	2.60
74C08	49	74C95	1.95	74C192	2.49
74C10	39	74C107	1.25	74C193	2.49
74C14	1.95	74C151	2.90	74C195	2.49
74C20	39	74C154	3.00	74C922	5.95
74C30	39	74C157	2.15	74C923	6.25
74C42	1.95	74C160	2.49	74C925	8.95
74C48	2.49	74C161	2.49	74C926	8.95
74C73	89			80C95	1.50
74C74	89			80C97	1.50

LINEAR

78MG	1.75	LM340K-18	1.35	LM710N	79
LM106H	99	LM340K-24	1.35	LM711N	39
LM300H	80	LM340T-5	1.25	LM723N/H	55
LM301CN/H	35	LM340T-6	1.25	LM733N	1.00
LM302H	75	LM340T-8	1.25	LM739N	1.19
LM304H	1.00	LM340T-12	1.25	LM741CN/H	35
LM305H	60	LM340T-15	1.25	LM741-14N	39
LM307CN/H	35	LM340T-18	1.25	LM747N/H	79
LM308CN/H	1.00	LM340T-24	1.25	LM748N/H	39
LM309H	1.10	LM358N	1.00	LM1310N	2.95
LM309K	1.25	LM370N	1.95	LM1458CN/H	59
LM310CN	1.15	LM373N	3.25	MC1488N	1.39
LM311N/H	90	LM377N	4.00	MC1489N	1.39
LM312H	1.95	LM380N	1.25	LM1496N	95
LM317K	6.50	LM380CN	1.05	LM1556V	1.75
LM318CN/H	1.50	LM381N	1.79	MC1741SCP	3.00
LM319N	1.30	LM382N	1.79	LM2111N	1.95
LM320K-5	1.35	NE501N	8.00	LM2901N	2.95
LM320K-5.2	1.35	NE510A	6.00	LM3053N	1.50
LM320K-12	1.35	NE529A	4.95	LM3065N	1.49
LM320K-15	1.35	NE531H/V	3.95	LM3900N(3401)	49
LM320K-18	1.35	NE536T	6.00	LM3905N	89
LM320K-24	1.35	NE540L	6.00	LM3909N	1.25
LM320T-5	1.25	NE544N	4.95	MC5558V	59
LM320T-5.2	1.25	NE550N	1.30	8038B	4.95
LM320T-8	1.25	NE555V	39	LM75450N	49
LM320T-12	1.25	NE556N	99	75451CN	39
LM320T-15	1.25	NE560B	5.00	75452CN	39
LM320T-18	1.25	NE561B	5.00	75453CN	39
LM320T-24	1.25	NE562B	5.00	75454CN	39
LM323K-5	5.95	NE565N/H	1.25	75491CN	79
LM324N	1.80	NE566CN	1.75	75492CN	89
LM339N	99	NE567V/H	99	75493N	89
LM340K-5	1.35	NE570N	4.95	75494CN	89
LM340K-6	1.35	LM703CN/H	69	RC4136	1.25
LM340K-8	1.35	LM709N/H	29	RC4151	2.85
LM340K-12	1.35			RC4194	5.95
LM340K-15	1.35			RC4195	4.49

74LS00TTL

74LS00	23	74LS47	69	74LS138	69
74LS01	23	74LS51	23	74LS139	69
74LS02	23	74LS54	23	74LS151	69
74LS03	23	74LS55	23	74LS155	69
74LS04	29	74LS73	35	74LS157	69
74LS05	29	74LS74	35	74LS160	89
74LS08	23	74LS75	49	74LS161	89
74LS09	29	74LS76	35	74LS162	89
74LS10	23	74LS78	39	74LS163	89
74LS11	60	74LS83	75	74LS164	99
74LS13	49	74LS85	99	74LS175	79
74LS14	99	74LS86	35	74LS181	2.49
74LS15	29	74LS90	49	74LS190	89
74LS20	23	74LS92	59	74LS191	89
74LS21	29	74LS93	59	74LS192	89
74LS22	29	74LS95	79	74LS193	89
74LS26	29	74LS96	89	74LS194	89
74LS27	29	74LS107	35	74LS195	89
74LS28	29	74LS109	35	74LS253	79
74LS30	23	74LS112	35	74LS257	69
74LS32	29	74LS123	89	74LS258	1.39
74LS37	35	74LS125	69	74LS260	55
74LS40	29	74LS132	79	74LS279	59
74LS42	69	74LS136	39	74LS367	59
				74LS368	59
				74LS670	1.95

EXCITING NEW KITS!

Regulated Power Supply
5 to 15 VDC

NEW

- Full 1.5 amp at 5-10V output – Up to .5 amp at 15V output
- Heavy duty transformer
- 3 terminal I.C. Volt. Reg.
- Heat sink provided for cooling efficiency
- PC Board construction
- 120 VAC input
- Size: 3½"W x 5"L x 2"H

JE210 5 to 15 VDC **$19.95**

Digital Thermometer Kit

NEW

- Dual sensors—switching control for in-door/outdoor or dual monitoring
- Continuous LED .8" ht. display
- Range: -40°F to 199°F / 40°C to 100°C
- Accuracy: ±1° nominal
- Set for Fahrenheit or Celsious reading
- Sim. walnut case - AC wall adapter incl.
- Size: 3-1/4"H x 6-5/8"W x 1-3/8"D

JE300 .... **$39.95**

ALSO AVAILABLE:

JE900	Digital Stopwatch Kit	$39.95
JE301	6 digit Clock Kit	$19.95
JE730	4 digit Clock Kit	$14.95
JE2206B	Func. Generator Kit	$19.95
JE747	Jumbo 6 dgt. clock kit	$29.95

DISCRETE LEDS

.200" dia.				.125" dia.			
XC556R	red	5/$1		XC209R	red	5/$1	
XC556G	green	4/$1		XC209G	green	4/$1	
XC556Y	yellow	4/$1		XC209Y	yellow	4/$1	
XC556C	clear	4/$1					
.200" dia.				.185" dia.			
XC22R	red	5/$1		XC526R	red	5/$1	
XC22G	green	4/$1		XC526G	green	4/$1	
XC22Y	yellow	4/$1		XC526Y	yellow	4/$1	
.170" dia.				XC526C	clear	4/$1	
MV10B	red	4/$1					
.085" dia.				.190" dia.			
MV50	red	6/$1		XC111R	red	5/$1	
INFRA-RED LED 1/4"x1/4"x1/16" flat		5/$1		XC111G	green	4/$1	
				XC111Y	yellow	4/$1	
				XC111C	clear	4/$1	

TIMEX T1001
LIQUID CRYSTAL DISPLAY
FIELD EFFECT

4 DIGIT – .5" CHARACTERS
THREE ENUNCIATORS
2.00" X 1.20" PACKAGE
INCLUDES CONNECTOR

T1001-Transmissive	$7.95
T1001A-Reflective	8.25

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	270	2.95	MAN 6730	Common Anode-red ±1	560	99
MAN 2	5 x 7 Dot Matrix-red	300	4.95	MAN 6740	Common Cathode-red-D.D.	560	99
MAN 3	Common Cathode-red	125	25	MAN 6750	Common Cathode-red ±1	560	99
MAN 4	Common Cathode-red	187	1.95	MAN 6760	Common Anode-red	560	99
MAN 7G	Common Anode-green	300	1.25	MAN 6780	Common Cathode-red	560	99
MAN 7Y	Common Anode-yellow	300	99	DL701	Common Anode-red ±1	300	99
MAN 72	Common Anode-red	300	99	DL704	Common Cathode-red	300	99
MAN 74	Common Cathode-red	300	1.25	DL707	Common Anode-red	300	99
MAN 82	Common Anode-yellow	300	99	DL728	Common Cathode-red	500	1.49
MAN 84	Common Cathode-yellow	300	99	DL741	Common Anode-red	600	1.25
MAN 3620	Common Anode-orange	300	99	DL746	Common Anode-red ±1	630	1.49
MAN 3630	Common Anode-orange ±1	300	99	DL747	Common Anode-red	600	1.49
MAN 3640	Common Cathode-orange	300	99	DL749	Common Cathode-red ±1	630	1.49
MAN 4610	Common Anode-orange	300	99	DL750	Common Cathode-red	600	1.49
MAN 4640	Common Cathode-orange	400	99	DL338	Common Cathode-red	110	35
MAN 4710	Common Anode-red	400	99	FND70	Common Cathode	250	69
MAN 4730	Common Anode-red ±1	400	99	FND358	Common Cathode ±1	357	99
MAN 4740	Common Cathode-red	400	99	FND359	Common Cathode	357	75
MAN 4810	Common Anode-yellow	400	99	FND503	Common Cathode(FND500)	500	99
MAN 4840	Common Cathode-yellow	400	99	FND507	Common Anode (FND510)	500	99
MAN 6610	Common Anode-orange-D.D.	560	99	5082-7730	Common Anode-red	300	1.30
MAN 6630	Common Anode-orange ±1	560	99	HDSP-3400	Common Anode-red	800	2.10
MAN 6640	Common Cathode-orange-D.D.	560	99	HDSP-3403	Common Cathode red	800	2.10
MAN 6650	Common Cathode-orange ±1	560	99	5082-7300	4 x 7 sgl. Digit-RHDP	600	19.95
MAN 6660	Common Anode-orange	560	99	5082-7302	4 x 7 Sgl. Digit-LHDP	600	19.95
MAN 6680	Common Cathode-orange	560	99	5082-7304	Overrange character (±1)	600	15.00
MAN 6710	Common Anode-red-D.D.	560	99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA3023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	85	CA3401N	49
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	75
DM8889	75
9374 7 seg C.A. LED driver	

CLOCK CHIPS

MM5309	$4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
MM5841	9.95

MOTOROLA

MC1408L7	$4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$.17	16	15	22 pin LP	$.37	36	35
14 pin LP	20	19	18	24 pin LP	38	37	36
16 pin LP	22	21	20	28 pin LP	45	44	43
18 pin LP	29	28	27	36 pin LP	60	59	58
20 pin LP	34	32	30	40 pin LP	63	62	61

SOLDERTAIL STANDARD (TIN)

14 pin ST	$.27	25	24	28 pin ST	$.99	90	81
16 pin ST	30	27	25	36 pin ST	1.39	1.26	1.15
18 pin ST	35	32	30	40 pin ST	1.59	1.45	1.30
24 pin ST	49	45	42				

SOLDERTAIL STANDARD (GOLD)

8 pin SG	$.30	27	24	24 pin SG	$.70	63	57
14 pin SG	35	32	29	28 pin SG	1.10	1.00	90
16 pin SG	38	35	32	36 pin SG	1.65	1.40	1.26
18 pin SG	52	47	43	40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

8 pin WW	$.39	38	31	22 pin WW	$.95	85	75
10 pin WW	45	41	37	24 pin WW	1.05	95	85
14 pin WW	39	38	37	28 pin WW	1.40	1.25	1.10
16 pin WW	43	42	41	36 pin WW	1.59	1.45	1.30
18 pin WW	75	68	62	40 pin WW	1.75	1.55	1.40

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	50 PCS	$1.75
ASST. 2	5 ea	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	50 PCS	1.75
ASST. 3	5 ea	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	50 PCS	1.75
ASST. 4	5 ea	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	50 PCS	1.75
ASST. 5	5 ea	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	50 PCS	1.75
ASST. 6	5 ea	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	50 PCS	1.75
ASST. 7	5 ea	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

TELEPHONE/KEYBOARD CHIPS

AY-5-9100	Push Button Telephone Dialler	$14.95
AY-5-9200	Repertory Dialler	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	14.95
HD0165	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	5.95

ICM CHIPS

ICM7045	CMOS Precision Timer	24.95
ICM7205	CMOS LED Stopwatch/Timer	19.95
ICM7207	Oscillator Controller	7.50
ICM7208	Seven Decade Counter	19.95
ICM7209	Clock Generator	6.95

NMOS READ ONLY MEMORIES

MCM6571	128 X 9 X 7 ASCII Shifted with Greek	13.50
MCM6574	128 X 9 X 7 Math Symbol & Pictures	13.50
MCM6575	128 X 9 X 7 Alphanumeric Control Character Generator	13.50

MISCELLANEOUS

TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	19.95
95H90	Hi-Speed Divide 10/11 Prescaler	11.95
4N33	Photo-Darlington Opto-Isolator	3.95
MK50240	Top Octave Freq. Generator	17.50
DS0026CH	5Mhz 2-phase MOS clock driver	3.75
TIL308	.27" red num. display w/integ. logic chip	10.50
MM5320	TV Camera Sync. Generator	14.95
MM5330	4½ Digit DPM Logic Block (Special)	3.95
LD110/111	3½ Digit A/D Converter Set	25.00/set

LITRONIX ISO-LIT 1
Photo Transistor Opto-Isolator
(Same as MCT 2 or 4N25)
2/99¢

SN 76477
SOUND GENERATOR
Generates Complex Sounds
Low Power - Programmable
3.95 each

TV GAME CHIP AND CRYSTAL
AY-3-8500-1 and 2.01 MHZ Crystal (Chip & Crystal includes score display, 6 games and select angles, etc. **7.95/set**

EXAR

XR205	$8.40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1.55	JE2206KA	14.95	XR2567	2.99
XR-L555	1.50	JE2206KB	19.95	XR3403	1.25
XR555	39	XR1800	3.20	XR4136	1.25
XR556	99	XR2206	4.40	XR4151	2.85
XR567CP	99	XR2207	3.85	XR4194	4.95
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.30	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	75
XR1488	1.39	XR2212	4.35	XR4739	1.15
XR1489	1.39	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS W	PRICE
1N746	3.3	400m	4/1.00	1N4002	100 PIV 1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4003	200 PIV 1 AMP	12/1.00
1N752	5.6	400m	4/1.00	1N4004	400 PIV 1 AMP	12/1.00
1N753	6.2	400m	4/1.00	1N4005	600 PIV 1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N4006	800 PIV 1 AMP	10/1.00
1N757	9.0	400m	4/1.00	1N4007	1000 PIV 1 AMP	10/1.00
1N759	12.0	400m	4/1.00	1N3600	50 200m	6/1.00
1N959	8.2	400m	4/1.00	1N4148	75 10m	15/1.00
1N965	15	400m	4/1.00	1N4154	35 10m	12/1.00
1N5232	5.6	500m	28	1N4305	75 25m	15/1.00
1N5234	6.2	500m	28	1N4734	5.6 1w	28
1N5235	6.8	500m	28	1N4735	6.2 1w	28
1N5236	7.5	500m	28	1N4736	6.8 1w	28
1N5242	12	500m	28	1N4738	8.2 1w	28
1N5245	15	500m	28	1N4742	12 1w	28
1N456	25	40m	6/1.00	1N4744	15 1w	28
1N458	150	7m	6/1.00	1N1183	50 PIV 35 AMP	1.60
1N485A	180	10m	5/1.00	1N1184	100 PIV 35 AMP	1.70
1N4001	50 PIV 1 AMP		12/1.00	1N1185	150 PIV 35 AMP	1.70
				1N1186	200 PIV 35 AMP	1.80
				1N1188	400 PIV 35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C38M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

C106B1	50			2N3904	4/1.00
MPSA05	30	2N3055	89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369	5/1.00	MPS3705	5/1.00	2N5087	4/1.00
2N2369A	4/1.00	2N3706	5/1.00	2N5088	4/1.00
MPS2369	5/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2484	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2906	4/1.00	2N3711	5/1.00	PN5134	5/1.00
2N2907	5/1.00	2N3724A	65	PN5138	5/1.00
PN2907 Plastic	7/1.00	2N3725A	1.00	2N5139	5/1.00
2N2925	5/1.00	2N3772	2.25	2N5210	5/1.00
MJE2955	1.25	2N3823	1.00	2N5449	3/1.00
2N3053	2/1.00	2N3903	5/1.00	2N5951	3/1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
10 pf	05	04	03	001µF	05	04	035
22 pf	05	04	03	0047µF	05	04	035
47 pf	05	04	03	01µF	05	04	035
100 pf	05	04	03	022µF	06	05	04
220 pf	05	04	03	047µF	06	05	04
470 pf	05	04	035	1µF	12	09	075

100 VOLT MYLAR FILM CAPACITORS

001mf	12	10	07	022mf	13	11	08
0022	12	10	07	047mf	21	17	13
0047mf	12	10	07	1mf	27	23	17
01mf	12	10	07	22mf	33	27	22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

1/35V	28	23	17	1.5/35V	30	26	21
15/35V	28	23	17	2.2/25V	31	27	22
22/35V	28	23	17	3.3/25V	31	27	22
33/35V	28	23	17	4.7/25V	32	28	23
47/35V	28	23	17	6.8/25V	36	31	25
68/35V	28	23	17	10/25V	40	35	29
1.0/35V	28	23	17	15/25V	63	50	40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
47/50V	15	13	10	47/25V	15	13	10
1.0/50V	16	14	11	47/50V	16	14	11
3.3/50V	14	12	09	1.0/16V	15	13	10
4.7/25V	15	13	10	1.0/25V	16	14	11
10/25V	15	13	10	1.0/50V	16	14	11
10/50V	16	14	12	4.7/16V	15	13	10
22/25V	17	15	12	4.7/25V	15	13	10
22/50V	24	20	18	4.7/50V	16	14	11
47/25V	19	17	15	10/16V	14	12	09
47/50V	25	21	19	10/25V	15	13	10
100/25V	24	20	18	10/50V	16	14	12
100/50V	35	30	28	47/50V	24	21	19
220/25V	32	28	25	100/16V	19	15	14
220/50V	45	41	38	100/25V	24	20	18
470/25V	33	29	27	100/50V	35	30	28
1000/16V	55	50	45	220/16V	23	17	16
2200/16V	70	62	55	470/25V	31	28	26

BISHOP HILL — BISKOPSKULLA RADIO EXCHANGE AMATEUR RADIO OPERATORS in Sweden and the United States will attempt direct radio contact between Bishop Hill, Illinois and Biskopskulla, Uppland, Sweden on the weekend of May 26 and 27, 1979. Bishop Hill was a communal settlement established in the 1840's by Swedish migrants and is now an historical site maintained by the State of Illinois. Led by DX'ers W9FKC and SM0FY, the groups will try to contact as many stations as possible over the scheduled weekend. Operation will occur on all bands, phone and CW, full period. Special QSL's will be issued, SASE or IRC's requested, all others via bureaus. The Biskopskulla team will use the call SK0MG, the Bishop Hill group will use W9FKC. QSL via WA9AQN.

MASSACHUSETTS: NoBARC Hamfest July 21, 22 at Cummington Fairgrounds. Tech talks, demonstrations and dealers. Flea market, $1.00; advance registration $3.00 single, with spouse $5.00 to Tom Hamilton, WA1VPX, 206 California Avenue, Pittsfield, Massachusetts 01201 or $4.00/$6.00 at gate. Mobile talk-in on 146.31/91. Gates open at 5:00 PM on Friday for free camping.

SOWP 4TH ANNUAL CW QSO PARTY, sponsored by the Society of Wireless Pioneers (SOWP). From 0000 Z on June 6 thorugh 2359 Z on June 7. There are no formal requirements except an exchange of name, membership number and QTH. Suggested frequencies are 55 kHz (± 5 kHz) up from the low end of each amateur band. Novices will operate in the center of each novice band. Members who can only participate part-time are requested to make their calls on the even hours during the period. To optimize long distance contacts, it is suggested that ten and fifteen meters be used from 1400 to 2100 hours Z. The call will be CQ SOWP. A special certificate will be available to all members who contact a minimum of ten other members during the period. Requests for the certificate must include a list of stations contacted, dates, times and membership numbers. In addition, an SASE must be inluded. Certificates will be issued by the V.P. for Awards, Manuel "Pete" Fernandez, W4SM, 129 Hialeah Road, Greenville, South Carolina, 29607. Requests must be submitted not later than 30 June 1979.

NEW ENGLAND: The Hosstraders Net will hold its Sixth Annual Tailgate Swapfest, Saturday, May 12, at the Deerfield, New Hampshire, Fairgrounds (covered buildings in case of rain). Admission: one dollar, no percentage or commission, commercial dealers welcome at same rate. Excess revenues benefit Boston Burns Unit of Shriners' Hospital for Crippled Children. Last year we donated $1140.50. Talk-in .52 and 146.40-147.00. Questions about New England's biggest flea market? SASE to Joe DeMaso K1RQG, Star Route Box 56, Bucksport, ME 04416, or Norm Blake, WA1IVB, P.O. Box 32, Cornish, ME 04020.

PENNSYLVANIA: Fifth Annual Northwest PA hamfest, Saturday, June 9, 1979, Crawford County Fairgrounds, Meadville, PA. Note date change. Gates open at 8:00 AM. Bring your own tables. $2.00 in; $1.00 out to display. $2.00 admission. Hourly door prizes, refreshments, commercial displays welcome. Talk-in 04/64, 81/21, 63/03. Details C.A.R.S., P.O. Box 653, Meadville, PA 16335. Attention: Hamfest Committee.

INDIANA: The Cass County Amateur Radio Club's second annual hamfest, Sunday, May 6, from 7:00 AM to 4:00 PM, at the 4-H Fairgrounds. Rain or Shine. Go North to Logansport on Highway 25, turn right at road 100, follow QSY signs. Advance tickets $1.50, $2.00 at gate. Outside setup free, undercover $1.00. Bring your own tables. Free overnight camping, plenty of refreshments. Talk-in: 146.52 and Logansport Repeater: 147.78-18. Write to: K9DVL Dave Rothermel, RR 4, Box 146 G, Logansport, IN 46947.

MICHIGAN: The Monroe County Radio Communications Association's annual Hamfest Swap and Shop, June 10, 8 AM to 4 PM, Monroe County Community College, Raisinville Rd. off M-50. Donation $1.00 at gate. Free parking, trunk sales, indoor table space. Contests, auctions and displays. Technical forums and demonstrations. For reservations and info: Fred Lux, WD8ITL, P.O. Box 982, Monroe, MI 48161. Talk in 146.13/73 or 52 Simplex.

MICHIGAN: Central Michigan Amateur Repeater Association fifth Annual Swap & Shop in Midland, June 16th at the Midland County Fairgrounds. Computer Demonstrations, Door Prizes. Donation: $2.50 at door. Talk-in: 146.73 WR8ARB and 146.52 simplex. Tickets & Info, SASE to: R. L. Wert, W8QOI, 309 E. Gordonville Road, R #12, Midland, Michigan 48640.

MINNESOTA: Amateur Fair '79, Swapfest & Exposition, Saturday, June 2, Minnesota State Fairgrounds, St. Paul. Free overnight parking for self-contained campers June 1 only. Tailgaters flea market. Inside space available. Admission: $2.00. For info or reservations: Amateur Fair, P.O. Box 30054, St. Paul, MN 55175.

More Details? CHECK—OFF Page 118

More Details? CHECK—OFF Page 118

NEW JERSEY: The Raritan Valley Radio Club (W2QW Group) 8th annual Hamfest and Flea Market, Saturday, June 16, 8:30 AM to 4:00 PM, Columbia Park, Dunellen. For info: Raritan Valley Radio Club, RD 3, Box 317, Somerset, N. J. 08873 or (201) 356-8435 (WB2MNE).

NEW JERSEY: Tri County Radio Association, Inc. Flea Market will be held at the Passaic Township Youth Center, Stirling, on Sunday, May 20, 1979. For information write the Association at P.O. Box 412, Scotch Plains, New Jersey, 07076 or call W2CHA at (201) 647-3461.

NEW YORK: Rochester Hamfest, May 25-27, Monroe County Fairgrounds (Route 15A) Rochester. Registration $4.00. $1.00 parking permit good throughout Hamfest. Outdoor tables $5.00 each per day. Indoor/outdoor flea market. Indoor Saturday and Sunday only starting 7:00 AM Saturday. Outdoor starts Noon Friday through Sunday closing. For tickets: Rochester Hamfest, 737 Latta Rd., Rochester, N. Y. 14612.

NEW YORK: LIMARC's Hamfair '79, June 3, Islip Speedway, Islip Avenue (Route 111). Admission: $1.50, exhibitors $3.00 per space. Spouses, sweethearts and under 12 free. Door prizes for ticket holders. Starts 9:00 AM. Watch for special events. Talk-in 146.25/85 or 52. HEAVY raindate June 10. For info: Hank Wener, WB2ALW, 53 Sherrard St., East Hills, N. Y. 11577. (516) 829-5880 days or (516) 484-4323 nights to 2330.

NEW YORK: The Southern Tier Amateur Radio Club's (Binghamton) 20th annual Hamfest and dinner, May 5, Lutheran Fellowship Recreation Center, exit 71 N. on Stella Ireland Road. General admission: $2.00, Banquet $7.00 (including general admission). Free flea market parking, prizes, refreshments. Inside tables $5.00 each, reservations only. For tickets and info: S.T.A.R.C., P.O. Box 11, Endicott, N. Y. 13760.

WISCONSIN: The Milwaukee UHF Society's second annual Swapfest, Sunday, May 13, starting 7:00 AM, Waukesha County Expo Center Grounds, Waukesha. Admission: $1.50 advance; $2.00 gate. Prizes, refreshments. For tickets: SASE, Swapfest, Box 49, North Prairie, WI 53153.

1979 WEST VIRGINIA QSO PARTY. All Amateur Radio operators are invited to participate in the 1979 West Virginia QSO party. The party is sponsored by the West Virginia State Amateur Radio Council. The contest period runs from 2300 Z, June 16 to 2300 Z, June 17, and there are no time limits on operating. The contest rules are: 1. The same station may be worked on different bands for additional points. Only one contact of each station per band may be counted for scoring. 2. Stations making contact should exchange QSO number, signal report, and county (if in West Virginia), state or country. 3. West Virginia stations may work each other. 4. Out-of-state stations determine their score by multiplying the number of eligible QSO's with West Virginia stations by the number of different West Virginia counties worked. This total should be multiplied by the power multiplier indicated in paragraph 6. 5. West Virginia stations determine their score by multiplying the number of eligible QSO's by the sum of the different West Virginia counties, states, and countries worked. This total should be multiplied by the power multiplier indicated in paragraph 6. 6. A power multiplier will be allowed as follows: DC input of 200 watts or less — 1.5; DC input of 201 watts to legal limit — 1.0. 7. To be eligible for an award a station may have one unassisted operator. 8. Logs should be sent to: West Virginia QSO Party, P.O. Box 36, Seneca Rocks, West Virginia 26884.

THE MINNESOTA QSO PARTY, sponsored by the Heartland Amateur Radio Club will run from 1800 Z, June 2 to 2359 Z, June 3. No mode or time restrictions. Only one transmitter is allowed in operation at any one time; no crossband. Novices compete with other Novices, Technicians with other Technicians. Exchange: Minnesota stations send RS(T) and county. Other stations transmit RS(T) and ARRL section. For further information contact HARC, c/o Scott Nelson, WDØEZF, 421 West Wisconsin Avenue, Staples, MN 56479.

THE VK/ZL/OCEANIA DX CONTEST 1979 will be held June 16 and 17, 1979, running from 1000 GMT Saturday to 1000 GMT Sunday. All Amateur Bands, 3.5 MHz through to 28 MHz, can be used for contacts. There are three classes; (a) Single operator, (b) Multi-operator, (c) SWL operators. Logs of Multi-operator stations must be signed by all operators together with a list of their callsigns. Logs of SWL listeners MUST contain both numbers sent and the number received by the station logged. Incomplete loggins are not eligible for scoring. Stations will send serial number which consists of (a) RST, (b) Zone number, and (c) Time in GMT. Logs must show in this order, (1) Date, (2) Time (GMT), (3) Callsign of station worked, (4) Serial number received, (5) Serial number sent, (6) Points claimed. Logs must be received by the Contest Committee by the 18th of August 1979. The address for logs is: Bill Storer, VK2EG, 55 Prince Charles Rd., FRENCHS FOREST, 2086, N.S.W. Australia.

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More Details? CHECK—OFF Page 118

INDIANA: Madison County ARC Hamfest, Sunday, June 3, 8:00 AM to 3:30 PM, U.A.W. #662 Union Hall, 109 Bypass and Hillcrest Drive, Anderson. Talk in 146.22/.82 and 146.52 simplex. For info: WB9QDO.

MASSACHUSETTS: Eastern Connecticut ARC's Electronic Flea Market and Hamfest, May 20, 9 AM to 6 PM, Point Breeze Restaurant, Webster. For info: Richard Spahl, K1SYI, Lake Parkway, Webster, MA 01570. (617) 943-4420 after 8 PM.

WASHINGTON: Pacific Northwest Hamfest, July 14 & 15, HAM Inc., Box 78442, Seattle, WA 98178.

WISCONSIN: CWRA Swapfest Picnic, June 3, Stevens Point. For info: Frank Guth, W9BCC, 1632 Ellis St., Stevens Point, WI 54481.

CALIFORNIA: The North Hills Radio Club, Inc. of greater Sacramento's 7 annual Ham Swap on Sunday, May 6, 9 AM to 3 PM. Machinists Hall, 3081 Sunrise Blvd., Rancho Cordova, CA 95670. Take Hy 50 to Sunrise, turn left to signs.

ROCHESTER Hamfest & NY State ARRL Convention, May 25-27. Add your name to mailing list. Send QSL to Rochester Hamfest, Box 1388, Rochester, NY 14603. Phone (716) 424-1100.

ILLINOIS: The Radio Amateur Megacycle Society's third annual Antenna Measuring Contest, Saturday, May 19, 10 AM CDT, Flick-Reedy Corp. grounds, corner of Thorndale and York Roads, Bensenville. Equipment available to measure gain and SWR of 2-meter, 1¼-meter, and 70-cm antennas; equipment for higher frequencies brought by advance request. Prizes for highest-gain antenna in each category. Refreshments. For details SASE to: Joe LeKostaj, WB9GOJ, 2558 N. McVicker Ave., Chicago, IL 60639.

ILLINOIS: The Six Meter Club of Chicago, Inc.'s 22nd annual Hamfest, Sunday, June 10, Sante Fe Park, 91st street and Wolf Rd., Willow Springs, southwest of downtown Chicago.

OHIO: F.M. B*A*S*H, Dayton, April 27, 1979, Friday night of DAYTON HAMVENTION. Social evening for hams and friends, 8 PM til midnight, Dayton Convention Center, Main at Fifth Street. Admission free. Sandwiches, snacks and C.O.D. bar available. TV personality Rob Reider, WA8GFF, and his group will present a super show and there will be drawings for many fabulous prizes including a complete Drake UV-3 with 144, 220 and 440 MHz synthesized modules, power supply, encoder mike and antenna. For further information contact: Miami Valley F.M. Assn., P.O. Box 263, Dayton, Ohio 45401.

ILLINOIS: Starved Rock Radio Club Annual Hamfest, Sunday, June 3, Bureau County Fairgrounds, Princeton. Dealers' inside display area open for set-up 1:00 PM Saturday, June 2. Fairgrounds reached via routes 80-6-34-89-26; watch for signs. Free coffee and doughnuts to all registrants from 8:30 to 9:00 AM. Refreshments available. Reserved camper, van and trailer space available for nominal fee. Advance reservations $1.50 before May 20. $2.00 at gate. For info: SASE to W9MKS/WR9AFG, Starved Rock Radio Club, RFD#1, Box 171, Oglesby, IL 61348. (815) 667-4614.

MAINE: The Portland Amateur Wireless Assoc. and the University of Southern Maine Radio Club will hold a tailgate flea market on campus. May 26, 9 AM to 5 PM. Food available. Cost: $1.00. Talk in on 146.73 and 146.52. For info: John Taylor, N1SD. (207) 773-2651.

MARYLAND: The Potomac Area VHF Society's 8th annual Hamfest, Sunday, May 6, 8 AM to 5 PM, Howard County Fairgrounds, (approx. 15 miles west of Baltimore, int. I-70 and Rt. 32). Admission: $3.00 includes flea market and tailgating. Talk-in on 52 simplex. For info: Paul H. Rose, WA3NZL, 25116 Oak Dr., Damascus, MD 20750.

MARYLAND: The fifth annual Easton Amateur Radio Society's Hamfest, May 20, 10 AM to 4 PM, Easton Senior High School, Rt. 50, south of Easton, mile market 66. Talk-in on 52 simplex and 146.455/147.045 repeater in Easton. Tables inside, refreshments, tailgaters. Donation: $2.00; tables or tailgaters $2.00 additional. Write: Charles C. Walgren, WA3ZWX, Box 7, Trappe, MD 21673 or Easton ARS, Box 781, Easton, MD 21601.

INDIANA: Hamfest! Indiana's friendliest and largest hamfest. Wabash County Amateur Radio Club's 11th annual hamfest will be held Sunday, May 13, 1979, rain or shine, at the Wabash County 4-H Fairgrounds in Wabash. Large flea market (no set-up charge), technical forums, bingo, free overnight camping, plenty of free parking, good food at reasonable prices. Only one ticket to buy. Donation is $2.50 for advance tickets — $3.00 at the gate. Children under 12 years old free. For more information or advance tickets, write: Dave Nagel, WD9BDZ, 555 Valley Brook Ln., Wabash, IN 46992, S.A.S.E. Required.

More Details? CHECK—OFF Page 118

Introducing Kantronics' Field Day
TRADEMARK
Morse Code/teletype reader and code speed display:

Kantronics' Field Day Morse Code/teletype reader and code-speed display reads code signals right off the air. Its powerful microcomputer system picks out signals, computes their speed, and reads even sloppy copy up to 80 words per minute!

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Field Day is simple to use. You plug it into your station receiver just as you would a set of headphones.

Code and teletype conversations are converted from dots and dashes to standard alphanumeric text. The text advances across 10 big half-inch displays, and lab tests show that even the fastest CW is easily readable.

Field Day displays incoming or outgoing code speeds for you at the touch of a button. An accurate code speed-sampling program shows the speed right on the front panel. Everything is enclosed in a single, lightweight package that's small enough to fit in with the rest of your station.

2. Pay a little, get a lot.

In addition to a highly superior code-reading program and unique "on-board" speed display, **Field Day** has the specifications that make it a truly great code reader.

Modes: CW, RTTY and speed display. **Speed Range:** 3-80 WPM. **RTTY Speeds:** 60, 67, 75 and 100 baudot. **Code Display:** 10 alphanumeric displays. **Special Characters:** AS, AR, SK, BT, /, ?, ( ), ", ', comma, period, colon, semicolon, "understood," "attention," and "error." **Filtering:** Active, 750 Hz center, 200 Hz bandwidth. **Input Impedance:** 1,000 ohms. **Power Requirements:** 117 Vac, 20 watts. **Dimensions:** HWD 3.44" by 8.50" by 9.25". **Warranty:** Limited, one year parts and labor. **Price:** $449.95 Shipments after 3/1/79.

3. C'mon, take a test drive.

Check with these Authorzed **Kantronics** dealers for more information on the **Field Day** Morse Code/teletype reader and code-speed display:

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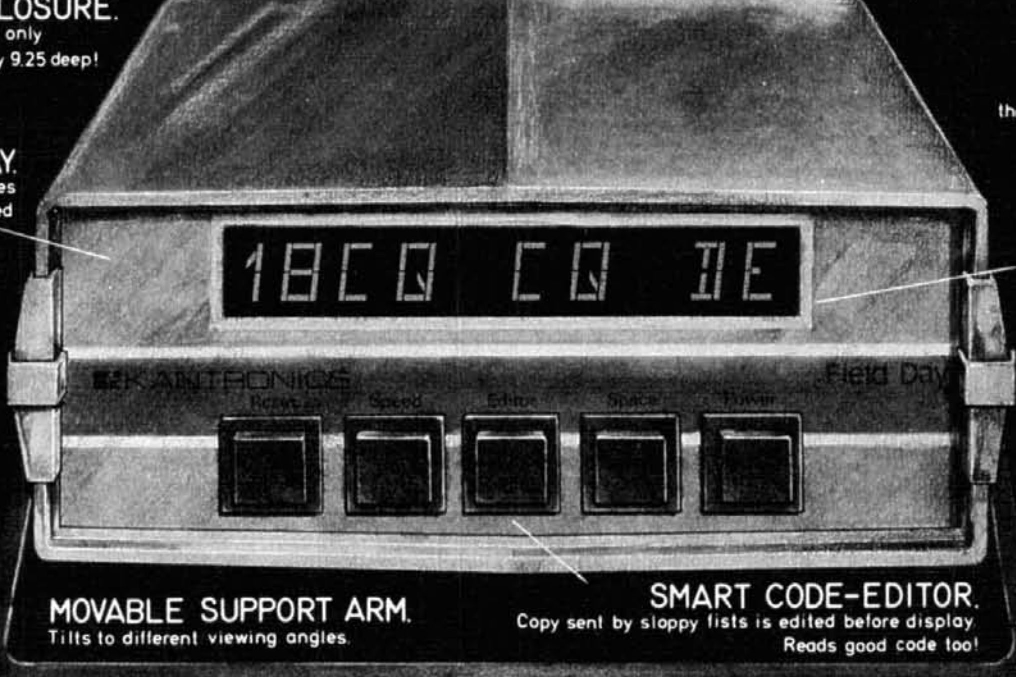

OHIO: The Champaign Logan Amateur Radio Club's annual Hamfest, July 1, Logan County Fairgrounds, Bellefontaine. (New Location). For info: John L. Wentz, W8HFK or Frank Knull, W8JS.

PENNSYLVANIA: The Schuylkill Amateur Repeater Association's 2nd annual Hamfest, Sunday, June 17. Rain or shine. Gates open 9:00 AM, Lakewood Park, Barnesville, Route 54, 3 miles east of Exit 37E on Int. 81. Registration: $2.00. Spouse and children free. Tailgaters $1.00 additional. Indoor tables $2.00 each. Indoor/outdoor areas, prizes, amusements, picnic tables, refreshments on grounds. Talk-in 147.78/.18 and 146.52 simplex. For info: S.A.R.A. Hamfest, P.O. Box 901, Pottsville, PA 17901.

PENNSYLVANIA: The Young Ladies' Radio League's International Convention, June 29 through July 1, Holiday Inn, 4th and Arch, Philadelphia. Events for all YLs (and their OM's too!) All YLs welcome — membership not necessary. Advance registration: $37.50 (includes meals). For details: Jan Scheuerman, WB2JCE, 616 Revere Avenue, Linwood, N. J. 08221.

PENNSYLVANIA: Breeze Shooters' 25th annual Hamfest, Sunday, May 20, noon to 5 PM, White Swan Park, Parkway West, near greater Pittsburgh airport. Flea market, prizes, children's amusements. Registration at gate: $2.00 or 3 for $5.00. Talk in 146.28/88 and 29 MHz. Under cover tables advance reservation only. For info: Rick Evanuik, WA3LUM, 311 Evergreen Ave., Pittsburgh, PA 15209.

VIRGINIA: The "Ole Virginia Hams" annual Hamfest, June 3, Prince William County Fairgrounds, Manassas, Rt. 234. Gates open 8:00 AM, tailgaters 7:00 AM. General admission: $3.00 PP. Under 12 free. Tailgating $2.00 per vehicle. Prizes: 5 band SSB Transceiver, Synthesized 2 meter Transceiver, etc. Refreshments available until 2:30 PM. Programs for spouse and children. Indoor space for dealers. For info: Sam Lebowich, WB4HAV, OVHARC, P.O. Box 1255, Manassas, VA 22110.

WASHINGTON: Fort Vancouver Hamfair, Saturday and Sunday, May 12 and 13, Clark County Fairgrounds, 7 miles north of Vancouver. Contests, seminars, commercial and amateur displays. Family events, flea market. Prizes awarded. Grand Prize: ICOM IC-701 hf transceiver and power supply. Trailer parking (no hookups), catered buffet Saturday night with musical entertainment. Registration: $4.00 PP includes drawing ticket. Dinner $5.00 adults. Tickets available at door. Registration: Ken Westby, W7DYX, 606 Miami Court, Vancouver, WA 98664.

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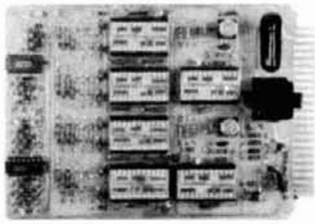

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7430	.10	7496	.40	74180	.50	74H61	.25	74L74	.45	74S74	.75	320K	1.00	709H	.15	5017N	1.50
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7438	.15	74107	.20	74182	.50	74H72	.25	74L90	.70	74S112	1.20	322N	1.15	723H	.30	5054N	2.50
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7441	.40	74123	.50	74189	2.50			74L93	.70	74S151	.75	(6,8,12,		741H	.15	5057N	1.60
7442	.40	74132	.50	74190	.70	74L00	.15	74L95	.70	74S157	1.00	15,18,24)		741N	.15	5058N	2.75
7445	.40	74141	.60	74191	.70	74L02	.15	74L98	1.35	74S200	4.00	371H	1.15	746H	.40	5060N	2.75
7448	.50	74145	.50	74192	.70	74L03	.15	74L157	.90			372H	.50	747H	.35	5736N	2.50
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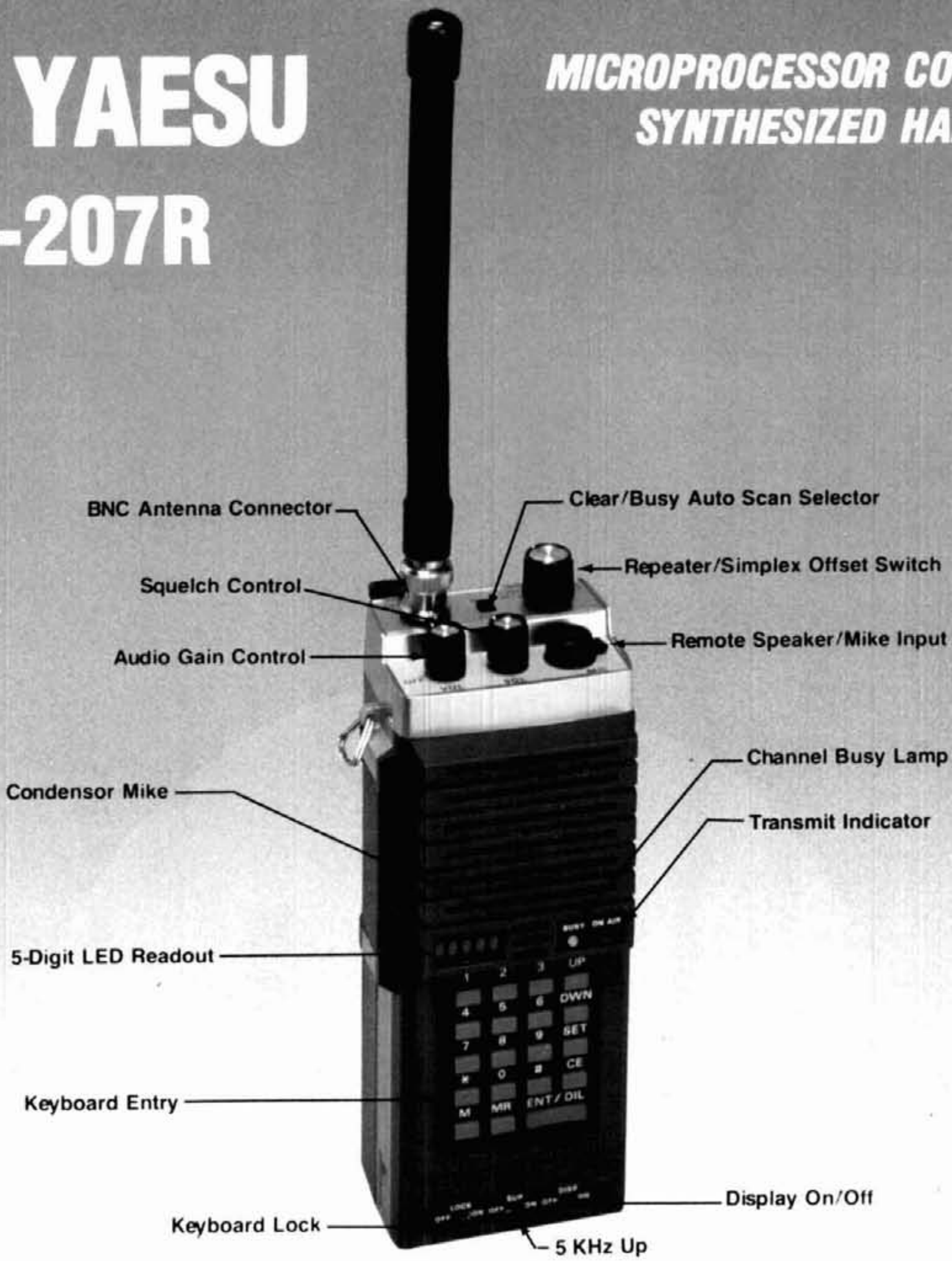

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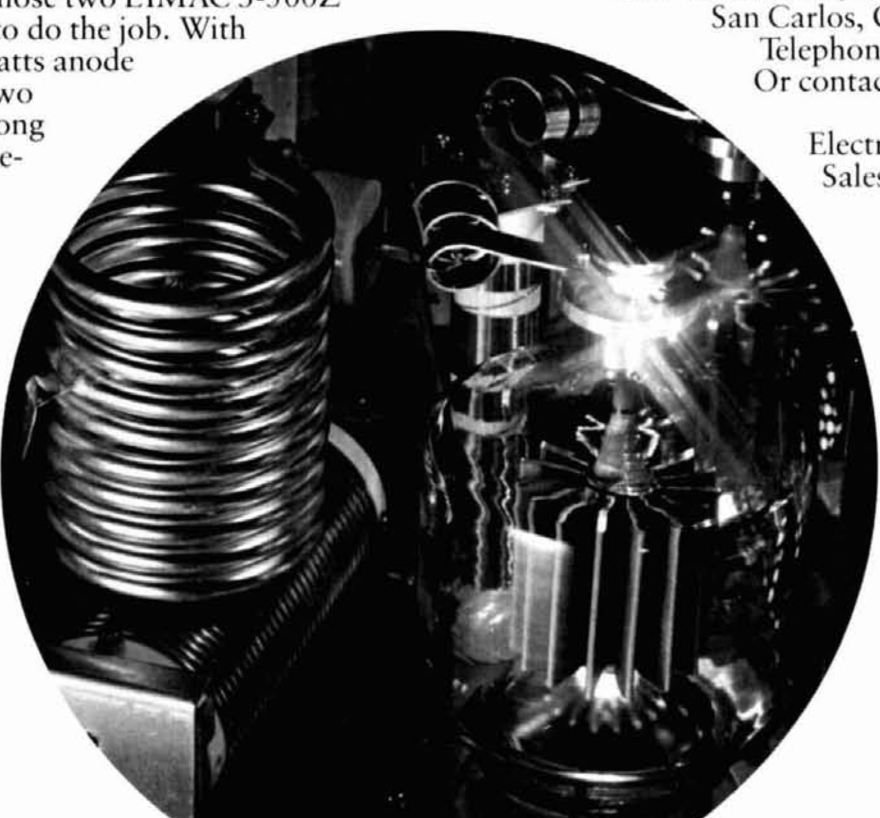

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