SPECIAL ANTENNA ISSUE

ham radio magazine

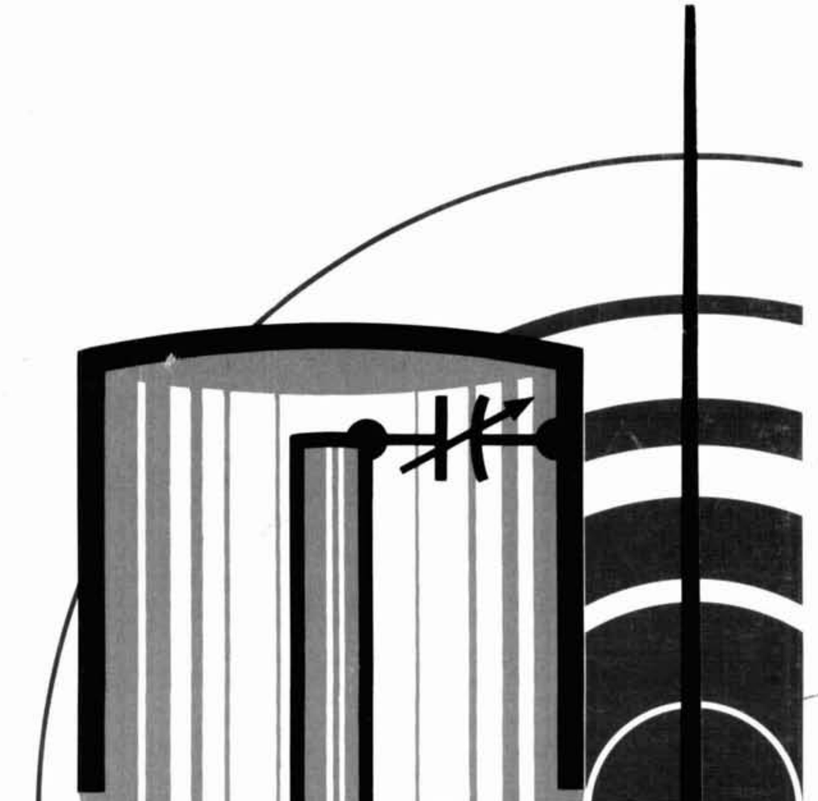
incorporating HAM RADIO HORIZONS

MAY 1981 / $2.50

- measuring coax cable loss
- the Giza beam
- coreless balun

hr

focus on communications technology



homebrew a coffee-can cavity antenna

tempo does it again

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Tempo was the first with a synthesized hand held for amateur use, first with a 220 MHz synthesized hand held, first with a 5 watt output synthesized hand held...and once again first in the 440 MHz range with the S-4, a fully synthesized hand held radio. Not only does Tempo offer the broadest line of synthesized hand helds, but its standards of reliability are unsurpassed...reliability proven through millions of hours of operation. No other hand held has been so thoroughly field tested, is so simple to operate or offers so much value. The Tempo S-4 offers the opportunity to get on 440 MHz from where ever you may be. With the addition of a touch tone pad and matching power amplifier its versatility is also unsurpassed.

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With 12 button touch tone pad...$399.00
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13.8 VDC power amplifier...$149.00

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S-30...$89.00* S-80...$149.00*

*For use with S-1 and S-5

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S-20...$89.00

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Channel Spacing: 25 KHz minimum
Power Requirements: 9.6 VDC
Current Drain: 17 ma-standby 400 ma-transmit (1 amp high power)
Antenna Impedance: 50 ohms
Sensitivity: Better than .5 microvolts nominal for 20 db
Supplied Accessories: Rubber flex antenna 450 ma ni-cad battery pack, charger and earphone
RF output Power: Nominal 3 watts high or 1 watt low power
Repeater Offset: ± 5 MHz

Optional Accessories for all models

12 button touch tone pad (not installed): $39 • 16 button touch tone pad (not installed): $48 • Tone burst generator: $29.95 • CTCSS sub-audible tone control: $29.95 • Leather holster: $20 • Cigarette lighter plug mobile charging unit: $6

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30W	130W	130A30	$199
2W	80W	80A02	$169
10W	80W	80A10	$149
30W	80W	80A30	$159
2W	50W	50A02	$129
2W	30W	30A02	$ 89

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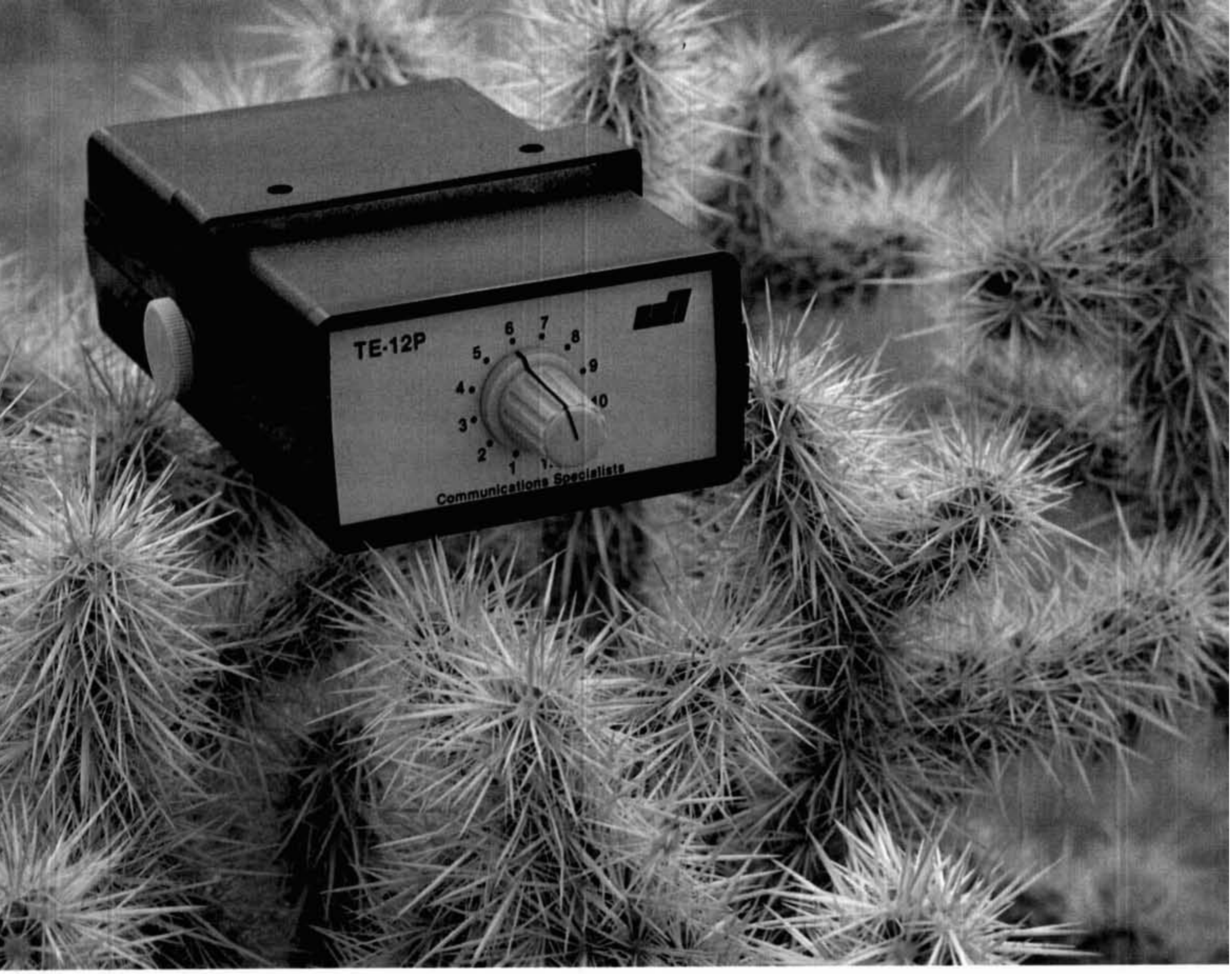

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74.4 WA	91.5 ZZ	110.9 2Z	136.5 4Z	167.9 6Z	
77.0 XB	94.8 ZA	114.8 2A	141.3 4A	173.8 6A	
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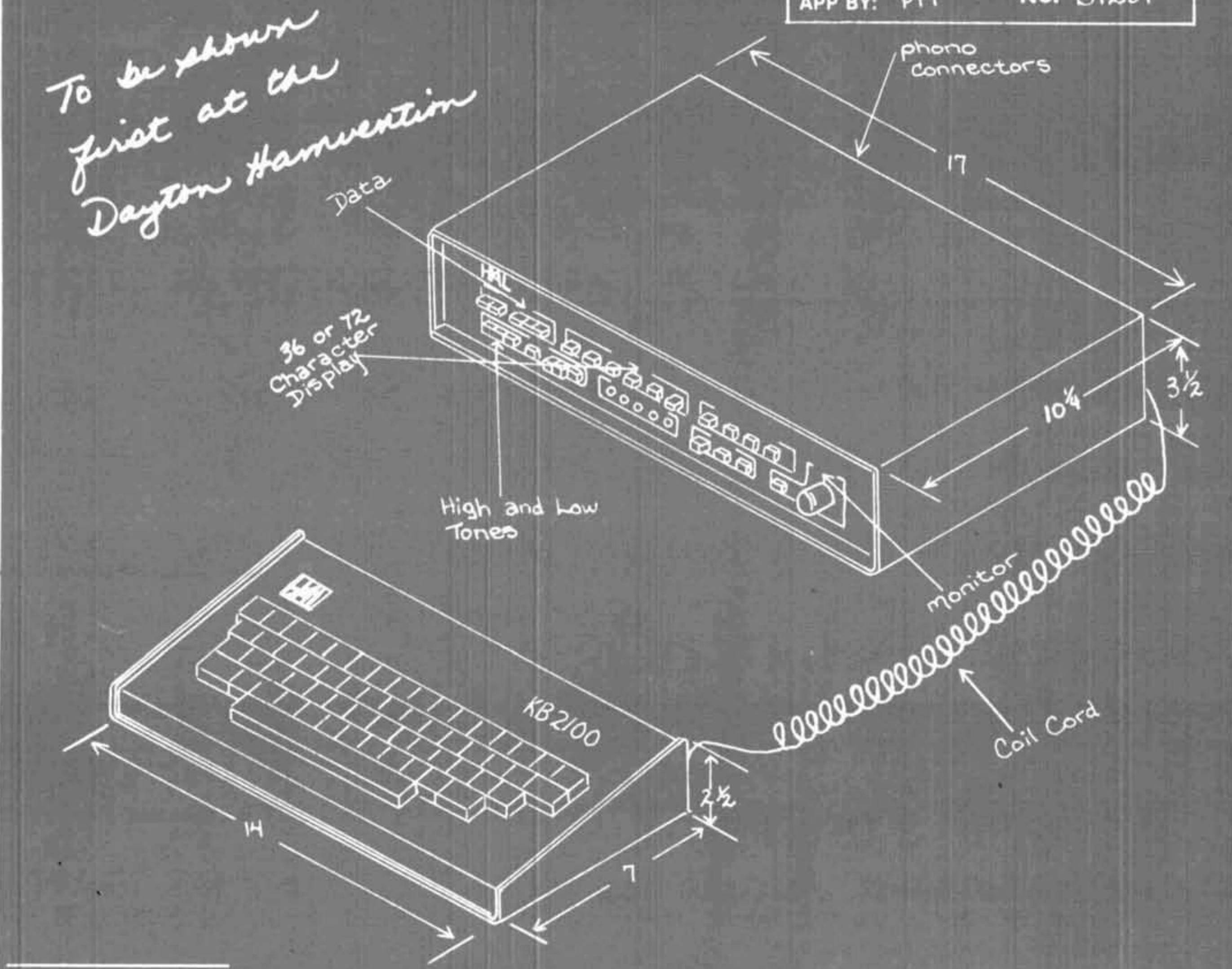

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incorporating HAM RADIO HORIZONS

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contents

Observation & Opinion

Here it is — our annual antenna issue. A great deal of care and planning has gone into this issue. We think the selection of articles is sufficiently well balanced to please everyone interested in antennas. And since it's hard to get on the air without an antenna, that should be just about all of our readers.

Our feature article describes a resonant reentrant cavity antenna, designed and patented by Bill Tucker, W4FXE. A thorough treatment of the theory of this antenna is given, followed by a discussion on how to build an experimental, basic cavity whose enclosure, of all things, is an ordinary coffee can. This antenna appears to furnish the answer to the problem of VHF-UHF receiver desense and intermod distortion, which is caused by out-of-band signals.

You'll also find in this issue articles on how to build two simple but very effective beam antennas from easy-to-find materials. They are so simple that just about anyone can put them together in a day or two at most — surely a pleasant way to spend a spring weekend.

And there's a surprise in this issue. It's something that has never been attempted in *ham radio*. Maybe I'm sticking my neck out, but somehow I have a feeling that the story of "Jim" will be a welcome change of pace. Let me know how you like it. If your response is positive, we'll have some more stories by old-timer John Flippin, W4VT.

A good barometer of how readers like *ham radio* was the ARRL National Convention at Orlando, Florida. Our booth at the convention was virtually besieged by Amateurs. Orlando was my first such show experience as editor, and it gave me the opportunity to meet a cross section of our readership. I want to thank everyone who took the time to offer comments. A great many expressed their compliments on the new *ham radio*. Of course there were some complaints too, but the number of positive remarks was greater than the complaints by an order of magnitude. I was greatly impressed by the enthusiasm of the crowd, which must have numbered in the thousands. I had a chance to meet some authors in person and exchange ideas for new articles. I wanted to circulate and take in some of the technical presentations, but business was so brisk at the *ham radio* booth that I didn't have a chance. Perhaps at Dayton!

The people at a large convention are most interesting. Young hams with 2-meter handhelds talking to each other across the room through the local repeaters; handicapped fellows in wheelchairs trying to see through the crowd; proud dads and their sons wearing identical T shirts with their callsigns displayed on the back; the fellow from a southern ham club wearing a red vest festooned with ribbons, badges, embroidered patches, Civil War medals, and his call sign spelled out in ¼-watt resistors. Then there was the fellow sporting a huge stovepipe hat with a miniature three-element Yagi beam on top, powered by a small electric motor. And last but not least, there was the youngster who bent my ear for a half hour asking for help in selecting study material for his Novice license (I fixed him up with some).

All in all, it was a rewarding experience and I wouldn't have missed it for anything. Those who forecast the demise of Amateur Radio should come out of their shells and take in one of the large conventions. Our future certainly looks healthy and hearty to me.

Alf Wilson, W6NIF
Editor

More Details? CHECK—OFF Page 118

comments

Dear HR:

Responding to your editorial in *ham radio*, December, 1980: The Bash situation is distasteful to many of us, but the practicalities of the situation remain. Memory plays a considerable part in all FCC exams, particularly Novice and Tech/General. There is no way to rationalize the FCC's rules and regulations — one must memorize them.

Let's face it, the majority of hams will not contribute to the technical advancement of Amateur Radio. (This is not to say that many non-technicals do not contribute greatly to the advancement of ham communications, emergency and otherwise.) For years, FCC-type exam questions were published and answers given out, even by the ARRL. So why not revert to this system — have the FCC change their present format and have many, many questions that could be used in the exams? Publish them and give the answers. One could not very well memorize them all, and, indeed, if anyone did, he would have quite a knowledge of radio and electronics.

Harry A. Lord, K4QJ
Palmetto, Florida

Dear HR:

Congratulations on your editorial in the December issue on the West Coast publisher who solicits and sells FCC exam information.

Since June, I have written to the FCC, to *Worldradio*, and, most recently, to Senator Goldwater on this very topic, which I, too, consider to be a serious threat to Amateur Radio as we know and esteem it. I feel, however, that there has already been too much time wasted in discussion of this problem in ham publications. The time has come for action.

I therefore encourage all hams who share our concern to write to Senator Barry M. Goldwater, Senate Office Building, Washington, D.C. 20510 and to their own representatives in Washington, urging legislation which would prohibit solicitation and divulgence of federal exam information, and provide specific penalties for such activities.

Paul Ellis, KN6D
Santa Cruz, California

Dear HR:

I read with interest your editorial of December, 1980, concerning FCC exams. The publisher of the exam questions and answers is doing little more than what the ARRL has done for years. I recall in the late 1950s, when I was in high school, my friend and I studied for and passed the exams for Novice and General licenses by using flashcards prepared from the ARRL *License Manual*. We memorized the answers and passed the tests, and we learned in the process.

Since then, I've passed the exams for Amateur Extra Class, 2nd Class Radiotelegraph, and 1st Class Radiotelephone. I have built transmitters and test equipment and am working on a high-frequency synthesizer. Electronics is a complex and difficult science, and people who are trained in it often seem to forget the energy and time they devoted to their training. For those of us with no training, it is impossible to thoroughly study basic electronics in the hope that we will learn what we need to pass the test. FCC exams *should* be designed so that, through memorization, those who take the tests will learn what they need to know to competently operate a station and to have an idea how to fix one. Most Amateurs learn more after the ticket comes, by operating a station and maintaining it. Only a few Amateurs (usually with formal training) will make a contribution to the art. Amateur Radio is more effective in allowing thousands of untrained hams an opportunity to learn through experience. Your magazine is excellent. I understand only half of the articles, but I'm learning!

Dave Moorman, K9SW
Downers Grove, Illinois

Dear HR:

Reading your latest Observation and Opinion, I immediately thought of the licensing system in West Germany. You may complain about an individual Amateur. We over here should complain about the communications administration in this country, as they publish a brochure containing questions and answers concerning the Amateur license exams. These booklets were originally meant to provide a certain help to the examining committee (most of them usually non-Amateurs) but are available to the public as well. Making it even worse, most of the time the questions used in exams are exactly the same as those in this official publication. In some cases, even the values of voltage and current in some basic Ohm's-law calculations were not even changed.

This leads to an entirely new type of Radio Amateur, which we could better call a "person licensed to participate on Amateur frequencies." The majority of these people can be found on 2-meter VHF (mainly fm), as this band requires no code test. Also, quite a lot of them are ex-CBers (from an absolutely saturated 12-channel CB band).

Although the situation in the U.S. is much different from the one over here, I agree with your opinion that memorizing questions and answers is definitely not the right way to get a license. I could list enough examples of the outcome of that type of preparation to fill another letter, but I should say you should be aware about the aftermath. It seems much better to stop things like that right in the beginning than to try to teach people after they receive their license.

Gerhard Petri, DF7BL
West Germany

presstop

SPREAD SPECTRUM HAS BEEN OK'ed for experimental use on a number of Amateur bands. An FCC Special Temporary Authorization agreeing to a proposal by AMRAD (the Amateur Radio Research and Development Corporation), was handed to W4RI and WB3KDU on Thursday, March 6. It grants them and 23 other members of AMRAD permission to conduct experiments using the revolutionary broadband modulation technique for a one-year period on both HF and UHF frequencies.

Four Different Experiments were proposed in the AMRAD request, and all were authorized in the FCC's STA. The first is for HF "frequency hopping," with the band determined by propagation at a given time. Frequencies authorized are 3675-3775 kHz, 7050-7150 kHz, or 14100-14200 kHz. "Service frequencies," where pre-test CW or SSB announcements and other conventional-mode traffic will be handled will be 3725, 7100, and 14150 +10 kHz.

10 Meters Will Be Used for the second experiment, also using frequency hopping between 28.1 and 29.3 MHz. The third experiment is a UHF "direct sequence" operation, utilizing 420-431 and 438-442 MHz to avoid possible conflicts with weak signal, OSCAR or FM users. Coordinated experiments with area ATV'ers and the Metrovision ATV group are planned. An E-M-E spread-spectrum experiment is also planned, operating on 432 MHz with bandwidths of from 16 kHz up to a megahertz.

Prior Warning Of The HF spread-spectrum operations is planned via W1AW and HR Report.

DIRE CONSEQUENCES FROM FCC budget cuts were spelled out by Acting Chairman Bob Lee in Capitol Hill testimony March 10. For private radio he noted the rules updating program (Plain Language Amateur Rules) would see serious delays, and that Amateur (and CB) license turn-around could slip from present 14-41 days to over two months. Rules enforcement efforts would also be reduced.

Field Offices Would Be Closed in Beaumont, Texas; Savannah, Georgia; Cincinnati; and Pittsburg. Also closed will be the Anchorage Monitoring Station and the two Special Enforcement Teams that operate in Powder Springs, Georgia, and in Detroit. Finally, Lee predicted that the traveling exam program, now covering 77 cities monthly, quarterly, or annually, would become entirely annual.

A RAISE IN DUES TO $25 and League General Manager Dick Baldwin's announcement that he plans to retire next year were two of the highlights of the ARRL Board meeting in Orlando March 11-12. Though the League has operated in the black the past two years, rising costs and projections for the near future convinced the directors that the increase in dues was necessary. It's to become effective July 1, and until then annual members can extend their memberships at the present $18 rate. Members over 65 will get a break after July 1, a 20% discount on their dues.

The Ad Hoc Committee On Ethics presented an extensive report on suggested conduct in future League elections, which was adopted by the board. They also agreed on a new bylaw establishing a procedure for recalling a League director. Expansion of General-class 75-meter phone privileges down to 3825 was proposed, but referred to the Plans and Programs Committee for study.

The Board Also Voted to discourage contest and awards use of the new 10.1-10.15 MHz band while it remains shared, and to petition the FCC to reinstitute issuance of the club station licenses.

MICROWAVE RADIATION KILLED a New York telephone company supervisor, the state's Workers' Compensation Board ruled recently in a decision believed to be the first official finding of its kind. The supervisor, who worked with TV relay equipment on the Empire State Building's 87th floor, died of "abnormal, premature aging" according to Dr. Milton Zaret, radiation specialist and professor at NYU Medical School. The supervisor, who lost his sight, hair, and coordination before dying at 58, had worked at the Empire State installation for eight years.

NEW REPEATERS NEAR THE NATIONAL Radio Astronomy Observatory and Naval Research Laboratory facilities must coordinate with the observatory and lab authorities, the Commission agreed recently. The action, which extends existing sanctions to Amateur repeaters in the quiet zone straddling the Virginia/West Virginia border and surrounding Green Bank and Sugar Grove, Virginia, applies only to new repeaters or modifications of existing machines. No already operating repeater, individual Amateur station, or mobile passing through the area is affected.

NEW CLUB STATION LICENSES are still a dead issue following the FCC agenda meeting March 26. A Petition for Reconsideration of Docket 21135, asking for new club station licenses and filed by the Capitol Hill ARS, was dismissed at the meeting without discussion.

Any Club Whose Amateur License has been lost since the ban on new club licenses began in 1977 should contact Perry Williams at ARRL. He plans to discuss such cases with the Commission shortly.

MFJ ANTENNA TUNERS 16 MODELS

MFJ-941C 300 Watt Versa Tuner II

Has SWR/Wattmeter, Antenna Switch, Balun. Matches everything 1.8-30 MHz: dipoles, vees, random wires, verticals, mobile whips, beams, balanced lines, coax lines.

Ham Radio's most popular antenna tuner. Improved, too.

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Fastest selling MFJ tuner . . . because it has the most wanted features at the best price.

Matches everything from 1.8-30MHz: dipoles, inverted vees, random wires, verticals, mobile whips, beams, balanced and coax lines.

Run up to 300 watts RF power output.

SWR and dual range wattmeter (300 & 30 watts full scale, forward/reflected power). Sensitive meter measures SWR to 5 watts.

Flexible antenna switch selects 2 coax lines, direct or through tuner, random wire/balanced line, or tuner bypass for dummy load.

12 position efficient airwound inductor for lower losses, more watts out.

Built-in 4:1 balun for balanced lines. 1000V capacitor spacing.

Works with all solid state or tube rigs.

Easy to use, anywhere. Measures 8x2x6", has SO-239 connectors, 5-way binding posts, finished in eggshell white with walnut-grained sides.

4 Other 300W Models: MFJ-940B, $79.95 (+ $4), like 941C less balun. **MFJ-945, $79.95** (+ $4), like 941C less antenna switch. **MFJ-944, $79.95** (+ $4), like 945, less SWR/Wattmeter, **MFJ-943, $69.95** (+ $4), like 944, less antenna switch. Optional mobile bracket for 941C, 940B, 945, 944, $3.00.

MFJ-900 VERSA TUNER

MFJ-900

$44.95 (+ $4)

Matches coax, random wires 1.8-30 MHz.

Handles up to 200 watts output; efficient airwound inductor gives more watts out. 5x2x6".

Use any transceiver, solid-state or tube.

Operate all bands with one antenna.

2 OTHER 200W MODELS:

MFJ-901, $54.95 (+ $4), like 900 but includes 4:1 balun for use with balanced lines.

MFJ-16010, $34.95 (+ $4), for random wires only. Great for apartment, motel, camping, operation. Tunes 1.8-30 MHz.

MFJ-949B VERSA TUNER II

MFJ-949B

$139.95 (+ $4)

MFJ's best 300 watt Versa Tuner II.

Matches everything from 1.8-30 MHz, coax, randoms, balanced lines, up to 300W output, solid-state or tubes.

Tunes out SWR on dipoles, vees, long wires, verticals, whips, beams, quads.

Built-in 4:1 balun. 300W, 50-ohm dummy load, SWR meter and 2-range wattmeter (300W & 30W).

6 position antenna switch on front panel, 12 position air-wound inductor; coax connectors, binding posts, black and beige case 10x3x7".

MFJ-962 VERSA TUNER III

MFJ-962

$199.95 (+ $4)

Run up to 1.5 KW PEP, match any feed line from 1.8-30 MHz.

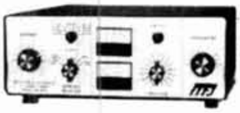
Built-in SWR/Wattmeter has 2000 and 200 watt ranges, forward and reflected.

6 position antenna switch handles 2 coax lines, direct or through tuner, plus wire and balanced lines.

4:1 balun. 250 pf 6KV cap. 12 pos. inductor. Ceramic switches. Black cabinet, panel.

ANOTHER 1.5 KW MODEL: MFJ-961, $179.95 (+ $10), similar but less SWR/Wattmeter.

MFJ-984 VERSA TUNER IV



MFJ-984

$299.95 (+ $10)

Up to 3 KW PEP and it matches any feedline, 1.8-30 MHz, coax, balanced or random.

10 amp RF ammeter assures max. power at min. SWR. SWR/Wattmeter, for./ref., 2000/200W.

18 position dual inductor, ceramic switch.

7 pos. ant. switch. 250 pf 6KV cap. 5x14x14".

300 watt dummy load. 4:1 ferrite balun.

3 MORE 3 KW MODELS: MFJ-981, $209.95 (+ $10), like 984 less ant. switch, ammeter. **MFJ-982, $209.95** (+ $10), like 984 less ammeter, SWR/Wattmeter. **MFJ-980, $179.95** (+ $10), like 982 less ant. switch.

MFJ-989 VERSA TUNER V

MFJ-989

$319.95 (+ $10)

New smaller size matches new smaller rigs — only 10-3/4Wx4-1/2Hx14-7/8D".

3 KW PEP. 250 pf-6KV caps. Matches coax, balanced lines, random wires 1.8-30 MHz.

Roller inductor, 3-digit turns counter plus spinner knob for precise inductance control to get that SWR down.

Built-in 300 watt, 50 ohm dummy load.

Built-in 4:1 ferrite balun.

Built-in lighted 2% meter reads SWR plus forward/reflected power. 2 ranges (200 & 2000W).

6 position ant. switch. Al. cabinet. Tilt bail.

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More Details? CHECK—OFF Page 118

More Details? CHECK—OFF Page 118

re-entrant cavity antenna for the VHF bands

Ideas for the experimenter interested in mobile antennas

This article introduces the Radio Amateur to a recently patented UHF-VHF mobile whip antenna* of unique design, the answer to the "intermod alley" problem that has plagued 2-meter mobile operation. While not precisely a construction article, this paper provides sufficient background for experimentation and construction.

Amateur Radio operators have had to contend with the steadily increasing problem of interference ever since the early days of radio communications. New designs and inventions have been steadily introduced to reduce or eliminate the various types of interference that have appeared.

With the greatly increased use of 2-meter mobile operation in recent years, intermod and desensitivity have been major problems, especially because of the closeness in frequency of neighboring commercial bands. The problem is not, by any means, unique to Amateur Radio; it's just as troublesome to commercial two-way radio.

Because the frequencies most widely used by Radio Amateurs for mobile operations are in the 2-meter band, all references and discussions relate to this band unless otherwise indicated. However, the principles and practices may be applied to all VHF-UHF bands, both Amateur and commercial.

interference

Critical voltage and current levels exist in the front end stages of the receiver section of the typical mobile transceiver. A strong local signal, even far removed in frequency, can get into the front end and upset those critical levels, causing considerable degradation in receiver sensitivity. This phenomenon is known as overloading or blocking and is referred to as desensitization, or *desense*. It is very common in VHF mobiles operating in metropolitan and industrial areas.

Another serious type of interference that plagues VHF mobile radio is intermodulation distortion, or *intermod*. This problem occurs when two or more strong local signals of different frequencies invade the front end of the transceiver receiver section, which is a nonlinear device capable of mixing, producing one or more new signals. If one of the new signals falls on or near the frequency being received, interference will result in the form of crosstalk or peculiar noises and, in many cases, will completely obliterate the desired signal.

A major source of intermod and desense in the 2-meter band is from the 150-170 MHz band, which is used extensively by commercial and governmental services. This problem is especially acute in the business areas of large cities, where certain sections have been dubbed "intermod alley."

Image frequency is sometimes a problem where the Radio Amateur is operating mobile in the vicinity of an airport. It's apparent that, with a 10.7-MHz i-f and a local oscillator that can be varied between 133.3 and 137.3 MHz, air traffic on frequencies between 122.6 and 126.6 MHz could get into the receiver front end and cause interference in the 2-meter band.

Often, interference may result when the mobile radio is in the strong-signal area of high-powered TV and fm broadcast stations whose frequencies are far removed from the 2-meter band. This interference occurs when the sum or difference frequencies of the two broadcast stations fall on or near the received frequency in the 2-meter band. Example: The mobile antenna receives both the video signal of TV channel 2 (55.25 MHz) and the audio signal of an fm station (91.3 MHz). Both signals mix in the receiver front end and produce an interfering signal on 146.55 MHz in the form of a broad, garbled audio mixed with video hash.

The examples mentioned above represent only a few of the many interference-causing combinations that might exist. All have one thing in common:

By William Tucker, W4FXE, 1965 South Ocean Drive, Apt. 15G, Hallandale, Florida 33009

*U.S. Patent 4,128,840, December 5, 1978. For those wishing copies of the patent, I will supply eight-page copies for $1.00 postpaid in the U.S.A.

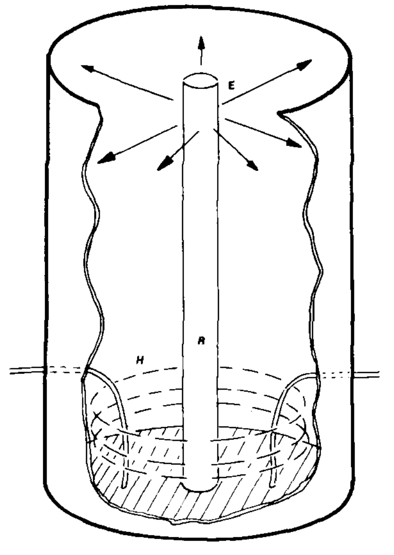


fig. 1. Concentration of magnetic field, *H*, and electric field, *E*, in a resonant cavity with a re-entrant section, *R*.

they're caused by unwanted out-of-band signals received by an antenna and fed to a vulnerable *receiver front end*.

countermeasures

The majority of transmitting and receiving antennas used in UHF-VHF mobile service are broadband. Although resonant at one frequency or band of frequencies, the antenna will receive signals far removed in frequency and feed them through the coax line to the receiver. The method of keeping such signals out of the receiver front end is to use highly selective bandpass filters. Not much can be done to keep unwanted in-band signals out, as the bandpass filter and the receiver front end are usually designed to accommodate the entire desired band.

At VHF or UHF, to obtain the high Q necessary for effective bandpass filtering, conventional lumped-constant components, such as coils and capacitors, will not suffice. The designer must resort to cavity resonant circuits (discussed later).

Manufacturers of Amateur Radio equipment have recognized the severity of the interference problem and have incorporated into their transceivers a hybrid cavity bandpass filter known as the *helical resonator*. This filter has helped the situation. However, in many cases, manufacturing engineering compromises leave something to be desired.

Helical resonators have gained wide acceptance because of their small size and the fact that they can be mounted directly onto the PC board close to the receiver front end. While this bandpass filter is effective in attenuating out-of-band signals that arrive through the antenna, very strong signals may still find their way into a vulnerable front end because of the closeness of the resonators to sensitive circuitry.

resonant re-entrant cavity

A resonant cavity is an enclosure, or partial enclosure, of any size or shape with conducting walls or surfaces that can support oscillating electromagnetic fields within it. It will have certain resonant frequencies when excited by radio-frequency currents. The basic paper on cavity resonators was written by Hansen in 1938.[1] When such an enclosure includes a re-entrant section, the electrical and magnetic fields tend to concentrate in different parts of the cavity, thereby relating to a circuit with lumped constants. The magnetic field is concentrated around the re-entrant section base, and the electric field is at a maximum at the open end, **fig. 1**.

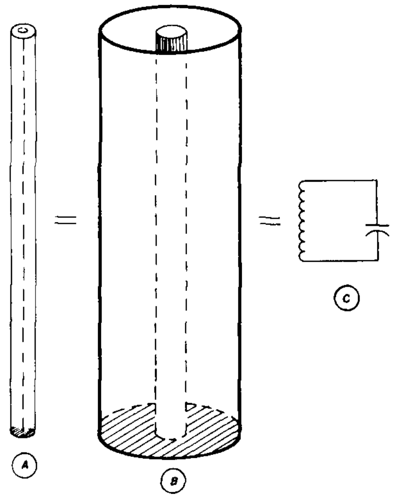


fig. 2. Quarter-wavelength coaxial cable (*A*) and re-entrant cavity (*B*), both short-circuited at one end, is equivalent to a parallel resonant circuit (*C*).

Quarter-wavelength cavity. A quarter wavelength of coaxial cable or concentric transmission line short-circuited at one end has properties similar to those of a parallel-resonant circuit. The resonant re-entrant cavity can be considered a wide-diameter section of concentric transmission line short circuited at one end with air as the dielectric, **fig. 2.** This type of cavity has been used as a very high Q coaxial tank circuit in VHF-UHF transmitters and has been widely used as a bandpass filter.

At the short-circuited end of a re-entrant cavity, rf current is maximum, requiring very high conductivity surfaces and a very low rf resistance connection between inner and outer conductors. Because of the prevalence of skin-effect at VHF and UHF, a surface plating of copper or silver is often used to ensure high conductivity, resulting in high Q throughout the cavity interior surfaces. In all discussions relating to re-entrant cavities, references to the outer conductor or housing indicates the interior surface only; references to the inner conductor indicates outer surface only. The housing exterior and the inner-conductor interior (if tubing is used) are cold insofar as rf is concerned and are at ground potential.

A very high impedance exists at the open end of the re-entrant cavity and is an area of high rf voltage. Where insulation is required in this area, great care must be used in the choice of low-loss material to prevent degradation of the very high Q.

It's desirable, from an optimum-Q standpoint, to make the center conductor of a resonant re-entrant cavity a *full* quarter wavelength. The frequency may then be adjusted by varying the conductor length within the cavity housing. In cases where the center conductor and its housing must be made shorter than a quarter wavelength, both will present an inductive reactance and will require the addition of capacitive reactance to achieve resonance.

In practice, this is readily accomplished by adding a capacitor across the open end of the cavity. Of course, using a variable capacitor makes it convenient to adjust this shortened length to the desired frequency, **fig. 3**. Actually, the physical length of a quarter wavelength center conductor is less than its electrical length because of the shunting effect of the stray capacitance that exists due to the proximity of the housing to the open end of the center conductor. It is axiomatic that, as frequency is increased, the optimum length of the cavity can be decreased.

While the cavity length and its inner conductor determine frequency, the outer-conductor diameter and its ratio to the inner conductor are important in determining optimum Q. According to Terman,[2] a ratio of 3.6 is considered optimum and, while maintaining that ratio, a further increase in Q is directly proportional to an increase in outer-conductor diameter within practical limits.

Half-wavelength cavity. The resonant re-entrant cavity may also be designed as a half-wavelength device, which also can be shortened by capacitive loading, **fig. 4**. In this design, which becomes practical as frequency is increased into the UHF range, the principles and practices are similar to those regarding

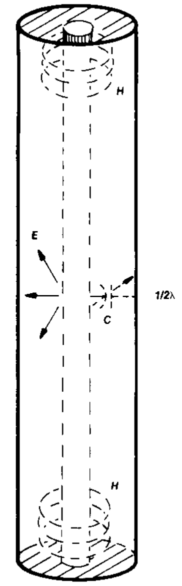


fig. 4. Half-wavelength resonant re-entrant cavity. Magnetic field, H, is at both short-circuited ends; electric field, E, is at center. Device is tuned to resonance by capacitor C.

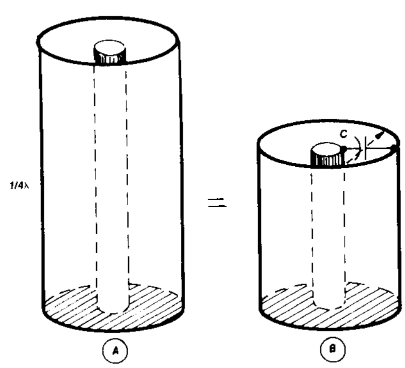


fig. 3. Quarter-wavelength resonant re-entrant cavity (*A*) shortened at (*B*) using capacitive loading to resonate to same frequency.

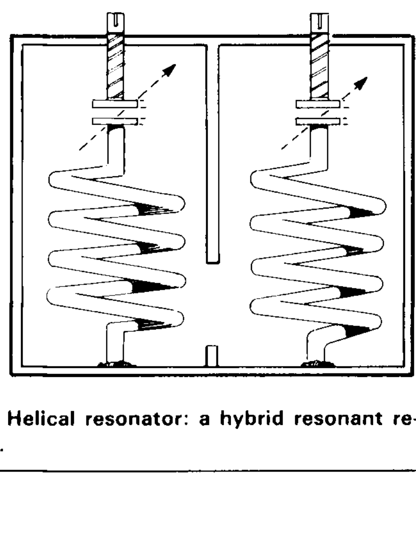


fig. 5. Helical resonator: a hybrid resonant re-entrant cavity.

the quarter-wavelength cavity. In the half-wavelength version, the two short-circuited ends are high current areas, while the center is the point of high voltage, where a variable capacitor is used to tune the cavity to resonance. Note that a 3/4-wavelength cavity has characteristics similar to those of the more widely used 1/4-wavelength cavity.

Helical resonator. The helical resonator (**fig. 5**) is a hybrid re-entrant cavity in which the center conductor has been shortened into the form of a helix placed inside a small cavity housing. While the Q of this hybrid is less than that of the conventional larger-size cavity, two or more can be cascaded in a small space to provide increased skirt selectivity with a broader bandpass characteristic. The design of helical resonators has been fully covered in another article.[3] For those who wish to investigate further, an original paper was presented by Macalpine and Schildknecht,[4] followed by several other important papers.[5,6] The RSGB *VHF-UHF Manual* also covers the subject quite well.

Re-entrant cavities and their many hybrids have been designed in many different shapes and sizes. They are referred to as coaxial filters, cavity bandpass filters, trough-lines, striplines, microstriplines, comblines, interdigitals, and helicals. They have one thing in common: all are in the re-entrant cavity family.

coupling

The manner and magnitude in which rf energy is coupled into and out of a resonant re-entrant cavity plays an important role in determining the selectivity, insertion loss, and impedance; all are interrelated.

Coupling may be accomplished by three basic methods; electromagnetic coupling using pickup loops, electrostatic coupling using capacity probes, and by direct connection to the inner conductor. A combination of these may be used, depending on the specific application.

When dealing with low impedances such as encountered with coaxial-cable transmission lines,

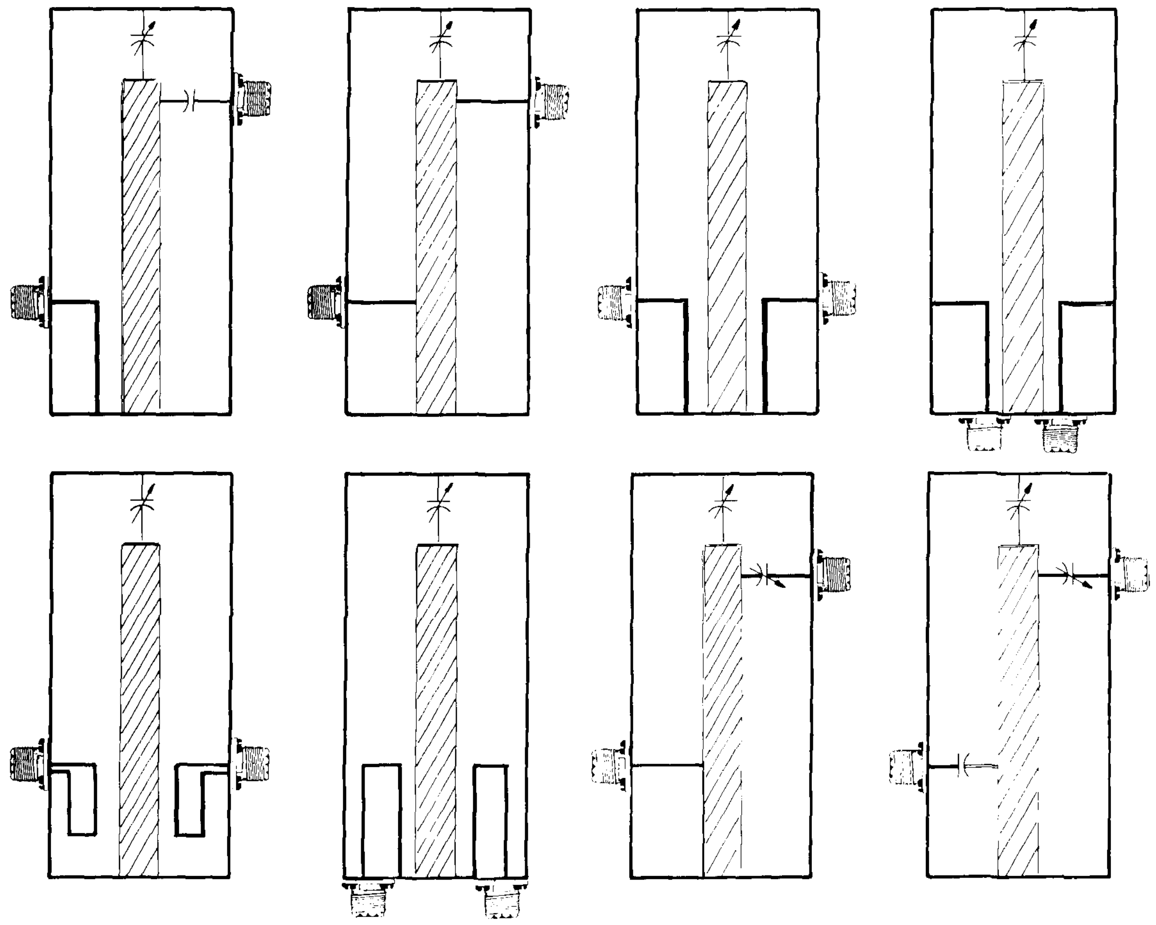


fig. 6. Coupling design for resonant re-entrant cavities.

pickup loops are usually used. In some cases, direct connection to low-impedance positions on the inner conductor is used, especially where cavities are connected in cascade. Capacitive probes provide a convenient method of feeding energy to or from high-impedance circuits. Some coupling configurations are shown in **fig. 6**.

Insertion loss. The insertion loss in a resonant re-entrant cavity depends on several factors, which include the cavity size, type of materials used in the construction, and the type and degree of coupling. Close coupling will decrease the insertion loss but will adversely affect selectivity; conversely, loose coupling will have the opposite effect.

Pickup loops are usually placed in the area of the high electromagnetic field, which exists at the short-

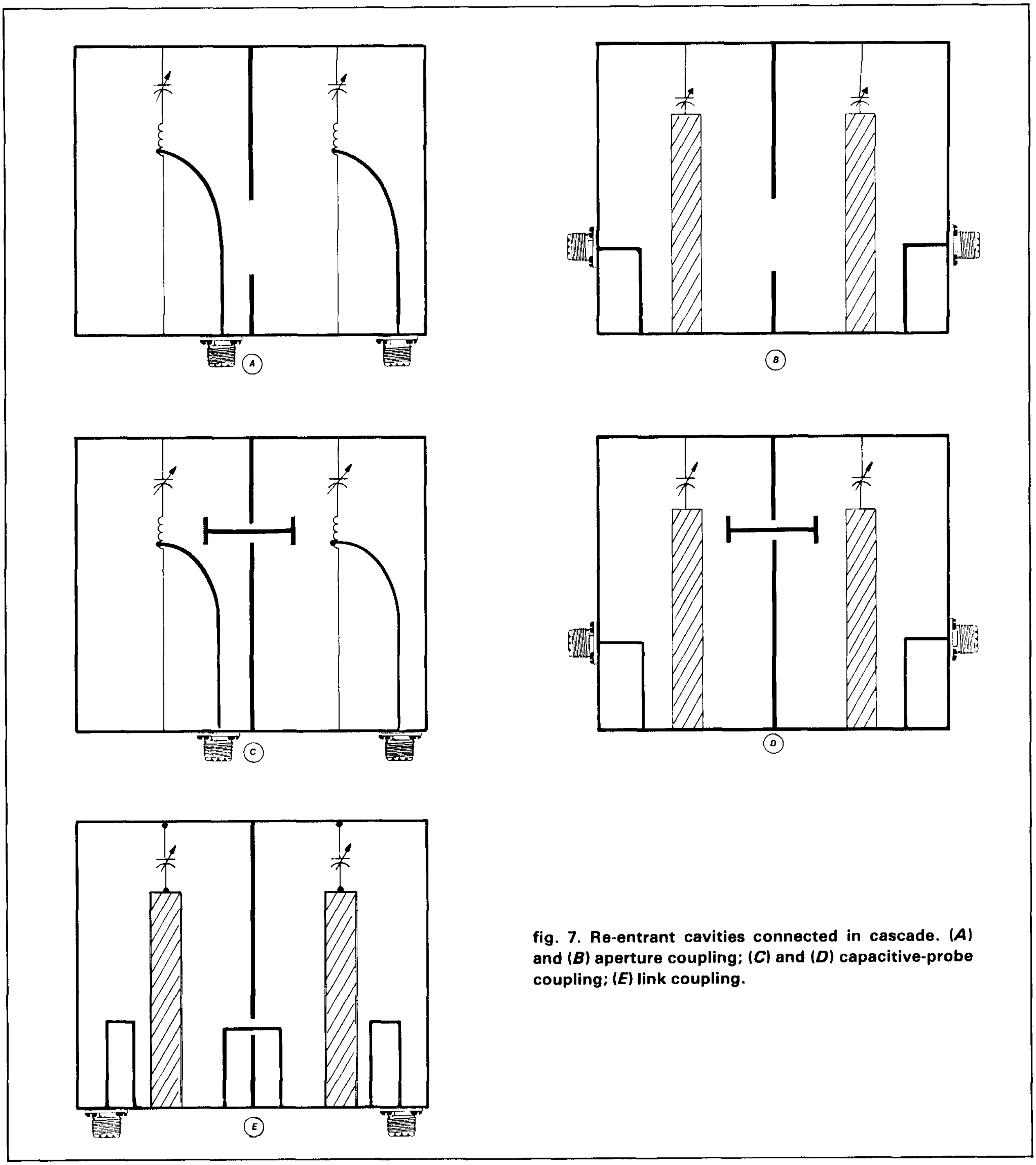


fig. 7. Re-entrant cavities connected in cascade. (*A*) and (*B*) aperture coupling; (*C*) and (*D*) capacitive-probe coupling; (*E*) link coupling.

circuited end of a resonant re-entrant cavity. Coupling is increased as the loop is positioned closer to the center conductor, as the enclosed area of the loop is increased, and as the plane of the loop is oriented to enclose a maximum of magnetic flux. The opposite of this action will reduce coupling. Capacitive probes are used to couple into and out of the electrostatic field, which exists at the open, high-impedance, end of the cavity. Coupling is increased as the probe is positioned closer to the center conductor.

Impedance matching. Impedance matching with loops isn't critical and is usually determined experimentally to obtain empirical guidelines inasmuch as the size, shape, and positioning will affect results. More precise design calculations are possible when direct connection is made to the center conductor when that method is called for. In most cases, an engineering compromise must be made in a particular application to obtain the desired selectivity, insertion loss, and impedance match.

Cascade coupling. Where more than one cavity is to be used in cascade, several coupling methods may be used, as shown in **fig. 7**. The degree of coupling is determined by the size of the window in aperture coupling, the interconnecting loops in loop coupling, and the proximity of the capacitive probes in capacitive coupling. In all cases, critical coupling will provide a greater usable bandwidth with steeper skirt selectivity, as shown in **fig. 8**.

The discussion above only scratches the surface with regard to resonant re-entrant cavity principles and practices. More detailed technical and construction information will be found in the literature listed in the bibliography.

a worthwhile project — basic cavity

For readers who wish to acquire a working acquaintance with re-entrant cavities, I strongly suggest the building of a simple, basic cavity. All that's required is a coffee can and a few parts usually found in the average junk box. Parts required are a 1- or 2-pound coffee can, a 50-pF variable air dielectric capacitor with a knob shaft, two coaxial-cable sockets, a center conductor made of copper or brass tubing anywhere from 1/4 to 1 inch (6.5-24.4 mm) OD, and a short length of No. 12 (2.1-mm) copper wire for the pickup loops.

Construction. Using **fig. 9** as a guide, make an opening in the center of the bottom of the can to provide a tight fit to the center conductor and solder securely in place. An alternative method is to solder the center conductor to a coax connector hood such as the UG-177/U or UG-106/U, then attach the assembly to the bottom plate with four machine screws and/or solder, **fig. 10**. Mount the variable capacitor close to the top of the can. Solder the stator to the center conductor using as short a lead as possible.

Make certain that the rotor wiper is clean. Ground it directly to the inside of the can. Mount the two sockets diametrically opposite each other about 3 inches (76 mm) above the base. Solder pickup loops

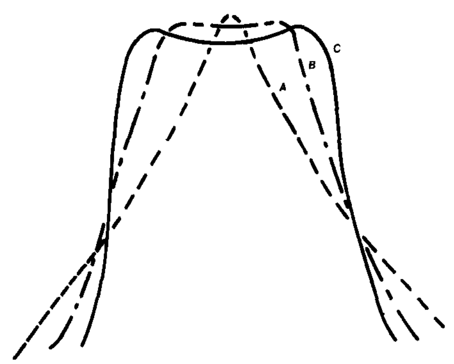


fig. 8. Relative selectivity curves. (*A*), undercoupled; (*B*), critical coupling; (*C*), over coupling.

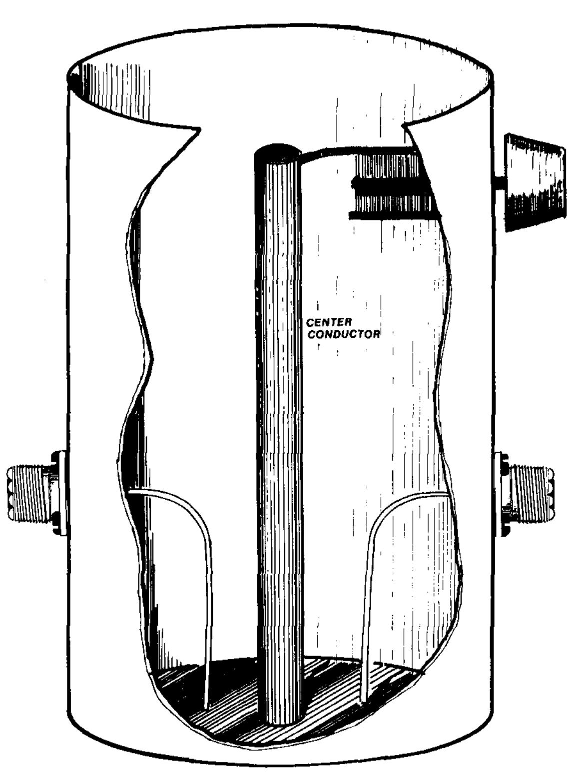


fig. 9. Cutaway of coffee-can resonant re-entrant cavity.

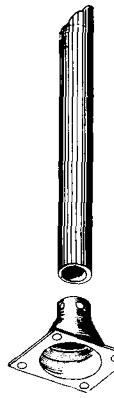


fig. 10. Alternative method of attaching center conductor to coffee can using UG-177/U or UG-106/U coax hood.

By experimenting with this simple re-entrant cavity, you should become familiar with its capabilities and also find it to be a useful piece of equipment in your 2-meter work.

five-eighth wavelength mobile whip antenna

For mobile operation in the 2-meter band, the 5/8-wavelength whip antenna has gained considerable popularity because of its widely publicized 3-dB gain over a 1/4-wave ground plane antenna. Gain figures for vertical antennas can be very confusing and not too meaningful unless referred to a particular vertical angle of radiation. For example, when compared with a 5/8-wavelength vertical, the 1/4-wavelength vertical may provide more gain at high angles and

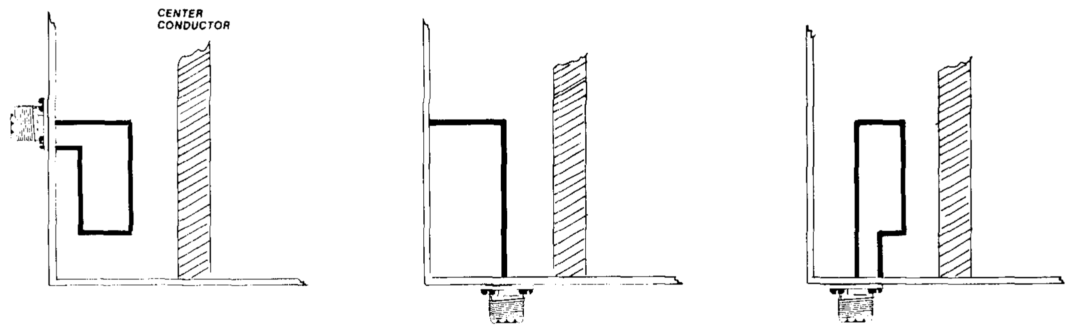


fig. 11. Other loop designs for coffee-can cavity.

as shown. Other loop configurations that can be used are shown in **fig. 11**.

Checkout. Insert the re-entrant cavity into the transmission line as shown in **fig. 12**. Select a weak signal in the 2-meter band and tune the variable capacitor for maximum response; don't be surprised at the very sharp tuning. On low-power transmit, readjust the capacitor slightly for the lowest SWR reading. Without disturbing the cavity tuning, change the transmit frequency about 1 MHz up, then down, and observe the change in SWR. This will give you a good idea of the selectivity of this re-entrant cavity. If you use a dummy-load and wattmeter instead of an antenna to make this test, you can correlate the SWR change with power-output change.

Try bending the pickup loops with long-nose pliers so that they extend closer to the center conductor. Your measurements should show a bandwidth increase, as evidenced by less change in SWR and power output as you repeat the first test. Then try bending the loops toward the housing; you should then notice a narrowing of the bandwidth, **fig. 13**.

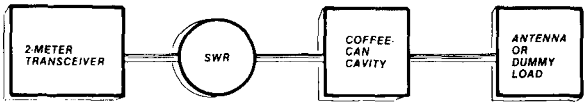


fig. 12. Test setup for coffee-can cavity.

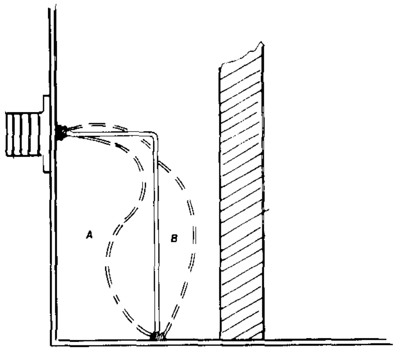


fig. 13. One method of increasing or decreasing coupling. Less coupling is at (*A*); more coupling is at (*B*).

less gain at very low angles. A direct comparison without reference to the vertical angle is like comparing apples to oranges.

In 2-meter mobile operation, where in most areas a low vertical radiation angle is highly beneficial, the 5/8-wavelength vertical outperforms the 1/4-wavelength vertical by about 3 dB. The chart in **fig. 14** shows a theoretical comparison between verticals of various lengths. An excellent discussion on this subject is presented by Lee[7] and Schultz.[8]

The 5/8-wavelength vertical antenna exhibits a radiation resistance of well under 100 ohms, which makes for convenient matching to a low-impedance transmission line, **fig. 15**. Because 5/8-wavelength is a nonresonant length, it appears highly capacitive in reactance (**fig. 16**) and requires the addition of sufficient inductive reactance to achieve resonance. As shown clearly in both **figs. 15** and **16**, the ratio of length to diameter, A/D, has a decided effect on the radiation resistance and reactance of a 5/8-wavelength vertical antenna.

Inductive reactance may be obtained for a 5/8-wavelength vertical antenna simply by using a small resonator coil at the antenna base. A section of coaxial cable, shorted at one end and less than a quarter-wavelength long, is equivalent to an inductive reactance and also can be used. Various combinations of coils, with or without capacitors, may be used to resonate a 5/8-wavelength whip antenna, as shown in **fig. 17**.

When measuring the length of a 5/8-wavelength vertical antenna, the physical length of the resonator assembly should be included unless it's shielded and at ground potential so that it doesn't radiate. (Note that there is a small insertion loss in the use of any type of resonator.)

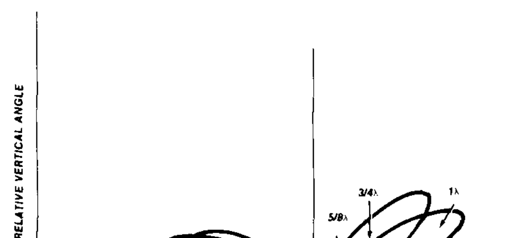


fig. 14. Vertical-angle patterns of various lengths of vertical radiators. Five-eighths wavelength, three-quarter wavelength, and full wavelength high-angle lobes are shown on right for clarity. (Note absence of low-angle lobe for full-wavelength vertical.)

resonant re-entrant cavity whip antenna*

The resonant re-entrant cavity whip antenna evolved as the result of an attempt to provide a means of eliminating the chronic interference problem that plagues 2-meter operation throughout the "intermod alleys" of our country.

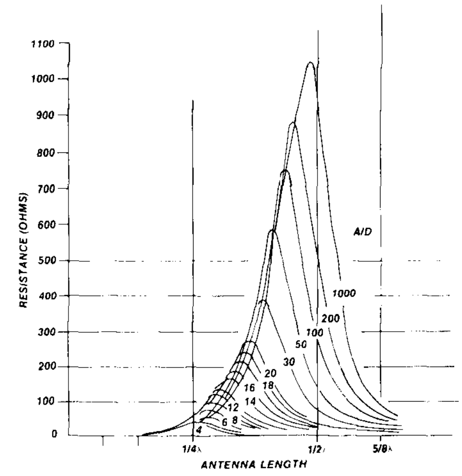


fig. 15. Terminal resistance as a function of antenna length. A/D is the ratio of antenna length to diameter.[10]

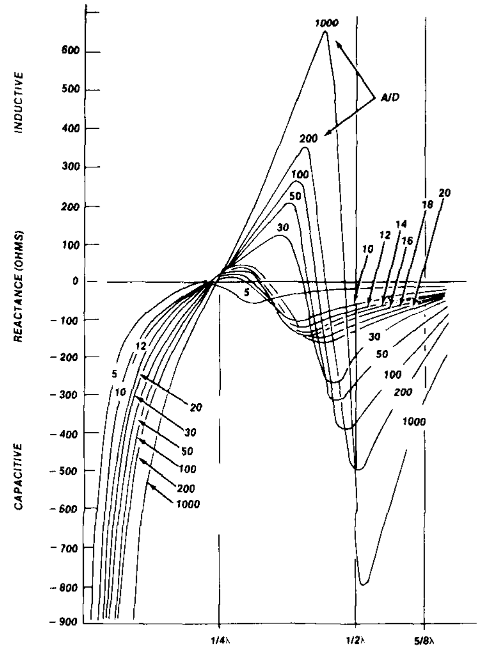
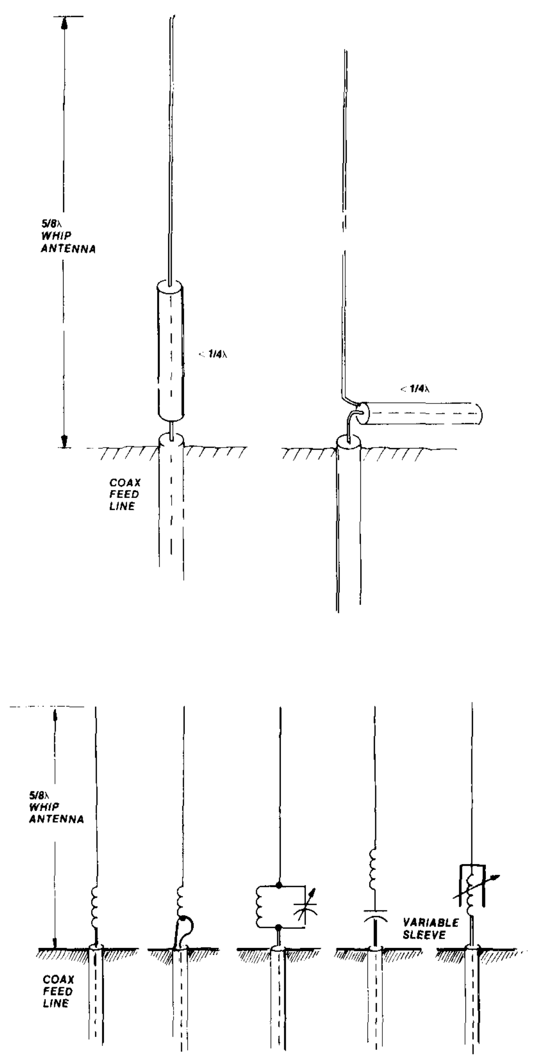


fig. 16. Terminal reactance as a function of antenna length. A/D is the length/diameter ratio.[10]

*U.S. Patent 4,128,840.



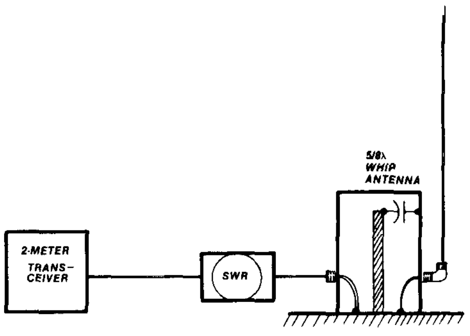


fig. 18. Coffee-can resonant re-entrant cavity used as a resonator for a 5/8-wavelength vertical. Pickup loops are adjusted for lowest SWR at resonance.

A re-entrant cavity is used to replace the usual base resonator used in the 5/8-wavelength whip antenna to provide much-needed bandpass filtering right at the antenna itself where it is most effective. In this manner, unwanted out-of-band signals will be attenuated before they enter the transmission line and ultimately reach a vulnerable receiver front-end.

At this point, you might question the need for this type of antenna for use with your latest-model transceiver with built-in helical resonators. The answer is self-evident in the fact that the proximity of these resonators to the receiver front end on the PC board still allows very strong unwanted signals to leak through and excite highly sensitive circuitry. Also, in many cases, due to space limitation and cost considerations, engineering compromises result in barely adequate helical resonator assemblies. Therefore, the use of this type of antenna will provide the additional bandpass filtering needed to enhance the ability of the receiver to reject unwanted signals.
receiver to reject unwanted signals.

Of course, in transceivers that don't have built-in helical resonators, the use of this type of antenna will be dramatically effective. In either case, because this antenna will be used in transmit as well as receive mode, bandpass filtering will attenuate spurious emissions, re-radiated intermod, and white noise.

As in all resonators, the re-entrant cavity used in

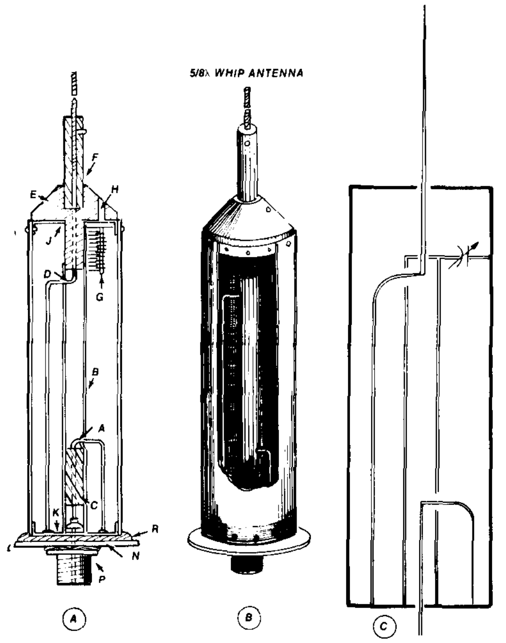


fig. 19. Five-eighths wavelength resonant re-entrant cavity whip antenna in cross section (*A*), cutaway (*B*), and schematic diagram (*C*).

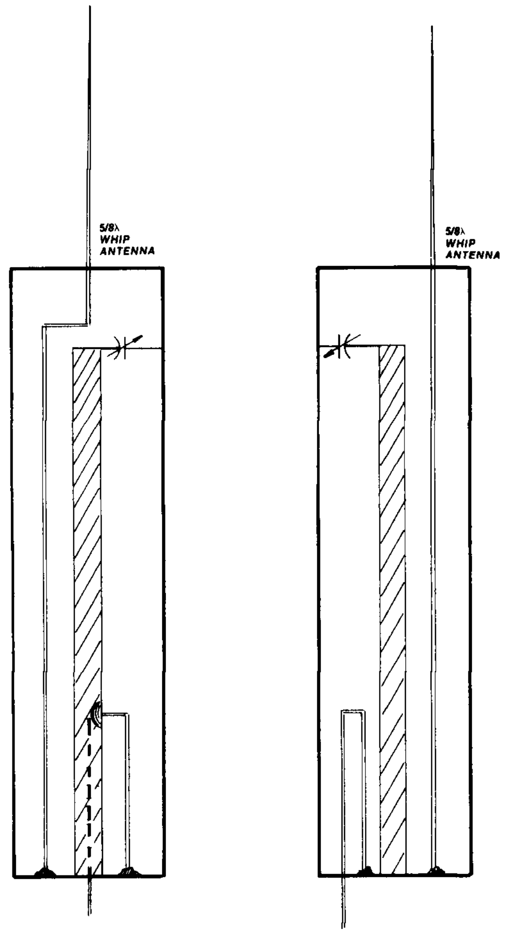
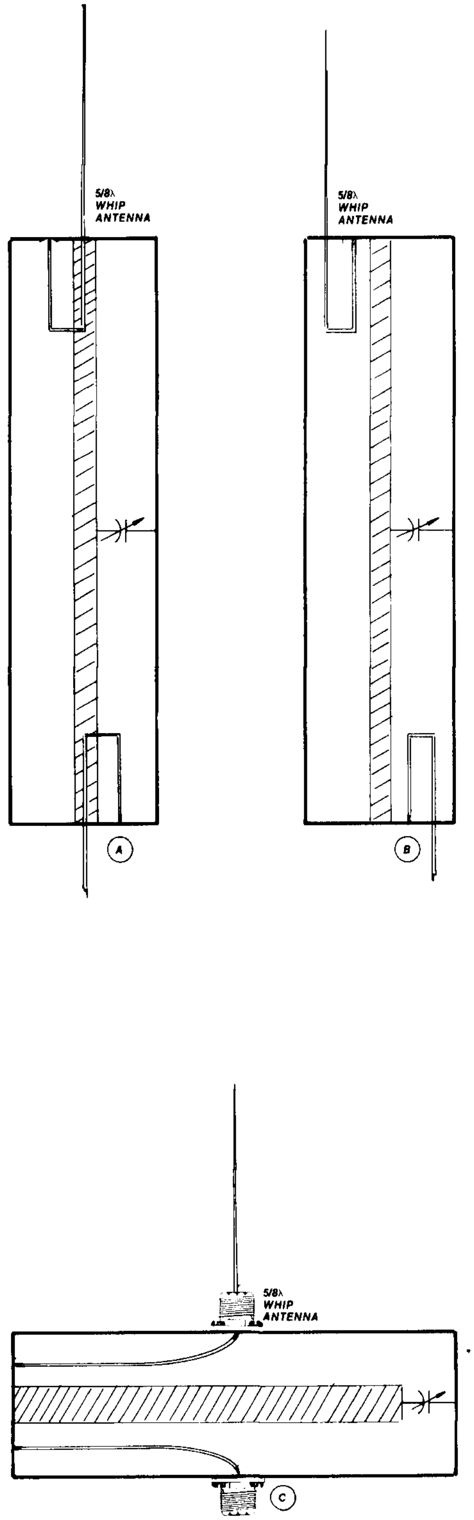


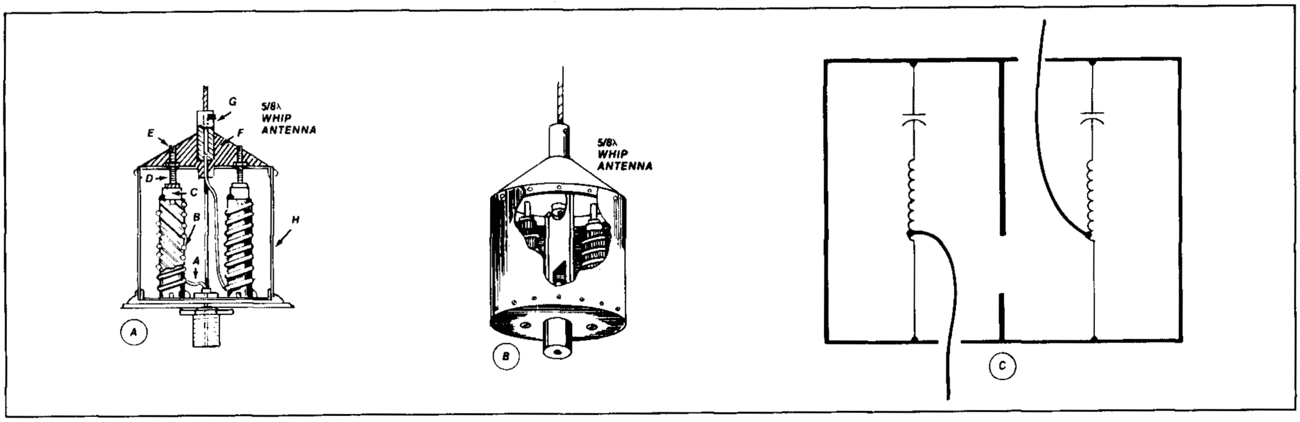
fig. 20. Example of other workable re-entrant cavity designs.



this antenna has a small insertion loss at resonance, which is about the same as the loss in the usual resonator that it replaces. However, there are bandwidth limitations under certain conditions which will be discussed later.

Coffee-can cavity. For those who wish to do a little experimental work to get the *feel* of this type of antenna, it's a simple matter to attach a 5/8-wavelength whip (about 48 inches or 122 cm) to a coffee-can type of re-entrant cavity as shown in **fig. 18**.

Construction and adjustment. Two strips of aluminum foil 45 inches (114 cm) long and about 4-5 inches (10-13 cm) wide placed under the can and grounded to it on any flat surface will provide an adequate ground plane. With an SWR meter in the feedline, tune the cavity for the lowest reading, which



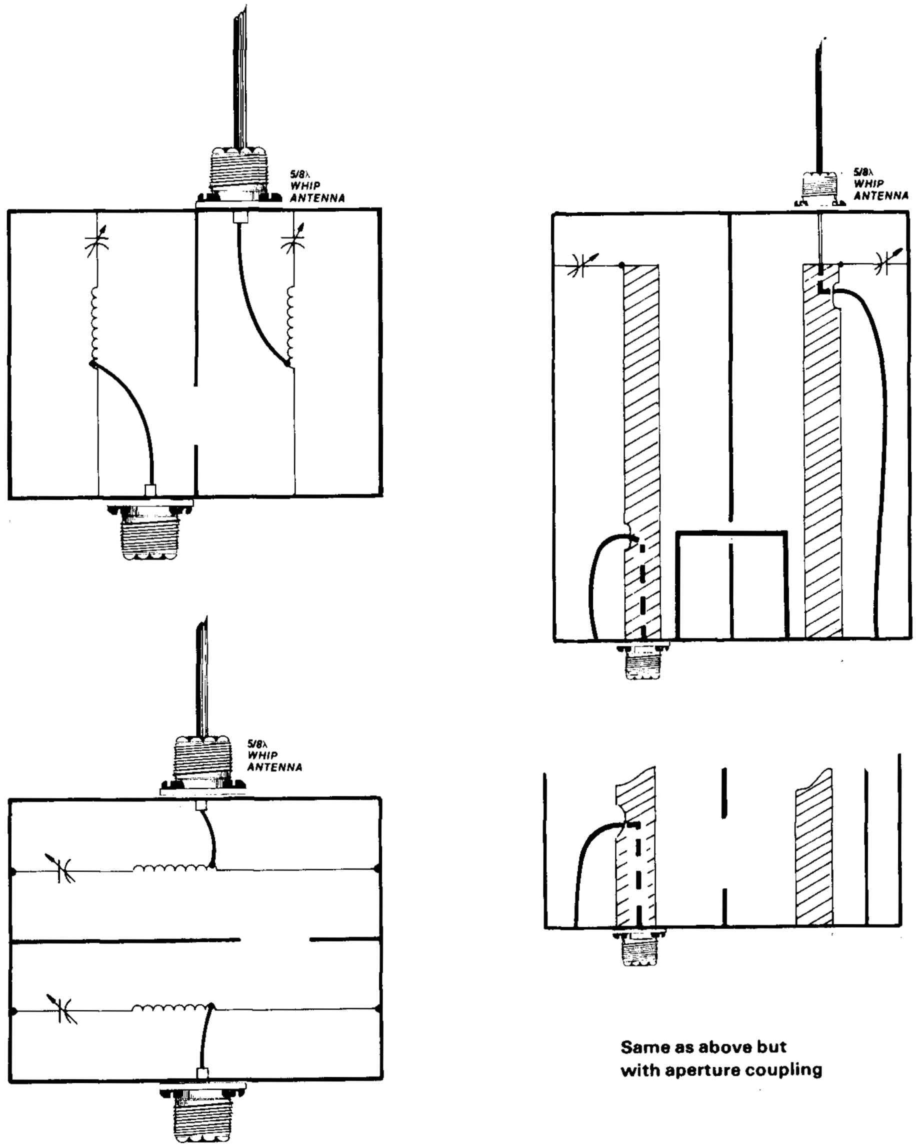


fig. 23. Other workable 2-meter 5/8-wavelength resonant re-entrant cavity whip antennas using cascaded cavity resonators.

may be too high. Adjust the antenna feed pickup loop until the SWR is very low at resonance; the whip has now been resonated. The input loop may now be repositioned and reshaped for the desired degree of selectivity versus insertion loss. Keep in mind that all adjustments are interdependent.

Fig. 19 shows two views and a schematic diagram of a resonant re-entrant cavity whip antenna in a more sophisticated configuration that has an external appearance similar to that of the usual 5/8-wavelength whip antenna. The cavity section is about 7 inches (18 cm) long and 1 1/2 inches (3.8 cm) in diameter.

To provide this concentric configuration, the input pickup loop, A, is fed through an opening in the center conductor, B. The insulation, C, and the lead wire passing through it actually extend the coaxial cable feedline to the loop opening. The antenna pickup loop, D, enters an opening very close to the top of the center conductor and feeds through the Teflon insulator, E, to the set screw adapter, F. The cavity is tuned to resonance by the variable air-dielectric capacitor, G, with a screwdriver adjustment at H.

The entire interior assembly is self-supporting and is held together by center conductor B, insulator E, top plate J, bottom plate K, and the variable capacitor, G. This allows the outer conductor to be removed for internal adjustments.

This antenna may be installed and grounded to the vehicle, N, using the coaxial connector, P, and its nut and lockwasher. The rubber gasket, R, provides a weatherproof seal to the vehicle body.

This model is just one example of how a 5/8-wavelength resonant re-entrant cavity antenna can be built. A sampling of other workable configurations in semi-schematic form for the 2-meter band is shown in **fig. 20**. Additional configurations, which are practical only for the higher-frequency bands, are shown

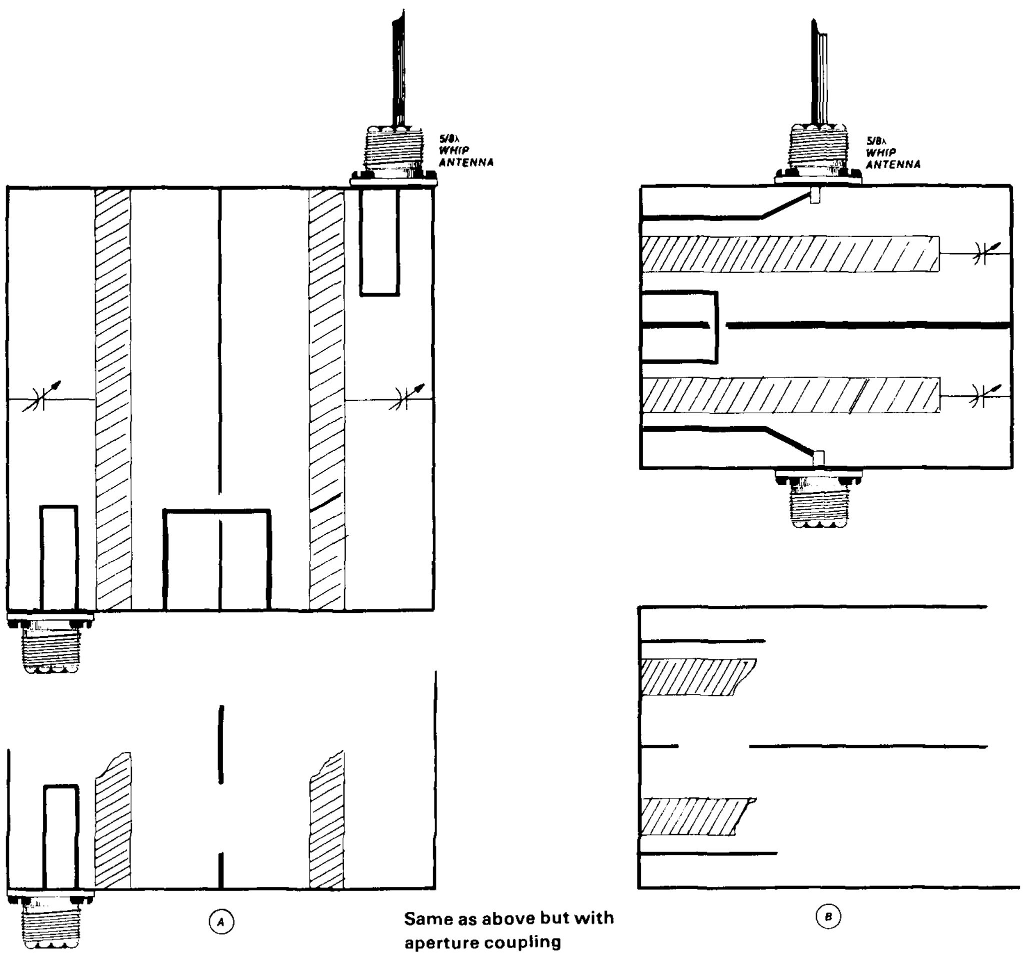


fig. 24. Designs for use on 220 MHz and higher bands. One-half wavelength resonant re-entrant cascaded cavities are shown in (*A*). One-quarter wavelength cascaded cavities are shown in (*B*).

in **fig. 21**.

Unfortunately, to obtain fairly high rejection of out-of-band signals 3-6 MHz away in frequency, such as encountered with interference from the 150-170 MHz commercial band, the usable bandwidth of a single-section cavity antenna is limited to less than 1 MHz. By using very tight coupling, the bandwidth can be increased considerably but at the expense of selectivity. Where the interference is from fm and TV broadcast stations, tight coupling will still provide sufficient selectivity. The solution to this problem is to use two re-entrant cavities fed in cascade which will, when critically coupled, provide a wider bandwidth with steeper selectivity skirts, as previously discussed.

another model — the helical resonator

Fig. 22 shows two views and a schematic diagram of a resonant re-entrant cavity whip antenna using two helical resonators aperture-coupled to each other. The input coaxial cable is fed to a low-impedance tap, A, on the input coil, B. This coil is tuned to resonance by a variable piston-type capacitor formed by C and piston D and is tuned by screwdriver adjustment, E. The tap on the antenna coil is fed through the Teflon insulator, F, and is attached to the set-screw whip adapter, G. The aperture in the center-shield partition provides the magnetic coupling between the resonators.

The entire assembly is self-supporting so that the outer conductor, H, can be removed for adjustment. This antenna may be installed and grounded to the vehicle in the same manner as the antenna previously described.

With the helical resonator, the aperture size is increased experimentally until critical coupling is noted by increased bandwidth and steeper selectivity skirts. The taps on the coil are determined to match the coaxial-cable impedance to that of the antenna. Tuning adjustment of the antenna coil will automatically resonate the 5/8-wavelength whip section. As in the other model, the resonator is tuned for minimum SWR.

This cascaded model is just one example of a dual-cavity whip antenna. **Fig. 23** shows other workable configurations for the 2-meter band, and **fig. 24** shows additional models for the higher-frequency bands.

microstripline antenna

A 5/8-wavelength whip antenna can also be built using another hybrid variety of the re-entrant cavity known as the microstripline, which consists of a two-sided PC board etched on one side only.

One side is the groundplane, and the other side is etched into strips, as shown in **fig. 25**. In this dual-section design, coupling is usually accomplished between sections at the high-impedance end with a small variable trimmer capacitor. The *Q* of this type of resonator is less than that of a helical resonator and has more restrictive power-handling capabilities. However, it should provide some interesting possibilities for the experimenter. The late Jim Fisk wrote a comprehensive article on microstripline design in 1978.[9] Also several articles by Shuch[10, 11, 12] in recent years cover the subject quite well.

conclusion

The resonant re-entrant cavity whip antenna, within its limitations, would provide Amateur Radio experimenters with a lot of new territory. I welcome comments from those who delve into it.

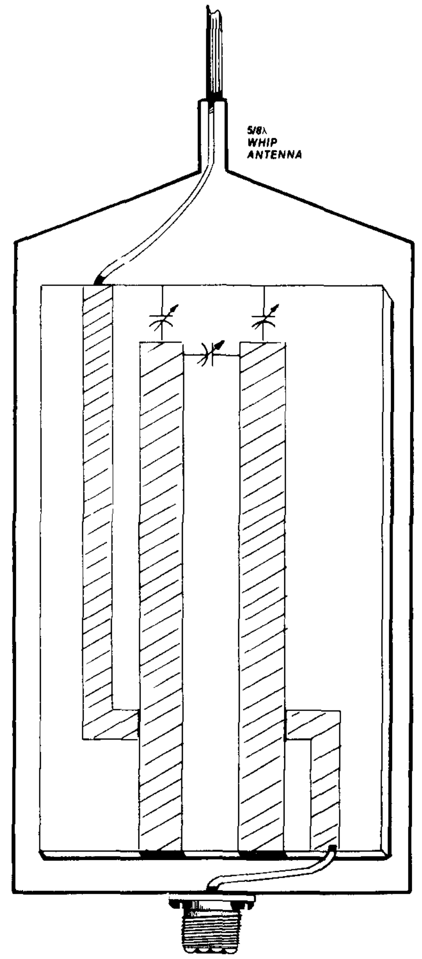


fig. 25. Resonant re-entrant cavity 5/8-wavelength whip antenna using microstrip techniques.

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ham radio

Jim

A Tug at Your Memory

By John C. Flippin, W4VT*

It was 1935 and the Great Depression was upon the land: people out of work, no money to pay the grocer, lines of men outside the Salvation Army building waiting for a cup of soup, men on street corners selling apples for a nickel. Walking down the boulevard, one was approached by ragged-looking souls, always with the same question: "Brother, can you spare a dime?" Yes, the country had fallen onto bad times. But, paradoxically, Amateur Radio grew at a phenomenal rate during this era. Perhaps the following story might contain a clue. Thanks to Laird Campbell of *QST* for allowing us to reprint the story of *Jim*. **Editor**

The fire in the shack of the university radio station burned low and conversation lagged. Every now and then someone yawned lustily. The hands of the old clock pointed to five minutes after two, yet half a dozen seniors lingered, for the fire was magnetic, the walk back to the dormitory and fraternity houses long; and the night was cold. Lazy, feathery flakes, beginning to drift down at midnight, had changed to a fine, peppery mist swirling in from the north, and the wind moaned down the chimney in icy cadences.

Jug Southgate stood up and stretched.

"See you mugs in church," he grunted, looking around for his overcoat.

"Wait a minute. I will let you walk with me. Hey! get your big feet off me!"

"Freshman, where are the earmuffs?"

"Right here, sir."

"Put them on at once. Anybody would think you had no modesty at all."

"Get up! Get up!"

"Coming, Ivy?"

"Let's go."

Exiled in a shadowy corner, a group of freshmen had been listening in respectful silence. Now they rose, after a discreet interval, and removing their sky blue caps from their hip pockets placed them carefully on the backs of their heads. Beside them stood a little fellow who was busily engaged in wrapping a rather frayed scarf around his small neck. Judging from his stature he could not have been much older than fourteen, and he looked very small and out of place beside them. The shadows from the fire treated mercifully the worn places on the elbows of the coat which was so obviously designed for a larger occupant; they shielded understandingly the worn, cracked shoes with the scuffed toes.

His name was Jim. Nobody knew much about him except that he lived up in town some where, and that every Saturday night he appeared at the shack, slipping quietly into a seat amid the shadows in the corner, and listened with rapt attention to every word that anyone uttered. He always stayed until the group of fellows broke up. Jim replied feebly and shyly to those who would talk to him,

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apparently embarrassed at the attention. His face and hands were very thin and his eyes were very bright. He was a small outsider looking in on a gathering with which he could join only in spirit. College would never be for Jim.

The wind whined savagely. A flurry of snow beat a faint tattoo on the window.

"Ouch!" muttered Ivy. "Listen to that!"

Jug cast his gaze around as he pulled on his gloves. The staccato clatter of the keying relay in the adjoining room reminded him to caution Parkes about playing the end of the band too closely since the multivibrator was down for revamping. Turning back, his glance rested for an instant on Jim stretching his hands out to give them a last warming. Something about the little fellow's appearance arrested Jug's attention. Maybe it was the tattered edge of that scarf about Jim's ears.

"What do you say over there, sport?"

Jim didn't notice.

"You over there by the fire! Got a way to get in?"

Jim looked up, and saw Jug looking at him. He straightened up quickly and thrust his hands into his coat pockets.

"Sir?"

"Got a ride into town with somebody?"

"No."

"What are you going to do — walk?"

"Yes," answered Jim.

"Pretty long way, isn't it?"

A pause.

"Not so much."

Jug embarrassed Jim a great deal, because Jug was the chief operator and wore sterling crossed bars of chain lightning on the shoulder of the navy blue jersey. There was no greater this side of Heaven, save perhaps the three comprising the transmitting staff.

Jug shoved his pipe in his mouth and turned the bowl down. He squinted up at the clock.

"Hold on, frosh!"

He pulled off his gloves and searched in his hip pocket, producing nothing but a handkerchief and a crumpled pack of cigarettes.

"Can't find 'em. Listen! You know where the Sigma House is? OK — you go over there and look around in the back. My iron ought to be there, but if it isn't, get any of them that will start. You know mine?"

"Yes, sir."

"Look around in the front seat and find you a hairpin or something and short around the switch under the dash. You know?"

"Yes, sir."

"And hurry up, frosh!"

Rather bewildered, Jim listened.

"I can get there all right," he said finally.

Jug grunted and sat down.

"Where do you live in town?"

"Er — down by the depot. The third house from the corner."

"Guess you know all the trains."

"I guess so. The freights make an awful lot of QRM when I'm trying to listen."

Jug stuffed his pipe slowly and extracted an ember from the hearth.

"You one of these amateurs, too?"

"Yes, that is — I mean, I have a station, but it's not much good, I guess."

A flicker of surprise crossed Jug's persistently sunburned countenance.

"Didn't know there was another station within fifty miles of here," he admitted. "What do you use? Never heard you."

"A 201-A," answered Jim.

The rectifiers down below howled faintly.

"Any DX?" asked Jug, quizzically, glancing at the little chap out of the corner of his eye.

"No, I — you see, I never worked anybody."

"What's the trouble?"

Jim stopped the nervous movements of his small hands and wiggled his thumb, just to see if it would wiggle.

"I don't know."

"Just don't come back, eh?"

"No."

"Call many of them?"

"Yes, I — well, I call a lot of fives and nines and fours."

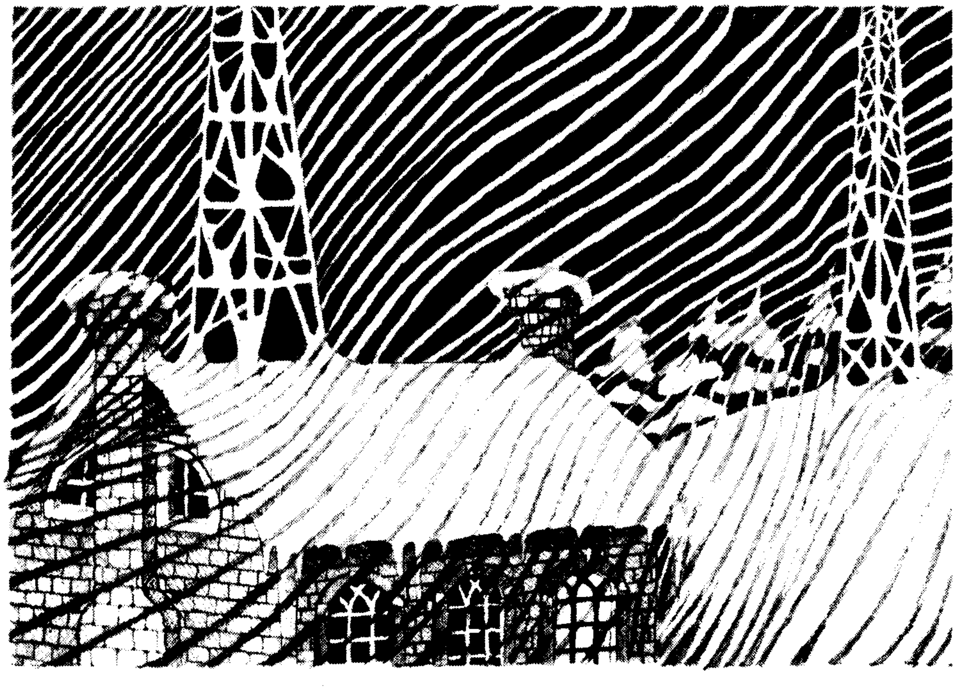
"Sure you're in the band?"

"Yes."

"How do you know?"

"I cover up my receiver with a cracker box and then I can hear the transmitter. After I take off my receiving aerial," he added.

Jug looked at Jim for an instant, and then gazed again into the fire. There was a pause while Jim twisted



his small, thin hands nervously.

"I know it's putting out," said Jim, faintly, "because I get a burn."

"Burn, eh?"

"Yes."

"Just don't come back."

"No."

The pity of it.

"Much of a burn?"

"Well, I can feel it on the back of my finger." Jim held up the radio frequency detector.

"How long have you been trying to raise them?"

"Since about May — I mean, April."

"Nine months."

"Yes," answered Jim, after a pause.

Jug exhaled a cloud of smoke through his nose and regarded the fire. Some game, this! Nine months and never a break.

There was a dull rattle of contactors down below, followed by a volley of clicks in the adjoining room.

"What made that?"

"Sounds like he switched in the '7' — the forty-meter rig."

"You mean he's using another set, now?"

"Just the amplifier. Switched over the exciter from the 80-meter to the 40-meter amplifier."

"Oh!"

"Sit down! Sit down! Make yourself comfortable. Guess it'll be about fifteen minutes, yet."

Jim slid cautiously into the nearest chair. Suddenly he turned and regarded Jug inquiringly.

"Would you mind — I mean, would it be all right if I looked in there?" he asked, pointing to the transmitter room.

"Sure! Go ahead. Help yourself. Wouldn't get too close, though, to the one nearest this side."

Jim opened the door cautiously and craned his small neck. He stood transfixed for long minutes.

"Gee!" he whispered.

"Look all right?" Jug asked, pulling his pipe apart and blowing through it with two short snorts.

"Gee!" said Jim again.

Five minutes passed with only the wind, the old clock, and the keying relay breaking the silence.

Jug looked at the swirl of smoke ascending the broad black throat of the chimney, and his thoughts travelled back to a day — so long ago, it seemed — when that UV-202, its plate glowing brightly, brought the antenna ammeter to life. As he recalled, the pointer moved over about a thirty-second of an inch, but at the time, it looked like a foot!

And then that red-letter day. He had just called CQ. It was just one of many scores of CQ's. There was nothing to distinguish it from all the others except that on this occasion 9EKY in St. Louis came back. The wild shout that brought the gardener, the chauffeur, and both maids breathless to the sanctum over the garage was not, as they feared, Mr. Edward Southgate III getting a mortal shock from his peculiar conglomeration of wires and sparkling Mason fruit jars, but merely the result of Mrs. Southgate's youngest son making contact number one with his trusty bottle!

Jug looked at Jim standing in the door. The frayed scarf. The worn old overcoat hanging awkwardly from his small body.

"Know the code pretty well?" Jug asked, rising slowly, and returning the tobacco pouch to his pocket.

"Sir?"

"Can you copy pretty well?"

"Yes — well, I guess I can copy ten words a minute, I guess."

"Want to go upstairs?"

"Upstairs?"

"Want to see the operating room?"

"Oh! Yes!"

Jug led the way with Jim following at his heels. A series of coughs escaped Jim at the top of the flight, and alarm possessed him that he would disturb the operator. He tiptoed in behind Jug, his small face radiant with excited expectation.

"What say, Jug?"

"'Lo, Bohunk. How goes it?"

"Fair."

"Where you working now?"

"Using 7005. Don't worry, it's inside."

"Did you check it with the oven?"

"Yes, it's right on the line."

Jim was all eyes. He looked at the Single-Signal receiver, at the typewriter, at the 100-kc. secondary frequency standard, at the steel front control panel alongside the operating desk. The shiny brass handwheel on it. The meters. All the relays in the back. The lacing on the cable runs. Resistors standing upright in groups. Jim's excited inspection saw it all!

"Anything coming through?"

"Few. Good many VK's and ZL's. Heard J2GX a minute ago. May be pretty fair later on."

Jug rested his elbows on the operating table and said something to Collier Parkes. Jim didn't hear. Jim was busy. He was looking intently at a Kleinschmidt perforator partially disassembled, wondering what manner of thing it was.

Parkes grinned.

"Sure! Sure!"

Jug's voice dropped lower.

"No," said Collier, "I got one with K6BAZ in fifteen minutes. Plenty of time for that, though. You go ahead while I go out here and look up another pad of message blanks — or something," he added.

He disappeared, clattering down the stairs.

"Want to listen in?" Jug asked, motioning to the receiver.

Jim came over to the operating desk and looked at Jug, then looked at the receiver. A great fear came over him. It was too beautiful to get close to; the baffling controls marked "R.F. Gain," "Selectivity," "A V C" "Voice — C.W.," and "Crystal Filter" were formidable. It was only to be looked upon from a distance.

Jug pulled the swivel chair up with his foot.

"Sit down. Sit down."

Jim let himself down slowly and looked around at the control panel. His elbow touched the shiny handwheel, and he hastily pulled it back, and then let it slide down again. This was real. It was not a dream.

Jug tripped one of the switches up with his thumb and motioned to the knob in the center.

"Turn that one."

Jim looked up at him inquiringly and touched the knob timidly. The shadow scale above it moved slightly. How easily it turned! Encouraged, he moved it a little more. A faint hiss which had begun to evidence itself in the dynamic speaker was at that instant ripped asunder by a kaleidoscope of crisp, bell-like signals which caused the moving coil of the speaker to wiggle perceptibly. Jim looked at it quickly. The sound seemed to hit him in the stomach, like when the bass drum passed in a parade. Just listen! A procession of grunts, drones and crystal ringing notes shrilled slowly by.

"Slow! Slow! Back this way."

Jim turned the knob back. Gee! It turned so easily, just seemed to glide! Entranced, he watched the shadowy divisions and numbers slip across the sloping, ground glass window. Was this real? His elbow slid back against the handwheel inquiringly. Yes, it was real, all right.

Slowly the dial moved back toward the 7000-kc. end. The terrific honk of W6's tore through. A myriad of faint signals in between that a touch of Jug's finger on the gain transformed into ear-splitting intensity.

"Whoa!"

A faint lisping note. Jug brought it up to a good level. It seemed to stand out on top of all the rest, miraculously. The lisp increased in intensity. It signed.

"Hear that?"

Jim nodded.

"Japanese."

Jim's heart skipped a beat.

"Go on."

The dial crept back up the scale. A terrific shot of 100-cycle r.a.c. A fluttering rattle.

"Alaskan."

A hollow ringing crystal note with a peculiar wavering undertone.

"Get this one."

It was a long, slow CQ DX.

Jim's hands were trembling.

"KA1HR. Get it?"

Jim nodded.

"Philippines."

Jim's trembling increased.

The signal faded in slowly, dying away into the background roar, returning.

Jim's heart was pounding so hard it shook him.

"Calling DX."

Thousands of miles of black, tumbling ocean intervened. Outside, the two great towers, outlined irregularly in white, rose up and up into the swirling snow; downstairs the input reactors sang monotonously in the ghastly glow of the rectifiers. The filaments of the push-pull stage in the 7-mc. amplifier imparted a dull radiance to the polished edges of the neutralizing condenser discs. All were waiting, ready to hurl the dynamite.

"AR," grunted Jug, and with his thumb tripped a breaker closing switch at Jim's side. "OK! Go after him! Use the straight key over there."

Little Jim was shaking noticeably. He reached hesitantly over the battery of Vibroplexes strewn before him and grasped the key knob. He felt paralyzed. An hour seemed to pass. Suddenly the knob gave. Awkwardly he sent "KA" and stopped.

"What was his call again? Oh, yes — er..."

He began to call slowly and erratically. After a little he steadied a bit, but his heart was pounding so hard he couldn't control his arm. He was trembling as with a chill.

Downstairs, the pair of 204-A's, no respecters of persons, fired skyward all the savage energy that 4400 volts could impart. At every closure of the relay, the burnished plates of the tank condenser paled fitfully in the semi-darkness.

"Give him a long buzz."

Jim heard, but couldn't obey. The strength was gone out of him. Suddenly he found himself signing. He signed twice. K.

"Boy, you sure must believe in this signal all right," grunted Jug, tripping the breaker release.

For an instant only the background roar. Then the wavering drone started up.

Calling them.

"Well, what do you say now?" muttered Jug, glancing quizzically at Jim.

He didn't answer for a moment. Two large drops deposited themselves suddenly upon the log.

A faint sob came from the little fellow.

"I worked somebody," whispered little Jim.

butterfly beam

This interesting little 15-meter antenna, which is called the butterfly beam, is small, light, and easily made from ordinary hardware store materials. It's also inexpensive. The butterfly beam weighs less than 10 pounds (4.5 kg), it's less than 12 feet (4 meters) square, and cost me less than $20 to build. But despite its small size and low cost, this antenna has given me excellent results on both CW and SSB.

The heart of my butterfly beam is the Lexan spider hub sold by Van Gorden Engineering, P.O. Box 21305, So. Euclid, Ohio 44121. The hub is solidly put together and rugged, and the first time I saw one I thought: *antenna*. The central hole is perfect for the supporting mast. Tubing can be easily attached, and there's even a molded-in socket suitable for an SO-239 chassis connector.

construction details

Four 8-foot (2½-meter) lengths of 1-inch (25.4 mm) diameter aluminum tubing are needed, along with a 50-foot (15-meter) roll of soft aluminum ground wire and four 1-inch (25.4 mm) hose clamps.

It was necessary for me first to calculate the appropriate lengths for the wire elements, based on the 8-foot (2½-meter) tubing I intended using to build the X frame. Not having a capacitor for tuning the director, I reasoned that a close-enough approximation to the desired lengths could be made on a cut-and-try basis, using the starting points calculated (see **table 1**). **Figs. 1** and **2** show the schematic and general arrangement.

I used some light nylon line to tie the ends of the wire together. It's a good insulating material, and also offers the springy support needed to put the elements under slight tension. The socket connector bolts right into the spider hub, and an extra pair of

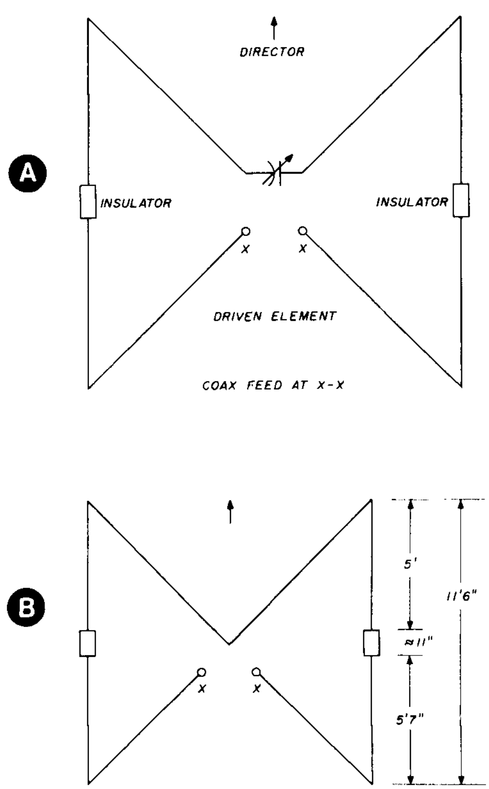


fig. 1. Schematic representation of the "butterfly" beam (A) showing the 'M'-shaped director, tuned by a capacitor, and the 'W'-shaped driven element with feedpoints X-X. It looks a bit like a quad loop, but lies flat instead of standing vertical. B shows dimensions of typical 15-meter version, constructed for lower band edge (21.0 MHz). In this figure, capacitor has been eliminated (see text).

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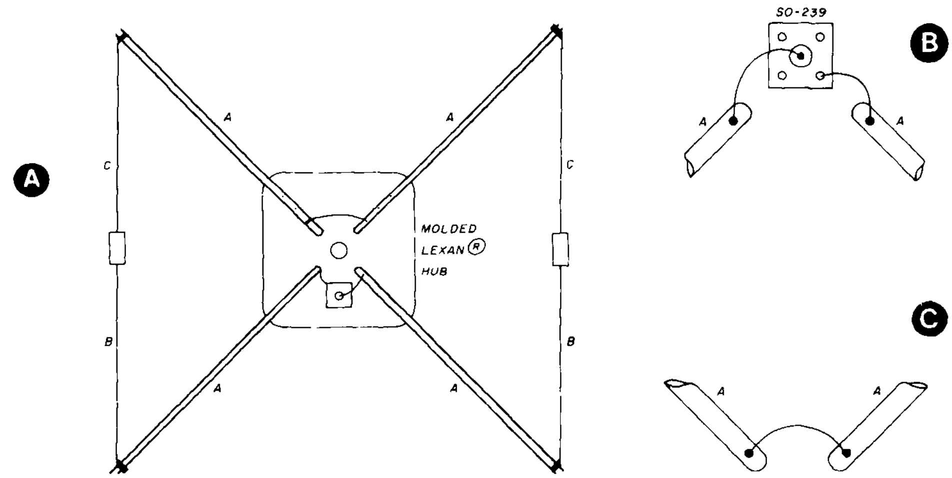

fig. 2. General arrangement of the "butterfly" beam as constructed by the author (A). B shows the SO-239 chassis connector with a wire from the center terminal to one leg of the driven element, and a wire from the shell to the other leg of the driven element. Make the connecting wires short, and use self-tapping screws and radio hardware. Solder connections, where possible. C shows bridge of wire between legs of the director. Variable capacitor could be substituted at this point (see text). Special molded hub available from Van Gorden Engineering (see text).

hose clamps can be used to couple the hub to the mast.

I used a short length of wire to bridge the inner ends of the director element. It's possible to use a tunable capacitor here, the rotor affixed to one leg of the director and stator to the other, because the Lexan hub makes a good insulator. Variable capacitor values would be 250 pF (for 20 meters); 175 pF (for 15 meters); and 125 pF (for 10 meters).

The overall size of each side of the antenna is approximately 11 feet 6 inches (3½ meters) on 15 meters, 17 feet (5 meters) on 20 meters, and 8 feet 6 inches (2½ meters) on 10 meters. The feed point is connected to the SO-239 chassis connector by means of some lengths of copper wire, the center terminal to one leg of the driven element and the ground, or surrounding part of the connector, to the other. The coax is attached to the connector and then waterproofed with a liberal coating of bathtub caulk.* A quarter-wave matching section is shown in **fig. 3**.

When mounting the butterfly beam on its mast, remember that the side wires, not the X-frame tubing, should be aligned with the direction of fire. The proper direction is a bisector of each X angle at the hub.

table 1. Dimensions for the Butterfly Beam (based on lower band edge).

	band		
dimension	**10 meters**	**15 meters**	**20 meters**
A	6′ (1.8 m)	8′ (2.4 m)	12′ (3.7 m)
B	4′3″ (1.3 m)	5′7″ (1.7 m)	8′6″ (2.6 m)
C	3′7″ (1 m)	5′ (1.5 m)	7′3″ (2.2 m)
D*	5′10″ (1.8 m)	7′9″ (2.4 m)	11′8″ (3.6 m)

Materials: X-arms are 1-inch (25.4 mm) diameter aluminum tubing; wire is soft-drawn aluminum ground wire, approximately 1/8-inch (3 mm) diameter; insulators are plastic, nylon cord is suitable. Hub is Lexan (see text).

*Assuming coaxial cable velocity factor = 0.66 Formula = 164/f(MHz).

SWR has been 1.5:1 or less across the 15-meter band, and I've received excellent reports from all sorts of DX, both CW and SSB. When compared with my 14AVQ on the same signals, the butterfly has resulted in a reported average improvement of two S-units, with some reports running as high as 3. Assuming 3.33 dB per S-unit, my butterfly beam

*A better alternative is COAX-SEAL available from Universal Electronics, Inc., 1280 Aida Drive, Reynoldsburg, Ohio 43086.

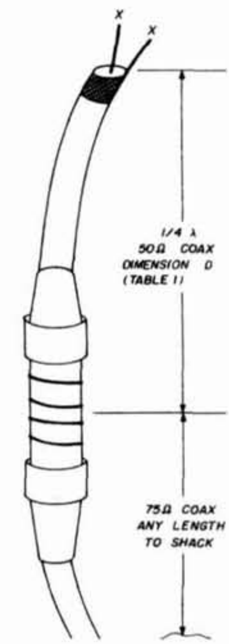

fig. 3. Typical means of constructing a quarter-wave matching section from coax. The feedpoint impedance of the beam (about 30 ohms) is transformed to the feedline impedance (72 ohms) by means of a quarter-wave transformer of 50-ohm coaxial cable. Accompanying table and notes show dimensions for various bands. Center connector consists of two male connectors joined by a female (barrel) connector, for convenience. Joint should be taped and waterproofed after completion.

represents a gain of 6 to 7 dB, and sometimes as much as 10 dB!

The front-to-back ratio runs only 10 to 15 dB, although the front-to-side ratio is considerably better, running about 30-40 dB. There seems to be a very deep notch in the position between side and back of the beam, although I have not made any pattern plots to verify this. A considerable improvement in front-to-back ratio might possibly be made by director tuning. Another interesting possibility is that of using a coaxial capacitor as a director tuning capacitor.

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Sensitivity:	Less than 10 MV to 150 MHz Less than 50 MV to 500 MHz
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Display:	9 digits 0.4" LED
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Time base:	1.0 ppm TCXO 20-40°C
Power:	12 VAC @ 250 ma

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Here's a handy, general purpose counter that provides most counter functions at an unbelievable price. The MINI-100 doesn't have the full frequency range or input impedance qualities found in higher price units, but for basic RF signal measurements, it can't be beat! Accurate measurements can be made from 1 MHz all the way up to 500 MHz with excellent sensitivity throughout the range, and the two gate times let you select the resolution desired. Add the nicad pack option and the MINI-100 makes an ideal addition to your tool box for "in-the-field" frequency checks and repairs.

SPECIFICATIONS:

Range:	1 MHz to 500 MHz
Sensitivity:	Less than 25 MV
Resolution:	100 Hz (slow gate) 1.0 KHz (fast gate)
Display:	7 digits, 0.4" LED
Time base:	2.0 ppm 20-40°C
Power:	5 VDC @ 200 ma

8 DIGITS 600 MHz $159.95 WIRED

NEW READ RECEIVER FREQUENCY

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Display:	8 digits 0.4" LED
Time base:	2.0 ppm 20-40°C
Power:	110 VAC or 12 VDC

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PRICES:

CT-50 wired, 1 year warranty	$159.95
CT-50 Kit, 90 day parts warranty	119.95
RA-1, receiver adapter kit	14.95
RA-1 wired and pre-programmed (send copy of receiver schematic)	29.95

DIGITAL MULTIMETER $99.95 WIRED

PRICES:

DM-700 wired, 1 year warranty	$99.95
DM-700 Kit, 90 day parts warranty	79.95
AC-1, AC adaptor	3.95
BP-3, Nicad pack + AC adapter/charger	19.95
MP-1, Probe kit	2.95

The DM-700 offers professional quality performance at a hobbyist price. Features include; 26 different ranges and 5 functions, all arranged in a convenient, easy to use format. Measurements are displayed on a large 3½ digit, ½ inch LED readout with automatic decimal placement, automatic polarity, overrange indication and overload protection up to 1250 volts on all ranges, making it virtually goof-proof! The DM-700 looks great, a handsome, jet black, rugged ABS case with convenient retractable tilt bail makes it an ideal addition to any shop.

SPECIFICATIONS:

DC/AC volts:	100uV to 1 KV, 5 ranges
DC/AC current:	0.1uA to 2.0 Amps, 5 ranges
Resistance:	0.1 ohms to 20 Megohms, 6 ranges
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measuring coax cable loss

with an SWR meter

One solution to
the high cost
of exotic test equipment
for measuring
transmission-line losses

Have you ever wondered how much loss a piece of coaxial cable has at a particular frequency? You could consult a chart or graph in a reference book. However, that would only tell you the *approximate* loss for coax from the manufacturer who supplied data to the editor of the book. Age and environment affect cable loss. Does the chart in the book include an age factor? The easiest way to determine loss in a piece of coax is by measuring it. You don't need expensive test equipment to do this. All you need is a) an SWR meter or a bidirectional wattmeter, b) a transmitter, and c) the desire to perform a few simple calculations.

determining cable loss

The loss in coaxial cable can be determined by connecting it to a source of rf (the transmitter) and measuring the SWR at the transmitter when the far end of the line is an open circuit. At first this method may sound too simple to work, but it does, and here's why.

Transmission line theory tells us that the SWR will be:

$$SWR = \frac{R}{Z} \qquad (1)$$

where R is the load resistance, and Z is the line impedance.[1] An open circuit would present an infinite load resistance and therefore an infinite SWR. Trans-

By **John W. Frank, WB9TQG**, P.O. Box 5113, Madison, Wisconsin 53705

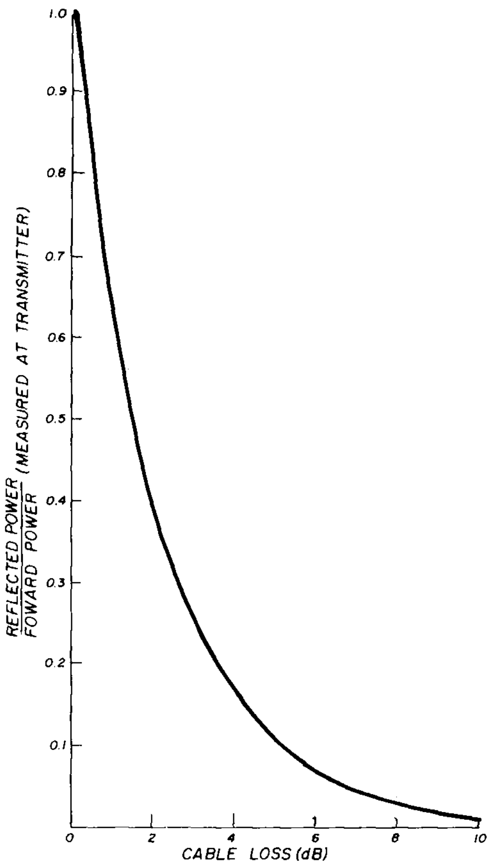

fig. 1. Ratio of reflected power to forward power as a function of cable loss (*eq. 4*).

mission line theory also tells us that the reflection coefficient[2] will be:

$$K = \frac{SWR - 1}{SWR + 1} \qquad \textbf{(2)}$$

Since the SWR of an open circuit will be infinite, the reflection coefficient will be, for all practical purposes, unity (100 per cent). Therefore, all the power reaching the end of the line will be reflected to the source.

However, not all the power from the source reaches the end of the line; some is lost along the way. And not all the reflected power returns to the source; some of it is also lost along the way.

The reflected power measured at the source represents twice the loss of the coax: the loss forward and loss reflected. The standard formula for calculating the dB loss or gain[3] is:

$$dB = 10 \log \frac{P1}{P2} \qquad \textbf{(3)}$$

In this application, **eq. 3** would tell us the loss for the round trip. Since we are interested in the loss in only one direction, and since the loss forward should be the same as the loss reflected, **eq. 3** becomes:

$$dB = 5 \log \frac{reflected}{forward} \qquad \textbf{(4)}$$

Eq. 4 is fine if you have a bidirectional wattmeter. Since many low-priced SWR meters measure SWR *without* indicating actual power in watts, and since SWR is a function of forward and reflected power, **eq. 4** can be transposed:

$$dB = 5 \log \left(\frac{SWR - 1}{SWR + 1}\right)^2 \qquad \textbf{(5)}$$

Eq. 4 is shown graphically in **fig. 1**. **Eq. 5** is shown in **fig. 2**.

examples

Before going any further, let's consider two simple hypothetical examples. A transmitter feeds 100 watts of rf power into a length of RG-58 cable. A bidirectional wattmeter at the transmitter indicates a reflected power of 25 watts. From **eq. 4** we can calculate

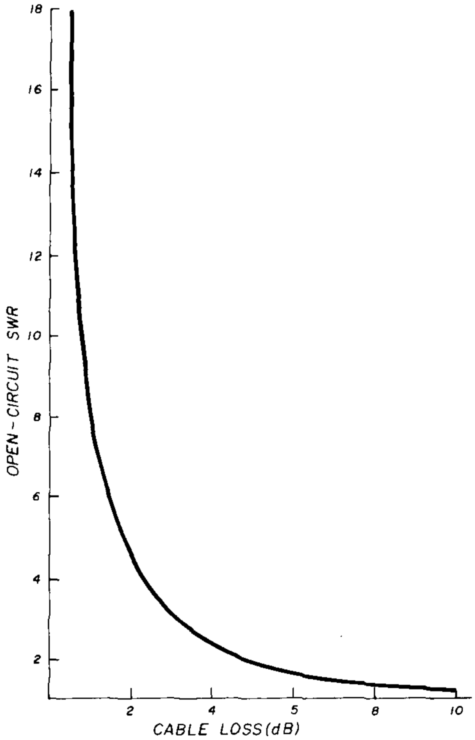

fig. 2. Open-circuit SWR as a function of cable loss (*eq. 5*).

$$5 \log \frac{25}{100} = 5 \log 0.25$$

$$= 5(-0.602) = -3.01\ dB \qquad (6)$$

The minus sign indicates a loss. To further verify **eq. 4**, let's consider what happened to the rf as it made its round trip through the coax. If the coax really did have 3 dB of loss, approximately 50 watts would reach the open end. When that 50 watts was reflected, the same 3 dB loss would result in *25 watts being lost in the coax*. Thus, only 25 watts would be measured as reflected power at the source.

For our second hypothetical case, let's assume the use of an SWR meter that doesn't indicate forward power; the meter scale reads directly in SWR. A transmitter of unknown output is connected to a length of RG-8/U cable, and the SWR at the transmitter is 6:1. We can use **eq. 5** to calculate the loss:

$$5 \log \left(\frac{6-1}{6+1}\right)^2 = 5 \log (0.714)^2$$

$$= 5(-0.29) = -1.45\ dB. \qquad (7)$$

Again, the minus sign indicates a loss.

system accuracy

This will depend on the accuracy of the SWR meter or wattmeter used to make the measurement. Several precautions must be observed:

1. Some lengths of coax at some frequencies could act as resonant circuits and cause inaccurate measurements.

2. Short lengths of good-quality coax will show a very high SWR. Make sure the transmitter used as a source of rf can withstand a high SWR.

3. The transmitter impedance must match that of the coax.

4. Measurements should be made at the frequency at which the coax will be used.

One more item must be taken into account. This system for measuring loss in coaxial cable assumes that the load will be perfectly matched to the line. Any mismatch will create standing waves that will cause additional loss.[4]

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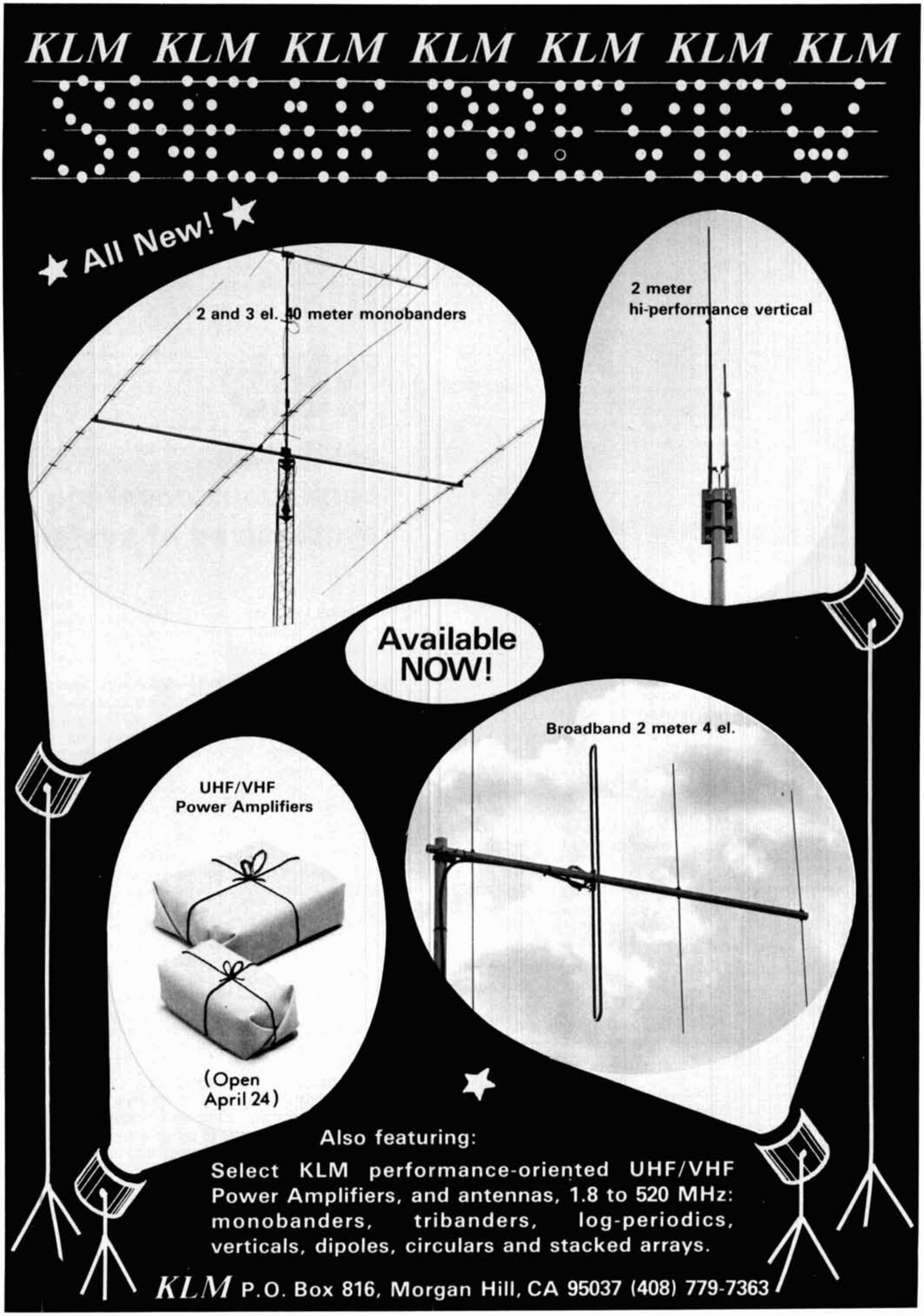
More Details? CHECK—OFF Page 118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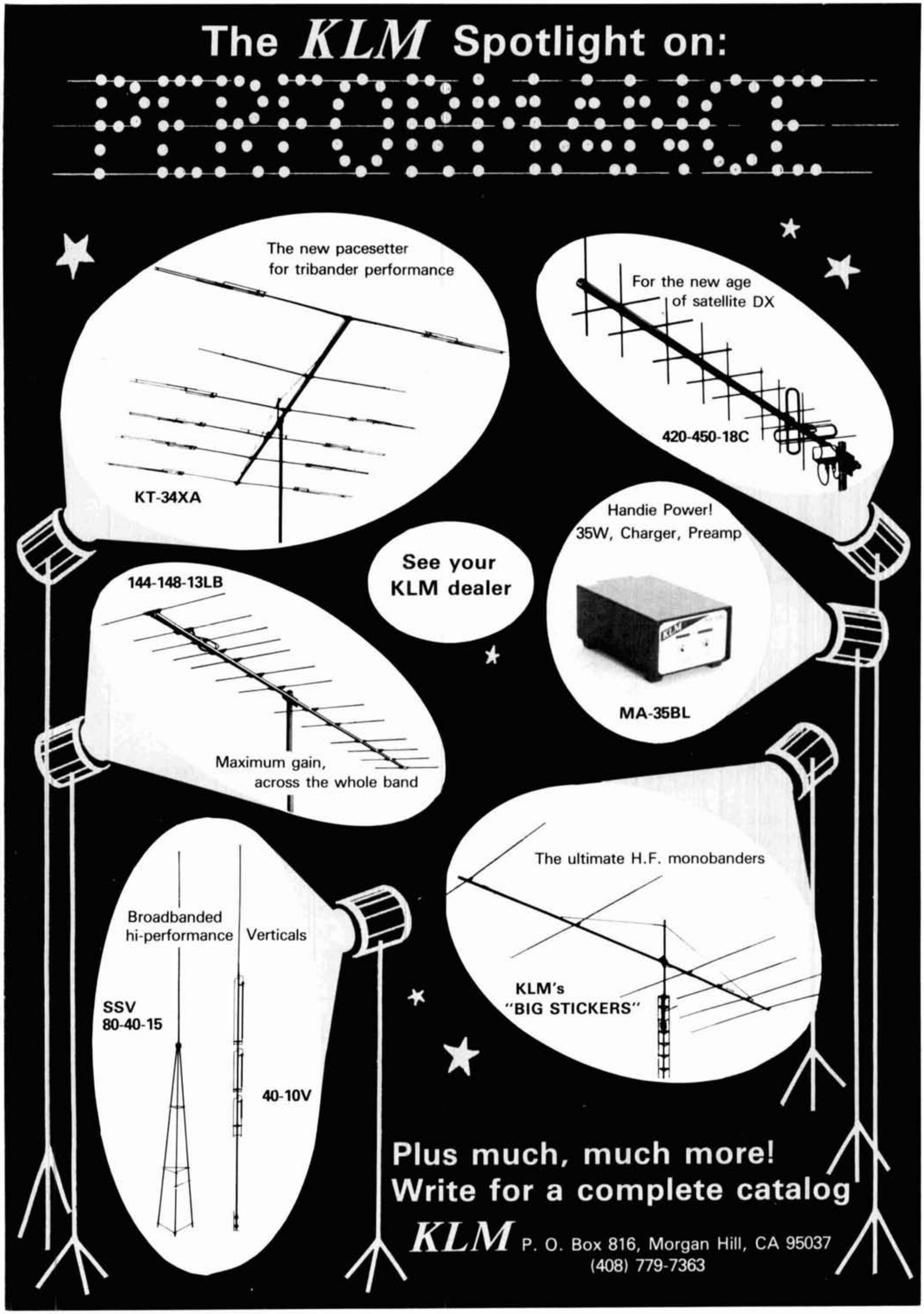
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for pattern calculation phased vertical arrays

Solving pattern equations using a programmable calculator

The vertical, quarter-wave ground-plane or ground-mounted antenna is a popular choice. Much interest has been shown recently for vertical arrays in the Amateur literature. The vertical array can give good results in directivity for less investment than a rotatable antenna such as the Yagi or quad beam.

This article examines the procedures for pattern calculation of phased vertical arrays having arbitrary layout, antenna height, phasing, and power division among array members.

phased vertical arrays

Several classic vertical arrays have been implemented and described in the Amateur literature. Many Amateurs have obtained good performance with such antennas. However, several problems arise when constructing vertical arrays. Lack of appropriate real estate is foremost: the pattern of the classic array may not fit your location. You don't need to depend on a classic layout if one or more of the following is available:

1. A scientific calculator and a lot of time.

2. A programmable calculator and moderate amount of time.

3. A microcomputer and very little time.

All three depend on mathematical relationships, and these are shown for arrays of an arbitrary nature. Computation procedures are outlined.

A Hewlett-Packard HP-67/97 programmable calculator program is given, followed by the BASIC source code listing for a Radio Shack TRS-80 microcomputer. The latter will run on a Level-II machine with as little as 4k of memory. Both programs are adaptable to other machines, especially the computer program.

pattern equations

The directivity pattern of any antenna or array is three-dimensional in nature. Convention gives a plot of relative field strength at various angles, θ, above the horizon. Azimuth is fixed, and the pattern is defined relative to an array axis.

Conversely, patterns may be given in the horizon-

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tal plane with θ fixed and azimuth angle, ϕ, varying 0 to 360 degrees. **Fig. 1** is a pictorial description of both patterns.

Relative field strength of a single vertical antenna having sinusoidal current distribution and a current node at the top is given by:

$$f(\theta) = \frac{\cos(G \sin \theta) - \cos G}{(\cos \theta)(1 - \cos G)} \qquad (1)$$

where: $f(\theta)$ = Relative vertical field strength (N.D.)
G = Electrical height of antenna (degrees).
θ = Angle above horizon (degrees).

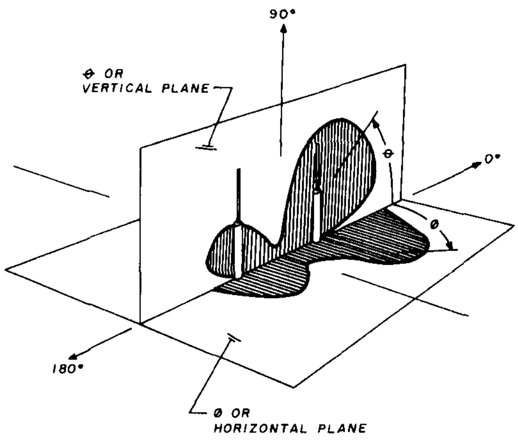


fig. 1. Two-dimensional representation of an array field strength.

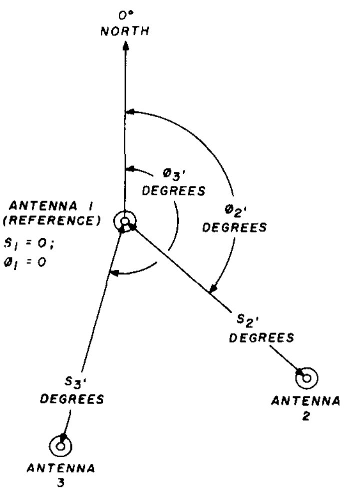


fig. 2. Geometric relationships of spacing and location, top view.

As an example, solution of **eq. 1** for a quarter-wavelength antenna requires G equal to 90 degrees. A zero value of θ (on the horizon) yields an $f(\theta)$ of unity; $f(\theta)$ will be zero for $\theta = 90$ degrees (straight up). All other angles of θ will yield a result between zero and one.

The field-strength pattern for a single vertical antenna in the horizontal (ϕ) plane is a circle. The composite field strength of an array of antennas in the ϕ plane is given by:

$$E = \sum_{k=1}^{n} E_k f_k(\theta) \angle B_k \qquad (2)$$

$$B_k = S_k(\cos \theta)[\cos(\phi_k - \phi)] + Y_k \qquad (3)$$

where E = Total relative field strength of all antennas in ϕ plane (N.D.)
E_k = Component of total field strength due to k^{th} antenna alone (N.D.)
$f_k(\theta)$ = Vertical field strength of the k^{th} antenna for the θ chosen for pattern calculation (N.D.)
B_k = Phase angle relationship of the field vector from the k^{th} antenna with respect to the reference (degrees)
S_k = Physical spacing of the k^{th} antenna with respect to the reference antenna (electrical degrees)
θ = Vertical angle chosen for the pattern and held constant for all ϕ angles (degrees)
Y_k = Relative drive phase of antenna k at its feed point with respect to the reference (degrees)
ϕ_k = Azimuth bearing from the array reference point to the k^{th} antenna (degrees)
ϕ = Azimuth bearing from the reference point in direction of interest (degrees)
n = Number of antennas in the array

Eqs. 2 and **3** are explained with the aid of a three-antenna array shown in **fig. 2**. An elevation angle, θ, is chosen for all horizontal angles, ϕ. **Eq. 1** is solved for each array antenna to yield $f(\theta)$; it may be considered constant for all values of ϕ. The array geometry will define S_k and ϕ_k.

One antenna must be a reference. Values of S_k, ϕ_k, Y_k, and B_k for this antenna will be zero; E_k value will be one. E_k values of the other antennas will be the ratio of drive power of the reference versus the other antennas. The value of other antenna drive-phase angles will be positive for lead, negative for lag.

The summation in **eq. 2** requires that **eq. 3** be solved first. The polar form of $[E_k f_k(\phi) \angle B_k]$ is then converted to rectangular form, summing the real and im-

table 1. Hewlett-Packard HP-67 program listing.

STEP	KEY ENTRY	KEY CODE	STEP	KEY ENTRY	KEY CODE	STEP	KEY ENTRY	KEY CODE
001	f LBL A	31 25 11	041	0	00	081	CHS	42
002	0	00	042	STO 2	33 02	082	1	01
003	STO 2	33 02	043	STO 3	33 03	083	+	61
004	STO 3	33 03	044	f GSB 1	31 22 01	084	RCL 0	34 00
005	STO 1	33 01	045	RCL 3	34 03	085	f Cos	31 63
006	f LBL 2	31 25 02	046	RCL 2	34 02	086	x	71
007	f GSB 1	31 22 01	047	g R → P	32 72	087	h 1/x	35 62
008	RCL 1	34 01	048	h RTN	35 22	088	RCL (i)	34 24
009	h PAUSE	35 72	049	f LBL D	31 25 14	089	f Cos	31 63
010	RCL 3	34 03	050	STO 0	33 00	090	CHS	42
011	RCL 2	34 02	051	0	00	091	RCL 0	34 00
012	g R → P	32 72	052	STO 2	33 02	092	f Sin	31 62
013	R/S	84	053	STO 3	33 03	093	RCL (i)	34 24
014	RCL 4	34 04	054	f GSB 1	31 22 01	094	f DSZ	31 33
015	STO + 1	33 61 01	055	RCL 3	34 03	095	x	71
016	0	00	056	RCL 2	34 02	096	f Cos	31 63
017	STO 2	33 02	057	g R → P	32 72	097	+	61
018	STO 3	33 03	058	h RTN	35 22	098	x	71
019	GTO 2	22 02	059	f LBL 1	31 25 01	099	RCL (i)	34 24
020	f LBL B	31 25 12	060	9	09	100	f DSZ	31 33
021	0	00	061	h STi	35 33	101	x	71
022	STO 2	33 02	062	f GSB 0	31 22 00	102	RCL (i)	34 24
023	STO 3	33 03	063	1	01	103	f DSZ	31 33
024	STO 0	33 00	064	4	04	104	RCL 1	34 01
025	f LBL 3	31 25 03	065	h STi	35 33	105	-	51
026	f GSB 1	31 22 01	066	f GSB 0	31 22 00	106	f Cos	31 63
027	RCL 0	34 00	067	1	01	107	RCL 0	34 00
028	h PAUSE	35 72	068	9	09	108	f Cos	31 63
029	RCL 3	34 03	069	h STi	35 33	109	x	71
030	RCL 2	34 02	070	f GSB 0	31 22 00	110	RCL (i)	34 24
031	g R → P	32 72	071	2	02	111	f DSZ	31 33
032	R/S	84	072	4	04	112	x	71
033	RCL 4	34 04	073	h STi	35 33	113	RCL (i)	34 24
034	STO + 0	33 61 00	074	f GSB 0	31 22 00	114	+	61
035	0	00	075	h RTN	35 22	115	h x ⇆ y	35 52
036	STO 2	33 02	076	f LBL 0	31 25 00	116	f P → R	31 72
037	STO 3	33 03	077	RCL (i)	34 24	117	STO + 2	33 61 02
038	GTO 3	22 03	078	f X=0 ?	31 51	118	h x ⇆ y	35 52
039	f LBL C	31 25 13	079	h RTN	35 22	119	STO + 3	33 61 03
040	STO 1	33 01	080	f Cos	31 63	120	h RTN	35 22

aginary parts separately, then converting the final summation back to polar form.*

The result at any given ϕ is in the form $E \angle B$ with E being the magnitude of relative field strength at azimuth ϕ. Resultant angle B is unimportant at far distances, but all B_k angles must be calculated as indicated for solution of **eq. 2**.

example

To illustrate, consider a simple array of two quarter-wave vertical antennas spaced 120 electrical degrees on a north-south bearing. With the south antenna as the reference, the north antenna is fed with equal power but at a phase lead of 60 degrees. Initial data is then (numbers in electrical degrees):

antenna	G	ϕ	S	E	Y
1 (reference)	90	0	0	1	0
2	90	0	120	1	60

Set θ equal to zero. Since $G_1 = G_2$ **eq. 1** solutions are identical and:

$$f_1(0) = f_2(0) = \frac{\cos(90^\circ \times \sin 0^\circ) - \cos 90^\circ}{(\cos 0^\circ)(1 - \cos 90^\circ)}$$

$$= \frac{\cos 0^\circ - \cos 90^\circ}{1(1-0)} = \frac{1-0}{1} = 1$$

*The Greek letter sigma in **eq. 1** means the summing of all individual k-subscript terms calculated separately in the form to the right of sigma. The **fig. 2** example would have k values of 1, 2, and 3, since $n = 3$. **Editor**.

Choose the first azimuth of interest to be 15 degrees. **Eq. 3** values are then

$$B_1 = 0^\circ[(\cos 0^\circ) \times \cos(0^\circ - 15^\circ)] + 0^\circ = 0^\circ$$

$$\begin{aligned} B_2 &= 120^\circ[(\cos 0^\circ) \times \cos(0^\circ - 15^\circ)] + 60^\circ \\ &= 120 \times 1 \times \cos(-15^\circ) + 60^\circ \\ &= 120 \times 0.966 + 60 = 175.92^\circ \end{aligned}$$

Equal power magnitude is at each feedpoint, so $E_1 = E_2 = 1$. From **eq. 2**

$$\begin{aligned} E &= [E_1 f_1(0) \angle B_1] + [E_2 f_2(0) \angle B_2] \\ &= [1 \times 1 \angle 0^\circ] + [1 \times 1 \angle 175.92^\circ] \\ &= (1 + j0) + (-0.997 + j0.071) \\ &= (1 - 0.997) + j(0 + 0.071) \\ &= 0.003 + j0.071 \\ &= 0.0711 \angle 87.58^\circ \end{aligned}$$

Maximum relative magnitude of a double, equal size and power antenna array is 2. The low magnitude at 15 degrees east of north indicates a null in the northerly direction.

Calculations may be carried out for all azimuths of interest or in a series from zero to 360 degrees for pattern plotting. For example, this array has a field strength of $1.732 \angle -29.9^\circ$ at $\phi = 180^\circ$; gain exists toward the south. Numerical solution steps are left as an exercise.

Keeping a constant elevation angle, θ, requires only one solution of **eq. 1**. **Eq. 3** must still be solved at each azimuth.

table 2. Operating instructions for the HP-67 calculator program.

User Instructions

PHASED ARRAY PATTERN CALCULATION

VARIABLE Ø | VARIABLE θ | FIXED Ø | FIXED θ

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	MODE A - Variable Ø (Incremented)			
1.	Load R0,R4,R5-R9,Rs0-Rs9,RA-RE			
2.	Run program. Program will pause to show Ø (0° first time) then stop to show the magnitude of E for that Ø.		A	Ø/deg. E/dim.
3.	If desired show phase ∠ for E.		h x⇄y	∠Phase/°
4.	Press R/S. Ø is incremented by amount in R4 and calculation proceeds with the next Ø and E shown as in Step 2.		R/S	
	MODE B - Variable θ (Incremented)			
1.	Load R1,R4,R5-R9,Rs0-Rs9,RA-RE			
2.	Run program. Output will be as in MODE A except θ is shown instead of Ø.		B	θ/deg. E/dim.
3.	As in Mode A, Step 3.		h x⇄y	∠Phase/°
4.	As in MODE A, Step 4 except θ is incremented.		R/S	
	MODE C - Fixed Ø			
1.	Load registers as in MODE A.			
2.	Enter chosen Ø in display.			
3.	Perform calculation for the given Ø. Output will be E for chosen Ø.		C	E/dim.
4.	Same as in MODE A, Step 4.		h x⇄y	∠Phase/°
5.	Return to Step 2 for next Ø.			
	MODE D - Fixed θ			
1.	Load registers as in MODE B.			
2.	Enter θ in display.			
3.	Perform calculation for the given θ. Output will be E for the chosen θ.		D	E/dim.
4.	Same as in MODE B, Step 3.		h x⇄y	∠Phase/°
5.	Return to Step 2 for next θ.			

using a programmable calculator

Computations are greatly simplified through the use of a programmable calculator such as the Hewlett-Packard HP-67 or HP-97. **Table 1** is a flexible program for the HP-67.* This program can handle up to four antennas in an arbitrary array and can be used in four modes.

Mode A operates with a fixed elevation angle, θ. Azimuth increment is stored in register 4 after loading required data in registers indicated in step 1. Initial computation is begun by pressing function key A. The first stop indicates field strength magnitude at zero azimuth. Pressing the R/S key causes the *working-*ϕ to be incremented by the amount in register 4; next stop will show field strength magnitude at the next azimuth. This may be repeated by pressing the R/S key for each azimuth increment until the entire pattern is described.

Mode B is similar except azimuth is held constant, and the output describes the vertical plane pattern. The value in register 4 is the incremental elevation angle, θ. Initial calculation is zero elevation after pressing function key B.

Mode C calculates field strength at any azimuth manually entered before pressing function key C. Mode D is similar except the calculation is made on entered elevation angles.

Program instructions are given in **table 2.** Preloading of all registers except 2 and 3 is required for each array. Zero is loaded into registers designated for unused antennas.

a basic computer program

Ultimate ease of calculation is with a computer. **Table 3** is a program written in BASIC for the Radio Shack TRS-80, Level II microcomputer. The program requires only 4k of RAM, the minimum configuration for this machine. It will run on other BASIC language computers with minimal alteration.

The program is largely self-prompting, given an understanding of the terms in this article. It allows initial entry of all antenna data, an increment value for ϕ, and elevation angle θ. Subsequent runs do not require full data re-entry; the user may branch to a data alteration routine for specific changes, then re-run.

Coding and formatting is for CRT monitor output. Printer tabulation is possible by changing PRINT to LPRINT in lines 250, 251, 255, 256, 1020, and 1022. A sample output at azimuth increments of 15 degrees is given in **table 4** for the previous two-antenna array.

*A few simple changes allow operation on the HP-97. Consult the owner's manual for 67/97 differences.

table 3. BASIC program listing for the Radio Shack TRS-80. This may be used for other BASIC interpreters with appropriate language alteration.

```
10 CLS:PRINT TAB(21)"VERTICAL ANTENNA ARRAYS":PRINT
20 PRINT TAB(16)"DIRECTIONAL PATTERN COMPUTATION":PRINT:PRINT
30 INPUT"ENTER THE NUMBER OF ANTENNAS IN THE ARRAY";NANT:CLS
40 PRINT TAB(20)"DATA ENTRY INSTRUCTIONS":PRINT
50 PRINT TAB(6)"CHOOSE A REFERENCE POINT FOR THE ARRAY TO BE"
60 PRINT"ONE OF THE ANTENNAS THEREIN. THEN THE POSITION AND"
70 PRINT"EXCITATION DATA FOR ALL OTHER MEMBERS OF THE ARRAY"
80 PRINT"ARE TO BE SPECIFIED WITH RESPECT TO THIS REFERENCE."
90 PRINT TAB(6)"FOR EACH ANTENNA THE COMPASS BEARING FROM THE"
100 PRINT"REFERENCE TO IT;(THE AZIMUTH) MUST BE ENTERED. NEXT,"
110 PRINT"THE DISTANCE TO THE REFERENCE IN ELECTRICAL DEGREES"
120 PRINT"IS ENTERED. FINALLY ENTER THE DRIVE PHASE LEAD OR LAG"
130 PRINT"RELATIVE DRIVE AND ELECTRICAL HEIGHT."
135 PRINT TAB(6)"THE AZIMUTH, PHASE, AND SPACING MUST BE 0,"
136 PRINT"AND RELATIVE DRIVE POWER 1 FOR THE REFERENCE.":PRINT
140 INPUT"PRESS ENTER TO BEGIN DATA ENTRY SEQUENCE";DUM:CLS
150 DIM A(NANT,5):DIM PL(4,2)
160 FOR I=1 TO NANT
170 PRINT TAB(19)"INPUT, FOR ANTENNA NO. "I:PRINT
180 INPUT"AZIMUTH, DEGREES";A(I,1)
190 INPUT"SPACING, DEGREES";A(I,2)
200 INPUT"PHASE,    DEGREES";A(I,3)
210 INPUT"RELATIVE POWER INPUT, DIMENSIONLESS";A(I,4)
215 INPUT"ELECTRICAL HEIGHT, DEGREES";A(I,5):CLS:NEXT
220 GOSUB 700
230 GOSUB 800
235 PRINT
240 CLS:INPUT"ENTER DATA OUTPUT AZIMUTH INCREMENT, DEGREES";INC
245 INPUT"ENTER VERTICAL ELEVATION ANGLE, DEGREES";THETA:CLS
250 PRINT TAB(10)"RELATIVE FIELD STRENGTH CALCULATION RESULTS"
251 FOR O=1TO64:PRINT"-";
252 NEXT O
255 PRINT TAB(20)"ELEVATION ANGLE =";THETA:C$="AZ. = RFS"
256 PRINT TAB(1);C$;TAB(16);C$;TAB(31);C$;TAB(46);C$
260 I=0
270 J=0
274 SX=0:SY=0
275 FOR M=1 TO NANT
280 GOSUB 950
284 NEXT M
285 RFS=SQR(SX↑2.+SY↑2.)
290 J=J+1:PL(J,1)=I:PL(J,2)=RFS
300 IF I=360 THEN 1000
310 I=I+INC:IF I>360 THEN I=360
320 IF J=4 THEN 1000
330 GOTO 274
335 PRINT:PRINT"ENTER 0 TO COMPLETELY RERUN"
340 INPUT"ENTER 1 TO REVISE DATA AND RERUN";T:CLS
350 IF T=1 THEN 220:IF T=0 THEN 360
360 RUN
700 CLS:PRINT TAB(1)"ANT.";TAB(31)"REL.";TAB(39)"REL.PWR";
705 PRINT TAB(49)"ELECT."
710 PRINT TAB(2)"#";TAB(8)"AZIMUTH";TAB(19)"SPACING";
720 PRINT TAB(30)"PHASE";TAB(40)"INPUT";TAB(49)"HEIGHT":PRINT
730 FOR K=1 TO NANT:PRINTTAB(1)K;TAB(10)A(K,1);TAB(20)A(K,2);
740 PRINT TAB(30)A(K,3);TAB(41)A(K,4);TAB(50)A(K,5):NEXT
750 RETURN
800 PRINT:INPUT"DATA OK? ENTER 1. ENTER 2 TO CHANGE DATA";X
810 ON X GOTO 840,850
820 GOSUB 700
830 GOTO 800
840 RETURN
850 GOSUB 900
860 GOSUB 700
870 GOTO 800
900 GOSUB 700
910 INPUT"ENTER ANTENNA #, COLUMN #, REVISED DATA";X,Y,Z
920 Y=Y-1:A(X,Y)=Z:RETURN
950 C=.0174553:AZK=A(M,1)*C:AA=I*C:PH=A(M,3)*C:V=A(M,5)*C
951 EL=THETA*C:NUM=COS(V*SIN(EL))-COS(V):DEN=COS(EL)*(1-COS(V))
952 F0=NUM/DEN:EFE=F0*A(M,4)
960 BK=A(M,2)*C*COS(AZK-AA)+PH:X=EFE*COS(BK):Y=EFE*SIN(BK)
970 SX=SX+X:SY=SY+Y:RETURN
1000 TB=-15
1010 FOR L=1 TO 4
1020 TB=TB+15:PRINT TAB(TB)USING"###";PL(L,1);:PRINT"=";
1022 TC=TB+6:PRINT TAB(TC)USING"#.##";PL(L,2);
1030 IF PL(L,1)=360 THEN 335
1035 NEXT L
1036 PRINT
1040 GOTO 270
```

construction cautions

Inadequate ground radial installation will reduce any vertical antenna performance. Improper radials will change both field strength and pattern depending on local ground conductivity.

Hardware implementation must match the calculation model. Antenna spacings should reflect the center of the band of interest. Phasing lines should be cut for both center of band and for the velocity of propagation of the line. Band-edge patterns can be checked by recalculation. Calculation spacings and length will change inversely proportional to frequency.

Each antenna must be matched to its own feedline. A good power divider must be used at the common feedpoint. Broadband division should be used to reduce phase unbalance on phasing lines. Simply connecting phasing lines in parallel at the common point will cause an impedance mismatch.

table 4. Example tabulation of computer program of the two-antenna array described in text.

elevation angle = 0

AZ. =	RFS	AZ. =	RFS	AZ. =	RFS	AZ. =	RFS
0 =	0.00	15 =	0.07	30 =	0.28	45 =	0.60
60 =	1.00	75 =	1.40	90 =	1.73	105 =	1.94
120 =	2.00	135 =	1.95	150 =	1.85	165 =	1.77
180 =	1.73	195 =	1.77	210 =	1.86	225 =	1.95
240 =	2.00	255 =	1.94	270 =	1.73	285 =	1.40
300 =	1.00	315 =	0.60	330 =	0.28	345 =	0.07
360 =	0.00						

ENTER 0 TO COMPLETELY RERUN
ENTER 1 TO REVISE DATA AND RERUN?

Close spacings will cause a slight individual antenna impedance change due to mutual coupling. This can be checked with a noise bridge for each antenna, all other antennas loaded. Amateur literature contains information on all of these factors and a bit of study is recommended.

Recognizing the factors beforehand should show any problems. The reference gives a complete discussion of the vertical array. This work was the mathematical basis for this article.

reference

Carl E. Smith, *Theory and Design of Directional Antennas*, Smith Electronics, Inc., 8200 Snowville Rd., Cleveland, Ohio 44141, approximately $6.00 plus postage.

bibliography

Reference Data for Radio Engineers, Sixth Edition, Howard W. Sams & Co., Inc., 1975. Page 27-6 contains the general field formula of a vertical antenna; page 27-22 contains the general array formula.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

160 meters today

Have you looked closely at some of the beautiful full-color advertisements of the new generation of Amateur transceivers? Very interesting. And they are advertising *nine high-frequency* bands. I'm sure you are aware by now of the forthcoming 10, 18, and 24.5 MHz bands that are a result of the last WARC Conference. These bands are on the bandswitch of the newer transceivers. And look! They also have a switch position for 1.8 MHz. That's the 160-meter band.

A quick look-see across the 160-meter band by the proud owner of the "all-band" transceiver usually proves to be a disappointment. Perhaps one or two weak signals, some shot-type interference (Loran navigation signals) and plenty of rough QRM from the sweep oscillators of nearby TV receivers. And if the listener is unlucky, he'll get a blast of nasty noise from a light dimmer or two. Seems hopeless, doesn't it?

"top band"

Once the backbone of Amateur Radio, the 160-meter band has languished since World War II. During that distressing period, the Long Range Navigation System (LORAN) was placed in this region and the band has never been the same since.

Now, with the coming demise of LORAN in this frequency range, and the expansion of the band in the United States and overseas, 160 meters has a bright and promising future.

The casual tuner across 160 meters, unfortunately, gets an inaccurate impression of the band, particularly if he is listening on a nondescript antenna. Hook a good antenna on the receiver and, given a break in sweep oscillator QRM, an observant Amateur will find the band full of interesting signals at certain seasons and times of the day. A lot of activity takes place on 160, and there will be more in the future!

At the dawn of Amateur Radio, some years before World War I, Radio Amateurs — a few hundred of them — started out with crude spark transmitters and coherer receivers. It was difficult to tell what frequencies were in use; the spark transmitter took up a good chunk of the spectrum. *Wavelength of operation was* moot until the Radio Act of 1912, which removed Amateurs from the long wavelengths and restricted them to the "useless waves" below 200 meters.

Finally, as a result of heroic efforts of the American Radio Relay League, Amateur Radio became less chaotic and, after the war was over, Amateur Radio grew rapidly, with hundreds of stations operating in the 150 to 200 meter region. By 1922, worldwide

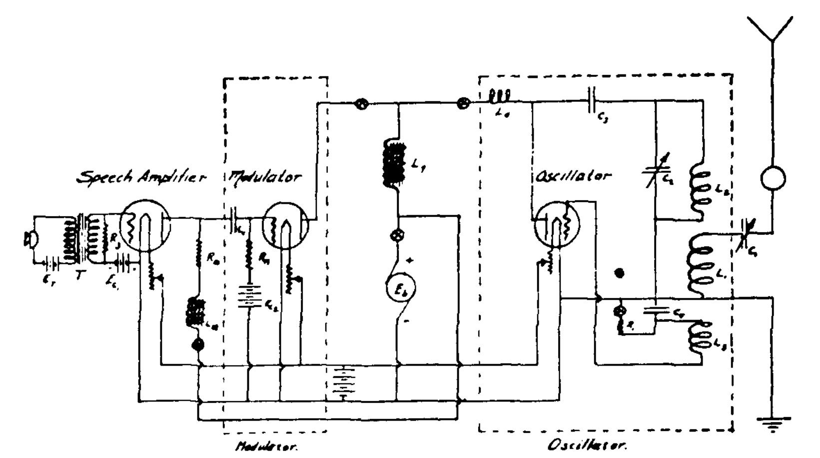


fig. 1. An early "constant-current" phone transmitter. Audio signal applied to the modulator tube varied its plate resistance and amount of current flowing through it. A large inductor (L1) in series with plate voltage to modulator and oscillator tube resists variations in current flow. Consequently when modulator draws a high level of current, oscillator current is reduced. Sum of two currents remained constant — hence the name. Drawing is from *Fifty Years of A.R.R.L.* published by the American Radio Relay League.

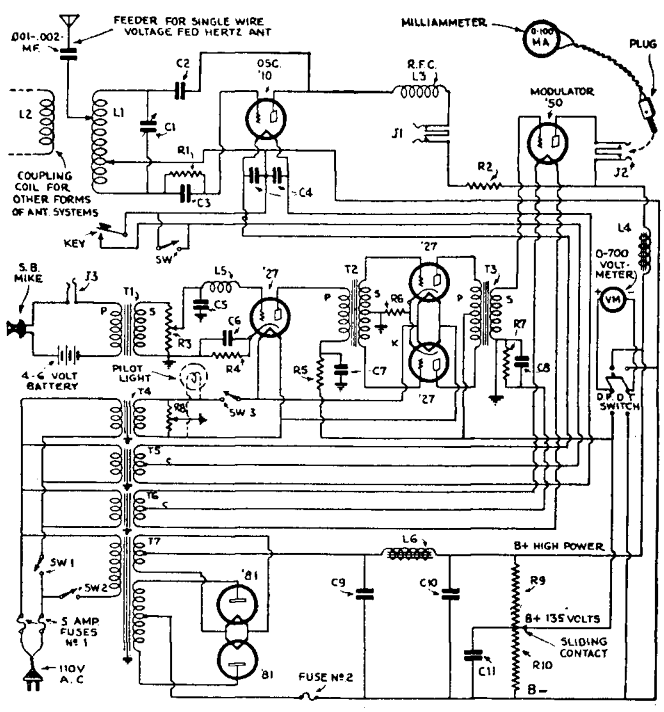


fig. 2. The 1930 phone transmitter of L.B. Robbins, W1AFQ. The 210 oscillator runs about 20 watts input from a 500-volt supply. The 250 tube modulator provides about 60-percent modulation. The tuned circuit consists of a copper tubing coil, 20 turns of 1/4-inch tubing, four inches in diameter and spaced out the tubing diameter. The capacitor is 500 pF. The coil is adjusted so that operation at the desired frequency occurs with the capacitor nearly fully meshed. The bias resistor of the modulator (R7) is adjusted until the no-signal plate dissipation of the 250 tube is about 24 watts. Believe it or not, a modern version of this antique transmitter is on the air today and it sounds quite good! (The drawing is from the August - September, 1931 issue of *Short Wave Craft* magazine, published by Popular Book Corporation.)

Amateur communications was possible, and it was noted that as wavelengths grew shorter, DX improved. The exodus from the 200-meter region seemed to be certain.

In 1924, the Department of Commerce assigned new bands for American Radio Amateurs centered about 80, 40, 20, and 5 meters. Development of the shorter waves was underway! An assigned 160-meter band was largely forgotten in the rush to high-frequency DX.

the 160-meter doldrums

Between 1924 and 1930 there was little interest in 160 meters, as exciting things were happening elsewhere. But the years between 1929 and 1934 were boom years for Amateur Radio. And there was a great and growing interest in telephony. Up to this date, there was little information and little interest in phone transmission. It was the exclusive domain of those few Amateur-engineers who knew their onions. And besides, voice transmission was very expensive.

About 1930, the collapse of the broadcast-receiver building boom turned many experimenters into the more interesting field of shortwave broadcasting. In a year or so, hundreds of thousands of "shortwave listeners" sprang up, and many of those switched to Amateur Radio. Amateur phone, especially for the beginner, was extremely restricted: no phone on the 40-meter band and a class-A license requirement for phone on 80 and 20 meters. And, of course everybody knew that 10 and 5 meters were useless: short-range bands on which it was almost impossible to get equipment working! So that left 160 meters for the beginning phone ham.

the rebirth of 160 meters

Amateur Radio really took off in 1932-33. In 1931 there were about 23,000 U.S. Amateurs. In 1932 there were about 30,000 and in 1933 about 42,000. By early 1934 the Amateur population of the U.S. had doubled the 1931 figure!

The boom in phone operation first started on 160 meters, to be followed in a year or so by practical use of the 5-meter band. But the 160-meter band was the beginner's phone band for a few Golden Years.

It was relatively easy to get going. The famous "constant current" (Heising plate modulation) circuit would do the job, and the modulated oscillator of 1921 (**fig. 1**) could be modernized for 160 meters (**fig. 2**). This simple circuit was very popular until the famous "46 job" came along in mid-1932 (**fig. 3**). The "46 job" was the ultimate phone transmitter, that brought about the explosion of 160-meter activity from 1933 to 1940. For well under a hundred dollars the lowly Class B Amateur could go on phone and enjoy himself!

what 160 meters was like

What was 160 meters like during the winter months of 1934? During the day there wasn't much activity until late in the afternoon when the high-school crowd got home. And then from about 3 to 6 pm the band was full of low-power phone operators. In the New York area there were literally hundreds of phones, running from 10 to 50 watts — and most of them were licensed. In truth, there was a good amount of bootlegging — enthusiasts who hadn't gotten around to making a trip to the FCC for the ham exam. They just "borrowed" a call and went on the air. Next higher in social acceptability were the unlicensed operators who borrowed a ham friend's call. And finally, the "kings of the band," the newly licensed Amateurs.

By 5 pm the older Amateurs started coming home from work, and the disposition of the band changed. The bootleggers disappeared, and the call-borrowers subsided. The interference level picked up sharply as the "old timers" with their 100- and 250-watt phone transmitters gradually took over.

When evening came the band was bedlam. Only the Old Timers remember what a phone band sounded like when it was loaded with a-m phones. Newer hams can get the idea by listening to the CB channels. It was the survival of the fittest. You could judge your transmitter's ability by the DX you worked. From New York City, most low-power phones could work up into Canada. Given a little luck, they could work into Florida late at night when the bedlam had died down. And the real DXers — the sturdy fellows who stayed up into the early morning hours — could prove themselves by working into California if conditions were just right!

But the majority of young Amateurs enjoyed 160 meters during the daylight hours and were content to work their friends in the immediate area. Since most stations were crystal controlled (the modulated oscillator quickly dying out as the band population grew), you knew the fellows who operated near your frequency. Stations on the other end of the band were a mystery, known only to those fortunates who owned two crystals!

It was rumored that transatlantic contacts were possible, and some of the better stations got listener cards from "across the pond." And almost everyone on 160-meter phone got SWL (shortwave listener) cards from local would-be hams. The old a-m transmitters were easy to tune in, even with the most rudimentary receiver.

All this bee hive of activity came to a close on December 7, 1941.

the post-war band

After the war, the 160-meter band was revived, but it was divided up into segments based on proximity of Loran networks. A bewildering set of restrictions and regulations crippled the band, and 160-meter operation was not licensed in many countries. This stalemate continued for many years and only a few hardy souls operated on the band. True, it would come to life a bit during a DX contest, but since most ham gear didn't cover the band, it became lifeless during the fifties as the interest in SSB grew.

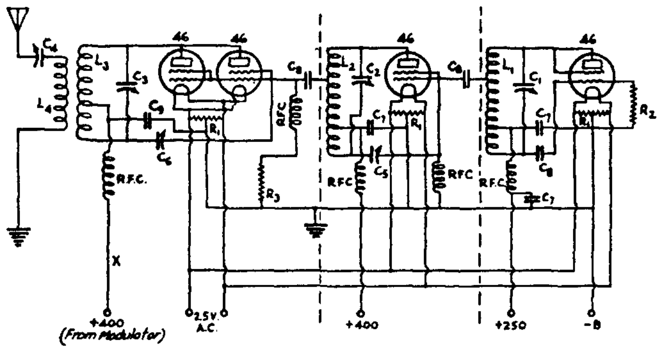


FIG. 1 — WIRING DIAGRAM OF THE RADIO-FREQUENCY END

C_1 — 500-μμfd. variable condenser.
C_2, C_3, C_4 — 250-μμfd. variable condensers.
C_5 — 100-μμfd. midget condenser.
C_6 — 50-μμfd. midget condenser.
C_7 — 005-μfd. fixed condensers.
C_8 — 250-μμfd. fixed condensers.
C_9 — 001-μfd. fixed condenser.
R_1 — 20-ohm center-tapped resistor.
R_2 — 50,000-ohm, 1-watt resistor.
R_3 — 1000-ohm, 2-watt resistor.
RFC — Radio-frequency chokes, Silver-Marshall Type 275 or equivalent.
L_1 — 17 turns of No. 12 enamelled wire, spaced to occupy 2½ inches on 2½-inch diameter form, tapped at 5th turn from grid end. Buffer excitation tap at 10th turn from plate end.
L_2 — Plate portion: 30 turns No. 18 enamelled, spaced to occupy 1½ inches on 2½-inch diameter form, tapped at 23rd turn from plate end for excitation to following stage. Neutralizing portion: 12 turns same spaced to occupy ¾-inch on same form, ½-inch away from plate portion.
L_3 — 38 turns of No. 14 enamelled wire, spaced to occupy 3½ inches on 2½-inch diameter form, tapped at center.
L_4 — 30 turns of No. 18 enamelled wire on 1½-inch diameter form; no spacing between turns.
Key or keying relay may be placed at X for c.w. transmission.

fig. 3. The famous "46 job." This 40-watt transmitter was popular on 160 meters in the prewar period. The class-B modulator and driver also used type 46 tubes. Many builders substituted a crystal oscillator in place of the self-excited oscillator (tube at right). Illustration from *QST*, August, 1932.

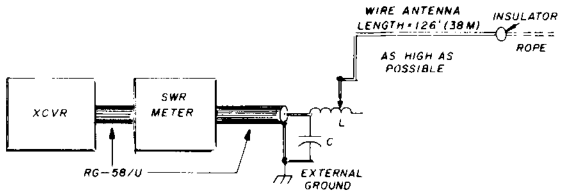


fig. 4. Simple Marconi antenna for 160 meters. Variable capacitor (C) is 400 pF. Inductor (L) is airwound coil, 2 inches in diameter, 8 turns per inch, 4 inches long (32 turns). Inductor is adjusted for lowest SWR when capacitor is adjusted to provide 50-ohm load. Both devices may be simply adjusted for lowest SWR on the meter. Antenna wire should be as high as possible. See text for information on ground connection. Note that the antenna may be made shorter, but more inductance is required in the coil.

160 meters today

Interest is again growing in this old-time band. Most new transceivers cover the band, and the Loran networks are being rapidly phased out. And it looks as if the band will be expanded to near its pre-war dimensions in a few months. As a result of the recent WARC Conference, Amateurs in many foreign countries who never had this band can now enjoy operation in certain selected segments. During DX contests, the band is jumping, and more and more Amateurs look to 160 meters for reliable, short-range daylight communications.

During the week the band is relatively quiet through the daylight hours. At night, things pick up a bit. Most CW operation falls between 1800 and 1810 kHz. Sideband occupies the region immediately above this segment. (In some areas of the country operation is permitted at the high-frequency end of the band, and certain power-input restrictions apply. See the current edition of the ARRL *Handbook* for details.)

On contest weekends the band is alive with plenty of overseas DX coming through. A handful of WACs have been made on 160, along with a few prized DXCC awards. But it is not the typical station that achieves these results!

More and more Amateurs are experiencing the fun of working 160. It is entirely different from the other bands. All you need to get in the action is a good antenna.

a practical antenna for 160 meters

Any antenna design capable of working on the other high-frequency bands will operate on 160 meters. Size is the problem. A half-wavelength at 1850 kHz is 253 feet (77 meters) and at 1950 kHz it is 240 feet (73 meters). That rules out a coaxial-fed dipole for most Amateurs. Those lucky enough to have the room would be well advised to erect a dipole for 160 meters as high as possible.

The next best bet is an end-fed quarter-wave Marconi antenna (**fig. 4**). The antenna shown will operate at any frequency in the band when properly adjusted for the lowest SWR reading. The antenna uses ground as the return circuit and one of the chief problems of obtaining good performance is that of getting a good ground connection.

If the residential water system is made of copper tubing, it may be used for a radio ground. Connection should be made by a short, heavy lead to a nearby cold-water pipe. Flexible braid removed from a defunct length of old RG-8/U coaxial cable makes a good ground lead.

Not all piping systems make a good ground, and it may be necessary to drive several rods into the ground and connect them to the water pipes. You'll have to experiment with this.

Another idea used on 160 meters is the radial ground. This is an insulated wire a quarter-wavelength long (about 126 feet for operation at the low end of the band). One end of the wire is attached to the common ground point of the transmitter, and the wire is run along near (but not touching) the ground. I use a radial ground wire in conjunction with a water pipe ground for 160-meter work, and it seems to be a good combination.

The radial ground wire can run through bushes or along a fence. The far end of the wire should be covered with tape because it can be "hot" with rf during transmission.

Once you get on the band and make contact with a few stations, you'll find out a lot more about 160-meter antenna systems. Some of the better stations have quite exotic antennas. The vertical antenna is much prized; a station with a good vertical antenna and a fine ground system can really place a big signal on the band. But for everyday operation and a lot of fun, a simpler antenna will do the job.

When operating this band it's interesting to think that these frequencies are the oldest operating range for Amateur Radio and that you are following in the footsteps of a lot of famous Amateurs and experimenters. And no doubt a lot of interesting experimental work is going on in this band right now. Some Amateurs are experimenting with loop antennas for low-noise reception as well as large Beverage antennas. And there are some experimental beam antennas on 160 meters, too!

But why spoil your fun? Get on this reborn Amateur band yourself and take part in the interesting work going on today!

ham radio

the weekender

plumber's delight coax connector

About three years ago while looking over flea-market offerings at a ham convention, surplus TV hardline coax cable caught my eye. The coax line was quite inexpensive, but the connectors were expensive and difficult to obtain. To make a long story short, the line I brought home ended up in my already cluttered garage. For the next year or so I wondered just why I had bought it and what I was going to do with it. One day, while sorting some copper-plumbing fittings, I had an idea. I have a plumber's delight beam, so why not a plumber's delight connector?

The result was a successful connector for which I make the following claims:

1. Low cost (approximately $1.50 each).
2. Long life.
3. Waterproof.
4. Makes a rigid connection.
5. Material readily available.
6. No great skill needed.
7. Can be removed and disassembled for inspection.

Only one possible problem was noted: a ½-inch pipe die is required. This is really not too difficult. A pipe die may be obtained by purchase or rental.

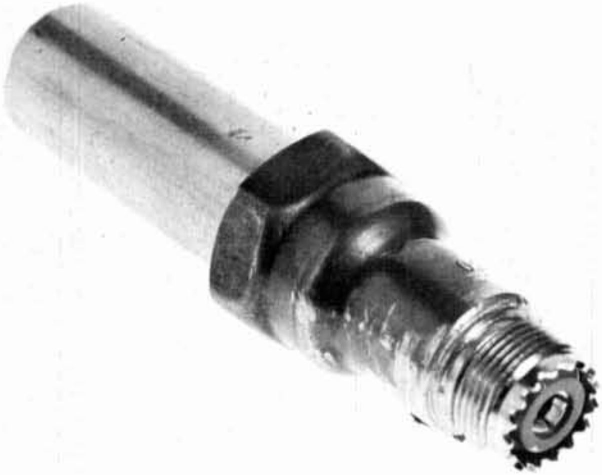
The following material covers only 3/4-inch coax hardline. Copper fittings for other sizes, 1/2 and 1 inch, I believe, are also obtainable. So if you have coax other than 3/4 inch, check with plumbing-supply houses.

First off, 1/2-inch iron or steel pipe has an outside diameter of 3/4 inch. Only two parts are needed to make the new connector, (1) a copper-plumbing connector to join 1/2-inch OD copper tubing to 1/2-inch threaded pipe (3/4-inch OD), and (2) a double female coax connector, PL-258.

By James R. Yost, N4LI, Box 94, Route 1, Polkton, North Carolina 28135

Exploded view of the assembly. From left are PL-258 barrel connector, homebrew copper plumbing connector, plastic insulators and retaining ring.

Another view of the homebrew hardline coax connector assembly.



Details of finished connector.

step-by-step instructions

1. Using a hacksaw or tubing cutter, cut off 5/8 inch of the outer conductor of the hardline. Do not cut the foam insulation or center conductor. The half-inch pipe die is now used to cut 5/8 inch of threads on this end of the line. Trim off the exposed foam insulation. The center conductor of the hardline is copper-plated aluminum. When removing the insulation be careful not to cut or scratch the copper plating.

2. The inner conductor and the two plastic insulators must be removed from the PL-258 connector. This is necessary because the high heat required in the next step would melt the insulators. You'll find a retaining ring just on the inside of one end of the connector. Remove this ring with a sharp pointed pick. It takes a little patience but it can be done. After the retaining ring has been removed, the center conductor and two insulators will easily slide out of the shell.

3. Solder the PL-258 shell or body to the copper fitting. The PL-258 has a shoulder in the center that makes a good fit to the inside of the copper fitting. This shoulder should have about 1/32 inch showing outside the copper fitting when correctly positioned. Be sure the end of the PL-258 that does *not* have the retaining ring groove is inserted into the copper fitting. Use a heavy soldering iron, or preferably a propane torch, to solder the two together.

4. The inner conductor of the hardline is larger than that of a PL-259 connector, which is usually used to connect with a PL-258. It will be necessary to complete the following:

a. Using a 1/4-inch drill bit, ream out one of the PL-258 plastic insulators.

b. Spread the prongs of one end of the PL-258 center conductor so that it will make a snug fit with the center conductor of the hard line. Do not change the other end, as it will later mate with a PL-259 connector.

5. You're now ready to reassemble the PL-258 connector.

a. Insert the small end of the reamed insulator first, followed by the spread prongs of the center conductor. This is followed by the large end of the other insulator.

b. Re-install the retaining ring.

Your connector is now complete.

final remarks

Before installing it on the coax line, here's a suggestion. To prevent chemical reaction of the copper and aluminum use a small amount of joint compound on the threads of the aluminum tubing. Electrical-supply houses carry several brands, as aluminum wire is used in industrial and house wiring. Two brands are listed below:

NOALOX — Joint compound for Al/Al and Al/Cu wire connections and aluminum conduit joints. Made by Ideal Industries, Sycamore, Illinois, catalog No. 30-030.

OXIBAN — Oxide-inhibiting compound. Made by ITT Holub Industries, Sycamore, Illinois 60178, catalog No. 15-001.

These or similar compounds are also recommended for use on mating aluminum tubing as used in beam antennas to ensure electrical connection and to prevent seizing.

ham radio

the K2GNC Giza beam

A novel approach to directional antennas

If you happen to be *looking for something simple* and inexpensive in a beam antenna, take a look at this one. I haven't determined if this is a new concept, but it may be some time before anyone comes up with a design that performs better. What is it? The Giza beam — a lightweight, low-cost, rugged, directional array that almost anyone can make in an evening from junk-box parts.

I've tried just about every beam over the past 45 years. The design shown in **fig. 1** is easy to build and erect and provides plenty of punch. It's a modification of the conventional delta-loop wire beam (**fig. 2**).

In the Giza design, I removed the upper boom (**fig. 2**) and brought the apexes of the two loops together, which I fastened to the top of the supporting mast. There was no obvious difference in the antenna's operation. Front-to-back ratio seemed the same, it tuned up just as well, and the signal reports remained good. One major structural member had been removed and a more rigid, lighter-weight array with a lower center-of-gravity resulted. Its pyramidal shape and firm, solid construction reminded me of the great pyramids of Giza in Egypt, so it seemed appropriate to name it the K2GNC Giza beam.

a practical 15-meter beam

A bit of shopping brought together all the parts for a functional 15-meter Giza beam. I bought two straight, knot-free, furring strips for about $1.00. I used some No. 18 (1.0-mm) stranded, plastic-covered hookup wire for the elements. Lightweight TV mast sections provided the main supporting member. A few hose clamps, a scrap piece of plywood, and a few miscellaneous small items rounded out the bill of materials.

construction

Fig. 1 shows construction details with dimensions given for 10-, 15-, and 20-meter beams.

Making the four wooden spreaders, the main structural members, requires the most consideration. These were ripped from the two furring strips as shown in **fig. 3**. Painting or varnishing the wood will help preserve its shape and give it a professional appearance. The spreaders may be made of many

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materials, including bamboo, fiberglass, metal tubing, or thin plastic pipe.

The mounting plate (**fig. 4**) for the spreaders was made from exterior-grade plywood. It can be any convenient size, or you can use dimensions shown (**fig. 4**). Drill or saw a hole into the center slightly larger than the mast you're using, then drill some holes through it at the proper places for the spreader hinge wires. Any stiff, strong wire may be used for the hinges; there are no strong mechanical forces on them. (A heavy wire coat-hanger is a good choice.)

To assemble, lay the parts out flat. Run short lengths of the hinge wire into the spreader holes, bend them, run them through the holes in the mounting plate, then twist the ends together to hold them in place.

Mount the four corner braces on the top and bottom of the spreader mounting plate using bolts, lock washers, and nuts. Space the braces so that the vertical mast fits snugly between them.

Wrap lengths of stiff, insulated wire around the tip of each spreader and twist together tightly, leaving the ends pointing upward. These wires will hold the corners of the triangular loops.

The spacer cords (**fig. 1**) are lengths of nylon cord or fish line tied securely between the spreader tips. They should separate the lower sides of the loops by the distance shown. To form the loops, cut two lengths of plastic-covered, stranded hookup wire to the length shown in the table of dimensions in **fig. 1**.

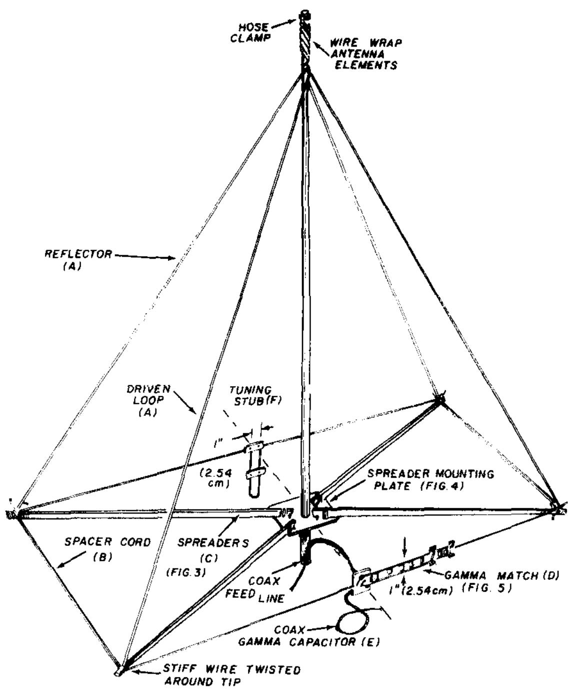
You don't have to use insulated wire for the loops. Bare wire, if used, need only be insulated at the spreader tips where the voltage is high. I used plastic-covered hookup wire because it's readily available, quite strong, and doesn't kink during assembly. Mark the *exact* center of both loops.

matching section

The gamma match (**fig. 5**) can be made from a length of 450-ohm line or two lengths of bare No. 16 wire. A variable capacitor is usually used for adjusting the match to the feed line. However, there's an old trick of using a length of RG-58/U or RG-59/U coax in its place because it's convenient and doesn't require a waterproof housing. These cables provide capacitances of about 30 pF and 20 pF per foot respectively. They will withstand full legal power at this low-voltage point. In fact, for low-power use, it may be more convenient to use two- or three-wire shielded microphone cable, which has a greater capacitance.

Connect the inner conductors together at the end and use them for one side of the capacitor. The shield is the other side.

Remove a length of wire from the end of one loop and replace it with the gamma match section of that



Amateur band, meters	loop length A, ft (meters)	spacing B, ft (meters)	spreader length C, ft (meters)	gamma match D, inches (cm)	gamma capacitor E,* inches (cm)	stub length F, inches (cm)
10	35.8 (10.8)	4.5 (1.37)	6 (1.83)	24 (60)	28 (70)	10 (25)
15	47.0 (14.3)	6.0 (1.83)	8.0 (2.44)	32 (80)	36 (90)	16 (40)
20	71.6 (21.9)	9.0 (2.74)	12.0 (3.66)	48 (120)	48 (120)	28 (70)

*Length of RG-58/U coax cable before trimming.

fig. 1. Design of the Giza beam with dimensions for the three high-frequency bands. Simplicity and readily available parts make this antenna a definite candidate for the homebrewer.

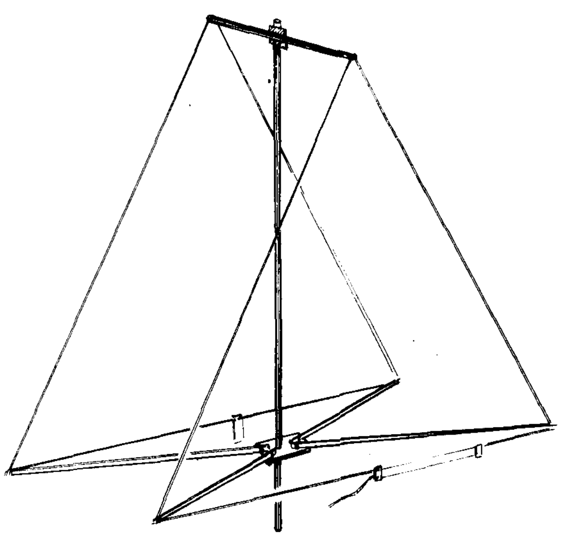


fig. 2. The conventional delta-loop wire beam. The top boom is eliminated in the Giza design, which results in a more rigid structure.

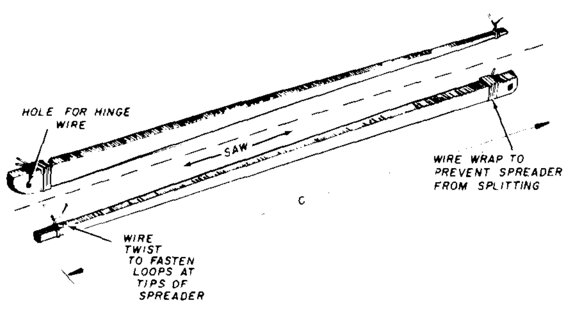


fig. 3. Two spreaders are made from one furring strip.

length. Attach the loop ends to the appropriate plastic insulator of the gamma match and the tuning stub. Secure the lower sides of the two loops loosely to the spreader tips with the stiff wires on each tip. Meanwhile keep the insulators centered and the two lengths equal. Pull the wires taut so that no slack exists in the spacer cords, then firmly twist the stiff wire so that the loop wires will not slip through.

final assembly

Secure the midpoint of each loop to the mast top with a hose clamp and place the mast in the center hole of the mounting plate. It doesn't matter whether the wire is actually grounded to the mast or not. Allow the spreader assembly to fall into a place on the mast where the spreaders are horizontal. Use hose clamps around the corner braces and tighten the mounting plate to the mast. Your Giza beam is now assembled.

tune up

The array is tuned in the conventional manner. However, I suggest that it be tuned to the low-frequency end of the band first for reasons to be explained.

First, adjust the reflector stub for best front-to-back ratio using your receiver and a strong, distant signal. Then position the gamma match slider to a point that provides lowest SWR. Once this point is found, adjust the gamma coax capacitor by snipping off short lengths from its end. At the same time, re-adjust the gamma match slider. An SWR near 1:1 should be easily obtained.

To prevent the coax from shorting at the end, remove a very short length of the outer insulation and the shield; then seal both ends of the coax with rubber cement, or tape them tightly to prevent water from creeping into the shield. Attach your coax feed line and you're ready to go on the air at the low end of the band.

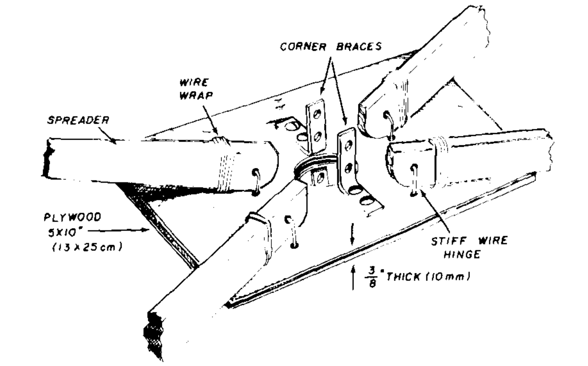


fig. 4. Details of the spreader mounting plate.

a new twist

When it comes to peaking the antenna at a specific frequency in the band, the K2GNC Giza beam has no equal. This operation was discovered by mistake: Once, while making some adjustments, the resonant frequency mysteriously shifted a considerable amount. After some investigation I observed that the spreader section had twisted around the mast while the mast stood still. This action caused the wire at the top of both loops to wrap around the mast. The loop lengths had shortened, thus increasing the resonant frequency. The SWR held at 1:1.

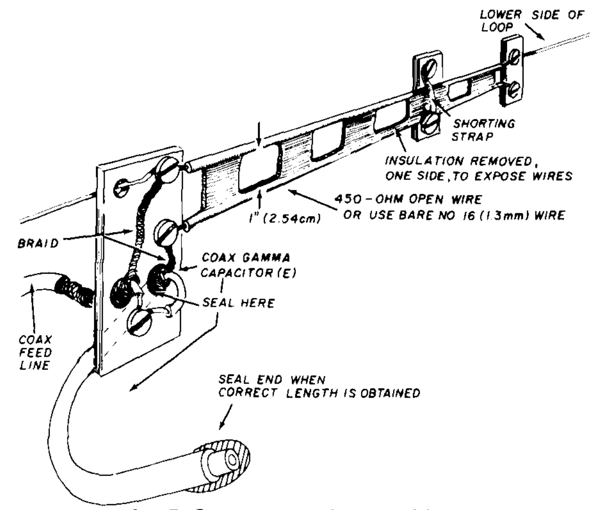


fig. 5. Gamma-match assembly.

Wrap the wires around the pole by twisting the spreader assembly under controlled conditions. I tried it and got just what I wanted — an antenna that can be set mechanically to any desired frequency in the band.

Loosen the hose clamps on the spreader mounting plate and, with the transmitter on the desired frequency, rotate the spreader assembly until you get 1:1 SWR.

Once you've made one of these little giants and tried it out, you'll want to try some variations. A number of them are obvious. Wrapping the apex of the loops around the pole is only one way of accomplishing a resonant-frequency shift. The loop wires could be pulled down into the mast pole by a wire going up through the pole. They could be fastened to a yoke and pulled through a ring at the top of the mast down the outside of the mast. Combining these ideas with flexible spreaders or ones that are hinged at the central mounting plate could bring about some broad frequency variations. You may even encompass another band, especially one of the newly acquired bands.

A triband Giza would give many pluses. Using the usual feed methods for three-band quads, a few additional loops going from the mast to appropriate places on the spreaders would result in a more rigid structure than a single bander. A two-band model, already constructed, has proved this to be true.

A super lightweight, 20-meter Giza has been built using element-size aluminum for the mast and thin-walled, small-diameter aluminum tubing for the spreaders. These spreaders were tipped with lengths of plastic rod and insulated from each other. The mast, in this case, extended far enough below the spreader mounting plate for thin nylon rope guys to be run between it and the tips of the spreaders. This design resulted in an extra strong array that has withstood some pretty heavy winds. Mounting the antenna on the rotor was easy.

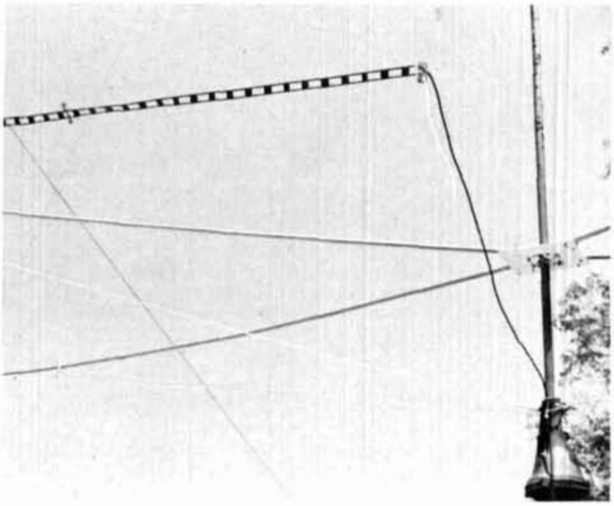
For portable operation or Field Day, what else but a Giza, pre-assembled, folded up umbrella-fashion, and stowed in the trunk or on the car roof? Be watchful that the loop wires don't get tangled with each other. (Perhaps it will help to first check with your nearest skydiver friend on how he packs a parachute.)

The small size and light construction should encourage more beams for 40, 80, and who knows, 160 meters. The same is true regarding the new bands when they become available.

Those who shy away from mounting a big Yagi on the roof because of the wife or the neighbors, or who otherwise want to be inconspicuous as hams, can use No. 22 electric fence wire for the loops. With almost invisible wires, the Giza looks like an fm ground plane to the untrained eye. (Don't ask me who ever saw a ground plane with a rotor on it.)

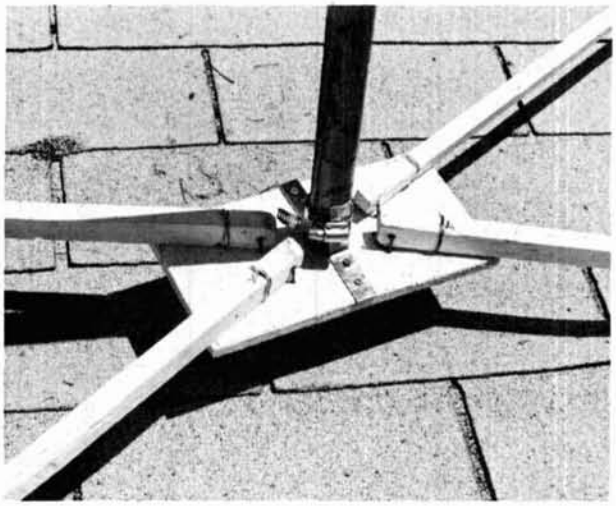
does it work?

So far, the simple construction and light weight of the antenna have been extolled. Now, what happens when rf goes into it? How does it work? There is an inclination to reply, "Try it, you'll like it." However, that answer will not satisfy many.



Twenty-meter Giza beam uses 450-ohm, parallel wire line for gamma match. Insulation is stripped from one side of line at left end of line for adjustable shorting strap. Microphone cable at feed line input terminal serves as gamma capacitor. Nylon guy lines from aluminum spreader tips to rotor make structure rigid.

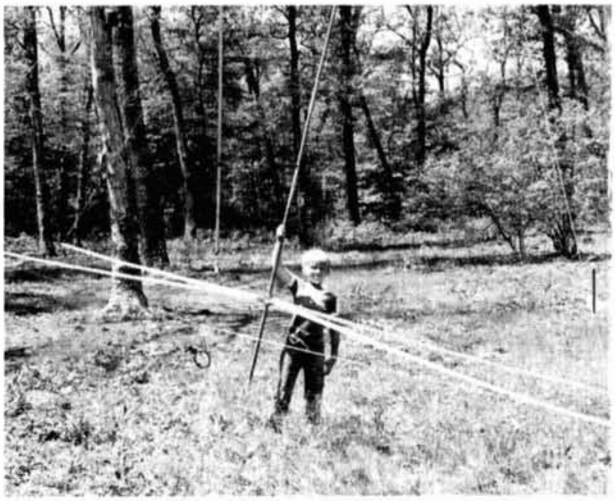
Without an accurate means of measuring forward gain, one way to determine performance is to get front-to-back readings. So, with the 20-meter array at a height of only 30 feet (9 meters), readings were gathered from many sources both in the U.S. and foreign countries. The readings averaged around 30 dB. Some readings went as high as 35 dB. Off the sides the reports were about 35 dB lower than off the front. One report said the signal disappeared off both the side and the back when it was 35 dB on the front.



Stiff wire hinges secure spreaders to central spreader mounting plate. Corner braces and hose clamps fasten mounting plate to vertical pole. Wire wraps on spreaders prevent wood from splitting.

This all compares favorably with most other good, normal-sized beams. It is probably better than other beams when they are operating off their resonant frequency.

Performance off the front made my heart leap many times. Signal reports rarely, if ever, have any real technical merit, so to say that RST 599 or 599FB was a common report from DX stations is insignificant. However, using the Giza on 20 meter phone has, for the first time, given me 100 percent contacts one time after another, and 20 meters is where you separate the men beams from the boy beams.



Author's second-generation harmonic, Brett, shows off lightweight (7-1/2-pound, 3.4-kg), sturdy construction of 15-meter Giza beam.

Running barefoot with a beam at 30 feet (9 meters) just cannot, of course, compare with the real professional, uppercrust gang and their five elements at 150 feet (46 meters). But when this antenna gets its dander up in the air, fully charged with a linear, it should hold its own with any array of comparable size.

conclusion

There is still much work to be done. What happens when you change the spacing between elements? What is optimum? Can a third or fourth element be added? This remains to be seen. But at this station it is very unlikely that I will ever go back to making a quad, Yagi, or conventional delta loop again. This one does the job so much more easily.

Thanks to my ever-loving wife, Roz, who has put up with a yard full of wires and poles these many years of our happy married life. Also, thanks to all those hams who gave reports at various headings, and my daughter, Lee, who so willingly typed this article.

ham radio

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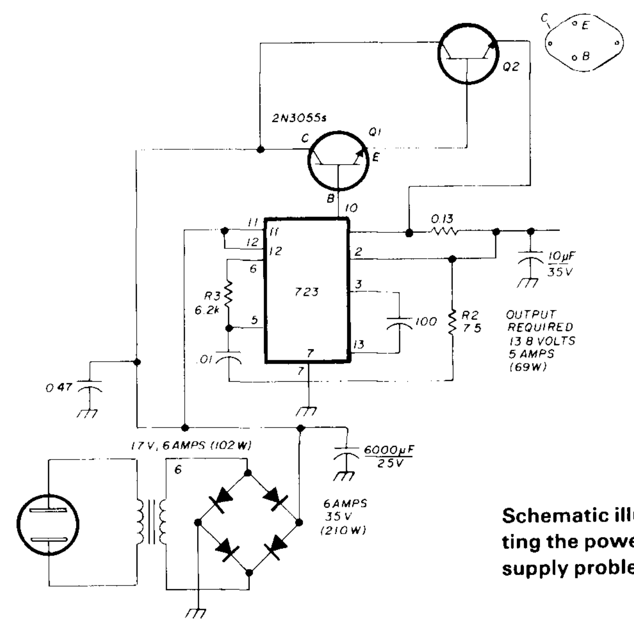
power supply regulation

I need some insight on why the output of the regulator shown in the schematic diagram does not function properly. John R. Pape, KA2FJA.

The regulator circuit looks OK, but you may be asking too much from the power transformer. According to your schematic diagram, it is rated at 17 volts at 6 amperes (102 watts) input, but it is asked to deliver 5 amperes at 35 volts (175 watts) out. To overcome this problem, change the rectifier circuit from bridge to full-wave. This will provide you with 17.5 volts at 5 amps (87.5 watts) output. Of this, 69 watts will be delivered to the load, while 18.5 watts will be dissipated as heat. The load on the transformer will now be within its rating. Of course, you will need a transformer with a center-tapped secondary.



Schematic illustrating the power-supply problem.

soldering RG-8 to a PL-259

How do you get a decent solder connection to RG-8 braid when installing a PL-259? James T. Petersen, WDØGYD.

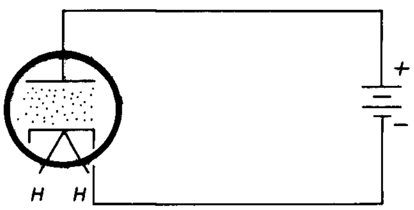
There is a step-by-step procedure for assembling PL-259 fittings to RG-8 cable on page 17-11 of the 1981 edition of the ARRL *Handbook*. Note that soldering of the braid to the plug, or tinning, is the last step in the procedure; even though the dielectric material may soften, it should not run out or be deformed because it is held in place by the body of the assembly.

Another excellent source is *Practical Antennas for the Radio Amateur*, by Robert M. Meyers, W1XT, published by Scelbi Publications. Both books are available from Ham Radio's Bookstore, Greenville, NH 03048.

current flow

Could you explain how it is possible that electrons flow from negative to positive but conventional current flow is from positive to negative? Fred Nordstrom, KA4IZK.

As a matter of convention, when we discuss electric current flow, we always show the direction in which a *positive* charge would flow. Electrons always flow in the opposite direction. For example, in a vacuum tube circuit, as shown here, electrons are boiled out of the cathode and are attracted to the positive plate. By convention, however, we indicate the direction of current flow with an arrow which points in the direction opposite to the flow of electrons.



It is interesting to note that in an electrolytic cell or battery, electrons accumulate on the negative terminal because of a chemical reaction. If then, an external conducting circuit connects the negative with the positive terminal, electrons will flow from the negative to the positive terminal over the external circuit. By convention, we indicate this "current" flow by an arrow pointing from the positive to the negative battery terminals. Confusing, isn't it?

PEP input and output

What is the easiest, most appropriate and least expensive method for determining input and output power in dc or PEP watts? David Ruscitti, WA1FRC.

To determine dc input power, all you need do is multiply the PA plate current by the plate voltage with key down or while whistling into the microphone. Determining input and output PEP is not quite so simple. Peak envelope power cannot be measured directly with meters, since meters respond to the average amplitude of the modulation envelope. It has been generally agreed that peak-to-average input power ratios during a modulation peak will be about 2:1 with the average human voice. The FCC allows 2-kW PEP input maximum, assuming the *average* dc input power (as indicated by the meters) does not exceed 1 kW. Thus, if your voice characteristics are such that the peak-to-average dc input power ratio is more than 2:1, you must run less than 1-kW dc input, as measured by the meters, to comply with the FCC regulation.

About the same things can be said for average and PEP *output* powers. If you have access to a well-calibrated rf power meter, you can determine the key-down power output (or average voice output power) of your transmitter in the usual manner, but the PEP output remains as elusive as ever.

If your rig employs ALC or speech processing, the chances are very good that the peak-to-average output power ratio is about 2:1.

two-tone test

Heathkit mentions the two-tone test to check my linear's linearity. My text books mention this test but fail to explain how these tones are generated or what frequencies are used. Would you tell me how this test is performed? George A. Brooks, WA1BUJ.

The 1981 edition of the ARRL *Handbook* includes information on page 12-18 for two-tone testing of SSB transmitters. An audio oscillator provides one of the two tones, while a small amount of carrier unbalance (purposely developed) provides the other tone. Or you can null out the carrier and feed two audio signals into the microphone jack. A two-tone generator is described for this purpose in *ham radio*, April, 1972.*

There are no specific tone frequencies that need to be used, but they should be within the audio passband of the exciter's microphone amplifier circuit. Generally, one tone is adjusted to 800 Hz while the other is set to about 2000 Hz.

*Hank Olson, W6GXN, "Low Distortion Two-Tone Oscillator for SSB Testing," *ham radio*, April, 1972, page 11.

rules of thumb for coils

Is there a general rule of thumb about the number of turns per inch and total number of turns to yield a given inductance? Don Richardson, WB5UIA.

A useful formula for determining the inductance of single-layer solenoids, which is sufficiently accurate for use in the Amateur high-frequency bands, is:

$$L = \frac{r^2 n^2}{9r + 10\ell}$$

where L = inductance (μH)
r = coil radius (inches)
ℓ = coil length (inches)
n = number of turns

Solving for n will give the number of turns:

$$n = \frac{\sqrt{L(9r + 10\ell)}}{r}$$

Once the number of turns is determined for a coil of a given inductance, merely divide n by coil length, ℓ, to obtain the number of turns per inch.

At VHF the formula becomes inaccurate because conductor thickness becomes an appreciable part of the size of the coil and cannot be neglected. The 1981 edition of the ARRL *Handbook* contains a handy graph for determining the inductance of coils wound with no. 12 (2.1 mm) bare wire, 8 turns per inch.

ham radio

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Matching accessories for fixed-station operation:

- SP-230 external speaker with selectable audio filters
- VFO-240 remote VFO
- AT-230 antenna tuner/SWR and power meter
- MC-50 desk microphone

Other accessories not shown:

- TL-922A linear amplifier
- SM-220 Station Monitor
- VFO-230 remote digital VFO with 20-Hz steps, five memories, digital display
- KB-1 deluxe VFO knob
- PC-1 phone patch
- HS-5 and HS-4 headphones
- HC-10 digital world clock
- YK-88C (500 Hz) and YK-88CN (270 Hz) CW filters and YK-88SN (1.8 kHz) SSB narrow filter
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a coreless balun

1:1 impedance-matching transformer using RG-8X coaxial cable

What's a balun? What good is it? Why use it? These are questions often heard among Amateurs. *Balun* is an acronym for balanced-to-unbalanced transformer. The balun is used predominantly in rf transmission lines. A balun placed between an unbalanced feedline (such as coax transmission line) and a balanced antenna (such as a dipole or Yagi-antenna driven element) will eliminate or reduce antenna currents on the transmission line, which could cause radio-frequency interference (TVI, BCI).

Much controversy exists in Amateur circles concerning the usefulness of the balun. Some Amateurs swear by it. Others swear at it, claiming that the balun is an unnecessary nuisance and expense. Be that as it may, good engineering practice says that a transition between an unbalanced transmission line and a balanced load is, indeed, necessary. We therefore present this article by Roy Lehner, WA2SON, on a coreless balun for Amateur transmission lines.
Editor

In pursuit of a balun for my new triband Yagi antenna, I found Badger's article[1] informative and encouraging. Attempting to adapt the design principles outlined in his article into a finished transformer was somewhat difficult for several reasons. The RG-141/U (Teflon dielectric) coaxial cable is extremely difficult to obtain and its cost is more than $3.00 per foot. How do I make the connections to the antenna and feedline that are waterproof and electrically sound? How can the finished unit be mounted on a Yagi-antenna boom in a neat and orderly manner? The following article discloses my resolution to these problems.

The coax I chose is the newly introduced RG-8X, a 52-ohm cable that's inexpensive (about 25 cents a

By Roy N. Lehner, WA2SON, 135 Theodore Street, Buffalo, New York 14211

foot) and capable of handling one kW. It is also easy to work with and coils neatly into a 4-inch (100-mm) diameter coil. (The coil diameter should be 15 to 20 times the coax diameter.)[1]

RG-8X cable can't withstand the same electrical stress as RG-141/U, because of its lower power rating. Using a badly mismatched antenna could ruin the RG-8X coax in the same way that coaxial feedlines may be ruined under high SWR conditions. In terms of balun efficiency and performance, both cables are equal and do a superb job — much better than the popular ferrite or air-wound enameled wire baluns on today's market.

construction

The balun consists of two equal windings of RG-8X coax, each 42 to 48 inches (1.07 to 1.22 meters) closewound into a single-layer coil (**fig. 1**). Although the exact length isn't critical, it's important that the two windings be equal in length to preserve electrical balance. Termination points **A-E** can be neatly made through use of No. 10 (M5) machine screws and eye-type wire terminals. Keep the connections as short and direct as possible. By keeping jumper **B-E** on the outside of the housing, the shield side of the input may be readily identified without having to remove the top cover once it is cemented in place (after, of course, the U-bolt is tightened to the supporting antenna boom).

The balun enclosure (**fig. 2**) should not be made of metal because of possible detuning effects on the resonant transformer. A functional and inexpensive container may be fashioned from a 4-inch (100 mm) PVC pipe coupling cut down to 2-1/2 inches (65 mm) long. Alternatively, a short length of acrylic tubing, or even some plastic freezer containers, may be used. In any case, be certain that the housing is watertight and that the top and bottom covers have no gaps, once cemented into place.

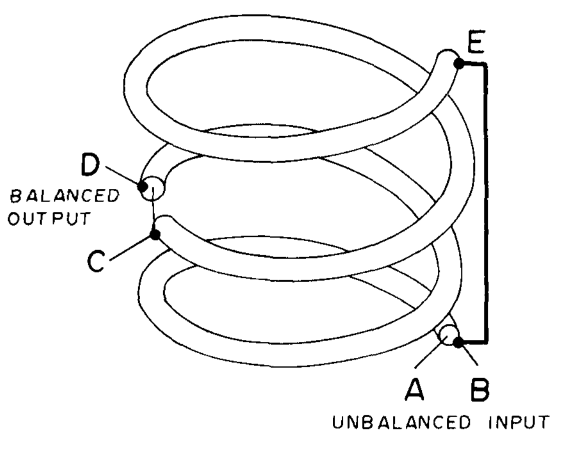

fig. 1. The 1:1 broadband coaxial balun. Actual transformer consists of seven turns closewound (3½ turns either side of the output) of RG-8X coax approximately 4 inches (100 mm) diameter. Center conductor in upper winding is not used.

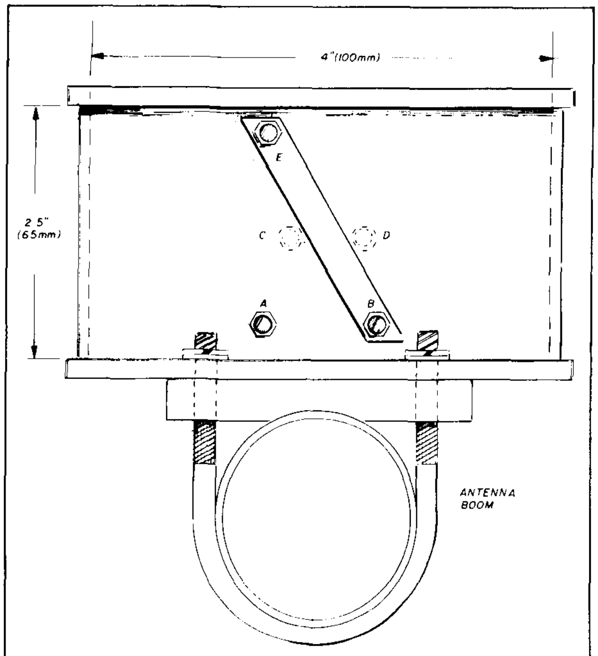

fig. 2. Physical layout of cylindrical balun housing. Output termination points *C* and *D* are located on the opposite side of the container. Top and bottom covers are epoxied in place. *B-E* jumper is mounted on outside of housing to identify shield side of input.

Placing the tube on a piece of sandpaper and slowly rotating it will help ensure a flat and even edge. Two 1/8-inch (3-mm) drain holes should be drilled into the housing bottom.

Similar baluns may be constructed for the 160-40 meter bands; however, a longer winding of coax will be required. (See reference 1 for details.) With a little mechanical ingenuity, there's no reason why this type of balun couldn't be used for flat-top wire dipoles, so long as the enclosure is capable of withstanding the stresses imposed.

What more can be said — good balun, good price, good luck! See you in the pileups.

references

1. George Badger, W6TC, "New Class of Coaxial-Line Transformers," *ham radio*, March, 1980, pages 18-29.

2. *Fundamentals of Single-Sideband*, Third Edition, September 15, 1960, Collins Radio Company, Cedar Rapids, Iowa, pages 10-11.

ham radio

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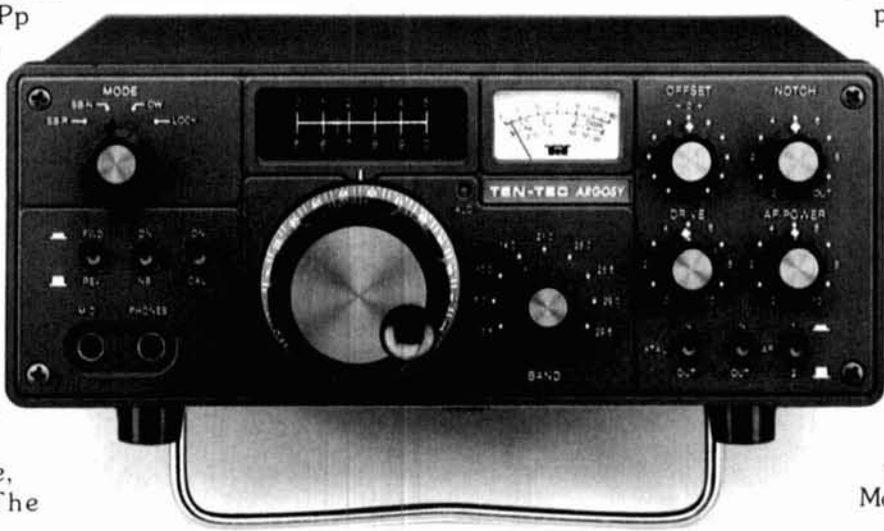

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low-noise, low-cost 10-60 MHz preamp

Design and construction of a narrow and wideband preamp for the vhf and microwave i-f bands

Amateur bands above 21 MHz offer a challenge for those who like to experiment and build their own equipment. The vhf-to-microwave frequencies allocated to the Amateur service are not overly populated, and this poses a problem. If these bands are not used, we stand a good chance of losing them to other services. Remember what happened to the 11-meter band — we didn't use it, so now it's dominated by Citizen Band users. It's possible that our vhf-microwave bands could suffer the same type of FCC regulation. If we don't use them, we lose them.

This article provides some interesting ideas for the vhf-microwave enthusiast. Are you thinking about adding a preamp to an old 6- or 10-meter receiver? Are you contemplating a low-noise i-f preamp for a microwave mixer with an i-f between about 10-60 MHz but don't want to spend a lot of money for very-low-noise transistors? Read on.

preliminary work

While doing some vhf-preamplifier work, I built and tested several units using the inexpensive NE41632E-2 bipolar transistor. This device (about $3.00 in 1-9 quantities) provided results equal to those obtained about two years ago with a preamplifier[1] using a pair of transistors costing about $16.50!

The results were so impressive that I decided to mount each of a pair of these preamps on two different 10-GHz Gunnplexers.®

®Microwave Associates registered trademark.

By **Geoff Krauss, WA2GFP**, c/o UHF Electrospecialties, Inc., 16 Riviera Drive, Latham, New York 12110

The preamps described below have either a narrow bandwidth, for single-band units, or a relatively broad bandwidth, which covers 10-60 MHz. The broadband circuit is particularly attractive for a Gunnplexer® i-f preamp because a very-low-noise figure and reasonable gain are obtainable over a bandwidth allowing relatively widely separated i-fs (such as 10.7 and 30 MHz) to be used, with a single preamp attached to a single microwave front end. In fact, the bandwidth-limiting factor appears to be the usable frequency range of the toroidal core used in the output-impedance matching circuit — a core rated for a wider frequency range will broaden the bandwidth range even further.

results?

If you're at all like I am, this is the first question you ask and the first information you look for (**table 1**).

C1,C2 C7,C9	5-80 pF
C3-C6, C8,C10	0.01 μF disc cap
CR1	"idiot diode" 1N914 or equivalent
CR2	5.1-volt zener
L1,L1	0.68 μH (30 MHz) variable
L1,L2	0.15 μH (50 MHz) 10 turns No. 28 (0.3 mm) on T25-12 core
Q1	NE41632E-2
R3	3 k

Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

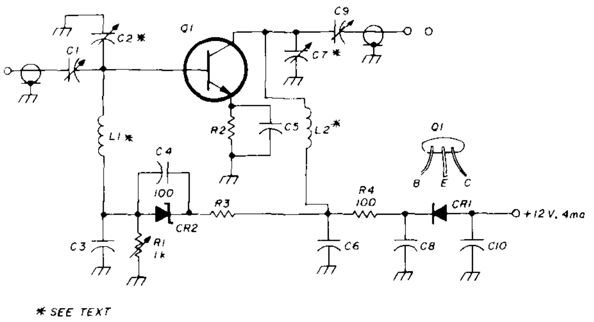

fig. 1. Schematic of narrowband preamplifier.

table 1. Comparison of test results for narrowband and broadband preamps.

	narrowband	broadband	
	50-ohm Z_S/Z_L	50-ohm Z_S/Z_L	200-ohm Z_S 50-ohm Z_L
10.7 MHz NF	—	1.57 dB	1.31 dB
G_f	—	15.00 dB	16.30 dB
G_r	—	− 44.00 dB	− 43.00 dB
30 MHz NF	1.03 dB	1.07 dB	0.94 dB
G_f	23.50 dB (31 dB max G_f)	21.00 dB	25.50 dB
G_r	− 34.00 dB	− 39.00 dB	− 38.00 dB
BW	10.20 MHz	—	—
50 MHz NF	1.07 dB	1.13 dB	0.98 dB
G_f	22.00 dB (30 dB max G_f)	22.00 dB	24.00 dB
G_r	− 33.00 dB	− 35.00 dB	− 32.00 dB
BW	6 MHz	—	—

Note: NF is noise figure. G_f is associated forward gain at the listed NF. G_r is reverse gain. BW is bandwidth, and max G_f is maximum forward gain if tuned without regard for NF.

circuit design

Both narrow and wideband preamps use the common-emitter configuration and an identical bias network (**figs. 1** and **2**). Note that both circuits use some common components (see parts lists). The device emitter is connected to ground through a 100-ohm resistor, R2, bypassed with a 0.01 μF disc cap, C5. A bypassed variable resistor, R1 (1-k pot), is connected to a bypassed 5.1-volt zener, 3-k resistor series circuit. The junction of the pot and zener is dc-connected to the device base, while the end of the 3-k resistor is dc connected to the device collector.

An "idiot" diode, 1N914, 1N4148, or any other small-signal diode rated for at least 15 volts, is in series with a current-limiting resistor, R4. If a 3-k resistor isn't available for R3, a 2.7 k will work as well, although slightly more preamplifier current will be drawn from the B + supply.

Resistor R1 sets device collector current for minimum noise figure (or for maximum gain, depending on the desired use). All of the preamplifiers were built on a "universal" single-sided PC board (see **fig. 8**, reference 2).

construction

The preamps were built in general accordance with the schematics of **fig. 1** (narrowband) and **fig. 2** (broadband), with exceptions as noted below.

Narrowband preamp. These units were built according to **fig. 1** except that I didn't use variable caps C2 and C7; instead I used two variable inductors (0.68 μH nominal inductance) for L1 and L2. (For the 50-MHz preamp, **fig. 2**, I used C2 and C7 with toroidal inductors for L1, L2.) This difference in tuned circuits was made because of the parts I had on hand at the time.

The 30-MHz preamp can be built with the toroidal inductor-variable capacitor circuits used in the 50-MHz unit. The adjustment range of C2 and C7 (**fig. 1**) is sufficient for tuning the preamp to either band.

Tuning is accomplished by first adjusting R1 (1-k pot) for about 4 mA of total preamplifier input current from a 10-12 volt dc source. (See **figs. 1** and **2**). If a signal generator isn't available, connect the unit in series with the receiver and tune in a moderately weak signal.

Adjust C1, C2, C7, and C9 (or C1, L1, L2, and C9 if

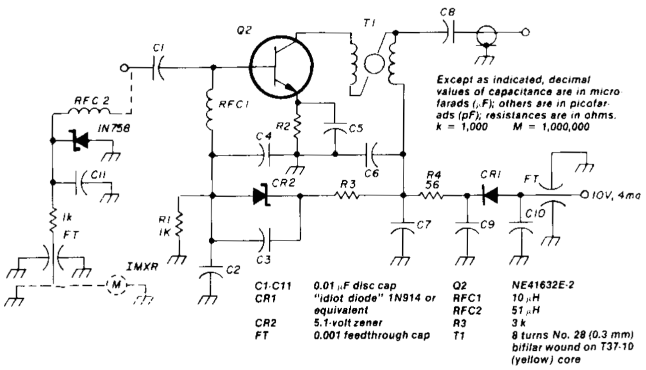

fig. 2. Schematic of wideband preamplifier. Connections also shown for use as a microwave mixer i-f amplifier.

variable inductors are used) to peak the signal on the receiver S meter. Try to use a signal that, even when tuning is complete, doesn't come close to pinning the S meter.

It's advisable to finely tune the preamp by repeating the adjustments several times as they interact somewhat. If a signal generator is available, the signal amplitude can be decreased as the preamplifier is tuned to maintain the receiver S meter at a point approximately *midway* on its scale. Tuning for minimum noise figure can be accomplished by the method of adjusting C1 (and either C2 or L1) for best

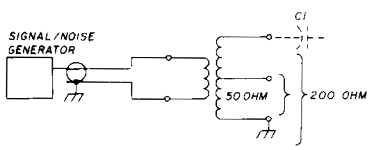

fig. 3. Test setup for a 4:1 input impedance.

signal-to-noise ratio on a *weak* signal. (A noise-figure test setup is preferable, although many can't obtain such equipment.)

Broadband preamp. No tuning components are used. Set R1 for minimum noise figure (about 4 mA total current) or maximum gain, as desired. As shown in **fig. 2**, the unit is designed for a 200-ohm source impedance, which may be provided by the output of a microwave mixer. **Fig. 3** illustrates the input test setup, in which a 4:1 impedance transformer can be used to increase the 50-ohm source impedance of a signal generator, or noise source, to 200 ohms. (I use a Minicircuits Labs T4-1 transformer, but another homebrew transformer can be used instead.) If used in a system requiring a 50-ohm source impedance, permanently connect the second toroidal transformer into the input circuit.

Gunnplexer adaptation

Fig. 4 illustrates one way to mount the i-f preamp to the mixer block, **A**, of a Gunnplexer® microwave front end. Hold block **A** so that you can see into waveguide opening **B**. Note that ferrite circulator rod **C** is to the right, and mixer diode **D** is to the left, of local oscillator injection screw **E**, which runs from the top center of the block in front of the Gunn oscillator iris, **F**.

On the top surface of block **A** are: injection screw **E** (front center), which is held from turning by a nut **I**; the mixer-output post, **G**, to the left and behind

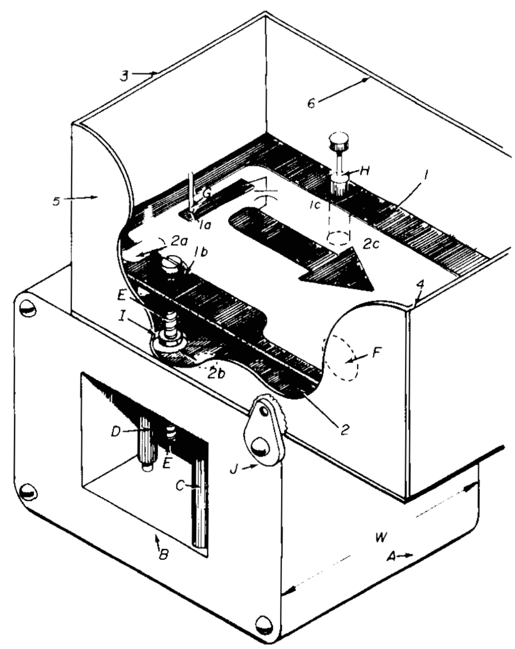

fig. 4. Mechanical mounting details for using the preamp on a Gunnplexer.

screw **E**; and a ground stud, **H**, almost directly behind screw **E**.

Start with the preamp, built on a piece of PC board **1**. (The preamplifier shown is for the universal board of reference 2. The large arrow is the base lead on the board.) This PC board is slightly wider than width **W** of block **A** (**fig. 4**).

Carefully unsolder the leads of the 1-k resistor and zener, which come with the Gunnplexer®, from ground stud **H**; then remove mixer output post **G** (still soldered to the resistor and zener) by pulling *gently* straight up. This post fits over a smaller-diameter pin, which protrudes from the mixer insulator — *be careful not to damage this pin*.

Referring to **fig. 4**, drill a small hole, **1a**, into the PC board at the solder pad at the input end of C1. Align this hole over the mixer pin, now present at location **G**, and mark the PC board with the location for the head of screw **E** and ground stud **H**.

Remove the PC board, and drill hole **1b** to completely clear screw **E** and nut **I**. Drill another hole, **1c**, to clear the head of ground stud **H**. A safe method is to use increasingly greater-diameter drills and check the hole match often by placing the PC board[1] over the top of block **A**. *Do not* touch the setting of, or otherwise attempt to adjust, screw **E** or nut **I**, while fitting the board.

Preamplifier PC board **1** can be mounted directly on top of the block, with mixer output-post **G** soldered through hole **1a** to the C1 pad, and the preamp ground soldered to ground stud **H**. (However, I prefer to place a shield box completely around the preamp.)

I used a piece of unetched PC board, **2**, (single or double sided), which is slightly larger than preamplifier PC board **1** — and drilled three holes: **2a, 2b**, and **2c** to clear the respective mixer output insulator (a plastic "button" surrounding the mixer pin); nut **I**; and stud **H**. Unetched board **2** is placed right on the top of block **A** and soldered to stud **H**.

A pair of end walls, **3** and **4**, and side walls, **5** and **6**, are soldered to bottom piece **2** to make an open-top box, which will receive preamplifier PC board **1**. Mixer-contact terminal G is permanently soldered in hole **1a** at the input pad of preamplifier PC board **1**.

The PC board is now moved down through the open top of the box, with mixer contact terminal **G** being placed over and surrounding the mixer pin. Screw **E** passes through hole **1b**, and stud **H** passes through hole **1c**. The ground portion of preamp PC board **1** is soldered to stud **H** and is tack-soldered to the inside surfaces of the box side and end walls **3-6**. An rf output connector and B + feedthrough capacitor may be soldered through the box walls.

The box is then covered, and the shielded enclosure is complete. This mounting scheme has several important advantages:

1. Full shielding is achieved to minimize i-f interference.

2. Minimum input lead length, between the mixer output and the preamplifier input, is achieved to maintain minimum i-f preamp noise figure.

3. Injection-screw **E** is enclosed and made more tamper proof but is still accessible by removing the preamplifier box top if adjustment should ever be required.

4. Preamplifiers can be changed by untacking the soldered connections of the PC board **1** from the box walls and from ground stud **H** and lifting the preamplifier board out of the box.

I've found that, to provide even greater mechanical stability, large ground lugs **J** can be fitted under the screws holding block **A** to Gunn oscillator **C** or to the horn antenna flange, and the lug end(s) can be soldered to the preamplifier shield box.

By connecting the original 1-k resistor and zener (1N758) to the preamp input through RFC_2, as shown by the broken-line connection in **fig. 2**, the dc protection of the mixer diode is maintained, and mixer diode current can be read by placing a 1-mA (full scale) meter from the feedthrough to ground. If a meter is not used, merely ground the feedthrough center pin (on the outside of the preamp shield box). Capacitor C_{11} (**fig. 2**) helps prevent injection of noise from the zener into the preamplifier input.

conclusion

Low-noise preamps may be built for the 10-60 MHz region at low cost, using the NE41632E-2 device. The selection of narrow or broad bandwidth is determined by individual requirements. Similar preamps of either type have been illustrated. I'll be happy to answer any questions if a self-addressed, stamped envelope is enclosed.

Thanks to Jerry Arden, Vice President, Marketing and Sales, at California Electronics Labs* (the NE41632E-2 sales agents in the U.S.) for his interest in providing samples and data.

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2. G. Krauss, WA2GFP, "VHF Preamplifiers," *ham radio*, December, 1979, pages 50-59.

*3005 Democracy Way, Santa Clara, California 95050.

ham radio

7400

SN7400N	.25	SN7472N	.29	SN74156N	.79
SN7401N	.20	SN7473N	.35	SN74157N	.69
SN7402N	.25	SN7474N	.35	SN74160N	.89
SN7403N	.25	SN7475N	.49	SN74161N	.89
SN7404N	.25	SN7476N	.35	SN74162N	.89
SN7405N	.29	SN7479N	5.00	SN74163N	.89
SN7406N	.35	SN7480N	.50	SN74164N	.89
SN7407N	.35	SN7482N	.99	SN74165N	.89
SN7408N	.29	SN7483N	.69	SN74166N	1.25
SN7409N	.29	SN7485N	.89	SN74167N	2.79
SN7410N	.25	SN7486N	.35	SN74170N	1.95
SN7411N	.29	SN7489N	1.75	SN74172N	4.95
SN7412N	.35	SN7490N	.49	SN74173N	1.39
SN7413N	.40	SN7491N	.59	SN74174N	.99
SN7414N	.69	SN7492N	.45	SN74175N	.89
SN7416N	.29	SN7493N	.45	SN74176N	.79
SN7417N	.29	SN7494N	.69	SN74177N	.79
SN7420N	.25	SN7495N	.69	SN74179N	1.49
SN7421N	.29	SN7496N	.69	SN74180N	.79
SN7422N	.45	SN7497N	3.00	SN74181N	2.25
SN7423N	.29	SN74100N	1.49	SN74182N	.79
SN7425N	.29	SN74107N	.35	SN74184N	2.49
SN7426N	.29	SN74109N	.39	SN74185N	2.49
SN7427N	.25	SN74116N	1.95	SN74190N	1.25
SN7428N	.49	SN74121N	.39	SN74191N	1.25
SN7430N	.25	SN74122N	.55	SN74192N	.89
SN7432N	.29	SN74123N	.59	SN74193N	.89
SN7437N	.25	SN74125N	.49	SN74194N	.89
SN7438N	.40	SN74126N	.49	SN74195N	.69
SN7439N	.25	SN74132N	.75	SN74196N	.89
SN7440N	.20	SN74136N	.75	SN74197N	.89
SN7441N	.89	SN74141N	.99	SN74198N	1.49
SN7442N	.59	SN74142N	3.25	SN74199N	1.49
SN7443N	1.10	SN74143N	3.49	SN74221N	1.25
SN7444N	1.10	SN74144N	3.49	SN74251N	.99
SN7445N	.89	SN74145N	.79	SN74276N	1.95
SN7446N	.79	SN74147N	1.95	SN74279N	.79
SN7447N	.69	SN74148N	1.29	SN74283N	1.49
SN7448N	.79	SN74150N	1.25	SN74284N	3.95
SN7450N	.20	SN74151N	.69	SN74285N	3.95
SN7451N	.20	SN74152N	.69	SN74365N	.69
SN7453N	.20	SN74153N	.79	SN74366N	.69
SN7454N	.20	SN74154N	1.25	SN74367N	.69
SN7459A	.25	SN74155N	.79	SN74368N	.69
SN7460N	.20	SN74156N	.79	SN74390N	1.49
SN7470N	.29			SN74393N	1.49

74LS

74LS00	.29	74LS92	.75	74LS192	1.15
74LS01	.29	74LS93	.75	74LS193	1.15
74LS02	.29	74LS95	.99	74LS194	1.15
74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.29	74LS112	.45	74LS240	1.95
74LS09	.35	74LS113	.49	74LS241	1.95
74LS10	.29	74LS114	.49	74LS242	1.95
74LS11	.75	74LS122	.89	74LS243	1.95
74LS12	.35	74LS123	1.25	74LS244	1.95
74LS13	.59	74LS125	.89	74LS245	2.95
74LS14	.99	74LS126	.55	74LS247	1.19
74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.29	74LS133	.89	74LS249	1.19
74LS21	.35	74LS136	.49	74LS251	1.49
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.99
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.29	74LS154	1.76	74LS266	.69
74LS32	.35	74LS155	1.19	74LS273	1.95
74LS33	.59	74LS156	1.19	74LS279	.75
74LS37	.45	74LS157	.89	74LS283	1.09
74LS38	.49	74LS158	.99	74LS290	.99
74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.89	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.25
74LS49	1.15	74LS164	1.26	74LS365	.75
74LS51	.29	74LS165	1.26	74LS366	.75
74LS54	.29	74LS168	1.19	74LS367	.75
74LS55	.29	74LS169	1.19	74LS368	.75
74LS73	.45	74LS170	2.49	74LS373	1.95
74LS74	.45	74LS173	1.39	74LS374	1.95
74LS75	.59	74LS174	.99	74LS375	.89
74LS76	.45	74LS175	.99	74LS386	.69
74LS78	.49	74LS181	2.95	74LS393	2.49
74LS83	.89	74LS190	1.25	74LS399	2.49
74LS85	1.25	74LS191	1.25	74LS670	2.49
74LS86	.45			81LS95	1.95
74LS90	.59			81LS97	1.95

74S

74S00	.50	74S133	.55	74S244	3.25
74S02	.50	74S134	.69	74S251	1.45
74S03	.50	74S135	1.19	74S253	1.45
74S04	.55	74S136	1.75	74S257	1.35
74S05	.55	74S138	1.35	74S258	1.35
74S08	.50	74S139	1.35	74S260	.79
74S09	.50	74S140	1.15	74S280	2.95
74S10	.50	74S151	1.35	74S287*	4.95
74S11	.50	74S153	1.35	74S288*	4.95
74S15	.50	74S157	1.35	74S373	3.49
74S20	.50	74S158	1.35	74S374	3.49
74S22	.50	74S174	1.59	74S387*	5.95
74S30	.50	74S175	1.59	74S471*	19.95
74S32	.55	74S188	4.95	74S472*	19.95
74S40	.55	74S194	1.95	74S473*	19.95
74S51	.50	74S195	1.95	74S474*	21.95
74S64	.50	74S196	3.95	74S475*	21.95
74S65	.50	74S240	2.95	74S570*	7.95
74S74	.79	74S241	2.95	74S571*	7.95
74S86	.79	74S242	3.25	74S572*	19.95
74S112	.79	74S243	3.25	74S573*	19.95
74S113	.79			74S940	3.15
74S114	.79			74S941	3.15

* LIMITED AVAILABILITY ON THESE PROMS

CA–LINEAR

CA3013H	2.15	CA3081N	2.00	CA3089N	3.75
CA3023H	3.25	CA3082N	2.00	CA3096N	3.95
CA3039H	1.35	CA3083N	1.60	CA3130H	1.39
CA3046N	1.30	CA3086N	.85	CA3140H	1.25
CA3059N	3.25			CA3160H	1.25
CA3060N	3.25			CA3401N	.59
CA3080H	1.25			CA3600N	3.50

CD–CMOS

CD4000	.39	CD4041	1.49	CD4082	.39
CD4001	.39	CD4042	.99	CD4093	.99
CD4002	.39	CD4043	.89	CD4098	2.49
CD4006	1.19	CD4044	.89	CD4506	.75
CD4007	.25	CD4046	1.79	CD4507	.99
CD4009	.49	CD4047	2.50	CD4508	3.95
CD4010	.49	CD4048	1.35	CD4510	1.39
CD4011	.39	CD4049	.49	CD4511	1.29
CD4012	.25	CD4050	.69	CD4514	3.95
CD4013	.49	CD4051	1.19	CD4515	2.95
CD4014	1.39	CD4052	1.19	CD4516	1.49
CD4015	1.19	CD4053	1.19	CD4518	1.79
CD4016	.59	CD4056	2.95	CD4519	.89
CD4017	1.19	CD4059	9.95	CD4520	1.29
CD4018	.99	CD4060	1.49	CD4526	1.79
CD4019	.49	CD4066	.79	CD4528	1.79
CD4020	1.19	CD4068	.39	CD4529	1.95
CD4021	1.39	CD4069	.45	CD4543	2.79
CD4022	1.19	CD4070	.55	CD4562	11.95
CD4023	.29	CD4071	.49	CD4566	2.79
CD4024	.79	CD4072	.49	CD4583	2.49
CD4025	.23	CD4073	.39	CD4723	1.95
CD4026	2.95	CD4075	.39	CD4724	1.95
CD4027	.69	CD4076	1.39	MC14409	14.95
CD4028	.89	CD4078	.55	MC14410	14.95
CD4029	1.49	CD4081	.39	MC14411	14.95
CD4030	.49			MC14412	11.95
CD4035	.99			MC14419	4.95
CD4040	1.49			MC14433	13.95

LITRONIX DISPLAY SALE

LIMITED OFFER!!! — WHILE THEY LAST!!

DL-4500, DL-4507, DL-4520A, DL-4120A, DL-2300, DLG-2535, DL-4509, DL-6500, DL-6530, DL-3130

MULTI-DIGIT REFLECTOR ARRAYS FOR CLOCKS

PART NUMBER	CHAR HT. (IN.)	POLARITY	DESCRIPTION	LIGHT OUTPUT (MCD) TYP	MIN	@mA	FORWARD VOLTAGE SEGMENT (V) I_F = 20mA TYP	MAX	CONTINUOUS FORWARD CURRENT PER SEGMENT (mA) MAX	PRICE
DL 4500 (Red) / DL 4507 (Red)		C.C. MPX		8	5 / 1.0					2.49 / 2.49
DL 4507 (orng) / DLG 4507 (grn) / DL 4520A (red)	.50	C.C.non MPX	4 Digit 7 Segment With Colon And Auxiliary Indicators	8	5	10	1.7	2.0	30	4.95 / 4.95 / 2.49
DL 4120A (red)	1.0	C.C.non MPX		15	8		3.4	4.0		4.95

MULTI-DIGIT REFLECTOR ARRAYS

DL 2300 (Red)	.30	C.C. MPX	7 Seg. 2 Digit D.P. Right	2.6	1.1	20	1.7	2.0	30	.99
DLG 2535 (green)	.50	C.A. MPX	9 Seg. 2 Digit		2.6	20		3.5	25	1.49
DL 4509 (Red)	.50	C.C. MPX	9 Seg. 4 Digit D.P. Right	.8	5	10	1.7	2.0	30	2.49
DL 6500 (Red)	.50	C.C. MPX	7 Seg. 6 Digit D.P. Right	8	5	10	1.7	2.0	30	2.95
DL 6530 (Red)	.50	C.A. MPX	7 Seg. 6 Digit D.P. Right	8	5	10	1.7	2.0	30	2.95
DL 3130 (Red)	1.0	C.A. MPX	7 Seg. 3 Digit D.P. Right	15	10	10	3.4	4.0	30	3.95

DISCRETE LEDS

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

XC154 RED LED, METAL MTG. HDW. 2-4" LEADS.
RL-2 . . $.39 ea. or 3/$1.00

DISPLAY LEDS

C.A. — Common Anode · C.C. — Common Cathode

Type	Polarity	Ht	Price	Type	Polarity	Ht	Price
MAN 1	C.A.—red	.270	2.95	DLG507	C.A.—green	.500	1.25
MAN 2	5x7 D.M.—red	.300	4.95	DL704	C.C.—red	.300	1.25
MAN 3	C.C.—red	.125	.25	DL707	C.A.—red	.300	1.25
MAN 52	C.A.—green	.300	1.25	DL728	C.C.—red	.500	1.49
MAN 54	C.C.—green	.300	1.25	DL741	C.A.—red	.600	1.25
MAN 71	C.A.—red	.300	.75	DL746	C.A.—red ± 1	.630	1.49
MAN 72	C.A.—red	.300	.75	DL747	C.A.—red	.600	1.49
MAN 74	C.C.—red	.300	1.25	DL750	C.C.—red	.600	1.49
MAN 82	C.A.—yellow	.300	.49	DLO847	C.A.—orange	.800	1.49
MAN 84	C.C.—yellow	.300	.99	DLO850	C.C.—orange	.800	1.49
MAN 3620	C.A.—orange	.300	.49	DL33B	C.C.—red	.110	.35
MAN 3630	C.A.—orange ± 1	.300	.99	FND358	C.C. ± 1	.357	.99
MAN 3640	C.C.—orange	.300	.99	FND359	C.C.	.357	.75
MAN 4610	C.A.—orange	.400	.99	FND503	C.C. (FND500)	.500	.99
MAN 6610	C.A.—orange—DD	.560	.99	FND507	C.A. (FND510)	.500	.99
MAN 6630	C.A.—orange ± 1	.560	.99	HDSP-3401	C.A.—red	.800	1.50
MAN 6640	C.C.—orange—DD	.560	.99	HDSP-3403	C.C.—red	.800	1.50
MAN 6650	C.C.—orange ± 1	.560	.99	5082-7751	C.A., R.H.D.—red	.430	1.25
MAN 6660	C.A.—orange	.560	.99	5082-7760	C.C., R.H.D.—red	.430	1.75
MAN 6710	C.A.—red—DD	.560	.99	5082-7300	4x7 sgl. dig. RHD	.600	22.00
MAN 6750	C.C.—red ± 1	.560	.99	5082-7302	4x7 sgl. dig. LHD	.600	22.00
MAN 6780	C.C.—red	.560	.99	5082-7304	Overnge. char. (±1)	.600	19.95
DLO304	C.C.—orange	.300	1.25	4N28	Photo Xsistor Opto-Isol.		.99
DLO307	C.A.—orange	.300	1.25	LIT-1	Photo Xsistor Opto-Isol.		.69
DLG500	C.C.—green	.500	1.25	MOC3010	Optically Isol. Triac Driver		1.25

SOCKETS — RECEPTACLES

Test Textool Sockets

ZERO INSERTION FORCE

* Nickel Boron Plating
* G.F. PSF Plastic Body
* For testing IC's

* Nickel Boron Plating
* G.F. PSF Plastic Body
* Wire Wrap Contacts

Part No.	Pins	Price	Part No.	Pins	Price
214-3339	14 pin	5.95	222-3343	22 pin	9.95
216-3340	16 pin	6.49	224-3344	24 pin	9.75
218-3341	18 pin	7.95	228-3345	28 pin	11.95
220-3342	20 pin	8.95	240-3346	40 pin	12.95

Part No.	Pins	Price	Part No.	Pins	Price
214-3592	14 pin	9.75	222-3596	22 pin	12.96
216-3593	16 pin	9.95	224-3597	24 pin	12.75
218-3594	18 pin	10.95	228-3598	28 pin	13.95
220-3595	20 pin	11.95	240-3599	40 pin	15.95

LOW PROFILE (TIN) SOCKETS

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

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea.	10 Ohm 12 Ohm 15 Ohm 18 Ohm 22 Ohm 27 Ohm 33 Ohm 39 Ohm 47 Ohm 56 Ohm	50 pcs.	$1.95
ASST. 2	5 ea.	68 Ohm 82 Ohm 100 Ohm 120 Ohm 150 Ohm 180 Ohm 220 Ohm 270 Ohm 330 Ohm 390 Ohm	50 pcs.	$1.95
ASST. 3	5 ea.	470 Ohm 560 Ohm 680 Ohm 820 Ohm 1K 1.2K 1.5K 1.8K 2.2K 2.7K	50 pcs.	$1.95
ASST. 4	5 ea.	3.3K 3.9K 4.7K 5.6K 6.8K 8.2K 10K 12K 15K 18K	50 pcs.	$1.95
ASST. 5	5 ea.	22K 27K 33K 39K 47K 56K 68K 82K 100K 120K	50 pcs.	$1.95
ASST. 6	5 ea.	150K 180K 220K 270K 330K 390K 470K 560K 680K 820K	50 pcs.	$1.95
ASST. 7	5 ea.	1M 1.2M 1.5M 1.8M 2.2M 2.7M 3.3M 3.9M 4.7M 5.6M	50 pcs.	$1.95
ASST. 8R		Includes Resistor Assts. 1-7 (350 pcs.)		$10.95 ea.

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INTERSIL

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	22.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	28.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
7201IDR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	9.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	11.10
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.50
8212CPA	Volt Ref/Indicator	2.50

* INTERSIL'S EVALUATION KITS

74C

74C00	.39	74C106	.75	74C195	1.59
74C02	.39	74C107	1.89	74C221	1.95
74C04	.39	74C151	2.95	74C240	2.25
74C08	.39	74C154	3.95	74C244	2.25
74C10	.39	74C157	2.25	74C373	2.49
74C14	.75	74C160	1.69	74C374	2.59
74C20	.39	74C161	1.60	74C901	.89
74C30	.39	74C162	1.49	74C903	1.15
74C42	1.39	74C163	1.69	74C911	10.95
74C48	1.95	74C164	1.59	74C912	10.95
74C73	.79	74C173	1.39	74C915	1.69
74C74	.79	74C174	1.39	74C917	10.95
74C85	1.95	74C175	1.39	74C922	5.49
74C86	.99	74C192	1.69	74C923	5.75
74C89	6.95	74C193	1.69	74C925	7.50
74C90	1.29			74C926	7.50
74C93	1.29			80C95	.79
74C95	1.59			80C97	.79

LINEAR

LH0002CN	6.85	LM340T-5	1.25	NE570N	4.95
LM10CLH	4.50	LM340T-12	1.25	LM702H	.79
LM11CLH	4.75	LM340T-15	1.25	LM703CN	.89
LH0070-OH	6.05	LM341P-5	.75	LM709N	.49
TL071CP	.79	LM341P-12	.75	LM710N	.79
TL072CP	1.39	LM341P-15	.75	LM711N	.79
TL074CN	2.49	LM342P-5	.69	LM723N	.69
LH0082CD	35.80	LM342P-12	.69	LM733N	1.00
TL082CP	1.19	LM342P-15	.69	LM739N	1.19
TL084CN	2.19	LM348N	1.25	LM741CN	.35
LH0094CD	36.80	LM350K	5.75	MC1741SCG	3.00
LM300H	.99	LF351N	.60	LM747N	.79
LM301CN	.35	LF353N	1.00	LM748N	.59
LM302H	1.95	LF355N	1.10	LM1014N	2.75
LM304H	1.95	LF356N	1.10	LM1310N	1.95
LM305H	.99	LM358N	1.00	LM1458CN	.59
LM307CN	.45	LM359N	1.79	LM1488N	1.25
LM308CN	1.00	LM370N	4.49	LM1489N	1.25
LM309H	1.95	LM373N	3.25	LM1496N	1.95
LM309K	1.25	LM377N	2.95	LM1556V	1.75
LM310CN	1.75	LM380N	1.25	LM1800N	2.95
LM311H	.90	LM381N	1.95	LM1877N-9	3.25
LM312H	2.49	LM382N	1.79	LM1889N	3.20
LM317MP	1.15	LM384N	1.95	LM1896N	1.75
LM317T	1.75	LM386N-3	1.29	LM2002T	1.49
LM317K	3.95	LM387N	1.45	LM2877P	2.05
LM318CN	1.95	LM389N	1.35	LM2878P	2.25
LM319N	1.95	LM392N	.69	LM2896P-1	2.25
LM320K-5	1.35	LF398N	4.00	LM3189N	2.95
LM320K-12	1.35	LM399H	5.00	LM3900N	.69
LM320K-15	1.35	TL494CN	4.49	LM3905CN	1.25
LM320T-5	1.25	TL496CP	1.75	LM3909N	1.15
LM320T-12	1.25	NE510A	6.00	LM3914N	3.95
LM320T-15	1.25	NE529A	4.95	LM3915N	3.95
LM323K-5	5.95	NE531H	3.95	LM3916N	3.95
LM324N	.99	NE536H	6.00	RC4136N	1.25
LM329DZ	.65	NE540H	6.00	RC4151NB	3.95
LM331N	3.95	NE544N	4.95	RC4194TK	5.95
LM334Z	1.30	NE550A	1.30	RC4195TK	5.49
LM335Z	1.40	NE555V	.39	KB4428	4.25
LM336Z	1.75	LM556N	.99	KB4429	5.95
LM337T	1.95	NE564N	3.95	LM4500A	3.25
LM337MP	1.15	LM565N	1.25	ICL8038B	4.95
LM338K	6.95	LM566CN	1.95	LM13080N	1.29
LM339N	.99	LM567V	1.25	LM13600N	1.49
LM340K-5	1.35			75138N	1.95
LM340K-12	1.35			75450N	.89
LM340K-15	1.35			75451CN	.39

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.06
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

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

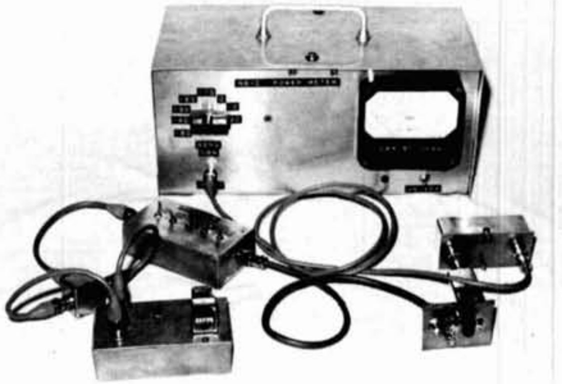
+20% DIPPED TANTALUMS (Solid) CAPACITORS

.1/35V	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.19	.16	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

More Details? CHECK—OFF Page 118



rf power meter

part 1 — instrument description and construction

Homebrewing Amateur gear can be an enormously satisfying experience. There's no reward like being able to say "I built it myself." Homebrew gear generally falls into one of two categories: it's either foolproof in construction and can be assembled with a reasonably good chance of having it work the first time you turn it on, or it's complex and needs test instrumentation for calibration and adjustment, which is simply not available to the average ham. This article is devoted to helping satisfy the need for good, accurate measurement instrumentation. This instrument ranks right along with your VOM, scope, and frequency counter in utility.

types of measurements

Frequency and amplitude of rf signals are, fundamentally, the two measurements made. Others are simply variations. Giant strides have been made with the introduction of simple and relatively inexpensive frequency counters priced within the Amateur's budget. Rf power measurements, however, have traditionally been limited to measuring voltage with an rf probe and VOM or a scope. In many cases this simply is not satisfactory due to the limited sensitivity of the instrumentation, or because the measurement is not easily adaptable to this technique.

This article describes an rf power meter that measures absolute power in dBm, 50 ohms, over a frequency range of 3.5-30 MHz. Measurement range, across a 50-ohm load, is between − 60 and 20 dBm with an accuracy of ± 1dB.* Armed with a frequency counter and the power meter and accessories described in this article, you can make a variety of scalar network measurements not ordinarily possible without access to sophisticated lab equipment. Best of all, the instrument isn't difficult to build or calibrate. Here are some of the things you can do, just to tickle your imagination, with the power meter and accessories. I have done most of these myself.

1. Evaluate oscillators, QRP transmitters, and small-signal amplifiers with respect to power output, flatness, harmonic distortion, and input return loss (VSWR).

2. Evaluate mixers for flatness, LO and rf suppression and conversion loss or gain.

3. Accurately measure your antenna VSWR down to 1.02 with an uncertainty of ±0.02. It's virtually impossible to get that kind of accuracy and resolution with a simple SWR meter.

*Verified with an HP-8640B signal generator.

By Ralph H. Fowler, N6YC, Route 1, Box 254, Pearl River, Louisiana 70452

4. Simplify filter construction. Synthesis of a 50-ohm LC preselector filter or other bandpass filters, for example, can be a ticklish job. Actual component values can depart considerably from theoretical values due to parts substitutions, tolerance unknowns, and stray capacitances. The power meter, combined with a counter and tunable source, enables alignment and evaluation of LC filters with respect to insertion loss, passband shape (ripple), shape factor, and skirt attenuation (up to 80 dB with a 20-dBm tunable source). If your source is stable enough you can even characterize crystal filters.

5. Adjust interstage and output matching networks (50 ohms). Even your transmatch can be adjusted with the power meter and a directional bridge.

6. Make similar measurements on your kilowatt rock-crusher by adding a simple in-line directional coupler (not described here) to your transmission line. You can, naturally, calibrate the coupler with the power meter.

As an academic exercise you can even measure a-m percentages between 25 and 100 per cent to within a few per cent accuracy. Some of these measurements, plus a few provocative ideas, will be discussed *in part 2 of this article*.

The power meter consists of three basic parts: a biased Schottky diode *broadband* detector (note the broadband emphasis — this becomes extremely important in the measurements described in part 2), a 37-dB broadband preamp, and a relay-switched 0-70 dB attenuator. These three elements are cascaded as shown in **fig. 1**. Each element is described in turn.

Operation is simple. The step attenuator and preamp set the level of the signal being measured to the proper amplitude for the square-law detector. This is essential since the square-law amplitude range of the detector is relatively limited, typically to between −40 and −10 dBm. Square-law, you may recall, means that the output *voltage* of the detector is proportional to the input *power*. Outside of this −40 to −10 dBm range, the detector does not follow the square-law relationship and will be uncalibrated. Even if the square-law range were greater than 30 dB, it would not be useful in this simple scheme since the meter itself can display only 10 dB of range with acceptable resolution (1 dB) without a logging amplifier included in the circuit. With these complicating factors in mind, I chose to accept a 10-dB measurement range per step of the input attenuator. The only inconvenience is that you have to switch the attenuator to bring the reading within the 10-dB display range of the meter. The meter, incidentally, has a 0 to −10 dB calibration scale. If you can't find a meter calibrated in dB (10 $\log_{10}$) it's easy to add your own calibration marks. A calibration table is shown in **fig. 2**.

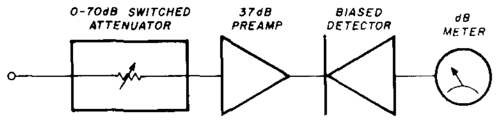


fig. 1. Power meter elements, consisting of broadband detector, broadband preamplifier, and relay-switched attenuator.

the detector

The heart of the power meter is the broadband square-law detector. The original circuit design was described by Wes Hayward, W7ZOI, in *Solid State Design for the Radio Amateur*, and the reader is encouraged to consult this excellent reference for more details. This detector is shown in **fig. 3**.

Construction is not particularly critical but should be done on PC or copper-clad Vector board to permit operation above 30 MHz, as described later. Leads up to and including the diodes should be kept short. The detector assembly should then be housed inside a compartment or BUD™ box.

The diodes are Schottkys, which are inherently better matched than conventional types and are essential. In addition, these diodes have a better sensitivity than ordinary silicon diodes, thus providing up to −40 dBm sensittivity with careful biasing.

A variety of op-amps were tried in this circuit with good results, including the 741, LM301A, and LM312. Doubtless there are others which would work equally well.

With this design and a little attention paid to short leads at the front end, my unit had a perfect square-law response between −23 dBm and −13 dBm and was virtually flat up to approximately 500 MHz.* An extra 10 dB of sensitivity could have been achieved by calibrating the detector for the −33 dBm to −23 dBm range, but op-amp drift effects began to show up here. Operation between −23 dBm and −13 dBm is drift free.

With this kind of frequency response, it would pay to provide a jumpered detector input on the back panel of the power meter to allow power measurements at vhf and above using the detector alone.

To access the detector (thus bypassing the switched attenuator and preamp, which are much more frequency limited) you could simply remove the jumper coax and plug right into the detector. I don't operate above 30 MHz so I did not include this in my set.

*Compared to a Hewlett-Packard 8640B signal generator as a reference.

dB	percent full scale
0	100
−1	79
−2	63
−3	50
−4	40
−5	32
−6	25
−7	20
−8	16
−9	13
−10	10
−20	1

fig. 2. Data for calibrating the dB meter.

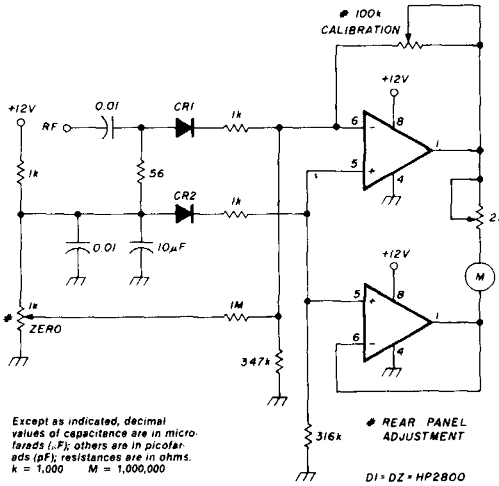
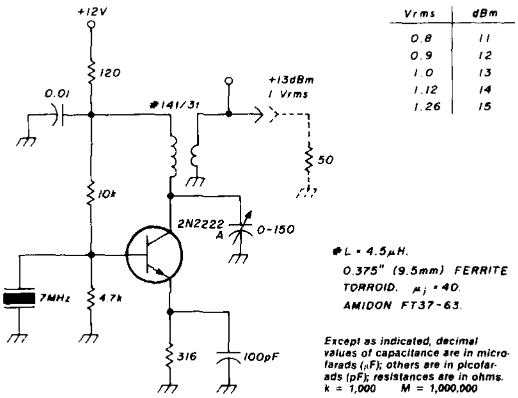
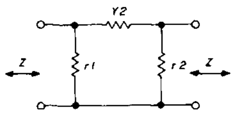


fig. 3. Biased detector schematic. CR1, CR2 are Schottky diodes. Meter is 0-100 microamps or higher. Original circuit was described by Wes Hayward, W7ZOI.



Vrms	dBm
0.8	11
0.9	12
1.0	13
1.12	14
1.26	15

fig. 4. Oscillator for calibrating the detector and preamp. Circuit delivers 13 dBm.



ATTENUATOR (dB)	r1 (OHMS)	r2 (OHMS)
1	910	6.2
3	300	18.0
6	150	39.0
10	91	68.0
20	62	240.0
40	51	2500.0

fig. 5. Symmetrical pi attenuator for bringing the 13-dBm oscillator signal into the range of the detector. $Z = 50$ *ohms resistive.*

calibration

Calibration of the detector is an intermediate step that should be accomplished to ensure that the detector is working properly and to provide a means of measuring the gain of the preamp once it is built. When the power meter is completed, it will then require only minor readjustment to bring it into absolute calibration.

Since the ultimate accuracy of the power meter depends on the reference used to calibrate it, it is crucial that care be taken in its selection. The ideal reference is an accurately calibrated signal generator that can be tuned over the full operating band. Usually this is impractical, so the next best alternative is to simply build a fixed frequency, high-frequency oscillator with an output of about 13 dBm into 50 ohms, corresponding to 1 Vrms. This level is easily measurable with an rf probe and VOM. This oscillator will be used to calibrate the detector and the preamp. **Fig. 4** shows a simple oscillator that will deliver 13 dBm. The relationship between output voltage and power in dBm (50 ohms) is given so that you should be able to compute the exact power output of your oscillator once the rf voltage is measured. Just remember that you must measure the voltage with the output terminated into 50 ohms (a 50-ohm noninductive resistor will do nicely as a temporary load).

The 13-dBm signal must now be attenuated to bring it into the range of the detector. Adding a total of 26 dB of attenuation to the oscillator output supplies the −13 dBm reference required. This reference is chosen since the detector is preceded by a 37-dB preamp, thus giving the desired −50 dBm (full scale) sensitivity. **Fig. 5** shows component values used for constructing the attenuators. Small adjustments to the oscillator collector voltage can also be made for small corrections to output level.

With no input connected to the detector, the zero adjustment should first be set to bring the meter reading to zero. Next connect the −13 dBm reference signal to the detector and adjust the calibration trimpot to set a full-scale reading. The meter multiplier pot will also have to be adjusted to accommodate your particular meter sensitivity. Disconnect the input signal and reset the zero adjustment. Continue alternating between the zero and calibration pots to complete the initial detector calibration.

To verify square-law operation of the detector, simply add a 3-dB attenuator between the −13 dBm reference signal and the detector input. The meter should indicate half scale, corresponding to 3 dB below full scale or −16 dBm absolute power. Replacing the 3-dB attenuator with a 10-dB attenuator should bring the meter indication to 0.1 of full scale, corresponding to 10-dB below full scale, or −23 dBm. The detector is now absolutely calibrated over the −23 dBm to −13 dBm range and will be used subsequently (along with the attenuators) to calibrate the preamp.

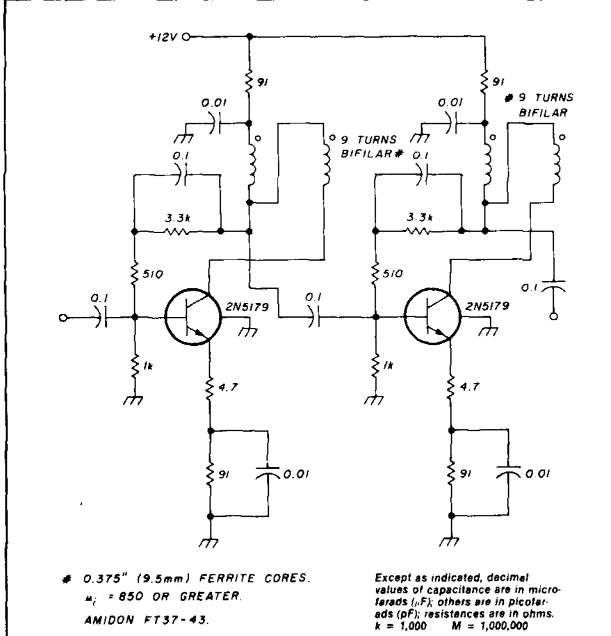


fig. 6. This 37-dB broadband preamplifier is stable, with emitter and shunt feedback. Measured input VSWR is less than 1.2.

preamplifier

The preamp used ahead of the detector supplies 37 dB of amplification using two 2N5179A transistors in a broadband configuration (**fig. 6**). Construction is not critical, and the amplifier should be stable with the emitter and shunt feedback. The feedback also provides a good input impedance match to 50 ohms. Measured input VSWR was better than 1.2. This is important to provide a good match to the step attenuator, which precedes the preamp. If you use another preamp circuit remember not to compromise this parameter.

The broadband transformers should be wound on high-permeability ferrite toroids to ensure the full bandwidth. Using the values shown, the 3-dB bandwidths were 3.0 and 77 MHz, and the 1 dB bandwidths were 3.5 and 37 MHz. Adding a few extra turns should increase the lower 3-dB frequency to allow coverage of the 1.8 MHz band if desired.

Once completed, the preamp should be tested to ensure that 37-dB gain is achieved. More or less gain will require reaccomplishing the detector initial calibration so that the preamp and detector combination have the required −50 dBm full-scale sensitivity. Assuming that the gain is measured to be 37 dB, ± a few dB, this final adjustment can be deferred until the power meter is completed.

To measure preamp gain, construct a 40-dB fixed attenuator and connect it to the −13 dBm reference output. This −53 dBm signal is now applied to the preamp input and the preamp output connected to

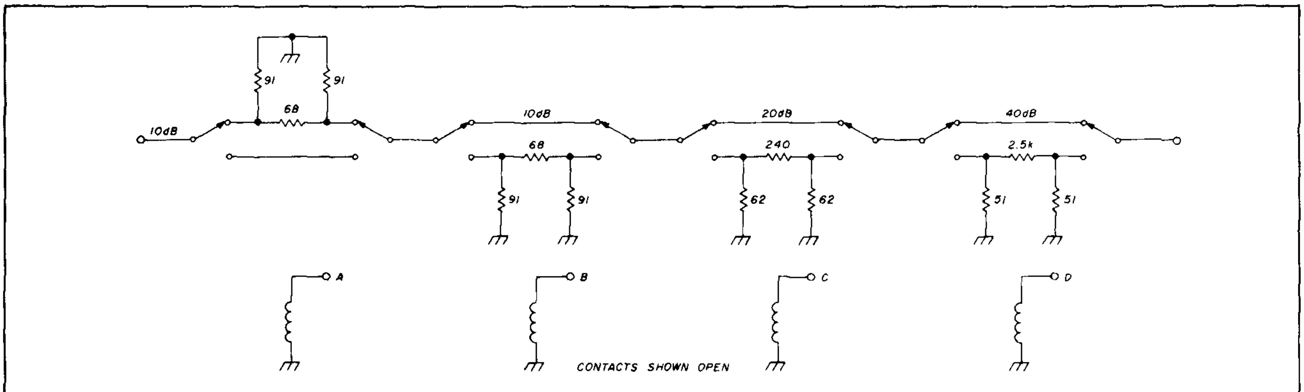


fig. 7. Input attenuator consists of cascaded pi networks. Relays are used here. A better alternative would be the slide-switch circuit in the 1980 *Radio Amateur's Handbook*.

the calibrated detector and meter. The meter should indicate −16 dBm (half scale, assuming full scale is −13 dBm), corresponding to 37 dB of preamp gain.

input attenuator

The switched input attenuator was unquestionably the most difficult part of the project. **Fig. 7** shows the completed unit. A number of prototypes were built with varying degrees of success. The problems encountered most often were (1) flatness variations (a few dB greater than the 1-dB design goal) at the high frequency end of the range, and (2) degraded input-to-output isolation at attenuation levels above 70 dB despite my attempts at shielding. This limits operation of the power meter to 20 dBm (where 70-dB attenuation is used).

As an alternative, you might consider building the attenuator using small slide or toggle switches, perhaps even external to the power meter. Such a unit would have other applications as well as being useful in calibration of the detector and preamp. The 1980 edition of the *Radio Amateur's Handbook* shows construction of a shielded 147-dB step attenuator using simple slide switches; it looks like a good prospect. Using this proven design, you could probably remedy the isolation problems I encountered and increase the measurement range to 30 dBm or higher.

If building the relay-switched attenuator still appeals to you, a couple of construction points are worth remembering:

1. A single-side PC or Vector™ board layout is desirable for minimizing isolation problems and frequency response resulting from impedance mismatches. While the 50-ohm environment of a transmission line is certainly not preserved, I found that by using small PC-mount relays on a Vector board and a physically small layout, an input VSWR less than 1.4 and ±1 dB flatness up to 30 MHz was attainable, even at the 0 dB attenuation setting (all attenuators switched out). Although not shown in my unit, shielding between attenuator sections would still be good insurance against isolation problems despite my experience.

The resistors used to build the attenuator sections are film type, 1 per cent tolerance, 1/4-watt units mounted close to the relay contacts. Physically small, low-wattage resistors reduce the capacitance to ground and help keep the flatness variations reasonable.

2. The attenuator sections consist of 10-, 10-, 20-, and 40-dB sections switched in as required to provide 0-70 dB of attenuation in 10-dB steps. A 10-dB section is used as the input section and remains switched in at all times except at the highest sensitivity setting of the power meter, −50 dBm. This helps establish the good input VSWR and is important when characterizing devices such as 50-ohm LC filters, which require a good 50-ohm termination.

Considering the isolation problems mentioned earlier, measurements at levels above 20 dBm should be done with fixed attenuation ahead of the power meter. Of course, this requires mentally adjusting the readings for the extra attenuation. Remember to construct the external attenuators with higher wattage resistors to dissipate the increased power.

To provide switching the input-attenuator relays, a 4p8t switch or sp8t switch (both make before break) with a diode switching matrix can be used. Since 4p8t switches are not too common, I chose the latter technique. The diode switching matrix is shown in **fig. 8**. The diodes used should be germanium or other low barrier diodes to minimize voltage drops and maintain switching reliability, especially if 5-volt relays are used. If 12-volt or higher relays are used, silicon diodes should be ok.

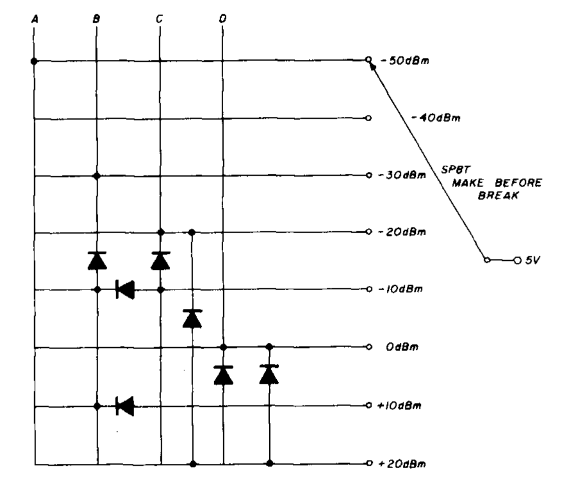


fig. 8. Diode matrix for switching input-attenuator relays. Single pole, 8-throw switch was used.

putting it all together

Once the detector, preamp, and attenuator modules have been constructed, they should be cascaded and the final calibration can be performed. If all goes well, the last step is to mount it all in a suitable box.

Final calibration of the power meter requires simply connecting the −13 dBm reference signal to the input, setting the input attenuator to the −10 dBm full-scale range (corresponding to 40-dB attenuation if an external switched attenuator is used), and tweaking the detector calibration pot to set the meter indication to −13 dBm, or half scale. Power-meter switching accuracy can be verified by using fixed at-

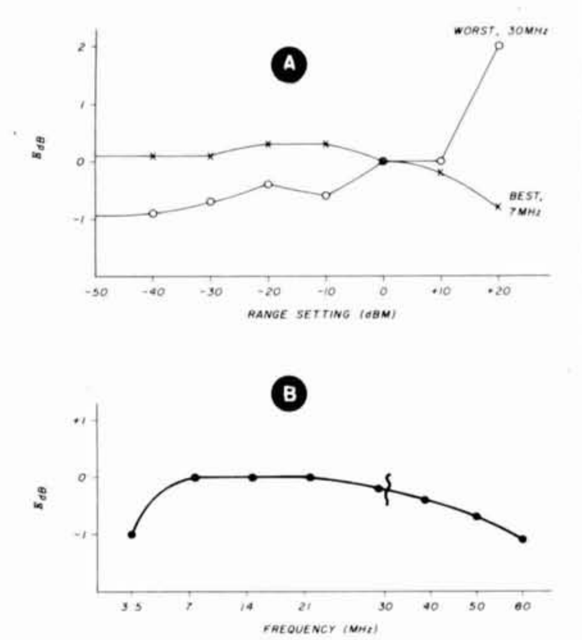


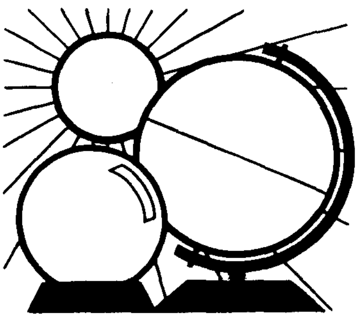
fig. 9. Power-meter step gain accuracy relative to 0 dBm (A) and relative frequency response (B). In-band flatness is less than ± 0.1 dB on all bands.

tenuators to attenuate the reference signal and comparing this known level to the power-meter reading. **Fig. 9** shows the flatness and step accuracy that I achieved with my power meter.

Performance testing was done using a Hewlett-Packard 8640B signal generator and fixed attenuators accurate to better than 0.1 dB. Keep in mind that, while you probably won't be able to perform such quantitative performance tests on your power meter, the *in band* flatness could be expected to be no worse than a few tenths of a dB, and the absolute accuracy could reasonably be less than a few dB, assuming the rf probe and VOM used in the detector calibration were accurate to within 10 per cent. Relative amplitude accuracy over the full −60 dBm to 20 dBm range at a fixed frequency should be even better and depends primarily on the precision of the attenuator sections used in the input attenuator. Not bad at all.

The second part of this article will deal with some of the measurements you can make using the power meter. Details of the construction of a return loss bridge, useful for making accurate measurement of low VSWR, and other measurement accessories will be given. We will look at some important measurement considerations aimed at improving the accuracy of your measurements.

ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The first of the month is expected to favor the lower frequencies over the higher bands for nighttime DX activities. DX conditions for the upper-frequency bands should improve during the third week, then round off and drop during the last week. Solar radio flux is expected to be high during that time. Propagation disturbances from solar-flare activity of 2 to 3 days' duration are possible around the 10th and 21st. Conditions will generally be poorer for hearing and working DX during these disturbances, but look for unusual DX locations to appear with weak, fading signals.

The lunar perigee, of interest to moonbounce DXers, will occur on the 4th of this month. An Aquarid meteor shower, of interest to meteor-scatter DXers, will show a maximum between May 4th and 6th, with a rate of 10 and 25 per hour for the North and South Hemispheres respectively.

sporadic-E propagation

One of the major paths for excellent DX signals is short skip, or multiple short skips, in the summer on the higher-frequency bands. The end of May heralds the beginning of the sporadic-E (Es) propagation season. Es is a thin layer of intense ionization about 60 miles (100 km) above the earth. It gives rise to strong, mirror-like signal reflections over the short-skip distance of 600 to 1200 miles (1000 to 2000 km). Signals remain strong from a half hour to a couple of hours on the average, as the name "sporadic" suggests, rather than all day or night as with other high-frequency propagation.

The maximum high frequency propagated by Es follows the sun across the sky; the highest probability of occurrence, however, is near sunrise and again around sunset. These two facets of Es affect short-skip openings differently. Openings on the higher-frequency bands occur near noontime, and the lower bands tend to have openings near sunrise and sunset.

Now look at the best locations for these Es openings: since Es is related to the summer sun, the effect is in the Northern Hemisphere from June on into September and in the Southern Hemisphere during their summer, December through March. The best Es is on either side of the geomagnetic equator; it's especially good where the geomagnetic equator has greatest separation from the geographic equator. These special areas are Southeast Asia in the Northern Hemisphere and South America in the Southern Hemisphere. The first is the best of the two because the E region ionospheric electric currents are strongest there.

To look for Es openings on the higher-frequency bands, monitor beacons on 6, 10, and 15 meters, WWV frequencies, and CB channel 19. Also check TV channels 2 through 5 for 6- and 2-meter openings. The lower bands don't need beacon monitoring, since Es openings (sunrise and sunset) are available most nights. Remember: couple your antenna to the ionosphere with take-off angles of 20-30 degrees (see the January, 1981, *DX Forecaster*).

band by band summary

Six meters will provide very good openings during high solar flux to South Africa, Australia, and New Zealand around local noontime. Look for possible Es short-skip by monitoring TV.

Ten, fifteen and twenty meters will have DX from most areas of the world during daylight and into the evening almost every day, either long skip to 2500 miles (4000 km) or Es short skip to 1200 miles (1920 km) per hop. The length of daylight is now approaching maximum, providing hours of good DXing.

Forty, eighty, and one-sixty meters are the night DXer's band. On many nights 40 meters will be the only usable band because of thunderstorm QRN, but signal strengths via Es short skip may overcome the static when Es is available. Es is not that available in May, although it should be better next month.

Choose the band that will give the best DXing for you at your and their operating times and locations.

ham radio

*Look at next **higher** band for possible openings.

MAY

WESTERN USA

GMT	PDT	N – ASIA FAR EAST	NE – EUROPE	E – S. AFRICA	SE – S. AMERICA	S – ANTARCTICA	SW – NEW ZEALAND	W – OCEANIA AUSTRALIA	NW – JAPAN
0000	5:00	—	20	—	15	10	10	10	15
0100	6:00	—	20	20	10	10	10	10	15
0200	7:00	—	20	20	10	15	10	10	15
0300	8:00	—	20	20	10	15	10	10	15
0400	9:00	--	20	40*	15	15	15*	10	15
0500	10:00	—	20	40*	15	15	15*	15*	15
0600	11:00	—	20	20	15	20	15	15*	20*
0700	12:00	20	20	20	15	20	15	15*	20*
0800	1:00	20	—	20	20	20	15	15	20
0900	2:00	20	--	20	20	20	15	15	20
1000	3:00	20	—	—	20	20	15	15	20
1100	4:00	20	—	—	20	20	20*	15	20
1200	5:00	20	—	—	20	40	20*	20	20
1300	6:00	20	20	20	20	40	20	20	20
1400	7:00	20	20	15	15	40	20	20	20
1500	8:00	20	20	15	15*	40	20	20	20
1600	9:00	15	20*	15	10	—	—	—	20
1700	10:00	15	15	15	10	—	—	—	15
1800	11:00	15	15	15	10	—	—	—	15
1900	12:00	15	15	15	15	—	15*	15	20*
2000	1:00	15	—	15	15*	—	10	10	15
2100	2:00	—	—	—	15	—	10	10	15
2200	3:00	—	20	—	15	—	10	10	15
2300	4:00	—	20	—	15	10	10	10	15

MID USA

GMT	MDT	N – ASIA FAR EAST	NE – EUROPE	E – S. AFRICA	SE – S. AMERICA	S – ANTARCTICA	SW – NEW ZEALAND	W – OCEANIA AUSTRALIA	NW – JAPAN	CDT
0000	6:00	—	20	15	15*	15	10	10	15	7:00
0100	7:00	15	20	15	10	15	10	10	15	8:00
0200	8:00	15	20	20*	15*	15	10	10	15	9:00
0300	9:00	15	20	20	15	15	15*	15*	15	10:00
0400	10:00	—	20	40*	15	15	15	15*	15	11:00
0500	11:00	—	20	40*	15	20	15	15	20	12:00
0600	12:00	—	20	20	20	20	15	15	20	1:00
0700	1:00	20	20	20	20	20	20	15	20	2:00
0800	2:00	20	—	20	20	20	20	15	20	3:00
0900	3:00	20	—	20	20	20	20	20	20	4:00
1000	4:00	20	—	—	20	40*	20	20	20	5:00
1100	5:00	20	—	—	20	40	20	20	20	6:00
1200	6:00	20	20	—	15	40	20	20	20	7:00
1300	7:00	20	20	15	15	—	20	20	20	8:00
1400	8:00	20	20*	15	15	—	20	20	20	9:00
1500	9:00	20	15	15	15	—	—	—	20	10:00
1600	10:00	20*	15	15	15	—	—	—	20*	11:00
1700	11:00	15	15	15	10	—	—	—	15	12:00
1800	12:00	15	15	15	10	—	15	—	15	1:00
1900	1:00	15	15	15	10	—	15	15	15	2:00
2000	2:00	15	15	—	10	—	15	10	—	3:00
2100	3:00	—	15	—	10	10	10	10	15	4:00
2200	4:00	—	15	—	10	10	10	10	15	5:00
2300	5:00	—	20*	—	10	10	10	10	15	6:00

EASTERN USA

GMT	EDT	N – ASIA FAR EAST	NE – EUROPE	E – S. AFRICA	SE – CARIBBEAN S. AMERICA	S – ANTARCTICA	SW – NEW ZEALAND	W – OCEANIA AUSTRALIA	NW – JAPAN
0000	8:00	15	20	15	15	20	15*	10	15
0100	9:00	15	20	15	15	20	15	10	15
0200	10:00	—	20	20	15	20	15	15*	20
0300	11:00	—	20	40*	15*	20	15	15	20
0400	12:00	20	20	40*	15	20	—	15	—
0500	1:00	20	20	40*	20	20	20	15	—
0600	2:00	20	20	20	20	20	20	20*	—
0700	3:00	20	20	20	20*	40*	20	20	—
0800	4:00	—	20	20	20	40*	20	20	—
0900	5:00	—	20	—	—	40*	20	20	—
1000	6:00	—	20	—	—	40*	20	20	—
1100	7:00	—	20	—	—	40*	20	20	20
1200	8:00	20	—	15	20	—	20	20	20
1300	9:00	20	15	15	20	—	20	20	20
1400	10:00	20	15	15	10	—	20	20	20*
1500	11:00	20	15	15	10	—	20	—	15
1600	12:00	20*	15	10	10	—	—	—	15
1700	1:00	15	15	10	10	—	—	—	15
1800	2:00	15	15	10	10	—	—	—	15
1900	3:00	15	15	15*	10	15	15	—	15
2000	4:00	—	15	15*	10	15	15*	15	20
2100	5:00	—	15	10	15	15	15*	15	20*
2200	6:00	15	15	10	15	15	15*	15*	15
2300	7:00	15	15	10	15	15	15*	10	15

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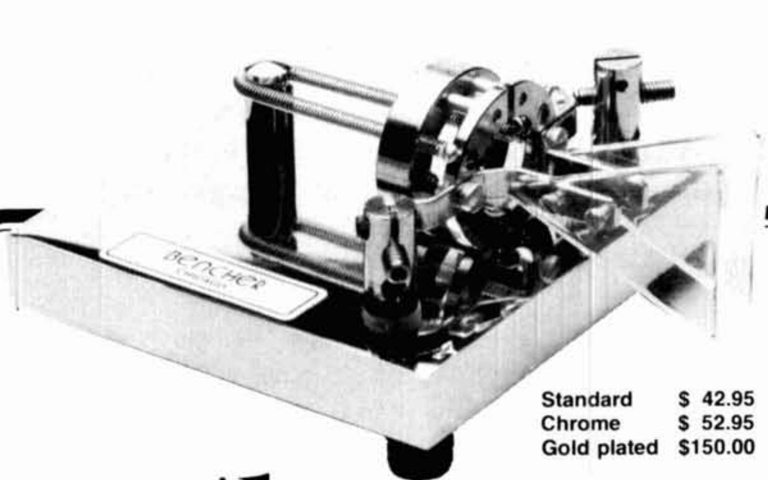

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NOVICE STATION: HR-10B, DX-60B and HG-10B, very good condition, $195.00. F.O.B. W9VZR, 4627 North Bartlett, Milwaukee, Wisconsin 53211.

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EME 2 METER DX. Complete machined metalwork for W6PO design 2 meter 8877 amp., $135.00. New RCA 7213, $325.00. New Eimac 3-500Z, $90.00 each. Icom IC-245-S SSB, CW, FM, 8 months old, $335.00. Bowman 770 converted to 10 meter SSB and AM, $145.00. New 30 amp, 220 volt Varac, $150.00. Drake AC-4, $80.00. No collect calls. (513) 683-0385. John Walker, 1930 Meredith Dr., Loveland, Ohio 45140.

NEED HELP for your Novice or General ticket? Recorded audio-visual theory instruction. No electronic background required. Free information. Amateur License, P.O. Box 6015, Norfolk, VA 23508.

VFO GLOVE 755 wanted with instructions. A.G. Rannie, W2EAI, 2 Farrell St., Newburgh, NY 12550.

CB TO 10-METER CONVERSIONS. SSB/AM/CW. Let a specialist convert your rig, or buy one complete. Write Conversion Engineering, Box 183, Sandwich, Massachusetts 02563.

MINT RCA-WV58B VTVM, $45.00; New Galaxy rejector & P.S., $30.00; WRL new DB68 Preselector, 80 thru 6 meters, tunable, $30.00; Following new CRTS 2-3FPTs, 2-5CP1s, 1-3ACPa, 1-3EP1, $5.00 each, all tested. U pay U.P.S. Chester Benson, 732 South 14th, Richmond, Indiana 47374.

MAKE HAM RADIO FUN! Supplement your learning programs with a motivational hypnosis cassette. Tape #3, Learning the Code; Tape #4, Breaking the Speed Barrier; Tape #7, Electronics Theory. Free catalog. For tapes, $10.95 each to John Wolf Hypnosis Center, P.O. Box 497, Hayden, Idaho 83835.

CASH for December 1915 to June 1920 QST's for personal collection. Kenn Miller, K6IR, 16904 George Washington, Rockville, Maryland 20853 (301) 774-7709.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

SALE: Heath 2021 2m HT, extra 'xtals, external microphone, touch-tone kit, $130.00. Isotron 80m antenna, $35.00. S.A.S.E. details. ELKIND, WB2ARN/3, 6340 Marchand, Pittsburgh, PA 15206 (412) 361-3788.

DISTINCTIVE QSL's — Largest selection, lowest prices, top quality photo and completely customized cards. Make your QSL's truly unique at the same cost as a standard card, and get a better return rate! Free samples, catalogue. Stamps appreciated. Stu Goodman, K2RPZ Print, P.O. Box 412, Rocky Point, NY 11778 (516) 744-6260.

FREE SAMPLE Ham Radio Insider Newsletter! Send large S.A.S.E.. W5YI, Box #10101-H, Dallas, Texas 75207.

MAGAZINE SAMPLES! For a free list of over 135 magazines offering a sample copy, send a stamped, addressed envelope to: Publisher's Exchange, P.O. Box 1368, Dept. 26A, Plainfield, NJ 07061.

QUIET DX LOCATION, SEPARATE HOME AND SHOP. 7-1/2% assumable plus owner's finance. Blaw-Knox 125' freestanding tower with attache 1 ladder, full-sized 6 element, 20m KLM beam and 3e 40m beam plus crank-up/TH6DXX. 3-phase, 2 lta power. Buildings total 2800 sq. feet roof. 5.6 acres redwood forest. Easy acces s, shopping, San Jose, Calif. 10 years old. Good er system included. Reduced to sell @ $220,000. 1/4 down, 1/5 assumable, balance @ below current rate or trade Calif. income property. W6MUR (DXCC 319/352). Callbook QTH or (408) 336-8800.

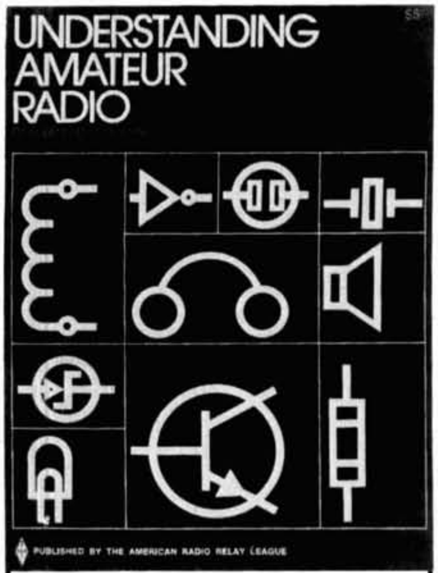
SOLD

SATELLITE TV self-help newsletter. Next 3 issues $6.00. WA4OSR 'Lite News, Box 973-HR, Mobile, AL 36601.

NEW ZEALAND AMATEUR wishes to complete his "Ham Radio" collection. Requires 1968, 1969, 1970 complete and January 1971. Will purchase 1971 complete if offered. Reply stating years available and price required to: G. Moles, ZL2AKI, International Callbook Address.

X-BAND GUN DIODE Amprex transmitter and receiver. Set has one 8mw transmitter, one receiver and two horn antennas. $90.00 per set. $10.00 down per set for C.O.D. I will consider swaps for OSI-CIP, 5¼ or 8" Shugart compatible disk drives, sym, RCA Microbds, AIM 65, and ROMS for any of the computers listed (BASIC, Assember). R. Riley, 6068 Grove, Flint, Michigan 48507. (313) 695-1117 - 7:00-9:00 weekdays.

FOR SALE: Heath HR-1680 Ham receiver hardly used, $190.00. Realistic comm. receiver DX-302, like new, $300.00. Microcraft Morse-A-Word 8-character display, wired and tested, $190.00. Manuals included. Jim Lofton, 134 Woodland Ave., Clarksburg, WV 26301 (304) 623-0940.



Coming Events
ACTIVITIES
"Places to go..."

ARKANSAS: The Northwest Arkansas A.R.C., Inc. will hold its first annual Hamfest/Swapfest on May 16th at the Siloam Springs Community Building starting at 8:00 AM. Door prizes, exhibitors, free parking and much more. Talk-in on .16/.76 or .52 simplex. More info: S.A.S.E. Bob Harmon, W5SEP, Route 1, Box 13E, Elkings, Arkansas 72727.

CALIFORNIA: 9th annual Sacramento Valley Radio Ham Swap on May 31st from 9:00 - 3:00 at the Machinist's Hall, 3081 Sunrise Blvd., Rancho Cordoval. Food, club auction, prizes, and FREE ADMISSION. Talk-in on K6IS on 144.59/145.19 and 223.18/224.78.

CALIFORNIA: ARRL Pacific Division Convention and 39th annual Fresno Hamfest on May 15th-17th at the Hacienda Inn in Fresno. More info: S.A.S.E. to Fresno Amateur Radio Club, Inc., P.O. Box 783, Fresno, California 93712.

CALIFORNIA: The 1981 International DX Convention at the Airport Holiday Inn, Visalia, California on May 1st-3rd. Hotel reservations via Holiday Inn's toll-free number. More info: N.C.D.X.C., P.O. Box 608, Menlo Park, California 94025.

GEORGIA: 1981 Atlanta HamFestival on June 20th and 21st at the Downtown Marriott Hotel. Second largest crowd in Ham Radio and the fastest growing microcomputer show. More info: S.A.S.E. to Atlanta HamFestival 1981, P.O. Box 27553, Atlanta, Georgia 30327.

IDAHO: The Kootenai Amateur Radio Society's Hamfest '81 on May 9th at the North Idaho Fairgrounds, Coeur D'Alene. Commercial displays, swap tables, food, raffles, prizes, plus more. Talk-in on 146.37/.97.

ILLINOIS: The Six Meter Club's 24th annual Hamfest on June 14th at the Santa Fe Park, 91st and Wolf Rd., Willow Springs. Advanced registration: $1.50 and at the gate: $2.00. Prizes, swapper's row, displays, plus much more. Talk-in on 146.52 or WR9ABC .37-.97 (PL2A). Advanced tickets or more info: S.A.S.E. to Val Hellwig, W9ZWV, 3420 S. 60th Court, Cicero, Illinois 60650.

ILLINOIS: Radio Expo '81 sponsored by the Chicago FM Club will be held, rain or shine, on September 19th and 20th at the Lake County Fair Grounds, routes 45 and 120 in Grayslake. Grayslake is 30 minutes north of Chicago and 45 minutes south of Milwaukee. This year we will have a super large flea market with plenty of indoor and outdoor space, free with a gate ticket. Just bring your own table and chair or tailgate it. Parking is free. We will also have new camping sites complete with power hookups. There will be Ham seminars both Saturday and Sunday. YL's have a ladies program and door prizes both days. Only the best manufacturers of Ham and computer equipment and their distributors will be at our huge display building for you to meet and buy from. As in the past, Expo will be giving out thousands of dollars worth of prizes and admission tickets are good for both days. For advanced registration, send $3.00 per person and a #10 S.A.S.E. to Radio Expo Tickets, P.O. Box 1532, Evanston, Illinois. Tickets at the gate are $4.00 each. Kids under seven are free. For more information call (312) BST-EXPO. Talk-in on 146.16/.76, 146.52, and 222.5/224.10.

KENTUCKY: The Northern Kentucky A.R.C. Ham-O-Rama on May 31st at the Boone County Fairgrounds in Burlington. Flea Market, exhibits, prizes and more. Admission: $4.00, children under 12 free. More info: Ken Miller, WD8ISC, P.O. Box 257, Erlanger, Kentucky 41018.

MAINE: Yankee Radio Club's Yankee Hamfest '81 on June 20th at the Oxford County Fairgrounds in Oxford. Displays, talks, XYL progam, swap tables, Flea Market, exhibitors, prizes and more. Registration: $8.00, complete with dinner and $7.00 for early registration. Admission at gate: $2.50. Talk-in on 146.28/.88 by Don Dean, W1BYK. More info and tickets: S.A.S.E. to Edward Fahey, Jr., 19 Farwell St., Lewiston, ME 04240.

MARYLAND: The Maryland FM Association's annual Hamfest/Computer show on May 31st at the Howard County Fairgrounds in West Friendship from 8:00 to 4:00. Talk-in on 146.16/.76. Admission: $3.00 donation. More info: MFMA, c/o Heru Walmsley, Post Office, Harmans, Maryland (301) 766-3545.

MARYLAND: Fourth annual Frederick Hamfest on June 21st at the Frederick Fairgrounds from 8:00 to 4:00. Free parking, prizes, demonstrations, exhibits, flea market tables and more. Admission: $3.00. YL's and children free. Talk-in on 146.52. Hamfest directors: Rick, N3RO and Peg, N3AIJ, 9425 Glade Ave., Walkersville, Maryland 21793 (301) 898-3233.

MASSACHUSETTS: The 7th annual Eastern VHF/UHF Conference on May 15th - 17th at the Sheraton Inn Conference Center, I-495 and Rt. 111, Boxborough. Banquet, technical talks, and many activities of interest to serious VHF experimenters. Preregistration is $13.50 from K1LOG, 3 Pryor Rd., Natick, Massachusetts 01760 before May 10th. Registration at the door is $20.00.

MICHIGAN: The Grand Rapids Spring Swap & Shop presented by the Independent Repeater Association on June 6th at the National Guard Armory, 44th Street just 1/4 mile west of US-131. Prizes, dealers, forums, plus much more. Starts at 8:00. Tickets: $2.00. Talk-in on 147.765. More info: David Jenista, WD8NZZ, 437 Airview S.E., Wyoming, Michigan 49508.

MICHIGAN: The Chelsea Swap and Shop on June 7th at the Chelsea Fairgrounds in Chelsea. Starts at 8:00. Admission: $1.50 in advance and $2.00 at the gate. Children under 12 and non-Ham spouses free. Talk-in on 146.52 simplex and 147.885 Chelsea repeater. More info: William Altenberndt, 3132 Timberlane, Jackson, Michigan 49201.

MICHIGAN: Cadillac's 21st annual "Swap Shop and Eyeball QSO" on May 16th at the Michigan National Guard Armory on Haynes Street in Cadillac. Admission: $2.00. Prizes, tables, displays, and more. Starts at 9:00. Talk-in on 146.37/.97. More info via Wexaukee Amateur Radio Association, Box 163, Cadillac, Michigan 49601.

MICHIGAN: Annual Monroe County Radio Communications Hamfest on June 14th at the Monroe Community College on Raisinville Rd. in Monroe. Tickets: $2.00 at the gate and $1.50 in advance. XYL's and children free. Contests, prizes, free parking, auction, displays and more. Talk-in on 146.13/.73 and .52. Starts at 8:00. More info or advanced tickets: Fred Lux WD8ITZ, P.O. Box 982, Monroe, Michigan 48161 or call (313) 243-1088 Hot Line.

NEW JERSEY: The Tri-County Radio Assocations annual indoor Hamfest/Flea Market on May 3rd at the Passaice Township Youth Center, Valley Rd., in Stirling. Donation: $2.00. Food, prizes and more. Starts at 9:00. Talk-in on 147.855/.255 and 146.52. Table reservations ($5.00) or more info: TCRA, Box 412, Scotch Pines, NJ 07076 or call Herb Klawunn, W2CHA at (201) 647-3461.

NEW JERSEY: The Raritan Valley Club, W2QW, will hold its 10th annual Hamfest and Flea Market on June 20th starting at 8:30 at Columbia Park, Kunellen, NJ. Prizes, food and more. Talk-in on 146.625/.025 W2QW and 146.52 simplex. Tickets: $2.00. Sellers: $3.00. More info call KB2EF at (201) 369-7038 from 9:00 to 4:00.

NEW YORK: The Long Island Mobile A.R.C.'s sponsors ARRL Hamfair '81 at the Islip Speedway in Islip. Over 350 exhibitors, food, awards and much more. Date: May 17th. Heavy rain date: June 7th. Call at night for more info: Sid Wolin K2LJH, (516) 379-2861 or Hank Wener WB2ALW, (516) 484-4322. Talk-in on 146.25/.85. Admission: $2.00. Family members are free.

NEW YORK: The Atlantic Division/New York State Convention combined with the Rochester Hamfest will be on May 15th and 16th at the Monroe County Fairgrounds, Route 15A in Rochester. Commercial exhibitors, huge outdoor Flea Market, FCC exams on Saturday, forums, ladies programs, the second annual Memorial Code Contest, prizes, annual banquet, and much much more. Registration: $4.00 in advance and $5.00 at the gate. Tickets: Rochester Hamfest Tickets, 737 Latta Rd., Rochester, NY 14612. More info: P.O. Box 1388, Rochester, NY 14603 or call (716) 424-1100.

OHIO: The Lancaster and Fairfield County A.R.C.'s annual Hamfest on June 21st at the P & R Part barn, four miles west of Lancaster off Route 188. Starts at 9:00. Tickets: $2.00 in advance and $3.00 at the gate. Refreshments, Flea Market tables, many activities for the whole family. Talk-in on 147.63/.03 or 146.52. More info: Box #3, Lancaster, Ohio 43130.

OHIO: The Clinton and Highland County Radio Club's annual Hamfest and Flea Market on June 14th at the Clinton County Fairgrounds on S.R. 22 in Wilmington from 1200 to 2100 UTC. Admission: $3.00. Flea Market space free with admission ticket. Food, auction, prizes and more. Talk-in on 147.72/.12, 147.81/.21, or 146.52. More info: Bob Lewis KE8E, 192 Northview Rd., Blanchester, Ohio 45107 or (evenings) — (513) 783-2740.

PENNSYLVANIA: Reading Radio Club's third annual Hamfest on May 24th in Hamburg. Starts at 8:00. Cash and equipment prizes, indoor/outdoor facilities, and more. Donation admission. Talk-in on 146.31/.91 and 146.52. More info: S.A.S.E. to Box 124, Reading, Pennsylvania 19603.

PENNSYLVANIA: The Breeze Shooters 27th annual Hamfest on May 17th from noon to five at the White Swan Park, on Route 60 (Parkway West) near the Greater Pittsburgh International Airport. Large Flea Market, prizes, contest, amusement park, and more. Admission: $2.00 or three for $5.00. Talk-in on 28/.88 repeater or 29.0

MHz. More info: S.A.S.E. to Don Myslewski K3CHD, 359 McMahon Road, North Huntingdon, Pennsylvania 15642.

PENNSYLVANIA: MARC's (Milton A.R.C.) 10th annual Hamfest on June 14th at the Allenwood Firemen's Fairgounds on U.S. Route 15, four miles north of Interstate 80. Starts at 8:00. Advanced registration: $2.50 and at the gate: $3.00. XYL's and children free. Flea Market, auction, contests and more. Talk-in on 37/.97 and .52 simplex. More info: Harold C. Dennin AC3Q, c/o Milton A.R.C., P.O. Box 235, Milton, Pennsylvania 17847 (717) 538-5455.

RHODE ISLAND: The Newport County Radio Club's auction on May 18th at the club headquarters (Seamen's Church Institute Bldg., 18 Market Square, Newport) Talk-in on 147.96/.36.

VIRGINIA: The Ole Virginia Hams A.R.C.'s seventh annual Manassas Hamfest on June 7th at the Prince William County Fairgrounds in Manassas (30 miles west of Washington D.C. on Route 234). Exhibits, dealers, food, prizes and much more. More info: S.A.S.E. to Ole Viriginia Hams A.R.C., Inc., P.O. Box 1255, Manassas, Virginia 22110.

VIRGINIA: The Lynchburg A.R.C.'s third annual swapfest on May 3rd at the Brookville High School in Lynchburg. Starts at 10:00. Tables, food, free parking, and more. Talk-in on 146.01/.61 and 146.52. More info: Kenneth D. Grimm K4XL, 505 Hayes Dr., Lynchburg, Virginia 24502.

OPERATING EVENTS
"Things to do..."

MAY 3rd: The 50th anniversary of the Reading Radio Club will be celebrated with a special event station (mini-DX-pedition) to Berks County's foremost spot, Virginville. The station W3BN will operate from 1300 UTC to 2200 UTC on May 3rd. Frequencies: 3.950, 7.250, 14.300, 21.400, 29.500, 146.31/.91 phone and 7.125 and 14.045 CW. Special QSL cards available. QSL the RRC direct.

MAY 16th AND 17th: The Blossomland Amateur Radio Association will sponsor a bicentennial expedition to Mackinaw Island during the Michigan QSO party. Operation on 80-10 CW and SSB with 2 meter SSB also planned. Look for W3MAI. S.A.S.E. for special certificate to P.O. Box 175, St. Joseph, Michigan 49085.

MAY 18th: Special Event Station W7AQ. The Yakima A.R.C. will commemorate the "Day The Sun Disappeared" (May 18th, 1980) when Mount St. Helens erupted. Yakima, 80 miles northeast of the volcano, saw the sun disappear by 10:30 and did not see it again until 7:00 the next morning. May 18th was as black as midnight by high noon. Over 600,000 tons of dust covered the city. Commemorate this and W7AQ's 50th year of existence...from 1700 to 0200 hours UTC on May 17th-18th. Listen for W7AQ on 28.660, 21.370, 14.280, 7.285, and 3.940 for SSB. CW will be on 28.120, 21.130, 14.040, 7.140 and 3.740. A special event QSL card will be available. Send a S.A.S.E. to: W7AQ, Yakima A.R.C., P.O. Box 9211, Yakima, Washington 98909.

MAY 31st: The Gabilan A.R.C. will put San Benito County on the air. Times of operation will be from 0800 PDT to 1600 PDT. Times will be extended if activity is good. Frequencies: 28.775 and 21.400 USB and 28.175 and 21.175 slow speed CW. Special certificate and QSL available to those who confirm with a S.A.S.E. QSL to John Kaudet KB6IT, 2001 Scenic Circle, Hollister, California 95023.

JUNE 19th - 21st: The seventh annual Summer Smirk Party Contest from 1900 hours CDT the 19th to 1900 hours the 21st or 0000 hours the 20th to 2400 hours the 21st. UTC/GMT/Z. Exchange SMIRK number and State, Province, Prefecture, or Country. Trophy for overall high score. Entries must be submitted on the Fall, 1980 edition of the official SMIRK log. Single copies available for a S.A.S.E. and photocopies may be used. More info or entries: Don Abell WB5SND, 6821 West Ave., San Antonio, Texas 78213.

THE ATLANTA RADIO CLUB announces the third annual competition for two $500 cash scholarships. Each scholarship will go to a licensed amateur entering college in the Fall of 1981. Deadline for completed application is May 31st; request an application from ARC Scholarship, 259 Wetherstone Parkway, Marietta, GA 30067.

AWARD INFORMATION: Revised. The "10-K" and "20-K" award, formerly issued by the CHC is available from KB7SB, P.O. Box 46032, Los Angeles, California 20046. Work 10 (or 20) stations in the outlying territories and possessions with the miscellaneous K calls (KG4, KC6, KP6, etc.). Send log data and #10 S.A.S.E. to KB7SB. Send 3 units postage for return in mailing tube. DX stations send 2 IRC, CPP will supply the envelope. Limited supply.

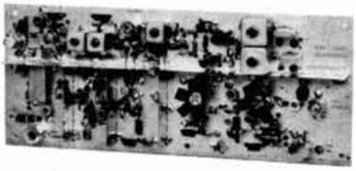
More Details? CHECK—OFF Page 118

Quality VHF/UHF Kits at Affordable Prices~

These Low Cost SSB TRANSMITTING CONVERTERS

Let you use inexpensive recycled 10M or 2M SSB exciters on UHF & VHF!

- Linear Converters for SSB, CW, FM, etc.
- A fraction of the price of other units; no need to spend $300 – $400!
- Use with any exciter; works with input levels as low as 1 mW.
- Use low power tap on exciter or simple resistor attenuator pad (instructions included).
- Link osc with RX converter for transceive.



XV4 UHF KIT — ONLY $99.95

28-30 MHz in, 435-437 MHz out; 1W p.e.p. on ssb, up to 1½W on CW or FM. Has second oscillator for other ranges. Atten. supplied for 1 to 500 mW input, use external attenuator for higher levels.

Extra crystal for 432-434 MHz range............$5.95
XV4 Wired and tested........................$149.95

XV2 VHF KIT - ONLY $69.95

2W p.e.p. output with as little as 1mW input. Use simple external attenuator. Many freq. ranges available.

MODEL	INPUT (MHz)	OUTPUT (MHz)
XV2-1	28-30	50-52
XV2-2	28-30	220-222
XV2-4	28-30	144-146
XV2-5	28-29 (27-27.4 CB)	145-146 (144-144.4)
XV2-7	144-146	50-52

XV2 Wired and tested........................$109.95

XV28 2M ADAPTER KIT - $24.95

Converts any 2M exciter to provide the 10M signal required to drive above 220 or 435 MHz units.

NEW! COMPLETE TRANSMITTING CONVERTER AND PA IN ATTRACTIVE CABINET

Far less than the cost of many 10W units!

Now, the popular Hamtronics® Transmitting Converters and heavy duty Linear Power Amplifiers are available as complete units in attractive, shielded cabinets with BNC receptacles for exciter and antenna connections. Perfect setup for versatile terrestial and OSCAR operations! Just right for phase 3! You save $30 when you buy complete unit with cabinet under cost of individual items. Run 40-45 Watts on VHF or 30-40 Watts on UHF with one integrated unit! Call for more details.

MODEL	KIT	WIRED and TESTED
XV2/LPA2-45/Cabt (6,2,or220)	$199.95	$349.95
XV4/LPA4-30/Cabt (for UHF)	$229.95	$399.95

Easy to Build FET RECEIVING CONVERTERS

Let you receive OSCAR and other exciting VHF and UHF signals on your present HF or 2M receiver

- NEW LOW-NOISE DESIGN
- ATTRACTIVE WOODGRAIN CASE
- Less than 2dB noise figure, 20dB gain

MODEL	RF RANGE	OUTPUT RANGE
CA28	28-32 MHz	144-148 MHz
CA50	50-52	28-30
CA50-2	50-54	144-148
CA144	144-146	28-30
CA145	145-147–or– 144-144.4	28-30 27-27.4 (CB)
CA146	146-148	28-30
CA220	220-222	28-30
CA220-2	220-224	144-148
CA110	Any 2MHz of Aircraft Band	26-28 or 28-30
CA432-2	432-434	28-30
CA432-5	435-437	28-30
CA432-4	432-436	144-148

Easily modified for other rf and if ranges.

STYLE	VHF	UHF
Kit less case	$34.95	$49.95
Kit with case	$39.95	$54.95
Wired/Tested in case	$54.95	$64.95

Professional Quality VHF/UHF FM/CW EXCITERS

- Double tuned circuits for spurious suppression
- Easy to align with built-in test aids

T51-30	10 Meter, 2W Kit	$44.95
T51-50	6 Meter, 2W Kit	$44.95
T51-150	2 Meter, 2W Kit	$44.95
T51-220	220 MHz, 2W Kit	$44.95
T450	450 MHz, 3/4W Kit	$44.95
T451	450 MHz, 3 W Kit	$59.95
A14T	5 Chan Adapter (T51&T451)	$9.95

See our Complete Line of VHF & UHF Linear PA's

- Use as linear or class C PA
- For use with SSB Xmtg Converters, FM Exciters, etc.

LPA2-15	6M, 2M, 220; 15 to 20W	$59.95
LPA2-30	6M, 2m; 25 to 30W	$89.95
LPA2-40	220 MHz; 30 to 40W	$119.95
LPA2-45	6M, 2M; 40 to 45W	$119.95
LPA4-10	430MHz; 10 to 14W	$79.95
LPA4-30	430MHz; 30-40W	$119.95

See catalog for complete specifications

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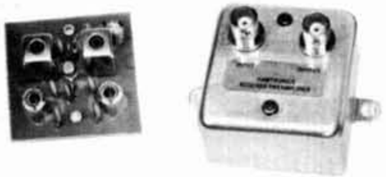
Let you hear the weak ones too! Great for OSCAR, SSB, FM, ATV. Over 14,000 in use throughout the world on all types of receivers.



- NEW LOW-NOISE DESIGN
- Less than 2 dB noise figure, 20 dB gain
- Case only 2 inches square
- Specify operating frequency when ordering

MODEL P-30 VHF PREAMP, available in many versions to cover bands 28-300 MHz.

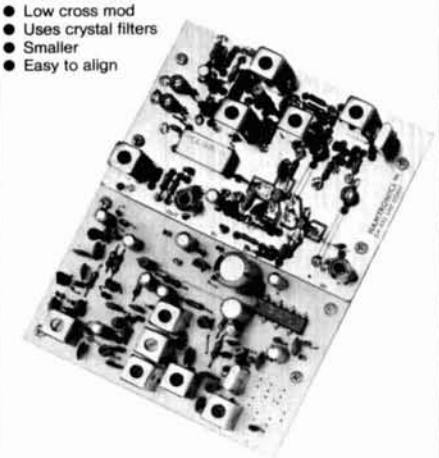
MODEL P432 UHF PREAMP, available in versions to cover bands 300-650 MHz.

STYLE	VHF	UHF
Kit less case	$12.95	$18.95
Kit with case	$18.95	$26.95
Wired/Tested in Case	$27.95	$32.95

NEW VHF/UHF FM RCVRS

Offer Unprecedented Range of Selectivity Options

- New generation
- More sensitive
- More selective
- Low cross mod
- Uses crystal filters
- Smaller
- Easy to align



R75A* VHF Kit for monitor or weather sattelite service. Uses wide L-C filter. -60dB at ± 30 kHz........$69.95

R75B* VHF Kit for normal nbfm service. Equivalent to most transceivers. -60dB at ± 17 kHz, -80dB at ± 25 kHz...$74.95

R75C* VHF Kit for repeater service or high rf density area. -60dB at ±14kHz, -80dB ±22kHz, -100dB ±30kHz....$84.95

R75D* VHF Kit for split channel operation or repeater in high density area. Uses 8-pole crystal filter. -60dB at ±9 kHz, -100dB at ± 15 kHz. The ultimate receiver!...$99.95

*Specify band: 10M, 6M, 2M, or 220 MHz. May also be used for adjacent commercial bands. Use 2M version for 137 MHz WX satellites.

R450( ) UHF FM Receiver Kits, similar to R75, but for UHF band. New low-noise front end. Add $10 to above prices. (Add selectivity letter to model number as on R75.)

A14 5 Channel Adapter for Receivers.............$9.95

NEW R110 VHF AM RCVR

AM monitor receiver kit similar to R75A, but AM. Available for 10-11M, 6M, 2M, 220 MHz, and 110-130 MHz aircraft band $74.95. (Also available in UHF version.)

IT'S EASY TO ORDER!

- Write or phone 716-392-9430 (Electronic answering service evenings & weekends)
- Use Credit Card, UPS COD, Check, Money Order
- Add $2.00 shipping & handling per order

Call or Write to get FREE CATALOG With Complete Details
(Send 4 IRC's for overseas mailing)

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More Details? CHECK — OFF Page 118

the ham notebook

using a 2-meter quarter-wave whip on 450 MHz

Many Amateurs who enjoy operating 2-meter fm also use a local 450-MHz repeater. One problem facing the dual-band mobile aspirant is placing two separate antennas on the car without jeopardizing its resale value.

Because the best location is the center of the roof and two antennas can't occupy the same place at the same time, I propose the use of a single antenna for both bands. Fortunately, because of the direct third-harmonic relationship between the popular 146-148 MHz and 442-450 MHz repeater sub-bands, a conventional 1/4-wave, 2-meter whip will perform admirably on both bands. At 450 MHz, the whip performs as a 3/4-wave antenna with a 50-ohm impedance. Although the 3/4-wave antenna has a higher angle of radiation than a 5/8 or 1/4 wave, this effect is negligible.

It has been pointed out in the past that a roof-mounted 1/4-wave whip on 2 meters will often outperform a 5/8-wavelength antenna at highway driving speeds because of the way the 5/8 flexes in the wind.

Note that, for best results, the whip should be pruned for best VSWR at the 450-MHz operating frequency.

Peter J. Bertini, K1ZJH

---

aligning Yagi beam elements

a correction

Some essential information was inadvertently omitted from Roy Lehner's article in the January, 1981 issue of *ham radio*. The complete article is presented below. **Editor.**

Assembling beam elements so that they are in line with each other and also parallel to the ground can be a frustrating experience when eyeball or ground-assembly methods are used. The scheme shown in the drawing provides a neat installation in a few minutes and doesn't require any special tools other than a small level. The steps below refer to the numbers in **fig. 1**.

1. Lay boom on concrete blocks or other suitable support.

2. A dummy mast stabilizes the boom structure by virtue of its offset, downward weight and does not permit boom to rotate while performing step **3**. Alignment of mast must be perfectly vertical (see detail A-A), and can be accomplished by sliding mast up or down relative to the boom-to-mast plate. Be sure that this mast rests on firm ground and can't slip through the clamps.

3. Again, using the small level, align the individual elements so they are parallel to the ground. Place the level on top of each element and as close to the boom as possible. A slight downward indication may be noticed due to the weight of the element; in this case, adjust for an equal declination on both sides of the boom.

Roy Lehner, WA2SON

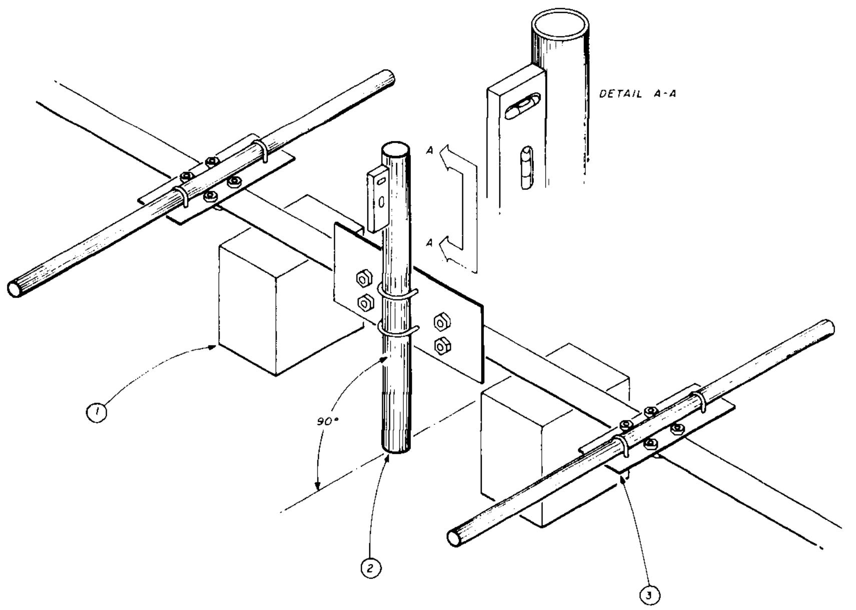


fig. 1

modification of K9LHA 2-meter synthesizer for 144-148 MHz coverage

The 2-meter CMOS frequency synthesizer described in *ham radio* for December, 1979, can be modified for full 2-meter band coverage by making the following modifications:

1. Remove the jumpers on pins 8 and 9 of U1 (CD4059).

2. Change the two high-frequency crystals (Y1 and Y2) to $47.333 - \frac{i\text{-}f}{3}$ *MHz* and *47.3333 MHz* respectively.

3. Provide a modified switch code for the MHz range switch as shown below.

4. Increase the VCO tuning range as required by increasing the size of the padding capacitor (C12).

MHz switch code (revised)

A new switch code is needed for the MHz switch for the increased frequency coverage. In addition to pin 10, which is programmed in the existing design, this switch code must be applied to pins 8 and 9, which were previously fixed in programming. A three-pole rotary switch can be used for each MHz range switch, or additional toggle switches can be used to select two coverage ranges: 144-146 and 146-148 MHz. This latter method is probably the simplest and cheapest, although it lacks the simplicity of directly reading frequency that the rotary switches would provide. The new MHz code is as follows:

MHz	pin 8	pin 9	pin 10
144	0	1	0
145	0	1	1
146	1	0	0
147	1	0	1

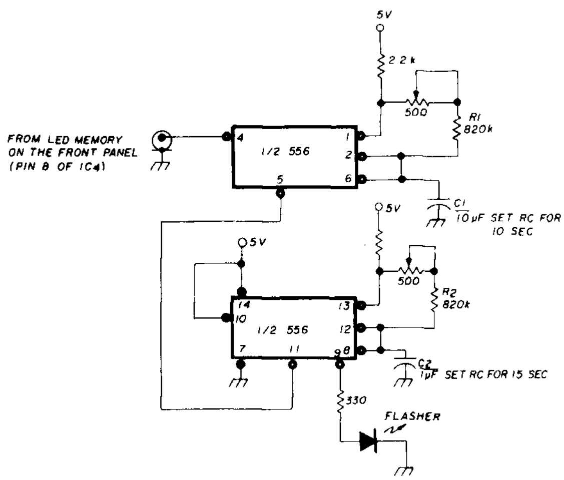
Tom Cornell, K9LHA

CW memory modification

The November, 1980, issue of *ham radio* had a fine article on a CW memory circuit by Ray Megirian, K4DHC.[1] I assembled the circuit on a perf board and installed it in a 7 × 5 × 4 inch (17.8 by 12.7 by 10 cm) cabinet with an internal power supply.

After I'd become familiar with the unit, I realized that the LED indication of one-half memory remaining during any keyed-in message left something to be desired, since it was too difficult to estimate remaining storage time while keying. Once the balance of memory was overridden, the additional data could not be stored.

fig. 2. CW memory[1] modification to add delayed second-LED flasher to memory, indicating reserve. One-half of the 556 holds the input high for 10 seconds. The second half is modulated by the first at pin 11 and allowed to flash on/off five times, which leaves approximately 6 seconds of memory storage before the LED light goes out.



circuit

A simple and easy add-on solution was made using the familiar NE555 in the dual 556 package (**fig. 2**). I assembled the circuit on a 2 by 1½ inch (5 by 3.8 cm) piece of perf board.

The one-half LED ON time came to about 20 seconds, as timed by the sweep second hand of my watch. I arbitrarily elected to use a flashing LED display to be set for five flashes and off, after which 5 seconds of storage remained for final keying.

The first section of the 556 was set up as a monostable with its time constant — determined by R1, C1 and the series 820-k resistor — as 10 seconds. The second, or flashing, section of the 556 was set up as an astable free-running oscillator, frequency modulated through pin 11 from pin 5 of the first monostable section. Timing in both cases was set by the miniature 500k pots.

operation

Since the trigger input to the first 556 section is taken directly from pin 8 of IC4 in Merigian's article,[1] timing begins as soon as that LED fires. The new timing (flasher) LED also fires and repeats for four additional flashes, equaling the passing of 15 seconds, after which it extinguishes. The storage LED will remain ON for the remaining 5 seconds of storage time.

You can make your own adjustments as to start and number of flashes with R1, R2. I first considered using only three flashes, in which case the 820k series resistor on R2 should be increased to 1 meg. However, I react only to the halting of the flashing during input keying, so I selected five flashes.

reference

1. Ray Megirian, K4DHC, "Simple CW Memory," *ham radio*, November, 1980, pages 46-47.

Gene Shapiro, WØDLQ

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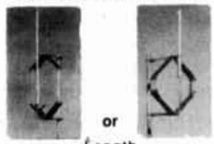

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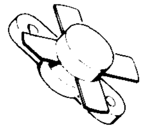

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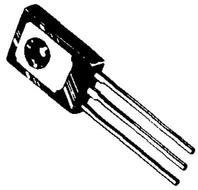

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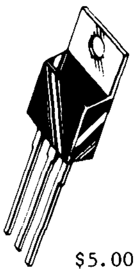

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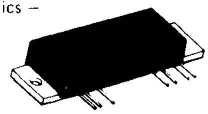

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561	DC to 10MHZ Scope Rack Mount	150.00
561A	DC to 10MHZ Scope Rack Mount	200.00

Scopes with Plug-in's

561A	DC to 10MHZ Scope with a 3S76 Dual Trace DC to 875MHZ Sampling Plug In and a 3T77A Sweep Plug In. Rack Mount	600.00
565	DC to 10MHZ Dual Beam Scope with a 2A63 Diff and a 2A61 Diff. Plug In's	900.00
581	DC to 80MHZ Scope with a 82 Dual Trace High Gain Plug In	650.00

Tubes

2E26	$ 5.00	4CX350FJ	$116.00	6146W	12.00
3-500Z	102.00	4CX1000A	300.00	6159	10.60
3-1000Z	268.00	4CX1500B	350.00	6161	75.00
3B28/866A	5.00	4CX15000A	750.00	6293	18.50
3X2500A3	150.00	4E27	50.00	6360	6.95
4-65A	45.00	4X150A	41.00	6907	40.00
4-125A	58.50	4X1500	52.00	6939	14.75
4-250A	68.50	4X150G	74.00	7360	12.00
4-400A	71.00	5728/T160L	39.00	7984	10.40
4-1000A	184.00	6LF6	5.00	8072	49.00
5-500A	145.00	6LQ6	5.00	8106	2.00
4CX250B	65.00	811A	12.95	8156	7.85
4CX250F/G	55.00	813	29.00	8226	127.70
4CX250K	113.00	5894/A	42.00	8295/PL172	328.00
4CX250R	92.00	6146	5.00	8458	25.75
4CX300A	147.00	6146A	6.00	8560A/AS	50.00
4CX350A	107.00	6146B/8298A	7.00	8908	9.00
				8950	9.00

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MHz electronics

MICROWAVE COMPONENTS

ARRA	DESCRIPTION	PRICE
2416	Variable Attenuator	$ 50.00
3614-60	Variable Attenuator 0 to 60 dB	75.00
KU520A	Variable Attenuator 18 to 26.5 GHz	100.00
4684-20C	Variable Attenuator 0 to 180 dB	100.00
6684-20F	Variable Attenuator 0 to 180 dB	100.00

General Microwave

Directional Coupler 2 to 4 GHz 20 dB Type N		75.00

Hewlett Packard

H487B	100 ohms Neg. Thermistor Mount (NEW)	150.00
H487B	100 ohms Neg. Thermistor Mount (USED)	100.00
477B	200 ohms Neg. Thermistor Mount (USED)	100.00
X487A	100 ohms Neg. Thermistor Mount (USED)	100.00
X487B	100 ohms Neg. Thermistor Mount (USED)	125.00
J468A	100 ohms Neg. Thermistor Mount (USED)	150.00
478A	200 ohms Neg. Thermistor Mount (USED)	150.00
J382	5.85 to 8.2 GHz Variable Attenuator 0 to 50 dB	250.00
X382A	8.2 to 12.4 GHz Variable Attenuator 0 to 50 dB	250.00
NK292A	Waveguide Adapter	65.00
8436A	Bandpass Filter 8 to 12.4 GHz	75.00
8471A	RF Detector	50.00
H532A	7.05 to 10 GHz Frequency Meter	300.00
G532A	3.95 to 5.85 GHz Frequency Meter	300.00
J532A	5.85 to 8.2 GHz Frequency Meter	300.00
809A	Carriage with a 444A Slotted Line Untuned Detector Probe and 809B Coaxial Slotted Section 2.6 to 18 GHz	175.00
X347A	8.2 to 12.4 GHz Noise Source	500.00
S347A	2.6 to 3.95 GHz Noise Source	600.00
G347A	3.95 to 5.85 GHz Noise Source	500.00
J347A	5.85 to 8.2 GHz Noise Source	500.00
H347A	7.05 to 10 GHz Noise Source	540.00
349A	400 to 4000 MHz Noise Source	310.00
P532A	12.4 to 18 GHz Frequency Meter	400.00
M532A	Frequency Meter	500.00
P382A	0-50 dB Attenuator	520.00
355C	.5 Watts, 50 Ohm DC to 1,000 MC Attenuator	132.50
NK292A	Adapter	100.00
3503	Microwave Switch	100.00
33001C	Pin Absorption Modulator	295.00
11660A	Tracking Generator Shunt	50.00
11048C	Feed-through Termination	25.00
10100B	Termination	25.00
H421A	7.05 to 10 GHz Crystal Detector	75.00
H421A	7.05 to 10 GHz Crystal Detector — Matched Pair	200.00

Merrimac

AU-26A/	801162 Variable Attenuator	100.00

Microlab/FXR

X638S	Horn 8.2 to 12.4 GHz	60.00
601-B18	X to N Adapter 8.2 to 12.4 GHz	35.00
Y610D	Coupler	75.00

Narda

4013C-10/	22540A Directional Coupler 2 to 4 GHz 10 dB Type SMA	90.00
4014-10/	22538 Directional Coupler 3.85 to 8 GHz 10 dB Type SMA	90.00
4014C-6/	22876 Directional Coupler 3.85 to 8 GHz 6 dB Type SMA	90.00
4015C-10/	22539 Directional Coupler 7.4 to 12 GHz 10 dB Type SMA	95.00
4015C-30/	23105 Directional Coupler 7 to 12.4 GHz 30 dB Type SMA	95.00
3044-20	Directional Coupler 4 to 8 GHz 20 dB Type N	125.00
3040-20	Directional Coupler 240 to 500 MC 20 dB Type N	125.00
3043-20/	22006 Directional Coupler 1.7 to 4 GHz 20 dB Type N	125.00
3003-10/	22011 Directional Coupler 2 to 4 GHz 10 dB Type N	75.00
3003-30/	22012 Directional Coupler 2 to 4 GHz 30 dB Type N	75.00
3043-30/	22007 Directional Coupler 1.7 to 3.5 GHz 30 dB Type N	125.00
22574	Directional Coupler 2 to 4 GHz 10 dB Type N	125.00
3033	Coaxial Hybrid 2 to 4 GHz 3 dB Type N	125.00
3032	Coaxial Hybrid 950 to 2 GHz 3 dB Type N	125.00
784/	22380 Variable Attenuator 1 to 90 dB 2 to 2.5 GHz Type SMA	550.00
22377	Waveguide to Type N Adapter	35.00
720-6	Fixed Attenuator 8.2 to 14.4 GHz 6 dB	50.00
3503	Waveguide	25.00

PRD

U101	12.4 to 18 GHz Variable Attenuator 0 to 60 dB	300.00
X101	8.2 to 12.4 GHz Variable Attenuator 0 to 60 dB	200.00
C101	Variable Attenuator 0 to 60 dB	200.00
205A/367	Slotted Line with Type N Adapter	100.00
195B	8.2 to 12.4 GHz Variable Attenuator 0 to 50 dB	100.00
185BS1	7.05 to 10 GHz Variable Attenuator 0 to 40 dB	100.00
196C	8.2 to 12.4 GHz Variable Attenuator 0 to 45 dB	100.00
170B	3.95 to 5.85 GHz Variable Attenuator 0 to 45 dB	100.00
588A	Frequency Meter 5.3 to 6.7 GHz	100.00
140A, C, D, E	Fixed Attenuators	25.00
109J, I	Fixed Attenuators	25.00
WEINSCHEL ENG.	2692 Variable Attenuator + 30 to 60 dB	100.00

COMPUTER I.C. SPECIALS

MEMORY	DESCRIPTION	PRICE
2708	1K x 8 EPROM	$ 7.99
2716/2516	2K x 8 EPROM 5 Volt Single Supply	20.00
2114/9114	1K x 4 Static RAM 450ns	6.99
2114L2	1K x 4 Static RAM 250ns	8.99
2114L3	1K x 4 Static RAM 350ns	7.99
4027	4K x 1 Dynamic RAM	3.99
4060/2107	4K x 1 Dynamic RAM	3.99
4050/9050	4K x 1 Dynamic RAM	3.99
2111A-2/8111	256 x 4 Static RAM	3.99
2112A-2	256 x 4 Static RAM	3.99
2115AL-2	1K x 1 Static RAM 55ns	4.99
6104-3/4104	4K x 1 Static RAM 320ns	14.99
7141-2	4K x 1 Static RAM 200ns	14.99
MCM6641L20	4K x 2 Static RAM 200ns	14.99
9131	1K x 1 Static RAM 300ns	10.99

C.P.U.'s ETC.

MC6800L	Microprocessor	13.80
MCM6810AP	128 x 8 Static RAM 450ns	3.99
MCM68A10P	128 x 8 Static RAM 360ns	4.99
MCM68B10P	128 x 8 Static RAM 250ns	5.99
MC6820P	PIA	8.99
MC6820L	PIA	9.99
MC6821P	PIA	8.99
MC68B21P	PIA	9.99
MCM6830L7	Mikbug	14.99
MC6840P	PTM	8.99
MC6845P	CRT Controller	29.50
MC6845L	CRT Controller	33.00
MC6850L	ACIA	10.99
MC6852P	SSDA	5.99
MC6852L	SSDA	11.99
MC6854P	ADLC	22.00
MC6860CJCS	0-600 BPS Modem	29.00
MC6862L	2400 BPS Modem	14.99
MK3850N-3	F8 Microprocessor	9.99
MK3852P	F8 Memory Interface	16.99
MK3852N	F8 Memory Interface	9.99
MK3854N	F8 Direct Memory Access	9.99
8008-1	Microprocessor	4.99
8080A	Microprocessor	8.99
Z80CPU	Microprocessor	14.99
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2650	Microprocessor	10.99
TMS1000NL	Four Bit Microprocessor	9.99
TMS4024NC	9 x 64 Digital Storage Buffer (FIFO)	9.99
TMS6011NC	UART	9.99
MC14411	Bit Rate Generator	11.99
AY5-4007D	Four Digit Counter/Display Drivers	8.99
AY5-9200	Repertory Dialer	9.99
AY5-9100	Push Button Telephone Dialers	7.99
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AY3-8500	TV Game Chip	5.99
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PR1472B	UART	9.99
PT1482B	UART	9.99
8257	DMA Controller	9.99
8251	Communication Interface	9.99
8228	System Controller & Bus Driver	5.00
8212	8 Bit Input/Output Port	5.00
MC14401CP	2 of 8 Tone Encoder	9.99
MC14412	Low Speed Modem	14.99
MC14408	Binary To Phone Pulse Converter	12.99
MC14409	Binary To Phone Pulse Converter	12.99
MC1488L	RS232 Driver	1.00
MC1489L	RS232 Receiver	1.00
MC1405L	A/D Converter Subsystem	9.00
MC1406L	6 Bit D/A Converter	7.50
MC1408/6/7/8	8 Bit D/A Converter	4.50
MC1330P	Low Level Video Detector	1.50
MC1349/50	Video IF Amplifier	1.17
MC1733L	LM733 OP Amplifier	2.40
LM565	Phase Lock Loop	2.50

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NEW GUNNPLEXER COOKBOOK

See Page 104

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- Signal Generators For Receiver Alignment
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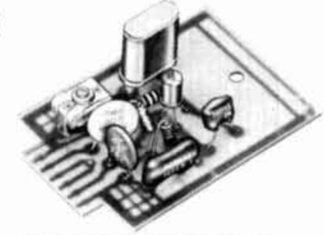
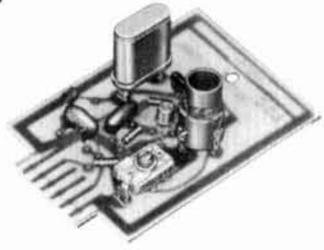


Five transistor oscillators covering 20 MHz-160 MHz. Standard 77°F calibration tolerance ± .0025%. The frequency tolerance is ±.0035%. Oscillator output is .2 volts (min.) across 51 ohms. Power requirement: 9 vdc @ 10 ma. max.

Catalog Number	Oscillator Type	Oscillator Range	Temperature Tol. −40°F to 150°F	Oscillator (Less Crystal) Price
035200	OT-124	20-40 MHz	±.0035%	$10.21
035201	OT-146	40-60 MHz	±.0035%	10.21
035202	OT-161	60-100 MHz	±.0035%	10.21
035203	OT-1140	100-140 MHz	±.0035%	10.21
035204	OT-1160	145-160 MHz	±.0035%	10.21

LOW FREQUENCY (70 KHz - 20,000 KHz)

- Band Edge Markers
- Frequency Markers For Oscilloscopes
- Portable Signal Standards
- Accessory Cases



Four transistor oscillators covering 70 KHz — 20,000 KHz. Trimmer capacitor for zeroing crystal. When oscillator is ordered with crystal the standard will be ±.0025%. Oscillator output is 1 volt (min.) across 470 ohms. Power requirement: 9 vdc @ 10 ma. max.

Catalog Number	Oscillator Type	Oscillator Range	Temperature Tol. −40°F to 150°F	Oscillator (Less Crystal) Price
035205	OT-11	70-150 KHz	±.015%	$10.21
035206 035207	OT-12A OT-12	150-400 KHz 400-5,000 KHz	200-600 KHz ±.01% 600-5,000 KHz ±.0035%	10.21 10.21
035208	OT-13	2,000-12,000 KHz	±.0035%	10.21
035209	OT-14	10,000-20,000 KHz	±.0035%	10.21

SUPPLEMENTAL CRYSTAL ORDERING INFORMATION FOR ICM OSCILLATORS

Please refer to the "4" Series Crystal Specification Sheets. **(Available on request.)** Prices on crystals will vary with frequency being ordered.

CALIBRATION TEMPERATURE:
Customer's choice, usually 26°C.

RANGE: Depends on crystal frequency being ordered.

TYPE: CS ② is recommended.

HOLDER:
F-605 ① for all except crystals below 160 KHz.
F-13 ⑧ required for crystals below 160 KHz.

LOAD:
OT-11, OT-12, OT-12A . . . 24PF ④
OT-13, OT-14 . . . . 20PF ③
OT-124, OT-146, OT-161,
OT-1140, OT-1160 . . . . . . SERIES ⓪
ALIGNMENT OSCILLATORS,
Models 812, 814 . . . . 32PF ⑤

Note: Circled numbers refer to numbers on Crystal Specification Sheets.

EXAMPLES

OT-11 Catalog Number = 4 1 1 2 8 4 (75 KHz*, CS, F-13 Holder, 24PF)

OT-14 Catalog Number = 4 3 3 2 1 3 (10.5 MHz*, CS, F-605 Holder, 20PF)

OT-1140 Catalog Number = 4 7 4 2 1 0 (120 MHz*, CS, F-605 Holder, Series)

**All "4" Series Catalog Numbers require crystal frequency specified by Customer.*

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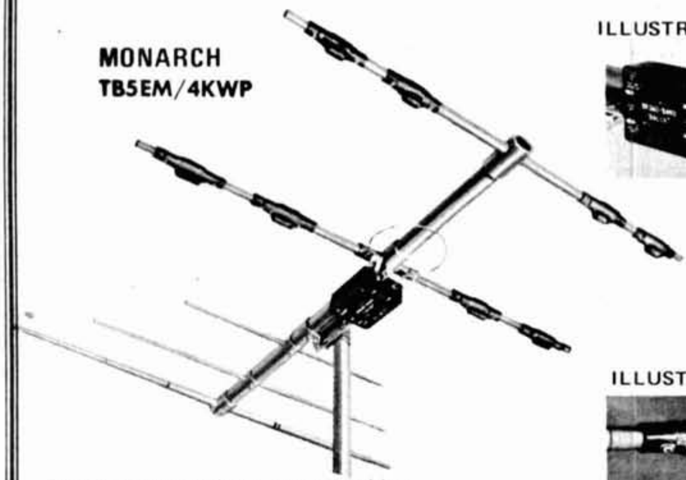
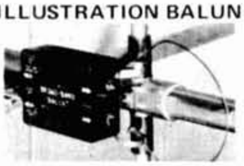


ILLUSTRATION BALUN



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June 1, 1981
See page 82

DX=

The Cubic 103. If you're looking for DX, the Cubic 103 is the rig you should be looking at. Because it's all solid state, state-of-the-art design and construction, with all bands,160-10 Meters (including the WARC bands) installed and operating. With Dual PTO's dual 8-pole filters (1.4:1 shape factor), true passband tuning, speech processor, 235 watts input and RF/IF gain controls, the 103 has the performance that's necessary for exeptional operation under the high cross modulation conditions found on today's crowded bands.

If you're lookin for DX, look no further. DX is the new Cubic 103.

The suggest retail price of the Cubic 103 is $1395.00. But a lower quote is just a phone call away.

The Specs: Solid State Construction, Dual PTO's for split frequency operation. All bands installed and operating, 160-10 Meters, including the 3 new WARC bands. 235 watts input. Fast break in (QSK). RTTY. VOX. Jack for separate receive antenna. Fully variable, AGC delay. Dual, 8-pole filters with 1.4:1 shape factor, −6 to −100 dB. Soft or hard CW out put pulse shaping. Sophisticated noise blanker. Exceptional dynamics: Noise floor −132 dBm; 3rd order intercept +15 dBm.

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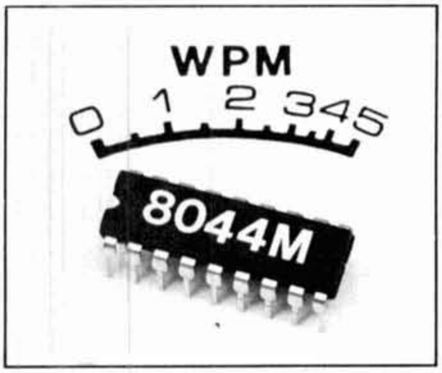
NEW products

Curtis 8044M adds speedmeter output

An enhancement of the popular 8044 CMOS keyer has been introduced by Curtis Electro Devices. Called the 8044M, this new integrated circuit adds an output designed to drive an analog meter for speed indication. Speed indication from 6 WPM to as high as 100 WPM can be accomplished by simply adding two capacitors, a resistor, and a 100-μA meter. The meter indication can be calibrated to be well within a 5 percent tolerance. The reading is stable, even at the lowest speeds.



The addition of two extra pins at the end of the package permits a pin-for-pin fit with the standard 8044. One of the pins is used for a timing capacitor and the other pin drives the meter directly. This allows retrofitting in many existing keyers with relative ease. The keyer function of the 8044M remains the same as in the 8044 design, providing dot and dash memories, iambic operation, key debouncing, weight control, monitor oscillator, and extremely low power dissipation.

Housed in an 18-pin plastic package, the 8044M is priced at $19.95 and is available from Curtis dealers or factory stock. Two kits are available to help in construction of a quality keyer. The 8044M-3 offers the IC, a PCB, edge connector, socket and manual for $29.95. The 8044M-4 is more complete offering all parts except chassis, knobs, jacks, switches, speaker, meter, and power supply. It is priced at $59.95. Various suitable meters are also available and are priced at $7.95. For further information, contact Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040.

"no-stretch" guys

Lightweight, noncorroding guys offered by Philadelphia Resin Corporation provide significant improvements in tension-elongation properties when compared with galvanized IPS wire strand, GRP rod and Phillystran PS29 (the manufacturer's original flexible, dielectric guys).

The new Phillystran HPTG tower guys are smaller in diameter and lighter than earlier Phillystran guys. Hence, wind resistance has been decreased and there is significantly less surface for ice accumulation. Weather resistance has been further increased by a new extruded olefin, copolymer jacket, which ensures complete protection against ultraviolet degradation.

The termination of factory-assembled, cut-to-length, dielectric guys has been upgraded with an improved potting system. However, the major improvement in Phillystran HPTG is its much lower elongation, not exceeding 0.3 per cent at normal working loads. This extremely low elongation — and the negligible creep of an assembled guying system — significantly decreases tower deflections, while providing riggers with the convenience of tension-once and walk-away installations.

The new dielectric tower guys incorporate all of the advantages provided by Phillystran guys, including the following:

Elimination of white-noise arcing, EMI, and complaints about TV reception near radio-broadcast sites.

Significantly fewer labor hours required to guy a new tower or to reguy an existing tower.

No insulators or painting required.

Resistant to icing and inclement weather.

High strength-to-weight ratio.

No problems with fire. A short, steel lead line is recommended between each ground-level turnbuckle and each flexible, dielectric guy.

Unlike conventional metal guys, Phillystran is not affected by salt-laden atmospheres or by airborne pollution from industrial plants or automobiles. It also has no internal-corrosion problems. On an installed-cost basis, the flexible, lightweight dielectric tower guys compare very favorably with insulated steel guys.

For more information, contact Rosely Stranski at Philadelphia Resins Corporation, Montgomeryville, Pennsylvania 18936.

police/fire converter

The new MFJ police/fire converter, model MFJ-311, will convert any 2-meter synthesized or VFO rig to cover the VHF-band police and fire frequencies. If your rig covers 144-148 MHz, just insert the MFJ-311 in line with the antenna, connect power, and turn on the converter, now you can receive 154-158 MHz. If your rig covers a larger or smaller section of the band, then with the MFJ-311 you can receive a correspondingly larger or smaller section of the VHF police and fire band. The frequencies between 154 and 158 MHz contain nearly all FCC allocated VHF police/fire activity.

You have direct frequency readout from your rig. If your rig indicates that you are receiving 145.55 MHz, just turn the converter on and you are receiving 155.55 MHz. A push-button switch turns the MFJ-311 on and off. In the off position, the converter is

See Page 104

NEW products

bypassed and you are ready to transmit (very low insertion SWR). If you forget and transmit with the converter on, it won't burn out (up to 25 watts).

Enjoy all the benefits of your rig, such as squelch, excellent sensitivity, selectivity, and stability. If your rig scans, then you can scan the police band. If your rig will search, then this will enable you to find new and exciting frequencies in the police/fire band. This new Police/Fire Explorer is small (only 3 × 4 × 1 inches) and has a mobile mounting bracket for installation in your car. It is black and eggshell white, and operates on 9-18 Vdc. The MFJ-311 retails for only $49.95. Contact MFJ Enterprises, P.O. Box 494, Mississippi State, Mississippi 39762.

diode selector guide

Motorola announces its new, free RF Signal-Processing Diodes Selector Guide. The six-page manual lists all Motorola tuning diodes for frequency control, plus hot-carrier diodes for mixing and detection, and PIN diodes for switching.

Included in this handy reference are several useful design curves, package information, and reliability data. To order the RF Signal Processing Diodes Selector Guide, write to Motorola Semiconductor Group, P.O. Box 20912, Phoenix, Arizona 85036.

new Hamtronics® kits

Hamtronics, Inc., has announced a new single-channel UHF fm exciter called the model T451. Patterned after the popular T450 exciter, the new unit is rated at 2 watts continuous output and is contained on a 3 × 5½ inch PC board. It is designed for the 50, 144, and 220 MHz bands and may be modified for use on adjacent commercial and government bands. It is ideal for control links, repeater service, telemetry, and other applications for which a small unit is required. A multichannel adapter is also available to extend operation up to five channels.

Features include low-impedance dynamic mike and high level audio inputs; crisp, clear modulation; low spurious output; pre-wound coils; adjustable output level; and built-in test points for easy alignment. A commercial-grade frequency stability option is available. The price of the T451 is only $59.95.

For further information, contact Hamtronics, Inc., 65F Maul Road, Hilton, New York 14468.

lightning protection

The new Zap Trapper, introduced by PolyPhaser Corporation, significantly outperforms previous lightning protection apparatus for communications antennas, cable, and equipment. The Zap Trapper impulse suppressor utilizes controlled atmospheric technology to ensure a microsecond response to lightning impulses, plus multiple impulse suppression, which is especially critical for the protection of today's solid-state communications equipment. Specifications, type N: bandwidth, 0.1 MHz to 1000 MHz; insertion loss, 0.1 dB maximum at 1000 MHz; VSWR, 1.15:1 at 1000 MHz; impedance, 50 ohms constant.

For more information, contact PolyPhaser Corporation, 1500 West Wind Boulevard, Kissimmee, Florida 32741.

antenna tuner

Designed to enhance reception throughout the 10-kHz through 30-MHz spectrum, this new shortwave/longwave antenna tuner boasts the widest frequency coverage of any tuner on the market.

The wideband tuner preselects desired signals while reducing or eliminating intermodulation, cross-modu-

NEW products

lation, images, and desensitization from unwanted signals.

Front-panel switching allows push-button selection of two antennas and two receivers, while a front tuning dial permits signal enhancement.

Guaranteed to improve reception on any shortwave or longwave receiver, the wideband tuner sells for only $59.95 plus $1.75 shipping and handling. Order toll-free by calling (800) 438-8155 or by writing Grove Enterprises, Inc., Dept. Y, Brasstown, North Carolina 28902.

transceiver preamplifier

Palomar Engineers announces a new preamplifier which is continuously tunable, and covers all Amateur bands from 160 through 6 meters. It provides 20 dB of gain with a dual-gate FET for low noise figure. The gain and noise figure greatly improve reception on most receivers, particularly on the higher frequency bands. The added selectivity reduces image and spurious response.

Gain is continuously variable to prevent overloading the receiver. An rf-sensing circuit allows the unit to be used with transceivers; the preamplifier automatically bypasses itself during transmit. The fail-safe switching circuit handles transceivers to 350 watts. Connectors are SO-239. The preamplifier measures 8 × 5 × 3 inches, and features an attractive brushed-aluminum control panel.

For free descriptive brochure write Palomar Engineers, P.O. Box 455, Escondido, California 92025.

Jim-pak electronic components

One-Stop Component Center ™

This is a partial listing of over 500 items available from 500 authorized Jim-pak Distributors:

TTL

7400	2/.85	7490	.85
7402	2/.85	7493	.85
7404	2/.85	74100	2.25
7406	2/1.19	74109	2/1.19
7407	2/1.19	74121	.69
7408	2/.89	74123	.99
7410	2/.85	74150	1.95
7414	.99	74154	1.95
7417	2/1.10	74157	.99
7420	2/.85	74161	1.19
7447	1.19	74164	1.59
7474	.69	74174	1.59
7475	.79	74175	1.49
7476	.69	74192	1.19
7485	1.19	74193	1.19
7486	2/1.19	74367	.99
7489	2.99	74393	1.95

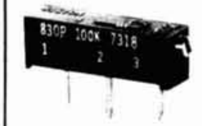
GRAB BAGS

GB100 Cer. Caps. (100)	2.95	GB123 Heat Sinks (30)	3.95
GB101 Mylar Caps. (60)	4.95	GB127 Transistors (100)	3.95
GB102 Electrolytics (60)	4.95	GB137 Chokes (50)	3.95
GB103 Tantalums (40)	4.95	GB139 Term. Strips (40)	3.95
GB108 TTL IC's (50)	4.95	GB140 Spcr/Stndff (150)	2.95
GB110 Asst. LEDs (100)	5.95	GB141 Washers (200)	2.95
GB113 Trimmers (30)	4.95	GB145 Lugs (100)	2.95
GB116 ¼w Resist. (200)	2.95	GB154 1&2w Resist. (100)	2.95
GB117 ½W Resist. (200)	2.95	GB162 7-Seg. Dsplys. (50)	5.95
GB120 Slide Switch (25)	3.95	GB173 3/8" Pots. (100)	5.95

LS Schottky

74LS00	.55	74LS109	.79
74LS02	.55	74LS123	1.95
74LS04	.69	74LS138	1.49
74LS08	.55	74LS139	1.49
74LS10	.55	74LS154	2.49
74LS14	1.09	74LS157	1.49
74LS30	.55	74LS161	1.79
74LS32	.69	74LS174	1.79
74LS38	.69	74LS175	1.79
74LS42	1.49	74LS192	1.89
74LS47	1.49	74LS193	1.89
74LS48	1.79	74LS221	1.95
74LS73	.79	74LS244	2.49
74LS74	.79	74LS245	3.49
74LS75	.99	74LS367	1.29
74LS85	1.95	74LS374	2.49
74LS90	1.09	81LS97	2.49

POTENTIOMETERS



2 Watt @ 70°C 7/8" Slotted Shaft Linear Taper	3/4 Watt @ 70°C 15 Turn Pot. Linear Taper
1K 5K 10K 25K 50K 100K 1 Meg	100Ω 500Ω 1K 5K 10K 50K 100K 500K 1Meg
CMU . . $2.95	**830P . . $1.79**

NEW! JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- Two, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2"w x 5-1/16"L x 2"H

JE215 Adj. Dual Power Supply Kit (as shown) . . $24.95

(Picture not shown but similar in construction to above)

JE200 Reg. Power Supply Kit (5VDC, 1 amp)	$14.95
JE205 Adapter Brd. (to JE200) ±5,±9 & ±12V	$12.95
JE210 Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp	$19.95

SOCKETS

Low Profile		Wire Wrap	
8 pin LP	2/.59	14 pin WW tin	.75
14 pin LP	2/.69	14 pin WW gold	1.09
16 pin LP	2/.79	16 pin WW tin	.79
18 pin LP	2/.89	16 pin WW gold	1.19
20 pin LP	2/.99	24 pin WW gold	1.69
22 pin LP	2/1.09	40 pin WW gold	2.75
24 pin LP	.79	14 p. plug/cover	1.29
28 pin LP	.82	16 p. plug/cover	1.39
36 pin LP	.99	24 p. plug/cover	1.95
40 pin LP	1.19	Also, The Molex Line	

DIODES & TRANSISTORS

IN751	2/.59	2N2219A	2/1.19
IN757	2/.59	2N2222A	2/.89
IN1188	2.69	2N2907A	2/.89
IN3600	5/.99	2N3055	.99
IN4001	4/.59	2N3772	2.25
IN4004	4/.69	2N3904	2/.69
IN4007	4/.79	2N3906	2/.69
IN4148	10/.99	2N4401	2/.79
IN4733	2/.69	2N4403	2/.79
IN4734	2/.69	2N5129	2/.69
IN4735	2/.69	2N5139	2/.69
IN4742	2/.69	2N5210	2/.79
IN4744	2/.69	2N5951	2/1.29

CMOS

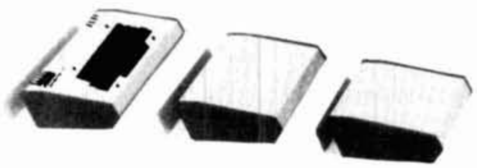
4000	.69	4030	.79
4001	.69	4040	1.95
4002	.69	4044	1.39
4006	1.95	4046	2.49
4009	.89	4047	2.75
4010	.85	4049	.89
4011	.69	4050	.89
4013	.85	4051	1.95
4016	.85	4066	1.19
4017	1.49	4069	.79
4018	1.49	4070	.79
4020	2.19	4071	.79
4023	.49	4081	.69
4024	1.29	4093	1.19
4027	.89	4511	1.95

CAPACITORS

Dipped Tantalum		ELECTROLYTIC	
.1mfd@35V	2/.89	1mfd@50V	3/.69
.47mfd@35V	2/.89	4.7mfd@50V	2/.59
1mfd@35V	2/.89	10mfd@50V	2/.69
2.2mfd@25V	2/1.09	22mfd@50V	2/.79
3.3mfd@25V	2/1.19	47mfd@50V	2/.89
4.7mfd@25V	2/1.39	100mfd@50V	.59
10mfd@25V	1.19	220mfd@50V	.69
33mfd@25V	3.95	1000mfd@25V	1.19
		2200mfd@16V	1.39

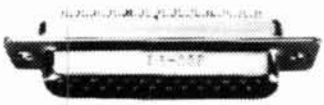
100V MYLAR		50V CERAMIC	
.001-.01mfd	4/.79	10pf-.022mfd	4/.59
.022mfd	4/.89	.047mfd	4/.69
.047mfd	4/.99	.1mfd	4/.79
.1mfd	4/1.19		
.22mfd	4/1.29		

DESK TOP ENCLOSURES



DTE-8 (Pictured)	$31.95
DTE-11 (Pictured)	34.95
DTE-14	36.95
DTE-HK (Case for JE600)	47.95
DTE-AK (Case for JE610) (Pictured)	52.95

CONNECTORS



DB25P	D-Subminiature Plug	3.95
DB25S	D-Subminiature Socket	4.95
DB51226	Cover for DB25P/S	2.25
22/44SE	P.C. Edge	2.95
UG88/U	BNC Plug	2.19
UG89/U	BNC Jack	3.95
UG175/U	UHF Adapter	.59
SO239	UHF Panel Recp.	1.49
PL258	UHF Adapter	1.95
PL259	UHF Plug	1.95
UG260/U	BNC Plug	2.39
UG1094/U	BNC Bulkhead Recp.	1.49

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Z80A	CPU (4MHz)	14.95
MC6800	8 Bit MPU	14.95
8080A	CPU	6.95
8212	8 Bit I/O Port	3.95
8216	Bi-Directional Bus Driver	4.49
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8T97	Tri-State Hex Buffer	2.25
AY-5-1013	30K Baud UART	6.95
AY-5-2376	88-Key Keyboard Encoder	13.95
2114-3	4K Static RAM (300ns)	6.95
MK4116	16K Dynamic RAM (250ns)	4.95
2708	8K EPROM	6.95
2716	16K EPROM (+5V)	10.95

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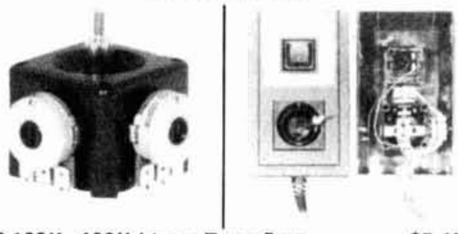
LM301N	.59	LM7805T	1.75
LM305H	1.39	LM7812T	1.75
LM307N	.75	LM7815T	1.75
LM308N	1.19	LM380N	1.49
LM309K	2.25	LM384N	2.49
LM310N	2.69	LM555N	.69
LM311N	1.49	LM556N	1.49
LM317T	2.29	LM565N	1.95
LM318N	2.95	LM566N	1.95
LM319N	2.95	LM567N	1.79
LM320K-5	2.25	LM723N	.79
LM7905T	1.75	LM741N	.65
LM7912T	1.75	LM1310N	2.95
LM7915T	1.75	LM1458N	.99
LM323K	5.95	LM1488N	1.59
LM324N	1.29	LM1489N	1.59
LM337T	2.29	LM1800N	4.49
LM339N	1.29	76477N	3.95

JOYSTICKS

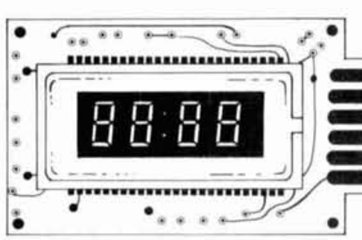


JS-100K 100K Linear Taper Pots	$5.49
JVC-40 40K (2) Video Controller	5.95

WALL TRANSFORMERS

AC250 250mA 12VAC (117V/60Hz)	$3.95
DV9200 200mA 9VAC (117V/60Hz)	3.95

12VDC AUTOMOTIVE/ INSTRUMENT CLOCK MODULE



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More Details? CHECK—OFF Page 118

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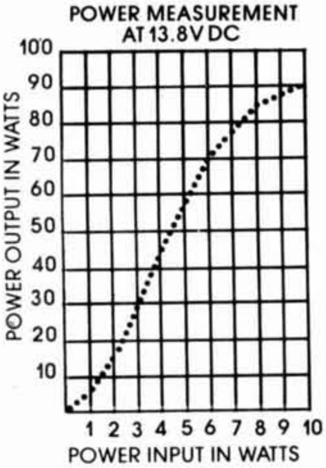

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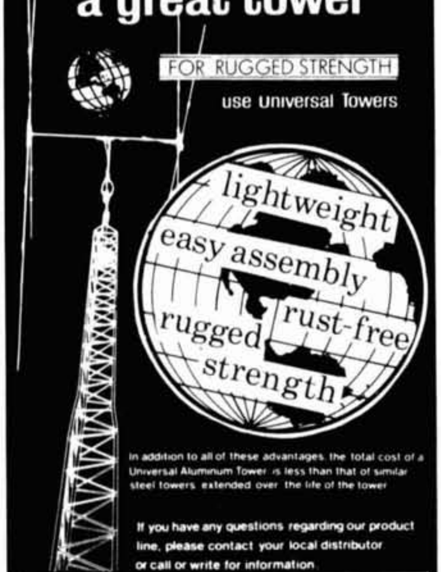

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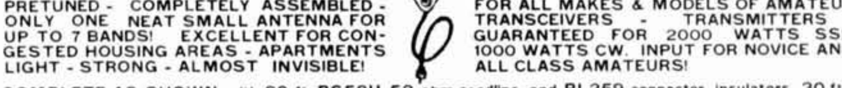

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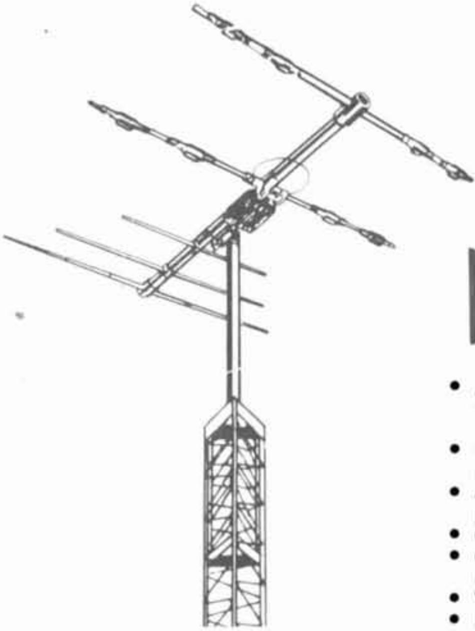

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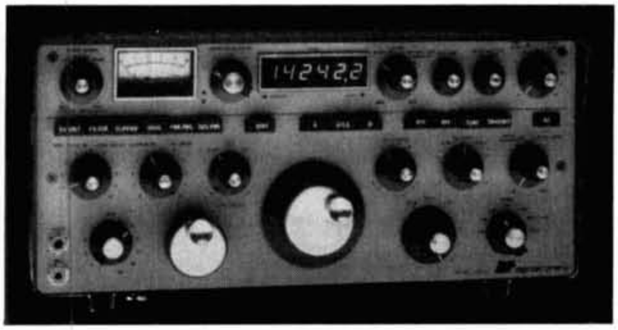

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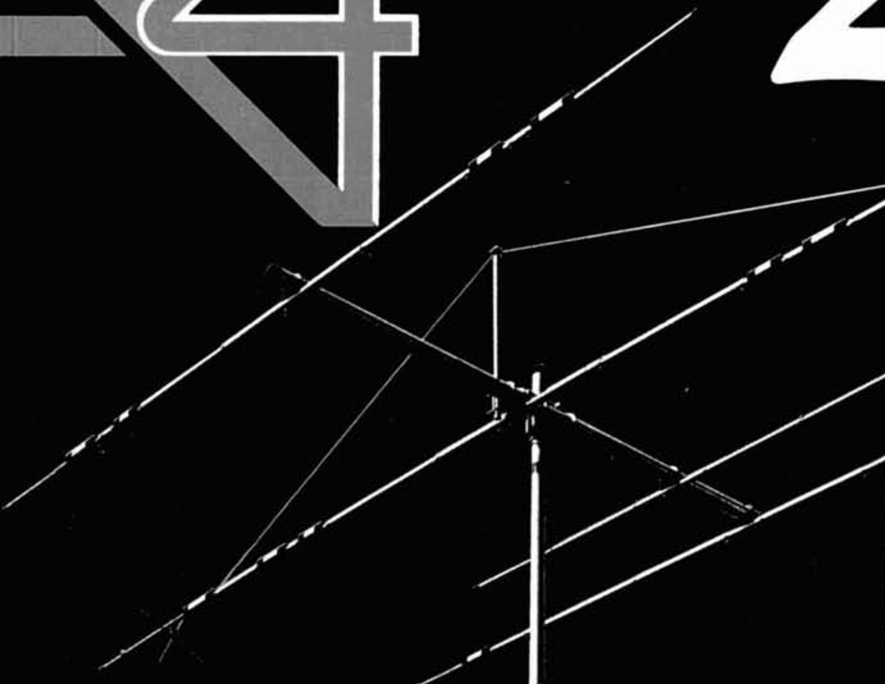

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IF Rejection: 70dB
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*AM 6 kHz at —6dB, 12 kHz at —60dB
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