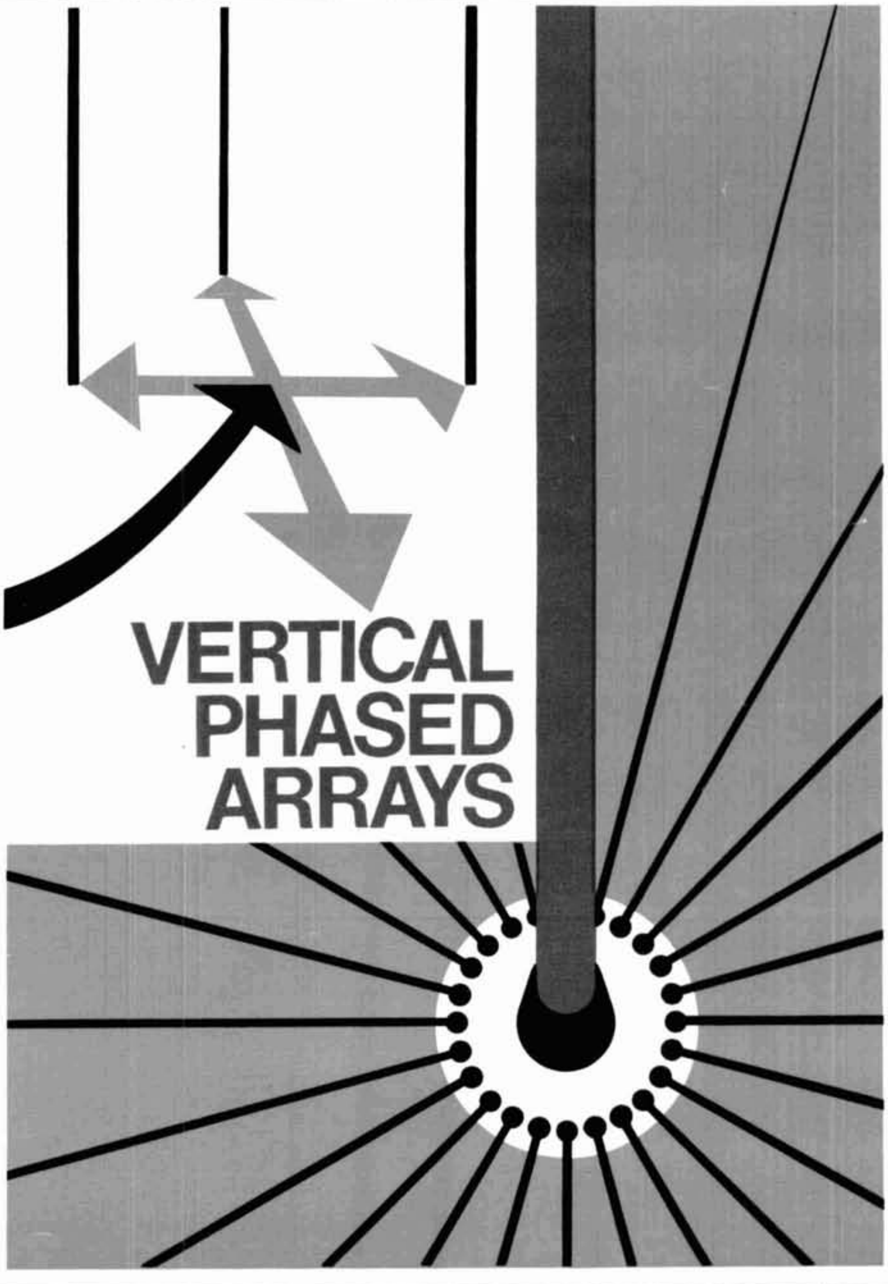
MAY 1983 / $2.50

ham radio magazine

- log-Yagis simplified
- 20-meter linear array
- inexpensive hardline connectors
- 20-meter mobile vertical
- stagger-tuned dipoles



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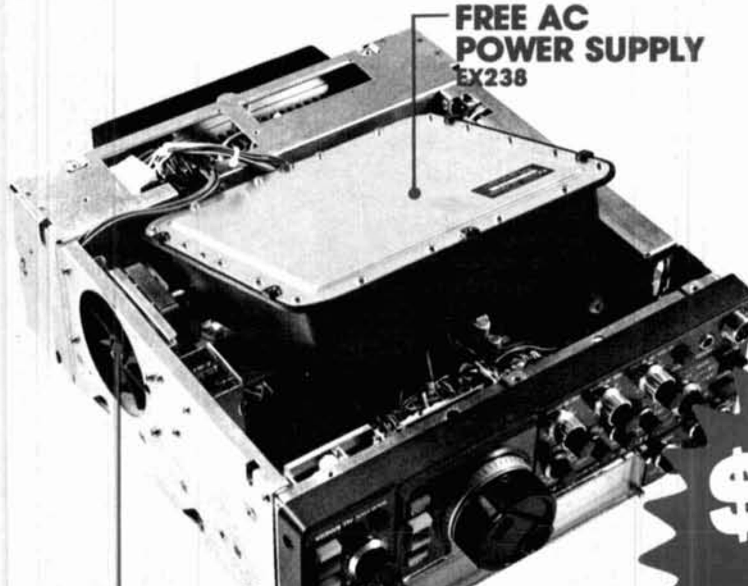
ICOM IC-740+

IC-740 PS + Cooling Fan + Mic + Rebate = Your Best Buy!



FREE AC POWER SUPPLY
EX238

FREE COOLING FAN
(Part of EX238 Kit)

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Included With IC-740

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Now the world's only completely self contained solid state 200W PEP, 12VDC/117VAC 9 band HF ham transceiver with a **Competition Grade Receiver** can be yours . . . at a special price.

Until July 31, 1983, the IC-740 and the optional IC-740PS ($159 value) internally mounted power supply are available at your authorized ICOM dealer for the price of the IC-740 alone. PLUS you get a $50 cash rebate directly from ICOM.

The ICOM 740 provides competition grade receiver performance with superb dynamic range in excess of **100dB** and a intercept point of **+18dBm** plus **pass band tuning, variable AGC**, and a **noise blanker** that works, all **standard.**

The IC-740PS AC power supply installs in under 30 minutes, making the IC-740 the ideal self contained rig for both summer vacation portable operation, as well as your main home rig . . . The benefits of 12 VDC and AC operation in one compact package.

For the ham who appreciates quality, get a competition grade receiver, rock solid solidstate transmitter, internal AC/DC power supply with cooling fan, and a microphone all for the price of the transceiver. Get extra savings while getting an ICOM IC-740 . . . simply the best ham transceiver in the world today . .

. . . Offer subject to equipment availability . . . at your authorized ICOM dealer . . .

ICOM
The World System

ICOM America, Inc., 2112-116th Ave NE, Bellevue, WA 98004 **(206)454-8155** / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234 **(214)620-278**

Power Supply / Rebate Combination Offer begins Mar. 21, 1983; ends July 31, 198

IC-R70 NEW!

The Commercial Grade Communications Receiver that everyone has been asking for........at a price you can afford!

GENERAL COVERAGE RECEPTION AT ITS BEST

Listen to the world of HF with the R70, a 100KHz to 30MHz commercial grade receiver designed by ICOM Incorporated, the leader in advanced receiver design. Built from knowledge gained by designing receivers for commercial, marine, and amateur use, the R70 surpasses other receivers on the market...even receivers costing more than twice as much.

Utilizing ICOM's DFM (Direct Feed Mixer), the R70 is a receiver which in normal usage is virtually immune to intermodulation distortion or cross modulation, yet still maintains superior sensitivity. Whether you are a SWL (short wave listener), Ham (amateur radio operator), maritime operator or commercial user, the R70 provides the features you need.

DESIGN

The R70 incorporates an UP conversion system, utilizing a direct feed mixer proven to be the best design for minimizing interference from strong adjacent signals. A preamp is provided for making the weakest of signals readable. High grade filters in conjunction with the built-in PBT (pass band tuning) system and notch filter, provide the ultimate in interference rejection. Selectable AGC (fast/slow/off), noise blanker (wide or narrow), and tone control improve readability under the worst conditions. An AGC derived squelch, operative in all modes, adds to operating ease.

Dual VFO's with three tuning rates provide quick QSY (frequency change), memory for an important station, or by equalizing the VFO's (A=B), a digital RIT. 13.8 VDC operation is provided as an option, 117 VAC is standard.

HAM'ING

The R70 is an ideal general coverage receiver to complement any ham shack. Use it with your existing tramsmitter or transceiver to provide dual receiver capability.

The R70's built-in monitor system lets you listen to your own transmitted audio and a mute input automatically protects the R70's receiver from your signal.

An option for FM allows listening to the 10 meter FM activity.

As an additional plus to ICOM IC-720A owners, the R70 has an optional interface that will allow the R70 to control the transmit frequency of the 720A for the ultimate in hamming versatility.

SWL'ING

For the short wave listener, the readout section of the R70 gives all the information for logging a station to be returned to at a later time. Frequency, mode, VFO, signal strength are all displayed. A dial lock prevents accidental loss of a signal.

A front mounted speaker provides 3 watts of crisp clear audio. A record jack allows easy attachment of a tape recorder.

ICOM SYSTEM

Like all ICOM HF products, the R70 fits into the ICOM system concept of accessories allowing you to use previously purchased accessories such as the HP1 headphone, SP3 external speaker, and AH1 auto bandswitching antenna.

PRICE

Check with your local ICOM dealer for pricing on the R70. You will be amazed.

ICOM
The World System

✓ 152

ICOM America, Inc., 2112-116th Ave NE, Bellevue, WA 98004 **(206)454-8155**/3331 Towerwood Drive, Suite 307, Dallas, TX 75234 **(214)620-2780.**

All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions.

TS-930S

"DX-traordinary"... superior dynamic range, auto. antenna tuner, QSK, dual NB, 2 VFO's, general coverage receiver.

A superlative, high-performance, all solid-state HF transceiver, that covers all Amateur HF bands, and incorporates a 150 kHz to 30 MHz general coverage receiver having an excellent dynamic range.

TS-930S FEATURES:

- 160-10 Meters, with 150 kHz-30 MHz general coverage receiver. Covers all Amateur frequencies, plus WARC, on SSB, CW, FSK, and AM. UP conversion digital PLL circuit.
- Excellent receiver dynamic range. Typical two-tone dynamic range, 100 dB (20 meters, 50-kHz spacing, 500 Hz CW bandwidth).
- All solid-state 28 volt operated final amplifier. Lowest IM distortion. Power input 250 W on SSB/CW/FSK, 80 W on AM. SWR/ Power meter.
- Available with AT-930 automatic antenna tuner built-in, or as an option. Covers 80-10 meters, including WARC bands.
- CW full break-in. CMOS logic IC, plus reed relay. Switchable to semi break-in.
- Dual digital VFO's, 10-Hz steps, includes band information.
- Eight memory channels. Stores frequency and band data. Internal battery memory back-up, est. 1 yr. life. (Battery not Kenwood supplied.)
- Dual mode noise blanker. NB-1, with threshold control, for "pulse" noise. NB-2 for "woodpecker."
- SSB IF slope tuning, allows independent adjustment of the low and/or high frequency slopes of the IF passband.
- CW VBT and pitch control. VBT tunes out interfering signals. CW pitch control shifts IF pass-band and beat frequency. "Narrow-Wide" filter switch.
- Tuneable, peak-type audio filter for CW.
- AC power supply built-in.
- Fluorescent tube digital display (100 Hz resolution, modifiable to 10 Hz) with digitalized sub-scale, in 20-kHz steps.
- RF speech processor.
- One year limited warranty.
- SSB monitor circuit.

Optional Accessories:

- AT-930 Auto. antenna tuner.
- SP-930 External speaker with selectable audio filters.
- YG-455C-1 (500 Hz) or YG-455CN-1 (250 Hz) plug-in CW filters for 455 kHz IF.
- YK-88C-1 (500 Hz) CW plug-in filter for 8.83 MHz IF.
- YK-88A-1 (6 kHz) AM plug-in filter for 8.83 MHz IF.
- SO-1 commercial grade TCXO.
- MC-60A deluxe desk micro-phone, 8-pin, with pre-amplifie UP/DOWN switches.

NEW

TS-430S

"Digital DX-terity"... General coverage, Superior dynamic range, 2 VFO's, 8 memories, Scan, Notch, COMPACT!

Combines compact styling with state-of-the-art circuit design and performance.

TS-430S FEATURES:

- 160-10 meters, with 150 kHz-30 MHz general coverage receiver. Covers all Amateur frequencies, plus WARC. UP-conversion digital PLL circuit.
- USB, LSB, CW, AM, and FM (optional) all mode.
- Compact lightweight design. Only 10-5/8 (270) W x 3-3/4 (96) H x 10-7/8 (275) D, inches (mm); only 14.3 lbs. (6.5 kg.).
- Superior receiver dynamic range with Dyna-Mix high sensitivity direct mixing system.
- 10-Hz step dual digital VFO's. Operate independently, include band and mode information. Dial torque adjustable. Step switch for 10-Hz or 100-Hz steps. A=B switch shifts "B" VFO to "A" VFO frequency and mode, or vice versa. VFO LOCK switch. RIT for VFO or memory. UP/DOWN manual scan with optional UP/DOWN microphone.
- Eight memories store frequency, mode, and band data. 8th memory stores RX/TX frequencies independently.
- Lithium battery memory back-up. (Est. 5 yr. life.)
- Memory Scan.
- Programmable automatic band scan width.
- IF shift circuit for minimum QRM.
- Tuneable notch filter, built-in.
- Narrow-wide filter selection on SSB, CW, AM (filter optional).
- Speech processor, built-in.
- All solid state. Input rated 250 W PEP on SSB, 200 W DC on CW, 120 W on FM (optional), 60 W on AM. Operates on 12 VDC or on 120 VAC, or 220/240 VAC with optional PS-430 AC power supply.
- Fluorescent tube digital display indicates frequency to 100 Hz (10 Hz modifiable).
- All-mode squelch circuit, built-in.
- Built-in noise blanker.
- RF attenuator (20 dB).
- VOX circuit, plus semi break-in with side-tone.

Optional accessories.

- PS-430 compact AC power supply.
- PS-30 or KPS-21 AC supplies.
- SP-430 external speaker.
- MB-430 mobile mounting brack
- AT-130 compact antenna tuner 80-10 m, incl. WARC.
- AT-230 base antenna tuner, 160-10 m, incl. WARC.
- FM-430 FM unit.
- YK-88C (500 Hz) or YK-88CN (270 Hz) CW filters.
- YK-88SN (1.8 kHz) narrow SSB filter.
- YK-88A (6 kHz) AM filter.
- MC-42S UP/DOWN hand microphone.
- MC-60A deluxe desk micro-phone, UP/DOWN switch.

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ham radio magazine

contents

REFLECTIONS

Antennas ... Antennas ... Antennas

Our May issue has historically been our antenna issue and this year will be no exception. Within the pages of this, our fattest issue in a long time, are twelve articles on antennas of all sizes, shapes, and applications. Let me, if I may, be your guide through the next 136 pages or so and provide you with a summary of the various articles contained within.

We start with part one in a series of articles on phased vertical antennas by Forrest Gehrke, K2BT. Forrest, you may recall, provided us with "A Precision Noise Bridge" in the March, 1983, issue of *ham radio*. He, like so many of us, is not satisfied with copying previous designs and letting it go at that. He must look into things, carefully examining the technical reasons for the correct operation of devices. It is with that approach that he examined the interrelated properties of phased vertical arrays — perhaps more closely than has ever before been done in the pages of a ham journal.

Part one of the series explores *incorrect* assumptions accepted by many (and unfortunately used by many) in their designs of antenna systems. Foremost among these incorrect assumptions is the concept that mutual coupling between elements can be ignored. Following close behind is the argument that, if an array requires equal current drive, then driving each element with equal *power* will always satisfy that requirement. Forrest leads us from the theoretical design to actual drive-network hardware, and shows us how a repeatable 30 to 40 dB F/B ratio is achieved. Like W2PV's series on Yagis, Forrest's series on phased verticals will be both interesting and useful.

K4MT shows us how it is possible to use one wire array over the widest (percentage bandwidth) Amateur band while not exceeding a 2:1 VSWR. His stagger-tuned dipoles cover the 13.3-percent-wide 80-meter band, producing a W-shaped SWR curve. This same design technique is easily applied to 160, 40, and 10 meters with their percentage bandwidths of 10.5, 4.2, and 5.9 percent, respectively.

For a change of pace, a few shorter articles by K9CZB, AA6PZ, W6SAI, and WA8DXB illustrate interesting ways of providing superior performance with little expenditure of time or money. K9CZB shows how an auto replacement antenna and a CB whip can combine to give broadband, durable mobile capability on the 20-meter band. AA6PZ illustrates three different 2-meter antennas or improvements that are lightweight and easy to build. His last design is a 10-dB-gain collapsible four-element Yagi. This weekend project will help you raise those distant repeaters that your handheld previously struggled to access. W6SAI brings us back to basics with his discussion on the various shapes and gains associated with loop antennas. He provides, in "Ham Radio Techniques," design data for two-element quads for the 10, 15, 20, and 40 meter bands. WA8DXB, in order to increase his station performance to Asia, reproduces a four-element 20-meter collinear that holds its own against some impressive high-gain Yagis — without going above 16 feet.

W7DHD brings us back to verticals with his examination of five different 1/16-wavelength-high shortened verticals. He compares top loading, top and base loading, center loading, and base-only loading. He quantitatively shows us how to compute the relative field strength of each antenna with respect to a reference quarter-wave, without actually erecting any antennas. An eye-opener is his calculation showing a difference of over 20 dB in performance between a base-loaded vertical and its full-sized quarter-wave counterpart.

John Belrose, VE2CV, a name familiar to many of us, walks us through a design of a highly efficient radiator known as a grounded monopole with elevated feed. This off-center-fed antenna is useful on six Amateur bands (for that matter, it can be used over the entire 3-30 MHz hf spectrum) and does not require traps. Its best feature is that it produces low-angle radiation at all frequencies.

W3EB explains the significance of his 10/11/12 number sequence in his article "Log-Yagis Simplified." Imagine a 10-meter antenna that achieves 11 dB (dipole) gain using only a 12-foot boom! He shows how, and creates even more interest in his longer beam designs with up to 15 dBd gain. He emphasizes the importance of maintaining close tolerances and using careful workmanship.

Broadcasters have been doing it for years: K3ED, in borrowing some of the same principles, shows how to produce steerable nulls with theoretically infinite attenuation in his article "Achieving the Perfect VHF Antenna Null." Construction details are provided for a trombone-type, adjustable-length phase line made from readily available hobby shop brass tubing supplies. It, and a variable-amplitude JFET preamp, are the main components for an electronically controllable antenna system of extremely high F/B ratio. If a particular direction must be locked out or nulled (as in some repeater applications), the same electronic-control can be used in a transmitting array.

Also on the subject of repeaters, K7NM shows how a low-signal condition known as shadowing can be reduced by judicious choice of the high site antenna. His rugged four-pole collinear uses progressive phase delay sections to tilt the beam pattern downward. This reduces overshooting the desired coverage area and cuts back on wasted higher-angle radiation from the same array. The article "Repeater Antenna Beam Tilting" is worthwhile reading for all clubs considering new or improved repeater site constructions.

Rounding out this issue is an article by WB4GCS entitled "Inexpensive Connectors for Hardline." With $2.00 worth of plumbing materials and ten minutes of labor you can build extremely low-loss homemade connectors to use with the surplus 1-inch (2.54-cm) CATV hardline cable now becoming available to hams at low cost. VHF and UHF enthusiasts can now use this high-quality, low-loss cable for repeaters or home stations, without the cost of expensive connectors.

Marty Hanft, KA1ZM, the editor of *ham radio*, is taking his leave, after five years with the magazine, to spend some time overseas. He joined the staff as administrative editor in 1978, working closely with the late Jim Fisk, and has continued providing us with his inimitable editing and organizational talents. We wish him all the best in his new endeavors.

Welcome aboard is extended to Dorothy Leeds, our new assistant editor. Dorothy brings with her technical-magazine editorial and production skills that will be constantly called upon for our rapidly growing Amateur technical magazine.*

Keep those letters coming. Our technical forum and correspondence departments are growing as a direct consequence of the interest shown in the past few months. Please be patient with us — the flood of mail has created a little backlog — but we love it.

Rich Rosen, K2RR
Editor-in-Chief

*This issue of *ham radio* is 42 percent larger than last January's issue.

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.

$89.95 (+ $4)

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

$49.95 (+ $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, $59.95 (+ $4), like 900 but includes 4:1 balun for use with balanced lines.

MFJ-16010, $39.95 (+ $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

$229.95 (+ $10)

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.

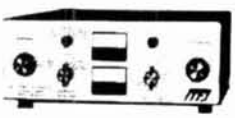
6 position antenna switch handles 2 coax lines (direct or through tuner), wire and balanced lines.

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

ANOTHER 1.5 KW MODEL: MFJ-961, $189.95 (+ $10), similar but less SWR/Wattmeter.

MFJ-10, 3 foot coax with connectors, $4.95.

MFJ-984 VERSA TUNER IV



MFJ-984

$329.95 (+ $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, $239.95 (+ $10), like 984 less ant. switch, ammeter. **MFJ-982, $239.95** (+ $10), like 984 less ammeter, SWR/Wattmeter. **MFJ-980, $209.95** (+ $10), like 982 less ant. switch.

MFJ-989 VERSA TUNER V

MFJ-989

$329.95 (+ $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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20 METER U.S. PHONE EXPANSION WAS APPROVED BY THE FCC at its March 31 Agenda Meeting. The new bottom edge will be 14150, with an exclusive Extra slot from 14150 to 14175. The Advanced Class lower edge moves to 14175, while the General portion now starts at 14225.
Expansion Of The Other HF Amateur Bands Was Held Off by the Commissioners, to be considered in a later NPRM. When the new 20-meter frequencies will actually be available for use hadn't been settled at presstime, but should be about the time you read this.
The 10-Year Amateur License Was Also Discussed at that same meeting. A Notice of Proposed Rulemaking was the result, and though it was not yet ready for release at presstime it's expected to be quite straightforward. The comment due date had not been set as we went to press, but the comment period should be short as little controversy is likely to be raised by this proposal.

COMMENT DUE DATE ON THE FCC'S "NO-CODE" LICENSE proposal has been extended to June 28. The FCC agreed to a 60-day extension of the Comment deadline on the request of the ARRL, whose next Board of Directors' meeting is set for late April. The League's final position on that bitterly contested issue won't be set until that meeting, and the original April 29 Comment due date would not have allowed the League enough time after the meeting to prepare and submit its comments.
Organized Opposition To A "No-Code" License has been developing in several areas. "Grassroots" anti-"No-Code" groups are reported active on both coasts, and one is seeking a spot on the Dayton Hamvention program to rally sentiment against the proposed new license.

THE PHASE 3B SATELLITE LAUNCH IS STILL SET FOR MID MAY, and the European Space Agency is still confident that the trouble-plagued Ariane rocket's problems have now been solved.
Don't Expect To Be Able To Use Phase 3B Right Away, even if the launch is on schedule and trouble free. Checkout and stabilization of the new bird could take several weeks or more, before Amateurs will be able to enjoy the benefits of its elliptical orbit.

AMATEUR OUTRAGE OVER N6BHU'S LICENSE REINSTATEMENT after it had been lifted by the FCC for "profane and indecent" language has now reached Congress. Sen. Barry Goldwater, K7UGA, challenged FCC Chairman Fowler about the FCC Review Board decision to return the violator's license at a recent Senate Communications Subcommittee meeting, and was promised the controversial action would be reviewed by the Commissioners at an early date.
N6BHU Has Promised To Take The Fight Into Federal Court if the Commission decides again to suspend his license. In a conversation with Westlink's WA6ITF, N6BHU said he'd go all the way to the Supreme Court if necessary to keep his Amateur license.
ARRL Has Also Formally Intervened In The N6BHU Case, concerned that the Review Board set an "unlawful and intolerable" precedent in its decision that the language N6BHU had used on the air was acceptable in the Amateur service.

ARTHUR GODFREY, K4LIB, PASSED AWAY MARCH 16 in a New York hospital from pneumonia. He was one of the nation's best known Amateurs, having been a top rated broadcast entertainer for many decades. Arthur, who was 79, narrated "The Ham's Wide World" in 1969 and had been co-narrator of "The World of Amateur Radio" in 1979.

STANDARDS FOR RF RADIATION SHOULDN'T BE THE FCC'S PROVINCE, an all-industry group agreed at a meeting with key Commission people March 16, but the FCC will have to fill a void until the Environmental Protection Agency can complete its RF studies and take on the responsibility. That's still probably two years off, and until then the FCC is expected to use the 10 mW/square centimeter 1982 ANSI standard (with reductions at frequencies to which the body is most susceptible) as meeting the requirement of the EPA. A major benefit will be federal preemption of proliferating state and local RF exposure regulations.

K5LFL's 2-METER OPERATION FROM THE SPACE SHUTTLE is now almost certain, following NASA's OK of the proposal. The only approval still required is from the European Space Agency, whose space lab will be the Shuttle's cargo for that late September launch.

A NEW 220-MHZ DX RECORD WAS SET MARCH 9 when KP4EOR worked LU7DJZ, a 3670 mile QSO. KP4EOR used both SSB and CW for the record-breaking trans-equatorial-propagation contact, while LU7DJZ used CW only. The previous 220 MHz record was 2540 miles between W6NLZ and KH6UK, set back in June, 1959.

CABLE TV CHANNEL E WON'T BECOME A PROBLEM TO 2-METER users in some parts of Chicago. Several of the successful bidders for the multi-area Chicago cable TV franchise, including Continental Cablevision, voluntarily agreed as part of their proposals to give up service on either channel E (2 meters) or K (220 MHz).

A $1000 FINE HAS BEEN LEVIED AGAINST A BURBANK (ILLINOIS) Amateur who recently erected a new 34-foot tower. The Amateur, a minister and former missionary in Nigeria, was anxious to resume contact with former colleagues. Court action on Burbank is still hanging fire.

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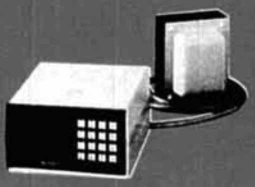

GOOD
PSE-1A

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This unit gives you the current position of your antenna digitally. It has 10 memories and command modes, plus single button operation. The "CONTESTER" comes with a 7.0 amp continuous duty motor supply.
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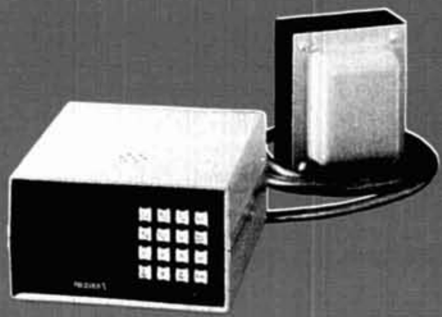

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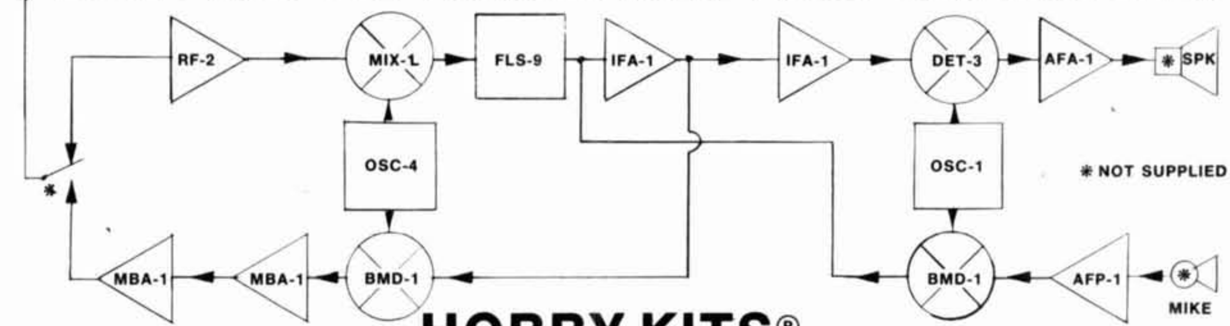

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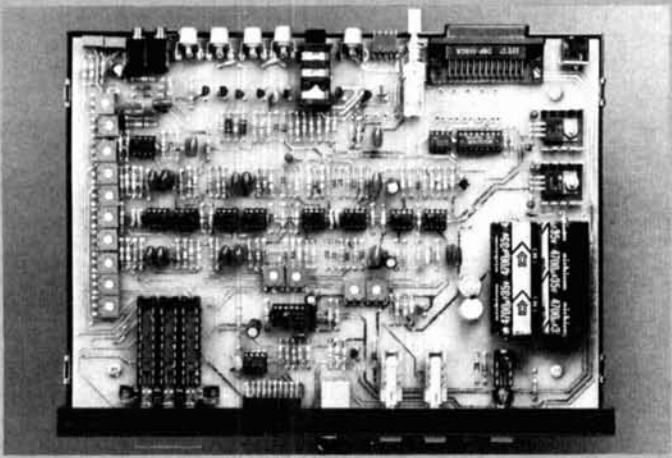

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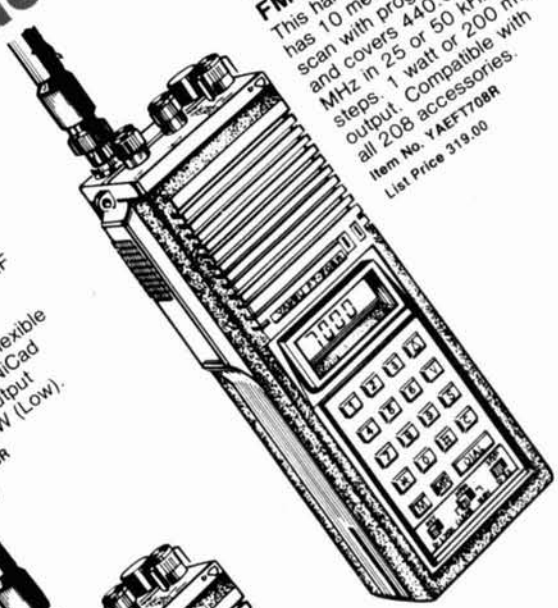

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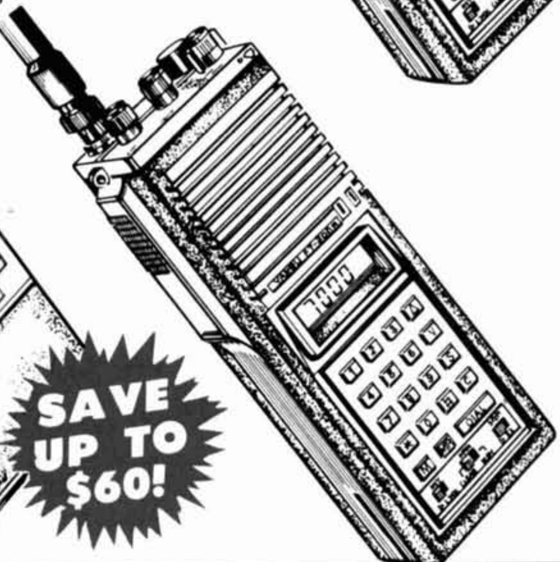

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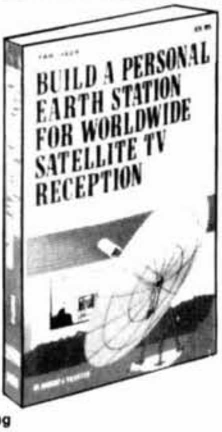

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ham radio Book Review

***ham radio** magazine takes pleasure in providing the following reviews of books pertinent to Amateur Radio.*

rf circuit design

The first word that comes to mind in reviewing the book *rf circuit design* by Chris Bowick, WB4UHY, is *practical*. The author has accomplished in this book what many more-expensive volumes have not been able to — he has provided in one 176-page volume a useful collection of material on rf techniques.

Most rf designers will probably agree that their knowledge took years to acquire and sometimes required access to many different volumes to understand even a single concept. Chris gets right into the essential aspects of each subject, using clearly defined terms, charts, and examples. An elementary example of this is seen on the first page of chapter one, Components. A chart on wire sizes shows how one can quickly determine unknown wire diameters if it's remembered that No. 50 AWG is 1 mil and doubles for each six wire sizes. No. 44 AWG has a 2 × 1, or 2 mil, diameter.

This book, useful to hams who are interested in designing their own equipment, provides numerous examples for guidance each step of the way. There are seven chapters, labelled: Components, Resonant Circuits, Filter Design, Impedance Matching, The Transistor at Radio Frequencies, Small Signal RF Amplifier Design, and RF Power Amplifiers.

There are also three additional sections: Appendix A, use of complex numbers, recommended for those who are not familiar with complex number arithmetic; Appendix B, noise calculations, a systems approach to low-noise design; and Appendix C, bibliography of technical papers and books related to rf circuit design. These additional sections complement this already useful book with material that enables the interested reader to continue his research.

Published by Howard W. Sams, this book is available soft cover (8½ × 11) from Ham Radio's Bookstore, Greenville, New Hampshire 03048, for $21.95 plus $1.00 shipping and handling.

directional antenna patterns

To this reviewer's knowledge, there is not another book around like *Directional Antenna Patterns* by Carl E. Smith, president of the Cleveland Institute of Radio Electronics. It provides under one cover a collection of 15,160 directional antenna patterns, and has become the bible for a-m broadcast antenna design engineers. With the current increase in interest in phased vertical arrays the Radio Amateur will find this material pertinent in several ways.

Part one contains the theory behind the determination of the size and shape of directional-antenna patterns, starting with the standard reference antennas (uniform hemispherical radiator, vertical current element, quarter-wave verticals) and developing into the generalized equation for a directional n-antenna array.

Part two, entitled "Systemization of Two Tower Patterns," provides 568 patterns available from a two-element array, examined at electrical and phase separation steps of 15 degrees and 45 degrees. It is worthwhile pointing out that commonly used 90 degree space/90 degree phase, that is, quarter-wave separated, quarter-wave-phase difference verticals are just one of the 568 cases considered. Amateurs who don't have the space to separate their verticals by a quarter-wave can still obtain a cardioid switchable pattern by choosing a different set of parameters.

Part three, Systemization of Three Tower Patterns, furnishes 14,592 field plots with 45 degree incremented spacings out to one wavelength for both antenna 2 and antenna 3. The guide to all these different patterns is provided by a systemization placement chart illustrated on each page of 64 patterns.

Directional Antenna Patterns is available hard bound (8½ × 11) by Carl E. Smith for $22.00, postpaid. Contact Smith Electronics, Inc., 8200 Snowville Road, Cleveland, Ohio 44141.

radio communications receivers

Radio Communications Receivers by Cornell Drentea is a new 280-page paperback book available from TAB Books, Inc. The book is billed as a comprehensive guide to radio receiver design and technology, and includes the history of radio technology as it has affected receiver design over the years.

Mr. Drentea attacks the subject of radio receivers systematically, introducing each aspect of a receiver, the design theory, and construction. He also presents an explanation and alternative routes for reaching the same result. State-of-the-art technology is traced from its more primitive beginnings, and future design trends are introduced.

The book is a blend of theory and application, and is meant as a reference for the design and construction of receivers. Design considerations for modern receivers are thoroughly covered, and include the use of computers. The book should prove to be a handy tool to have in your library.

Radio Communications Receivers is available from Ham Radio's Bookstore, Greenville, NH 03048 for $13.95 plus $1.00 shipping and handling.

digital PLL frequency synthesizers — theory and design

Dr. Ulrich Rohde, a name familiar to many of us, has borrowed from his years of knowledge and experience with synthesizers and produced under one cover a collection of data on this complex yet increasingly important subject: *Digital PLL Frequency Synthesizers — Theory And Design*. As stated by Dr. Rohde, the objective of the book is "to provide as much practical circuit information as possible while presenting only the necessary mathematical background and formulas."

This is accomplished in six chapters starting with Loop Fundamentals. Here he introduces the basic linear and digital loops with formulation provided for type 1 and type 2 — first through third order loops. As an example, in the discussion of a type 2, third-order loop, the transfer function is defined along with its application to the suppression of fm noise in a VCO.

Chapter 2, Noise and Spurious Response of Loops, considers an extremely pertinent and limiting factor in any system that uses a synthesizer — sideband noise. The noise sources indicated are leakage from the reference device in phase-locked loops, incomplete suppression of the unwanted component of the mixer output, and inherent noise from the oscillator.

Chapter 3 deals with special loops, that are basically one-loop synthesizers. Techniques are discussed that simultaneously solve the two major requirements of loop operation: resolution and speed. This leads us to a more sophisticated development

short circuits

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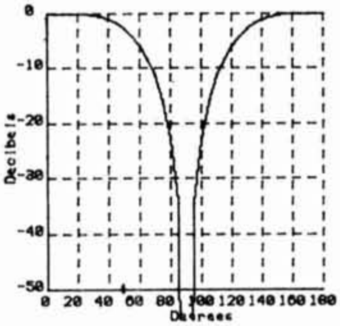
Bobtail curtain

The March, 1983, article by Woody Smith, "Bobtail Curtain Follow-Up," indicates that the half-power beamwidth of the Bobtail is 50 degrees. However, using a Sharp PC1500 and assuming a 1:2:1 current ratio, that calculates out to approximately *100* degrees. Note that only *half* the azimuth plot is shown in **fig. 1**; this symmetrical field pattern has a mirror image to its left.



Ed. note: Woody says he took only half of the 3-dB beamwidth numbers for both the Bobtail and half-square. The half-power beamwidths are 100 degrees and 120 degrees, respectively.

known as the fractional N phase-locked loop.

The Radio Amateur or experimenter will probably find Chapter 4 most useful. Here the loop components consisting of oscillator, reference standard, mixer, phase/frequency comparator, wideband amplifiers, programmable dividers and loop filters are clearly defined and designs provided. Numerous actual circuits are illustrated complete with component values.

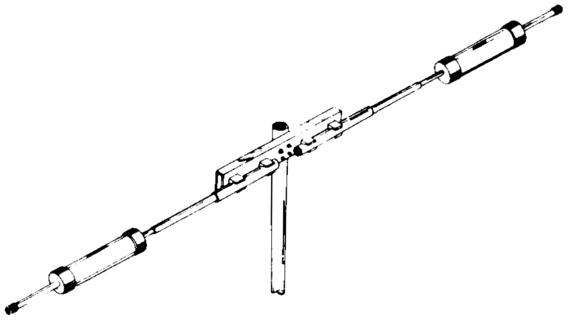
With the first four chapters providing a comprehensive understanding of loops, chapter five introduces the multiloop synthesizer that uses a combination of fractional division N synthesizer, sequential phase shifter and digital frequency synthesis techniques. The Rohde and Schwarz EK070 10 kHz to 29.99 MHz shortwave receiver incorporates several multiloop synthesizers and provides a working example of this modern loop concept.

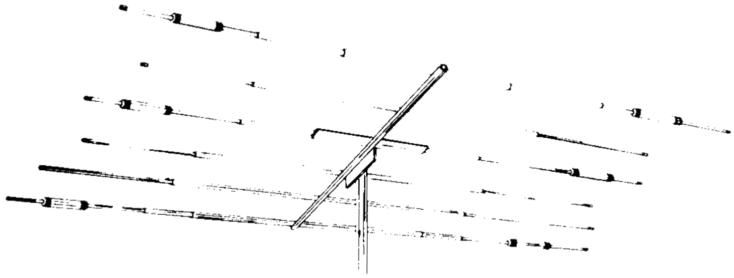
Chapter six finishes this discussion on digital PLL frequency synthesizers with three practical circuits: a) A single-loop, 1-kHz reference synthesizer operating from 41 to 71 MHz, used in a simple shortwave receiver; b) A fast, single-loop 25-kHz synthesizer operating from 41 to 71 MHz; and c) A low sideband noise multi-loop synthesizer covering 75 to 105 MHz in 100-Hz increments.

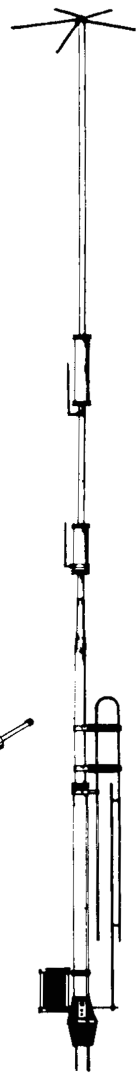
The appendix includes a mathematical review including a very useful table relating real-time functions with their LaPlace transforms. As indicated at the beginning of this review, Dr. Rohde has generated a 494-page compilation on the current state-of-the-art in digital PLL frequency synthesizers that is useful to the engineer or anyone else who needs a detailed working knowledge of these techniques.

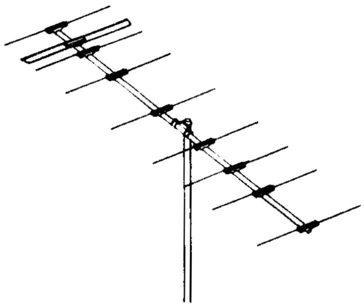
This book, published by Prentice-Hall, is available in hard cover from Ham Radio's Bookstore, Greenville, NH 03048, for $60.00 plus $2.00 shipping and handling.

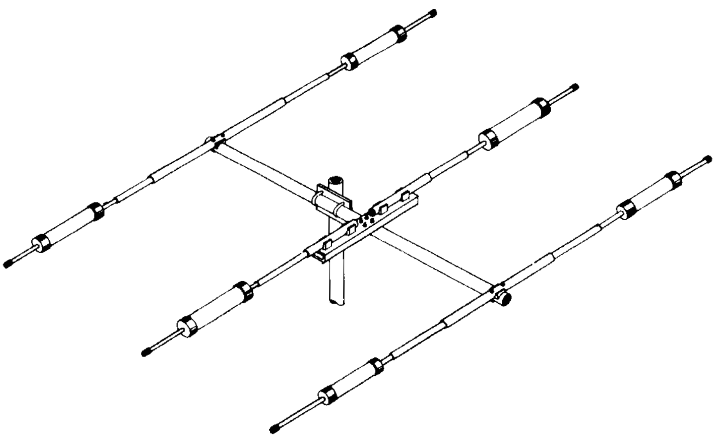
ham radio











vertical phased arrays: part one

Rotatable arrays for the low bands

Forrest Gehrke, K2BT, with two hundred and fifty-two countries worked on 75 meters, has, over the years, followed a natural progression from the use of simple antennas on the low bands to his present 4-square array. This first installment in a multipart series will help dispel some of the myths associated with phased array design. Though many of the statements might at first glance appear obvious, I cannot stress enough the importance of carefully reading this introduction. As Forrest aptly states, a phased array design is not black magic. Achieving outstanding performance just requires a clear understanding of the mechanisms involved. **Ed.**

Many DXers get on the low bands, if they do at all, to fulfill an award requirement. A low inverted-V or dipole is pitched up, the necessary QSLs collected, and then it's back to the HF bands. But some get hooked and stay. They relearn what the radio pioneers discovered: The low bands are a highly predictable and reliable means of long-distance communications, and, in low sunspot periods such as we are now entering, they're the only after-sunset DX game in town. Sorely missing is directional ability, such as even a modest tribander can provide in the HF bands.

Even if it were practical to rotate that low inverted-V or dipole, it would remain a sad fact that most of the signal is radiated at very high angles with virtually no azimuthal directivity. The result is that the impression easily might be gained that the low bands are good for 500 to 1000 mile contacts but no real DX — that is, until the newcomer happens to eavesdrop on one side of a real DX contact. Then he is amazed to hear a Q5 report given, and at the turnover hear nothing except noise. The old adage "You can't work 'em if you can't hear 'em" is particularly apt on the low bands, where atmospheric static as well as manmade noise is very high.

restricting noise pickup

How is it possible to get a low radiation angle and still beat the noise problem? Perhaps this question seems a contradiction because, as the radiation angle is lowered, the paths over which the antenna receives major noise sources are lengthened, whether the noise is manmade or natural. We may not be able to restrict noise pickup in the paths of interest, but we can at least reduce it from undesired paths with a directional array. On the low bands atmospheric noise is very often quite markedly directional, and it is not unusual to find noise levels differing by 30 dB or more between various quadrants of the horizon. Experience shows that high F/B ratio, that is, superior rejection of signals from undesired directions, has far more importance than gain on the low bands for this reason.

It is well known that for reliable DX work a horizontally polarized antenna array had best be one-half to

By **Forrest Gehrke, K2BT**, 75 Crestview, Mountain Lakes, New Jersey 07046

two wavelengths above the ground for optimum radiation angle. At 20 meters and shorter this is not too difficult, nor is rotating the antenna, but for 80 or 160 meters such heights become impractical — and rotation is virtually impossible.

One obvious alternative is a vertical antenna with electronic directional control. If such an antenna is combined with a good ground plane, one can get radiation angles as low as those possible with a horizontal antenna two wavelengths above ground. But doesn't a vertical "radiate equally poorly in all directions"? And isn't it said to be noisy? After all, everyone knows that, for some mysterious reason, man-made noise sources are supposed to radiate with vertical polarization. That a vertical's very low radiation angle may have something to do with this is seldom considered.

Widespread misinformation on the vertical antenna in Amateur publications is a serious problem. Recently I researched respected Amateur publications printed since 1970, looking for articles on the vertical that contained definitive technical data. I found only two, one quoting the typical dissimilar and reactive driving impedances of the elements of a two-vertical array,[1] and the other calling attention to the need for maintaining unity current ratio despite this dissimilarity.[2] No quantitative data was available for arrays with more than two elements. A few writers included qualitative comments on the vertical array, indicating awareness of the complexity of the matching situation, but most did not. Perhaps this is because, unlike many horizontal arrays, vertical arrays are often designed with all elements driven, thus making the job of satisfying drive current and phase conditions more complicated.

mutual coupling

At this point it may be useful to review the gain mechanism of a Yagi.[3] The Yagi creates gain in the favored direction as a result of the driving currents and phase currents induced in the parasitic elements by means of mutual coupling between the driven and parasitic elements. With appropriate spacings and lengths chosen for the design frequency, current and phase are caused to exist in each element such that the signal is reinforced in the forward direction and partially cancelled in the other directions. The single driven element will present a significantly lower impedance than it would as a lone dipole, because of the loads coupled to it from the parasitic elements. If a low VSWR is not a goal, this element may be driven directly without affecting the gain pattern of the array. The presence or lack of an impedance transformer (such as a Gamma match) has nothing to do with the gain pattern — only with the match to the feedline. A comparison of the current and phase at the midpoint of each element with respect to the driven element, shows that the current magnitude ratio is below unity (about 0.2 to 0.5.), generally rising or falling in each succeeding parasitic element. The phase angle will lead in the reflector (because this element is longer than a half-wavelength); it will lag at the directors (because they are shorter than a half-wavelength), the angle lagging more in each director as we move toward the front of the array. The interaction is quite complex, since there is mutual coupling among the parasitic elements as well as with the driven element. Nevertheless, it is this phenomenon of mutual coupling that permits us to produce directionality in multi-element arrays.

While it's true that driving each element provides an additional controllable variable, this does not mean that no other drive source is acting on the elements. The same mutual coupling that occurs in the Yagi is present here and must be taken into account as part of the total drive to each element. To illustrate, suppose you want to drive an element of an array with 1 ampere at 90 degrees lagging angle. Assume that, at the same termination impedance of this element, mutual coupling from other elements is inducing 0.8 ampere at 90 degrees lagging. An additional drive current of only 0.2 ampere at 90 degrees lag would be all that's needed. In practice, of course, mutual coupling and this additional drive from the feed network may not add arithmetically. Phase angles probably will be different, resulting in vectorial addition. There's another real life complication: The added drive changes the mutually coupled drive! In fact, changing anything at all changes all the other variables because the mutually coupled elements and feed network are all part of one coupled system. This is why the element driven impedances are referred to as driving-point impedances; they exist only while connected to the feed network. We cannot disconnect any element and verify its value with an impedance bridge.

The assumption that mutual coupling doesn't occur (or isn't important) is a mistake found in many articles on phased arrays, vertical or horizontal, in the Amateur publications. This error is almost invariably compounded by a second and more erroneous one: Electrical length of the delay line is equated to current delay in all circumstances, (for example, a quarter-wavelength line is assumed to produce a 90-degree delay regardless of its termination). But equating electrical length to current delay holds true only under certain conditions:*

1. For any length if terminated by a *pure* resistance equal to the characteristic impedance of the line.

---

*Except when specifically noted, only the lossless cases will be considered. At low-band frequencies, losses normally are negligible. Calculations including them add greatly to complexity while resulting in insignificant benefit.

2. For an odd number of quarter-wavelengths if terminated by a *pure* resistance of any value.

3. For any number of half-wavelengths regardless of termination impedance.

4. In some special cases (normally of no concern in these applications).†

Disregarding mutual coupling leads to inaccurate results, particularly as regards front-to-back ratio. The designer who makes this error is also typically led to some or all of the following subsidiary assumptions:

1. That the driven impedances of each element always are equal.

2. That if the elements are resonant, the driven impedance of each element is resistive.

3. That if array feedlines are quarter-wavelength, a 90 degree phase change in current is produced in each line.

4. That if the array requires equal current drive, driving each element with equal power will always satisfy the requirement.

5. That a current phase angle displacement of 90 degrees between array elements will occur by insertion of a quarter-wavelength line in the feedline of one of the elements.

Every one of these assumptions is **wrong**, because the premise on which they are based is not true.

Some writers suggest that great liberties may be taken with element feedline lengths. Without considering the effects upon phasing, they would use element feedlines of any length as long as they were equal. Except in very specific circumstances (when all driving impedances are equal), there is no way to justify taking these liberties with most multi-element array configurations.

array impedances and power distribution

It may be illuminating to examine a typical set of dynamic driven impedances for the quarter-wave resonant elements of a 4-square vertical phased array (fed with equal-magnitude currents of the proper phases to produce the main lobe along a diagonal). This will demonstrate the profound effects of mutual coupling.

element 1	$Z_1 = 7.9 - j7.8$
element 2 or 3	$Z_2 = Z_3 = 35.7 - j12.7$
element 4	$Z_4 = 59.2 + j42.6$

The first impedance is the reference, or zero-degree phased element; the next is the impedance of each of the two −90 degree phased middle elements; the last is the −180 degree phased element. That these impedances are quite dissimilar and reactive is obvious. Since drive power is a linear function of the *real* component of these impedances (being fed with currents of equal magnitude), it is clear that power division among these elements is far from equal. Assuming 1-ampere drive to each element, the drive power supplied to each is:

element 1	7.9 watts
element 2	35.7 watts
element 3	35.7 watts
element 4	59.2 watts

which, on a percentage basis, is 5.7 percent, 25.8 percent, 25.8 percent, and 42.7 percent, respectively. Thus a feed network aimed at supplying equal power to this array, such as a Wilkenson power divider, will be at cross purposes with the requirement. (Incidentally, a Wilkenson divider will *not* supply equal power to unequal terminations.) Also, since the 90-degree phased elements are not resistive, simply inserting a quarter-wavelength of delay line in their feeders won't do. Clearly, only a feed system designed for the array elements' driving-point impedances will carry out this unequal power division while producing the proper element phase displacements.

It is possible to devise a feed network which performs these functions while also matching the array to the transmitter feedline. Doing so is not even unduly complex, but calculating the driven impedances does require a knowledge of the self and mutual impedances of the elements. Methods for doing this will be detailed in a future article. The greatest benefit of a good match in multi-element arrays is the warning it provides when loss of continuity to an element occurs because of faulty switching relays or the like.

30 to 40 dB F/B are achievable

My interest in low-band DX began just as described in the beginning of this article. I started with a dipole 30 feet high, then progressed to a vertical, and then to in-line arrays of two and three verticals. With some cut-and-try, the arrays were made to work quite well.

Then came the articles by W1CF on the 4-square

†Special cases are mentioned for completeness. The situations governing them are not ordinarily encountered in phased-array feed network applications. These cases arise when the real and reactive components of a termination have a particular relationship with the characteristic impedance, Z_O, of the line and its electrical length. For example, an eighth-wavelength line will have a current delay of 45 degrees with terminated by an impedance whose arithmetic sum of the real and reactive components equals Z_O. A three-eighths wavelength line, under the same impedance relationships, will exhibit 135 degrees phase delay between input voltage and output current. These are two special cases which I explored; there may be more. I am indebted to W7EL for bringing the possibility of such unusual cases to my attention.

array[4] which inspired me, as they have many others, to duplicate his pathfinding work in building pattern controlled low-band arrays. For me at least, having achieved excellent F/B with simpler arrays (but without bothering to find out precisely why), the F/B results were disappointing. Cut-and-try led nowhere, this array's having too many variables for such blind stabs, and so I had to go back to basics for a more fundamental understanding. Thanks to the advice, encouragement, ideas, and boundless resource of mathematical tools contributed by my friend WB6SXV, as well as many information exchanges with W7EL and W2PV[5] I believe I now know how the 4-square should work.

Achieving theoretical F/B in practice ultimately becomes an exercise in achieving electrical symmetry of the array. This is not easy, but efforts continue to reach that goal. Fortunately, like Yagis, these arrays *want* to work. Less than optimum drive conditions for forward gain find them as tolerant as Yagis, but also as intolerant for high front-to-back ratio. Despite large departures from design drive currents and delay angles, forward gain is not affected much. But seemingly insignificant differences in drive currents or delay angles drastically reduce the maximum F/B capabilities. A 10 percent change in drive current of one element in a 4-square can bring the array from a really excellent 30 to 40 dB F/B down to an average 15 to 20 dB. Another way of looking at this is that excellent F/B ratios hold over a small frequency range, while gain holds over a relatively much larger range, as W2PV showed for the Yagi.[3]

Although the principles for correctly feeding a multiple driven element array have been known since the 1930s,[6,7] their primary application has been by the long-wave a-m broadcast industry, and relatively little has been published in Amateur Radio literature. Perhaps editors may have felt the subject too complex, or that it lacked broad reader interest. Another possible reason is that few modern antenna texts discuss feed methods for such arrays. Typically, many field plots are shown, but means for achieving them are left to the reader.

areas to be addressed

It is the purpose of this series of articles to attempt to fill this gap. Over the next few months I shall try to address the following considerations:

I. Theoretical Array Design
   - Element spacing
   - Drive requirements — magnitude and phase
   - Field plotting — how to calculate

II. Self and Mutual Impedance
   - Measurements and calculations
   - Ground planes
   - Element driven impedances

III. Drive Network Design
   - Four-terminal network matrices
   - Pi and T coax equivalents
   - Directional switching
   - Adjustment and measurement

Topics of this nature cannot be adequately discussed without presenting voltages, currents, and impedances in complex algebraic form, such as $R + jX$ for impedance. Those readers who understand them will have no difficulty in following the presentation; for those who do not, I am assuming that they have a good enough general understanding of the concepts (of resistance and reactance) to be able to understand the implications of the conclusions I present.

In general, I shall try to address myself to general solutions, without restriction to specific designs. Where particular designs are examined, these will be by way of illustration, not for the sake of presenting any one proposal. Rather, it is my hope that readers will find their own solutions to their particular problems within the space they have available. There is nothing writ in stone, for example, which requires the elements of an array to be resonant, to be spaced at 1/4 wavelength, to be phased in multiples of 90 degrees, or to have radials measured to some exact length. Neither do all arrays operate best with equal current magnitude to all elements. A few hours of mathematical experimentation will allow you to run through more designs than you could ever hope to build.

Building vertical phased arrays is not a black art; with accurate measurements of self and mutual impedances and with reasonably good electrical symmetry, theoretical design goals can be closely approximated in practice. Most of the explanation for the large gap between theory and practice which so many builders encounter lies in the many invalid assumptions discussed earlier.

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ham radio

Two crossed dipoles of different lengths cover the entire 80-meter band

stagger-tuned dipoles
increase bandwidth

A broadband antenna can be constructed by using a pair of stagger-tuned dipoles, either horizontal or inverted Vs, mounted at right angles to each other and connected in parallel. (See **fig. 1.**) A single 50-ohm coaxial cable is used for the transmission line. The dipoles are of different lengths, with the longer tuned to a frequency near the lower edge of the band and the shorter to a frequency near the upper edge of the band. Because the dipoles are at right angles, no cancellation or nulls occur in the combined radiated field. Near mid-band, the antenna is omni-directional.

The purpose of this article is to derive the basic equations which apply to the standing wave ratio curve for this antenna. These equations are then used to determine the fundamental relationship between the bandwidth and the SWR.

80-meter measurements

The entire 80-meter band is described by a W-shaped SWR curve with a maximum of about 2 (both at the middle and at the band edges). The measured curve of an experimental model is shown in **fig. 2.**[1]

The 80-meter band, having the greatest percentage bandwidth of all the Amateur bands, is covered by the stagger-tuned antenna without exceeding an SWR of 2. As used here, the term percent bandwidth of a circuit is defined as the bandwidth divided by the mid-band frequency, multiplied by 100.[2] The four Amateur bands considered here, 160, 80, 40, and 10 meters, have bandwidths of 10.5, 13.3, 4.2, and 5.9 percent respectively.

dipole impedance

The stagger-tuned antenna impedance is determined by the impedances of the parallel dipoles. An equivalent schematic for a single center-fed dipole, near its series resonant frequency, is shown in **fig. 3.**

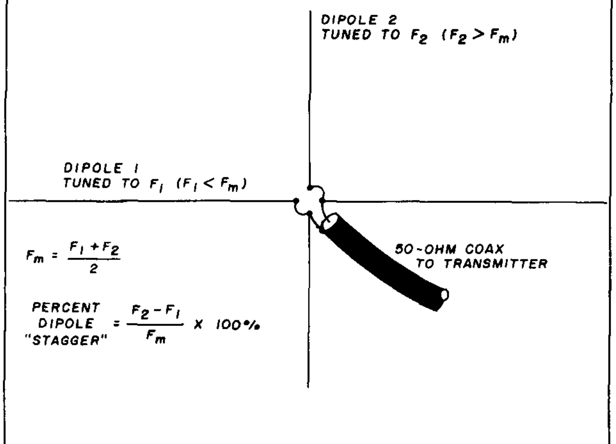

fig. 1. Top view of broadband stagger-tuned, crossed-dipole antenna.

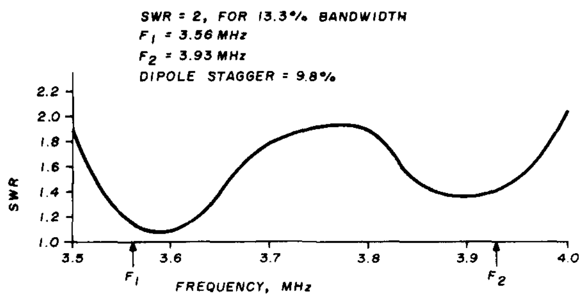

fig. 2. Measured SWR of broadband 80-meter stagger-tuned antenna using inverted Vs.

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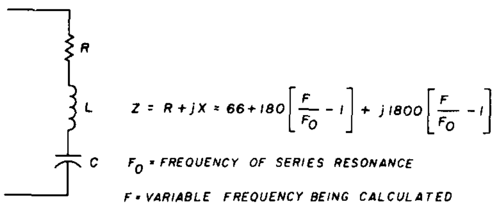

fig. 3. Dipole equivalent circuit and representative series resonant impedance.

The equation for the impedance of a dipole given in this figure curvature has been derived by fitting to dipole impedance curves.[3]

It is convenient to use normalized impedances, obtained by dividing by 50 ohms, a commonly used coaxial cable characteristic resistance (R_0). At resonance, the normalized radiation resistance of a dipole is 66/50, or 1.32,* numerically equal to its SWR.

For comparison, note that the calculated bandwidth of a horizontal dipole is 7.1 percent at an SWR extreme of 3.0:1. The reactance part of the dipole impedance is about equal to the resistance and the phase angle is approximately 45 degrees. This 7.1-percent bandwidth for a dipole is the basic building block of the stagger-tuned antenna.

impedance of parallel stagger-tuned dipoles

Fig. 4 shows the equivalent circuit for the parallel dipoles, with impedance Z_1 tuned to the lower frequency F_1, and Z_2 tuned to the upper frequency F_2. With F_1 and F_2 fixed, the equation in **fig. 3** first is used for each dipole in turn, to determine the two dipole impedances. From these, and at each frequency, the usual parallel impedance equation of **fig. 4** then gives the stagger-tuned antenna impedance. Finally, the SWR over the entire band is calculated.

For frequencies between the two dipole resonances, the lower F_1 and the higher F_2, an interesting and useful effect exists, which leads to wideband operation. Between F_1 and F_2, the F_1 dipole has a positive reactance while the F_2 dipole exhibits a negative reactance, each being in series with its own radiation (real) resistance. The network acts like a lossy anti-resonant circuit. It is the impedance of this anti-resonant circuit which produces the SWR maximum in the center of the band and limits the attainable bandwidth.

At the center, the two reactances always are equal in magnitude and opposite in sign. The two resistances differ somewhat because of the radiation resistance frequency dependency, that for F_1 being higher than the resistance at its resonance and that for F_2 being an equivalent amount lower. With a further increase in frequency separation (greater than 7.1 percent) the reactances increase faster than the resistances, causing an increasing anti-resonant resistance and SWR.

calculations

Two W-shaped SWR curves have been prepared, **fig. 5** for an antenna which turned out to be not quite wide enough for the 80-meter band, and **fig. 6** for an antenna not quite wide enough for the 160-meter band. The calculated curves have an appearance remarkably similar to the measured curve of **fig. 2** and confirm that an SWR of less than 2 can be expected for the entire 80-meter band. Using these trial curves, a very good estimate of the needed increase in stagger spacing can be made.

80 meters

The SWR curves of the individual dipoles F_1 and F_2 are drawn in to show that, even when they are far

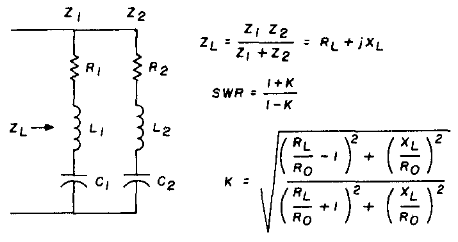

fig. 4. Equivalent circuit of two stagger-tuned crossed dipoles and SWR equation.

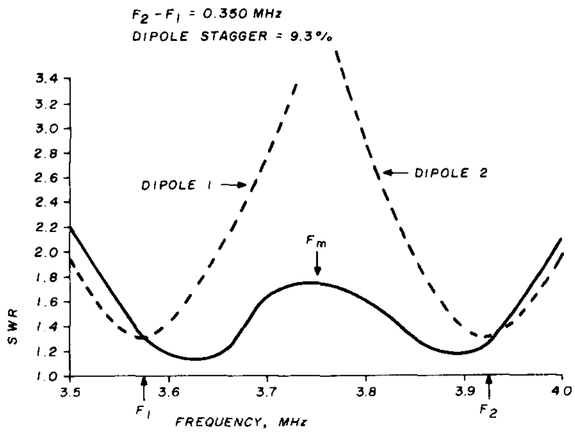

fig. 5. 80-meter stagger-tuned antenna calculated SWR versus frequency.

*In general, the series-resonant resistance varies with height above ground and wire size. **Ed.**

apart, they still interact to produce an acceptable SWR in the center. Further, the two frequencies where the stagger-tuned SWR curve is lowest, are lower than for individual dipoles.

For the 80-meter band, the stagger should be increased to 10 percent instead of 9.3 percent used in the computations, to fully cover the band. The SWR at the ends and the central maximum is about 2.

160 meters

For the narrower 160-meter band, the stagger should be increased to 9 percent, instead of the 7.9 percent used in the computations. The SWR is about 1.7, less than for the 80-meter band.

10 and 40 meters

The much narrower antenna bandwidths for the 10- and 40-meter bands do not exhibit a center frequency SWR maximum. Instead, a different consideration controls the dipole stagger. The computed SWR curve is shown in **fig. 7** for this condition. As the dipole stagger is reduced to fit these bands, the central maximum disappears and a broad minimum appears. This change occurs at a dipole bandwidth spacing of 7 percent. However, as the minimum is further reduced, the outside edge SWR begins to increase. A choice of 6 percent relative dipole stagger for both the 10- and 40-meter bands appears to be a reasonable compromise.

There is a low overall SWR. This places the dipoles at the edge of the 10-meter band but outside the edges of the 40-meter band! For 10 meters, the maximum SWR is about 1.5, and for 40 meters about 1.3.

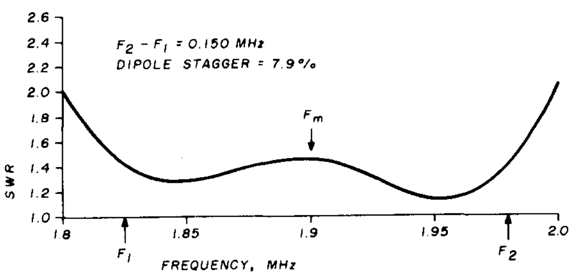

fig. 6. 160-meter stagger-tuned antenna calculated SWR versus frequency.

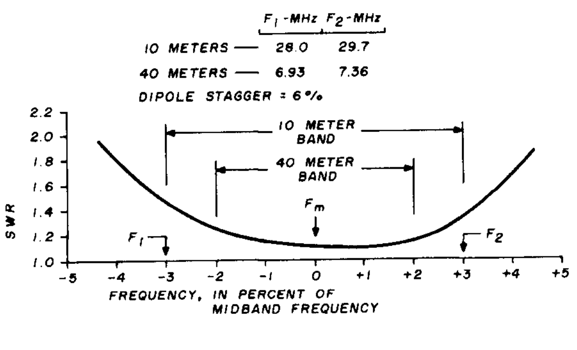

fig. 7. 10- and 40-meter stagger-tuned antenna calculated SWR versus frequency.

summary

Equations which apply to the stagger-tuned crossed dipole antenna have been specified. The 80-meter Amateur band is, relatively, the widest. Measurements and calculations confirm that this entire band can be covered with a SWR of about 2.

A tabulation of the calculated (required) resonant frequencies for the two dipoles, and the calculated maximum SWR for the 160-, 80-, 40-, and 10-meter bands, are given in **table 1**, below:

table 1. Calculated resonant frequencies and maximum SWR.

band meters	F_1 MHz	F_2 MHz	percent bandwidth	calculated maximum, SWR
160	1.81	1.98	9	1.7
80	3.56	3.94	10	2.
40	6.93	7.36	6	1.3
10	28.00	29.7	6	1.5

Note that, for the 40-meter band, the dipole resonant frequencies lie outside the Amateur band. Using only the formula for length is satisfactory, without a direct measurement of the resonant frequency, because the 40-meter band uses only the central 4.2 percent of the antenna's basic 6 percent width.

All the data presented in this article, except the measured curve of **fig. 2**, have been calculated using representative impedances for a dipole.[3] Calculations have insured that the results are comparable throughout, and help determine effects that might not be noticed using only measurements.

A dipole's impedance depends in part on nearby objects and the height above ground. Inverted Vs add even more variables. However, the calculated results show that the stagger-tuned antenna can be adjusted to develop the required wideband characteristic.

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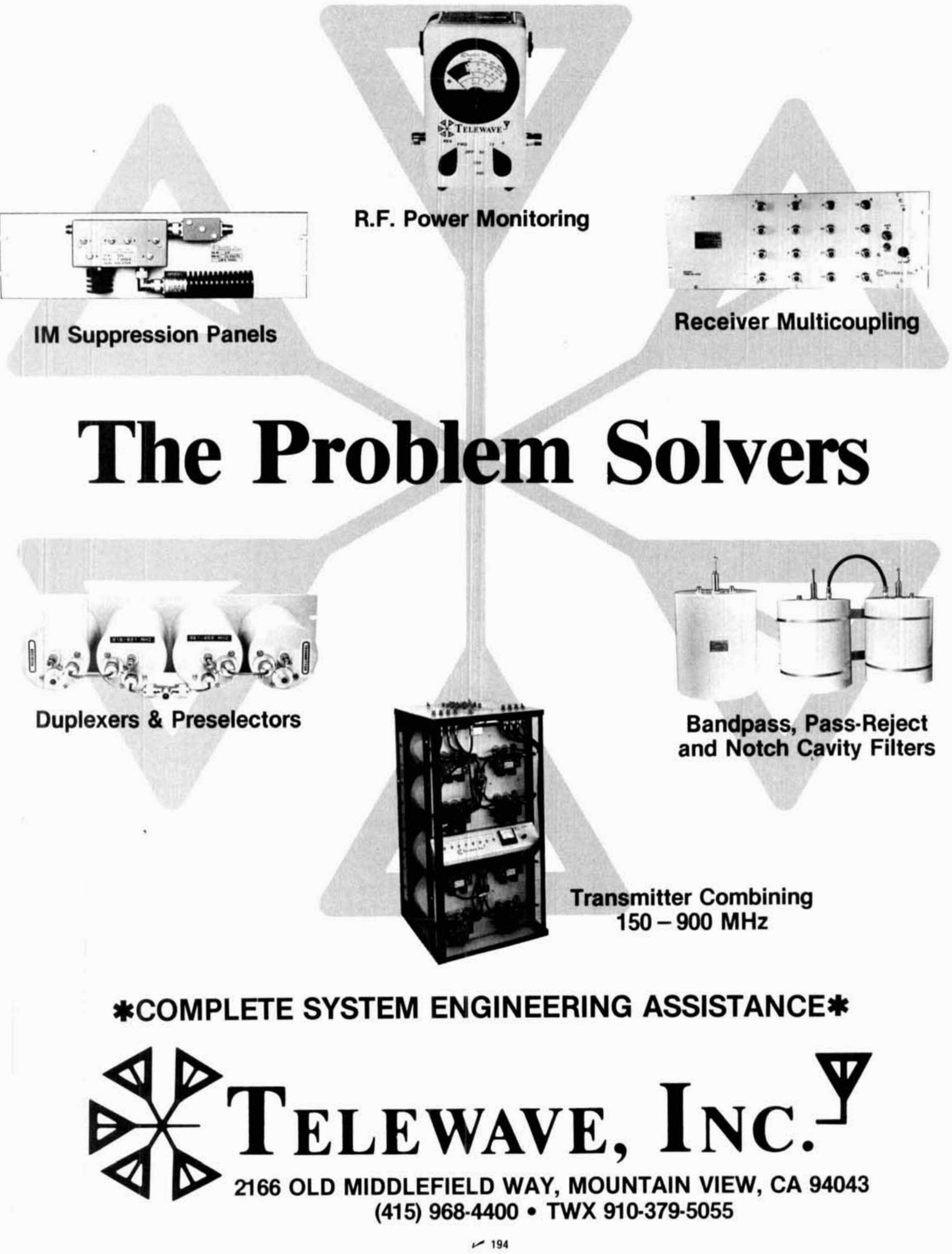
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20-meter mobile vertical

CB plus replacement auto antenna combine to make a durable performer with good bandwidth

It's unusual to find a homebrew mobile high-frequency antenna, partly because it's rather difficult to construct one which will withstand the 100-plus mph winds antennas encounter from time to time. However, it *is* relatively easy to convert a Radio Shack mobile CB antenna to 20 meters, and the resulting antenna is a surprisingly good performer.

The basis for the antenna is a Radio Shack 4-foot Fiberglass Whip, #21-934 (**fig. 1**). The whip is helically wound near the top and fits a standard 3/8 × 24 threaded mount. When mirror-mounted on my van using a Radio Shack #21-937 mount, the unmodified whip shows an impedance of 25-j1000 ohms at 14.3 MHz. It can be resonated at this frequency by adding, at the top, about 27 inches of straight whip, made from a replacement auto antenna.

Most replacement auto antennas are designed to attach to the broken stub with a set screw. To provide a stub attachment point at the top of the CB whip, carefully scrape away the outer fiber glass material to expose about 1/4-inch of the embedded wire. It appears to be 22-gauge enamel-coated wire. Bare the wire and tin it. Cut the head off a 1/4-inch diameter, 1 1/2-inch brass bolt, and tin the butt (thicker portion) of the threaded end. Solder this end to the wire.

This stub attachment will be secured to the CB whip with glass cloth and epoxy (**fig. 2**). First, however, it's necessary to fasten the bolt to the CB whip to prevent the fine wire from breaking during handling. Lay the CB whip horizontally and block it up so that the auto whip is aligned. Attach the auto whip to the bolt by tightening the set screw, and block it level with the CB whip. Put a dab of 5-minute epoxy on the end of the CB whip, press the two sections together, and visually align them.

After the epoxy has thoroughly hardened, remove the auto whip and sand the top 2 inches or so of the CB whip and bolt with fine sandpaper. This provides a clean surface for the fiber glass reinforcement. Glass cloth/epoxy repair kits are available at most

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hardware stores. Cut three strips of cloth about 12 inches long and 1 inch wide and saturate them with mixed epoxy resin. Starting about 2 inches below the joint, wind each strip in overlapping fashion, like tape, to cover the joint and 1/2 to 3/4 inch of the bolt. Three layers of cloth will provide ample strength. Be sure to follow all instructions provided with the kit, including the safety precautions.

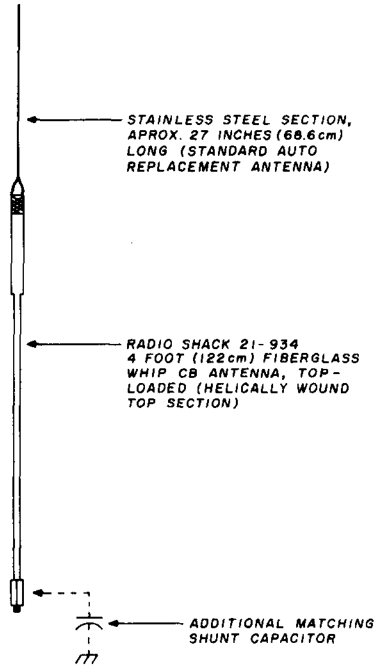

fig. 1. The assembled 20-meter mobile antenna. The capacitor may be attached with spring clips for improved matching (see text).

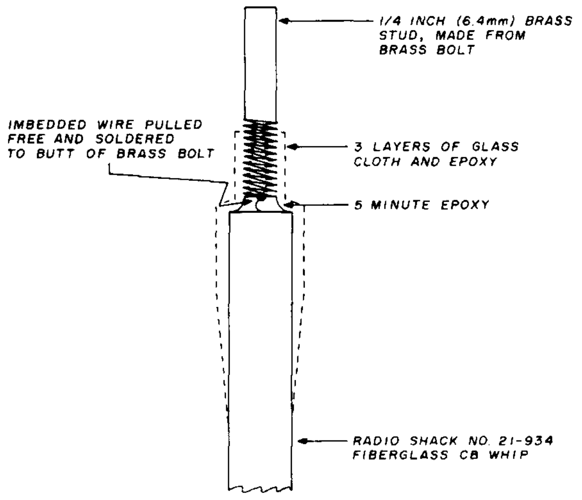

fig. 2. Detail of the attachment point for the replacement auto whip. Use 5-minute epoxy to cement the stud to the whip prior to applying glass cloth.

The joint will be messy at this point, but it can be smoothed out by sanding after the epoxy has cured completely. It probably will be necessary to scrape or sand the exposed portion of the bolt to remove epoxy that has formed on it. Attach the replacement auto whip securely, and you will be ready for tune-up.

matching to the whips

Each mobile installation differs by vehicle, the type of mount, and the position of the antenna on the vehicle. The 27-inch whip length mentioned earlier may not be correct in any installation but mine, but it should be close. Make adjustments as necessary for your situation.

A few hints may make the tune-up process a little less frustrating: 1) use a feedline that is a multiple of one-half wavelength (don't forget the velocity factor) to avoid transformer action in the feedline; 2) park the vehicle well away from objects, such as trees and overhead wires, to prevent detuning; and 3) shorten the whip a *little* at a time – no more than 1/8 inch per cut when you're near resonance. The *ARRL Antenna Book*[1] details other methods for resonating a mobile antenna.

At resonance, the antenna shows a resistive impedance of 30 to 35 ohms. The resulting SWR is adequately low for many purposes, but the bandwidth may be improved by better matching. Trim the whip to be inductive (too long), and then add the appropriate value of shunt capacitance from the base of the antenna to ground, forming an L-network which transforms the impedance to 50 ohms. I found that merely attaching a 200-pF, 500-volt mica capacitor to the base of the antenna and ground with spring clips, then shortening the straight whip until the antenna resonated, provided a feedpoint impedance that was very close to 50 ohms.

When tuned in the above fashion, the antenna showed a 2:1 SWR bandwidth of about 50 kHz for my installation. Consistently good signal reports have come from all areas of the U.S.; I've been running 100 watts PEP (no DX has been attempted). The small-gauge wire used in the CB whip probably has more ohmic loss than desirable, but the performance is not harmed noticeably.

reference

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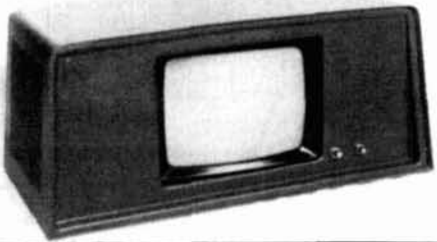

9 Inch monitor runs off of 115 VAC by Motorola in handsome styled case. This monitor accepts composite video thru a BNC connector mounted on rear of cabinet. Great monitor for surveillance, VCR playback, or computer use. These are used, but are in operational condition, each one checked out prior to shipment. Shpg. wt. approx. 20 lb. Stock # MOT-8 $40.00

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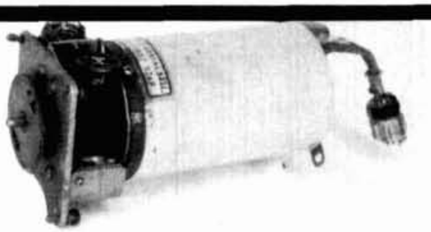


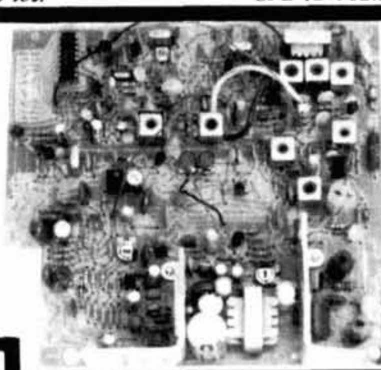
High priced VFO removed from Collins Military T-195 radio. Comes with matched pair of tubes 5749. One is Osc & one is buffer. Freq. range 1.5 to 3 Mhz Requires 150 volts DC, 28 volts for heater on oven, and 12 volts heater on tubes. Xlnt cond, tenderly removed from eqpmt. With schematic

Shipping wgt. 5 lbs. SPL-4B $12.50

This is the basic CB 40 channel synthesized PC board assembly. A value for the many parts such as "IF" cans, caps, resistors, "IF" crystal, phase lock loop IC, RF & modulation transistors, etc. We furnish a typical schematic. Spots on the board at first glance appear to be missing parts. Not so, the board was upgraded by adding more components for the higher priced more sophisticated sets. These boards were written up in "73" magazine Fall of 1978 for 10 meter conversion. Find a use for one lone part, and you have your full purchase price realized.

SP-126A $8.00

Two different writeups for 10 Meters in "73 MAGAZINE" Aug and Sept 1980



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repeater antenna beam tilting

A four-pole collinear reduces a shadowing effect common to mountainous areas

During recent years I've helped design and construct several commercial and Amateur repeaters. Most of these repeaters are located on high mountains where large elevation differences exist between mobile stations and the machine. From such sites, conventional antennas may overshoot the intended coverage area. I wish to introduce a method of electrical beam-tilting which will optimize the use of the antenna radiation pattern.

shadowing and overshoot

Western Montana and the Rocky Mountain region in general have similar topography. In these areas mountains rise from the prairie and valleys to form natural towers for prospective repeaters. Many exceed 10,000 feet (3049 meters) in elevation. From the early years of two-meter repeatering, Montana Amateurs have made use of these sites. In situations like this where very high repeater sites are used, a problem called shadowing can exist.

Fig. 1 is an example of a spot where a repeater site is 3000 feet (914 meters) higher in elevation than the desired coverage area. Additionally, the rise in elevation takes place over the relatively short, horizontal distance of five miles (eight kilometers). **Eq. 1** is used to calculate a depression angle of -6.5 degrees from the repeater to the coverage area. (The angle is approximate because curvature of the earth was not included.)

$$\theta = tan^{-1} \frac{C - R}{D} \tag{1}$$

where: θ = *The depression angle (degrees)*

R = *The repeater elevation (feet or meters)*

By Lee Barrett, K7NM, 214 East 1800 South, Apt. 0, Clearfield, Utah 84015

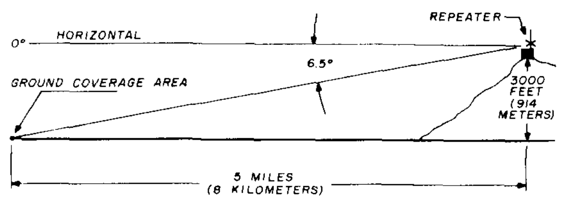

fig. 1. The repeater is much higher in elevation than the intended coverage area. Neglecting the earth's curvature, the antenna radiation pattern must be depressed 6.5 degrees to prevent shadowing of the desired coverage area.

C = *The coverage area elevation (feet or meters)*

D = *The horizontal distance from the repeater to the coverage area (feet or meters)*

Fig. 2 depicts the same site with an antenna radiation pattern added. With the pattern centered on the horizontal or zero-degree line, an antenna radiating a half-power beamwidth of 13 degrees is required for the lower half-power point to fall on the area of desired coverage. Any station closer to the repeater is not in the main pattern and, as a result, is shadowed. Also, the radiated power above the horizontal serves only to heat the ether. If this wasted radiated power could be salvaged to fill in the shadowed areas, a more efficient antenna system would result. I borrowed a solution to both shadowing and efficient energy usage from the field of broadcasting.

the solution

Commercial fm and television transmitters are often located on mountain-top sites. If necessary, beam tilting is used to direct the radiated energy downward from the transmitter site to the intended area of coverage. Beam tilting may be required at lower elevations than one might expect. With consideration given to the curvature of the earth, for example, a transmitter site only 1000 feet (305 meters) above the earth requires a 0.5 degree downtilt for the center of the main antenna radiation pattern to intersect the horizon![1] Obviously, the repeater described earlier could be a serious candidate for beam tilting.

antenna considerations

Through experimentation, the collinear[2] type of antenna seems to be a superior antenna choice for tall, mountain-top applications. Consequently, the discussion is limited to two types of collinear antennas.

The first is the familiar 24 foot (7.3 meters) high, fiberglass encased collinear, which is easy to mount and performs well. Also, some manufacturers will provide an electrical downtilt to your specifications for an additional charge and a shipping delay. For a repeater group working on a shoe-string budget, however, this antenna is not the most economical. Furthermore, if your site is subjected to icing and frequent high winds, the fiberglass collinear may not survive very well. Any small, internal fracture caused by flexing in the wind may cause an rf diode to form and introduce horrid screeches and howls into the repeater. Such slight defects are magnified where the receiver and transmitter of the repeater are closely spaced in frequency. In such cases, the unusable collinear for repeater applications may oftentimes be retired to satisfactory base station service.

I favor a second type of collinear antenna comprising four dipoles fed in phase. This array, illustrated in **fig. 3**, is commonly called the Four Pole antenna. It is derived from linear array theory[3] and can be used for electrical beam tilting. Some commercial Four Poles use folded dipoles with matching baluns as elements, while others use common dipoles with gamma matching or straight feeds. In any case, the antenna feed impedance should be 50 ohms.

Each 72-ohm cable section with a length equal to an odd multiple of a quarter-wave transforms a 50-ohm termination to 100 ohms at the driving end. The resulting 100-ohm impedances are combined in parallel through tee connectors to produce 50-ohm resultants. The 72-ohm coax harness shown in **fig. 3** is used to combine the element impedances to a common 50-ohm feedpoint. Also, since the signal must travel an equal distance from the feedpoint to each element, the elements are fed in phase.

All *cable* length calculations are multiplied by the cable velocity factor to obtain actual lengths. The *an-*

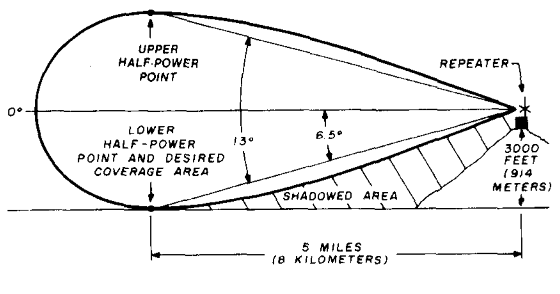

fig. 2. A repeater antenna with a vertical, 13 degree, half-power beamwidth barely meets the required depression angle. Any station closer to the repeater is shadowed while the repeater power in the pattern above 0 degrees is wasted.

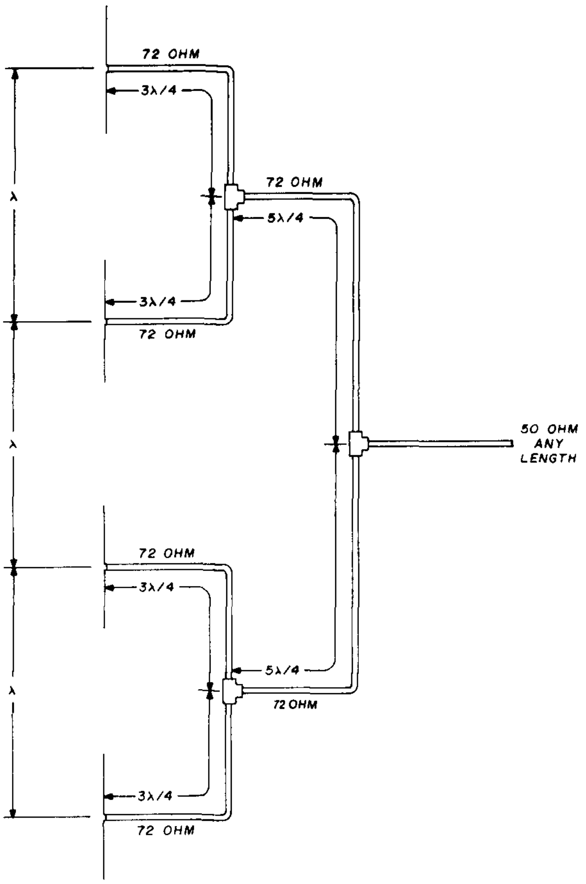

fig. 3. Odd quarter-wavelength coaxial transformers are used to match the dipole impedances to the driving point. The driving phase is the same to all dipoles due to feed system symmetry.

tenna lengths and spacings, however, are close to that of free space.

For strength and mounting convenience, the four dipole elements are usually mounted to a metal mast. Because the mast proximity distorts the element patterns, the four elements should be spaced at 90 degree intervals around the mast to obtain an omnidirectional pattern. If all the elements are mounted on the same side of the mast, the resulting pattern strongly favors the direction the elements are facing. Typical gains for the Four Pole are 6 dB for an omnidirectional pattern or 9 dB for a favored direction. The ability to steer elements and favor specific directions further enhances the utility of the Four Pole as a repeater antenna.

downtilt theory

The vertical radiation pattern of the Four Pole antenna results from pattern multiplication. The Four Pole elements are first considered as a vertical stack of four isotropic radiators (small radiating spheres), each spaced one wavelength above the next. The normalized far field pattern for this linear antenna array is given by **eq. 2**[4] and tabulated in **table 1**.

$$E_a = \frac{Sin\, n \;\; (180°s)cos\,\theta + \frac{d}{2}}{n\, Sin \;\; (180°s)cos\,\theta + \frac{d}{2}} \qquad \textbf{(2)}$$

where: E_a = *Field strength of the array (normalized to unity)*

n = *The number of antenna elements*

s = *The antenna spacing from center to center (wavelengths)*

d = *The progressive difference in phase shift between antennas. The top element considered at 0 degrees for reference (degrees)*

θ = *The counterclockwise angle off vertical formed by a line from the array center to the desired field point (degrees)*

(There are a few values that when substituted in **eq. 2** produce an indeterminate form, e.g., zero divided by zero. This problem is overcome by use of the mathematical technique known as L'Hospital's rule* *or* by recalculating **eq. 2** using a slightly greater angle, e.g., $\theta + 1$.)

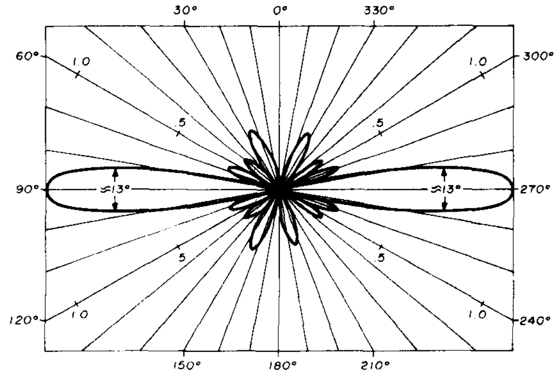

fig. 4. The vertical radiation pattern of a Four Pole antenna produces a half-power beamwidth of approximately 13 degrees. (Half-power points are synonymous with a 0.707 normalized field voltage.) The line of the Four Pole array is centered along the 0 to 180 degree axis with the top dipole in the 0 degree direction.

*Differentiate both the numerator and denominator and substitute 0 for θ. If eq. 2 is still indeterminate, repeat process. **Ed.**

Once the array pattern is solved the isotropic sources are replaced by vertical dipoles. This is accomplished mathematically by multiplying the linear array pattern by the dipole pattern given in **eq. 3.**[5] (The same method of overcoming indeterminates may be used here as was suggested for **eq. 2.**) The dipole calculations and pattern multiplication results are also shown in **table 1**. The resulting Four Pole pattern is plotted in **fig. 4**.

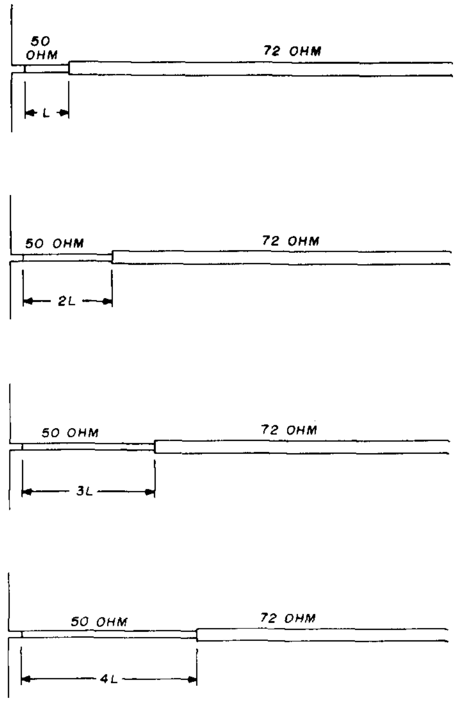

fig. 5. By inserting 50-ohm coaxial delay sections between the dipole feed points and the 72-ohm feed sections, a progressive phase shift is introduced. Selection of the proper phase shift causes the antenna pattern to electrically tilt downward.

$$E_d = \frac{\cos(90^\circ \cos\theta)}{\sin\theta} \qquad \textbf{(3)}$$

where: E_d = *Field strength of the dipole (normalized to unity)*

θ = *The counterclockwise angle off vertical formed by a line from the center of the dipole to the desired field point (degrees)*

Since the dipole pattern is a constant, the only hope of creating a downtilt is by modifying some parameter in the linear array pattern. In examining a

table 1. Calculated, normalized field strengths for the linear array (E_a), dipole (E_d), and Four Pole ($E_{Four\ Pole}$) antennas.

Angle θ (Degrees)		$\|E_a\|$	$\|E_d\|$	$\|E_{Four\ Pole}\|$
1,	181	1.000	.014	.014
11,	191	.992	.151	.150
21,	201	.894	.291	.260
31,	211	.562	.432	.243
41,	221	.021	.573	.012
51,	231	.272	.708	.193
61,	241	.048	.828	.040
71,	251	.238	.922	.291
81,	261	.489	.982	.480
83.5,	263.5	.710	.991	.704
91,	271	.993	1.000	.993
96.5,	276.5	.710	.991	.704
101,	281	.300	.973	.292
111,	291	.271	.906	.246
121,	301	.047	.805	.038
131,	311	.262	.682	.179
141,	321	.130	.545	.071
151,	331	.651	.404	.263
161,	341	.928	.263	.244
171,	351	.996	.124	.120

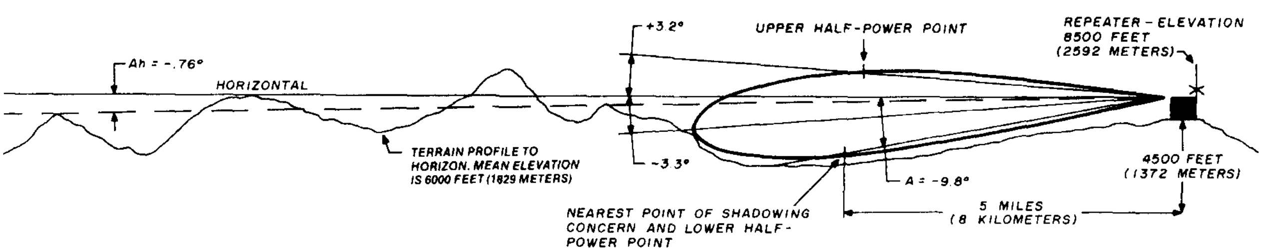

fig. 6. By selecting the proper beam tilt through the information presented in the text, shadowing may be eliminated through maximum utilization of the repeater antenna pattern. The curvature of the earth and the angle from the repeater to the horizon must also be considered.

table of linear array patterns,[6] I discovered that a progressive phase delay of the lower Four Pole elements would, in theory, tilt the beam downward. In practice, the phase delay is accomplished by placing appropriate lengths of 50-ohm coax cable between the antenna element feed points and the 72-ohm phasing harness, as illustrated in **fig. 5**. Although it is not necessary to add any length to the top element, doing so overcomes any phase errors caused by the addition of connectors used in the lower element phasing sections.

determining downtilt

The first step in formulating a downtilt is to determine two depression angles. The first is the angle of the horizon and the second is the deepest angle where repeater shadowing is *not* to be allowed. **Eqs. 4** and **5** may be used for these angles respectively.[7]

$$A_h = \frac{0.0108P}{D} \quad \textbf{(4)}$$

where: A_h = *The depression angle to horizon (degrees)*

P = *The elevation difference of the repeater site over the average terrain elevation (feet — multiply meters by 3.28)*

$$A = \frac{0.0109\,H}{D} \quad \textbf{(5)}$$

where: A = *The depression angle (degrees)*

H = *The elevation difference of the repeater site over the nearest point of shadowing concern (feet — multiply meters by 3.28)*

D = *The horizontal distance from the repeater to the nearest point of shadowing concern (miles — multiply kilometers by .62)*

Once these angles are known, the half-power beamwidth of the Four Pole may be fitted to these angles to provide optimum coverage.

For example, assume a repeater is located on an 8500 foot (2591 meter) peak overlooking a valley with an elevation of 4000 feet (1220 meters) and the difference in elevation occurs over a distance of five miles (eight kilometers). Because the area is fairly mountainous, the average terrain height to the horizon could be estimated at 6000 feet (1829 meters). From **eq. 4** and **5**, the two depression angles are $A_h = 0.76$ *degrees* and $A = 9.8$ *degrees*.

Fig. 4 and **table 1** show the half-power beamwidth of the Four Pole to be very close to 13 degrees or 6.5

```
20 CLS:PRINT:PRINT
30 PRINT"                    * * * * ANTENNA POLAR PLOTTING PROGRAM * * * *"
40 PRINT:PRINT"                              BY LEE BARRETT K7NM 1981"
50 PRINT:PRINT"                   * * * * PRESS ANY KEY TO CONTINUE. * * * *"
60 Y=RND(191)
70 FOR X=15360+63 TO 15360 STEP-1:POKE X,Y:NEXT
80 FOR X=15360 TO 16383 STEP-64:POKE X,Y:NEXT
90 FOR X=15361 TO 16383 STEP-64:POKE X,Y:NEXT
100 FOR X=15362 TO 16383 STEP-64:POKE X,Y:NEXT
110 FOR X=15360+960 TO 16383:POKE X,Y:NEXT
120 FOR X=16383 TO 15360 STEP-64:POKE X,Y:NEXT
130 FOR X=16382 TO 15360 STEP-64:POKE X,Y:NEXT
140 FOR X=16381 TO 15360 STEP-64:POKE X,Y:NEXT
150 R$=INKEY$:IFR$=""THEN 150  ELSE 170
160 GOTO 60
170 DIM E(360),M(70,50),Z(360),Y(360):G$="##.#####"
180 CLS
190 PRINT"TYPE NUMBERS GREATER THAN 10 FOR A YES ANSWER AND NUMBERS LESS THAN 1
0 FOR A NO ANSWER TO QUESTIONS."
200 PRINT:PRINT
210 INPUT"INPUT THE NUMBER OF ANTENNAS.";N
220 PRINT
230 INPUT"INPUT THE SPACING IN WAVELENGTH.";D
240 PRINT
250 INPUT"INPUT THE PROGRESSIVE PHASE SHIFT IN DEGREES.";P
260 PRINT
270 INPUT"INPUT DEGREE STEP DESIRED FOR CALCULATIONS.";K
280 CLS
290 C=3.14159
300 R=((2*C)/360)
310 FOR A=1 TO 360 STEP K
320 S=(((2*C*D)*COS(A*R))+(P*R))
330 B=(N*SIN(S/2))
340 IF B=0.0 THEN 370
350 T=SIN((N*S)/2)
360 GOTO 390
370 B=(N*COS(S/2))*((C*D)*SIN(A*R))
380 T=(COS((S*N)/2))*((N*C*D)*SIN(A*R))
390 E(A)=T/B
400 PRINTTAB(8)"ANGLE=";A;TAB(23)"E = ";USING G$;ABS(E(A));:PRINT
410 NEXT A
420 INPUT"PLOT ARRAY?";X
430 IF X > 10 THEN 680
440 INPUT"NEW PATTERN?";X
450 IF X > 10 THEN 180
460 FOR A = 1 TO 360 STEP K
470 B=SIN(A*R)
480 IF B<>0.0 THEN 520
490 B=COS(A*R)
500 T=(-1*SIN((C/2)*COS(A*R)))*((C/2)*(-1*SIN(A*R)))
510 GO TO 530
520 T=COS((C/2)*COS(A*R))
530 Z(A)=T/B
540 PRINTTAB(8)"ANGLE=";A;TAB(23)"E=";USINGG$;ABS(Z(A));:PRINT
550 NEXT A
560 INPUT"PLOT DIPOLE?";X
570 IF X>10 THEN 720
580 PRINT"FOUR POLE PATTERN:"
590 FOR A=1 TO 360 STEP K
600 E(A) = E(A)*Z(A)
610 PRINTTAB(8)"ANGLE=";A;TAB(23)"E=";USINGG$;E(A);:PRINT
620 NEXT A
630 INPUT"PLOT 4 POLE PATTERN?";X
640 IF X>10 THEN 680
650 INPUT"QUIT?";X
660 IF X>10 THEN 1080
670 GOTO 180
680 FOR A=1 TO 360 STEP K
690 Y(A)=ABS(E(A))
700 NEXT A
710 GOTO 750
720 FOR A = 1 TO 360 STEP K
730 Y(A)=ABS(Z(A))
740 NEXT A
750 FOR I=1 TO 64
760 FOR L=1 TO 50
770 M(I,L)=0.0
780 NEXT L
790 NEXT I
800 FOR A=1 TO 360 STEP K
810 U=(Y(A)*32)*SIN(A*R)
820 O=(Y(A)*23)*COS(A*R)
830 U=(31-INT(U))
840 O=(23-INT(O))
850 M(U,O)=1
860 NEXT A
870 CLS
880 PRINT TAB(50)"REFERENCE ANT"
890 PRINT TAB(50)"AT BOT. OF "
900 PRINT TAB(50)"ARRAY. ZERO"
910 PRINT TAB(50)"AT THE TOP"
920 PRINT TAB(50)"WITH CCW"
930 PRINT TAB(50)"INCREASING"
940 PRINT TAB(50)"ANGLES."
950 FOR I=1 TO 63
960 FOR L=1 TO 47
970 IF M(I,L)<>1 THEN 990
980 SET (I,L)
990 NEXT L
1000 NEXT I
1010 PRINT@930,"CALCULATE NEW ARRAY?"
1020 INPUT X
1030 IF X>10 THEN 180
1040 INPUT"CALCULATE DIPOLE?";X
1050 IF X >10 THEN 460
1060 INPUT"CALCULATE COMPOSITE?";X
1070 IF X >10 THEN 580
1080 END
```

fig. 7. The program presented is compatible with the TRS-80® microcomputer and may be used to speed and simplify the downtilt design calculations.

degrees from the beam center to either side. If necessary, the half-power beamwidth may be widened by placing the elements closer together (this can be done by substituting proper value of s less than one in **eq. 2**).

At this point, a decision must be made as to where the energy is to be distributed. I decided to use one wavelength spacing and to place the lower, half-power point at a depression angle of 9.8 degrees. As illustrated in **fig. 6**, the beam must be tilted downward 3.3 degrees. The upper half-power point then occurs at an elevation angle of 3.2 degrees which allows some of the signal to bend over the horizon to the DX stations.

Although the calculations may be done by hand using **eq. 2** and **3**, I used a computer program for the TRS-80 which is listed in **fig. 7**. As illustrated in **fig. 8**, the program results indicate that a three-degree depression angle can be achieved with a fifteen-degree progressive phase delay to the lower Four Pole elements. The fifteen-degree phase delay coax length is calculated using **eq. 6**.

$$L = \frac{C}{f} \times \frac{P}{360} \times 100V \qquad \textbf{(6)}$$

where: L = *The phase delay coax length (centimeters — divide by 2.54 for the length in inches)*

C = *Velocity of a wave in free space (300,000,000 meters/second)*

f = *The operating frequency (Hertz)*

P = *The phase delay required (degrees)*

V = *The velocity factor of the coax to be used*

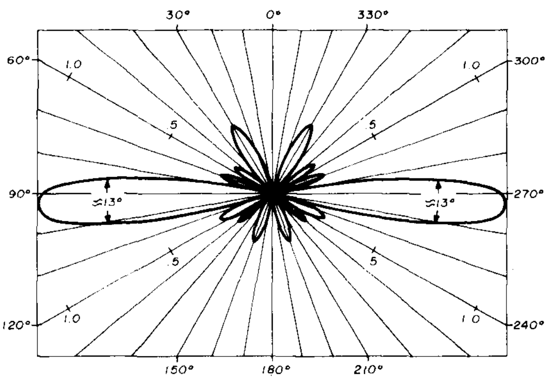

fig. 8. A 15-degree progressive phase delay (with the top dipole having the shortest delay line) produces the indicated beam tilt. The main radiation is depressed nearly 3 degrees from vertical while the half-power beamwidth remains near 13 degrees. The array is centered on the 0 to 180 degree axis with the top dipole in the 0 degree direction.

The phase delay length for 146.88 MHz will be 2.25 inches (5.72 cm), assuming the velocity factor of the coax to be 0.677. Referring to **fig. 5**, the phase delay coax lengths from top to bottom will be 2.25 inches (5.72 cm), 4.5 inches (11.43 cm), 6.75 inches (17.15 cm), and 9 inches (22.86 cm), respectively.

mechanical considerations

If the Four Pole is to remain free-standing in a high wind and ice environment, the antenna should be guyed at the top. A nonconducting guy cable such as Phillystran® may be used with standard-size cable clamps.[8] The bottom three to four feet (.914 to 1.22 meters) should be steel guy cable to prevent rodent damage.

Having worked on some pretty tough sites, I put quite a lot of thought into a Four Pole that would survive. **Fig. 9** details such an antenna, which I intend to test in the near future. A nonconductive support structure such as a wooden pole is ideal. However, with the antenna spaced a wavelength from the support structure, even a metal tower should not greatly degrade the pattern.

The antenna is constructed of alternate sections of the insulating guy material previously mentioned and no. 10 solid copper. Sections of PVC pipe are used to protect the horizontal runs of the phasing harness coax from ice damage. Since the tensile strength of the cable antenna is large, the antenna is used to support one end of the PVC sections. The opposite PVC section ends are clamped to the support structure.

A turnbuckle is used to tighten the antenna. The cross-sectional area of the antenna is small and presents a very low wind resistance. Any vibration in the cable antenna tends to clear itself of ice. Finally, the antenna is omnidirectional because the elements are truly collinear.

conclusion

Antennas and mousetraps seem to fit the same category — someone is always after a better one. At present, one downtilt system has been tested. From this initial experience, the downtilt seems to reduce the amount of mobile chopping usually experienced in the canyons and gullies. Only one comparative test has been made, and in that test the downtilt was generally better than the standard Four Pole in both transmitting and receiving.

This is an early stage in my experimentation with downtilt antennas and I would appreciate receiving

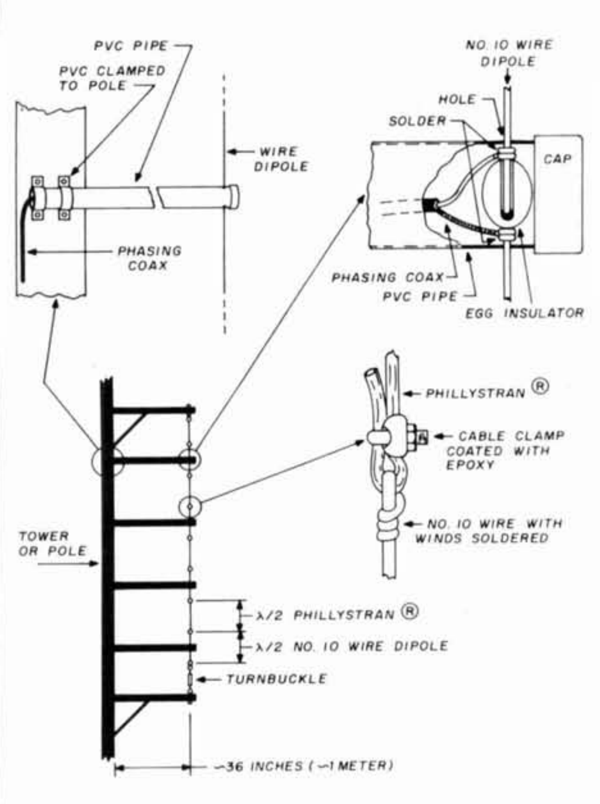

fig. 9. This suggested Four Pole array (constructed of cable with high tensile strength) may solve the tough environmental problems encountered on mountain tops. PVC pipe is used to protect horizontal feed cable runs from ice build-up.

any test results others might gather using these antennas.

acknowledgments

Thanks go to Dennis Nord, WB7UOI, for his aid and assistance with computing and testing of antennas.

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2. William I. Orr, *Radio Handbook*, Howard W. Sams & Co., Inc., 1972, page 26.9.

3. John D. Kraus, *Antennas*, McGraw-Hill, 1950, pages 76-83.

4. Ibid, page 78.

5. Ibid, page 142.

6. Carl E. Smith, *Theory and Design of Directional Antennas*, Smith Electronics, 1969, Appendices B-1 & B-9.

7. *AM/FM Radio Station Application Data and Reference Guide*, Broadcast Systems - RCA, 1978, page 44.

8. Phillystran®, a product of Philadelphia Resins Corporation, P.O. Box 454, 20 Commerce Drive, Montgomeryville, PA 18936.

ham radio

short vertical antennas for the low bands: part 1

Relative performance of 5 different shortened verticals is compared to full quarter-wave radiator

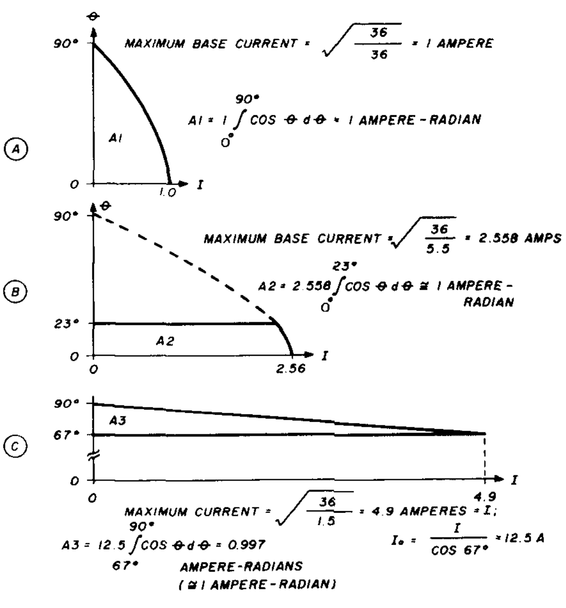

fig. 1. Current distributions for three referenced antennas, each over perfect ground, and 36 watts input to antenna terminals. All to scale, so areas are directly comparable. *(A)* Current distribution of λ/4 vertical (reference antenna) against a perfect ground, *(B)* Current distribution of λ/16 (23 degree) top-loaded vertical against perfect ground, *(C)* Current distribution of λ/16 (23 degree) base-loaded vertical against perfect ground.

By W.J. Byron, W7DHD, 5 Lambert Lane, Robbinsville, New Jersey 08691

The increasing popularity of the 160-meter band and recent FCC regulatory actions opening the lower 100 kHz to normal Amateur operations have attracted Radio Amateurs to the top band. Many are discovering that wire antennas normally used on the higher frequencies require difficult to achieve heights and lengths for effective operation, especially 160 meters.

The decision to investigate verticals rather than doublets or other horizontal antennas resulted from space limitations and performance requirements. (A maximum height of 35 feet, one of the constraints, equates to 1/8 wavelength on 75 meters and 1/16 wavelength on 160 meters. Most horizontal antennas at this height above *ground* provide only high-angle radiation.) A two-band trapped vertical is described that uses the same radiating element for both bands and isolates the top-loading capacity hats with a trap. A short vertical can be nearly as efficient as a full-size quarter-wave vertical if it is top-loaded, and has an extensive ground system.

design considerations

A quarter-wave vertical has a radiation resistance of approximately thirty-six ohms.[1] In quarter-wave (or shorter) systems, over non-ideal ground, a total resistance (R_T) would be:

$$R_T = R_r + R_\Omega + R_g$$

where R_r = radiation resistance
R_Ω = circuit resistance
R_g = ground resistance

Fig. 1 illustrates the calculated current distribution for three verticals. **Fig. 1(A)** is a plot of the current in the perfect quarter-wave, **fig. 1(B)** for a 23-degree high, top-loaded vertical, and **fig. 1(C)** for a 23-degree high, base-loaded system. **Figs. 2** and **3** show the values for helical, center-loaded, and 50/50 top- and base-loaded verticals, all 23 degrees in electrical height. The calculations show that short verticals can be nearly as efficient as full-size antennas. (The 23 degree electrical length is related to my height restriction.)

Short antennas have current distributions that can be approximated by triangular or trapezoidal shapes. The set of curves illustrated in **fig. 4**, extrapolated from a standard reference volume on antenna design[2] are used to determine the radiation resistance of short verticals for defined current distributions.

The curves worked very well for the 160-meter version of my antenna. I departed from the specific domain of the curves in the evaluation of the radiation resistance of the 75-meter system. The 19-ohm resistance for a top-loaded 48.9-degree-high vertical (determined from **fig. 4**) is very close to the measured value and to the value derived by original methods. **Figs. 5** and **6** resulted from my not knowing how far (or whether) to extrapolate the curves in **fig. 4**. **Fig. 5** has been modified to fit two well-measured resistances, but it is within three to five percent on the curve as derived. As modified, it is probably within one percent anywhere for θ between 3 and 90 degrees. **Fig. 6** presents the radiation resistances of base-loaded verticals ranging from 6 degrees to 90 degrees in height. Other combinations of base-loading and top-loading result in radiation resistances somewhere between these curves.

Free-space wavelengths were used to calculate antenna heights. No attention was given to the element length-to-diameter ratio, or to end-effects. For most systems the length-to-diameter ratio is high, and the differences between, say 20 degrees and 21 degrees in terms of radiation resistance is negligible.

Once the calculations were made for the radiation resistances, the feedpoint resistances were defined, and the final evaluation proceeded.

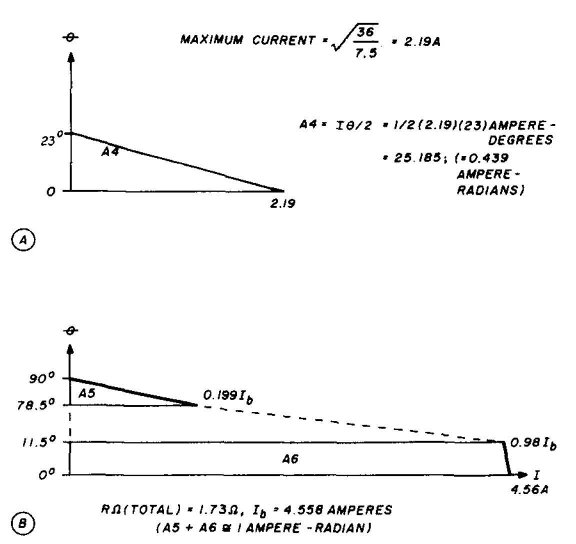

fig. 2. Current distributions for λ/16 (23 degree) helical and λ/16 center-loaded vertical antennas over perfect ground. No coil loss is assumed in center-loaded case, but 6-ohm helical ohmic resistance was included in *fig. 2A*. Figure is drawn to same scale as *fig. 1*. *(A)* Current distribution of λ/16 (23 degree) helical vertical over perfect ground, but with 6 ohm helical resistance, *(B)* Current distribution of λ/16 (23 degree) center-loaded vertical over perfect ground, no coil loss.

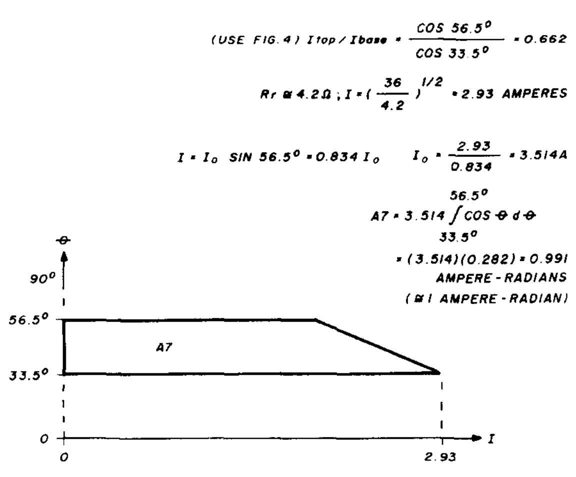

fig. 3. Current distribution on λ/16 (23 degree) vertical antenna with equal top- and base-loading, over perfect ground, no coil loss. (Same scale as *figs. 1* and *2*.)

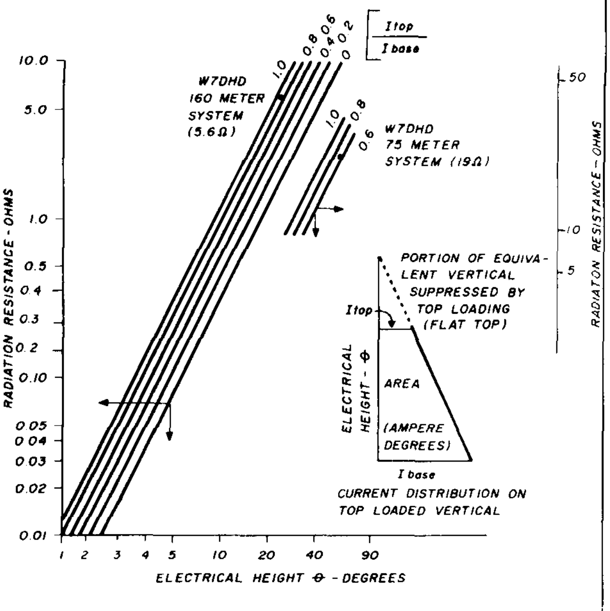

fig. 4. Radiation resistance versus angular aperture (electrical height), θ, for top-loaded vertical antennas.[2]

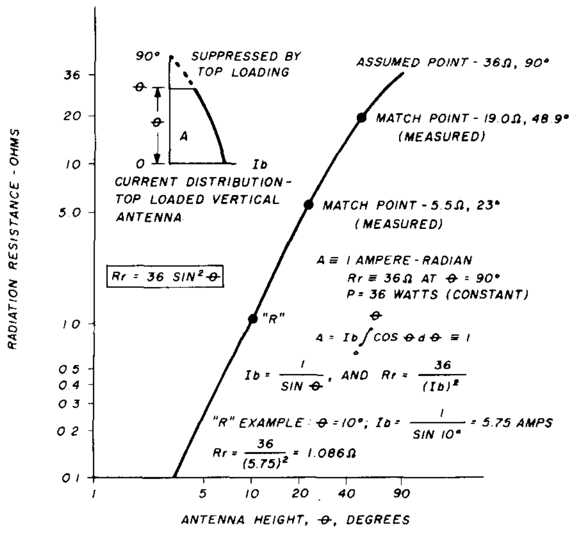

fig. 5. Radiation resistance of top-loaded vertical antennas from 3 to 90 degrees. Theoretically derived and modified to fit measured resistances (Δr less than 1 ohm at $\theta = 50$ *degrees*).

In all calculations a lossless quarter-wave vertical was used as reference. Field strength is directly proportional to the product of the length of radiating element, and the current in that element in ampere-degrees or ampere-radians. The areas under the profiles of currents in **figs. 1** through **3** are equal to one ampere-radian for 36-watts of input power. The one exception, the helical antenna, was calculated at six ohms rf-resistance in the helicoid, and the integration was done graphically, since current varies linearly along its length.

evaluation

In order to compare the vertical antennas, a ground system consisting of 40 1/8-wave radials was used.

A quarter-wave vertical working against this ground system (12 ohms at 1.8 MHz) exhibits a 75-percent efficiency.[3] This ground system is now used with the shortened verticals.

Since the calculated radiation resistance for a $\lambda/16$ base-loaded vertical is 1.5 ohms (see **fig. 6** with $\theta = 23$ *degrees*), the efficiency is

$$\eta = \frac{1.5}{1.5 + 12 + 2} = 9.7 \text{ percent}$$

where the 2 in the denominator is the rf resistance of the wire in the base-loading coil. Consequently a base-loaded antenna over the same ground system is one-tenth as efficient as a lossless quarter-wave antenna.

Since efficiencies are indicative of radiated field strengths, signal levels, referred to the quarter-wave standard, would be:

$$20 \log_{10} (\text{relative efficiency}) = dB$$

In the case of the base-loaded vertical, this becomes:

$$20 \log_{10} (0.097) = -20.26 \, dB$$

Table 1 lists the expected performance of seven vertical antennas:

All the calculations are the same, with the exception of the helical vertical. It was evaluated by making some assumptions: it requires $\lambda/2$ of wire to achieve $\lambda/4$ resonance; wire size is No. 12, 250 feet, $R_\Omega = 6$ ohms; overall height is 35 feet, or 23 degrees; very small (< 1 degree) top-hat (the pie tin); the current decreases linearly over the helix.

The current distribution is triangular with an area equal to $1/2 \, I\theta$ ampere-degrees. It ranks seventh out of seven verticals, and was not further considered. It is a poor choice, especially when the amount of material and the difficulty of construction are considered.

actual design

Two-band operation would be achieved with the same radiator if a method of switching top hats could be engineered. This was accomplished by use of two separate top hats and a parallel-resonant trap.

table 1. Relative ranking of several vertical systems by field strength, constant 23 degrees aperture and constant power input.

antenna system	description	conditions	relative field strength, dB
A	full-sized $\lambda/4$ vertical	zero losses	0
B	full-sized $\lambda/4$ vertical	12 ohm ground	−2.5
C	$\lambda/16$ top-loaded	12 ohm ground	−10.0
D	$\lambda/16$ top and base loaded	12 ohm ground, 1 ohm coil	−12.4
E	$\lambda/16$ center-loaded	12 ohm ground, 2 ohm coil	−19.25
F	$\lambda/16$ base-loaded	12 ohm ground, 2 ohm coil	−20.26
G	$\lambda/16$ helical	12 ohm ground, 6 ohm coil	−20.28

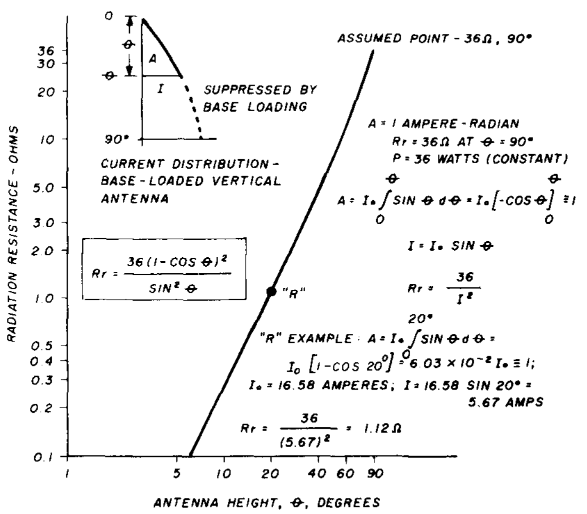

fig. 6. Radiation resistance of base-loaded vertical antennas from 6 to 90 degrees high, (theoretically derived).

The 75-meter top-hat seemed achievable while top-loading on 160 meters (accounting for 67 degrees or 105 feet of missing vertical) seemed more formidable. One source in 1915[4] describes short vertical antennas that use umbrella-loading for top hats.

trap affects performance

Antenna performance depends on the behavior of the trap, tapped onto the 75-meter section at the 49 degree point. The voltage is estimated at 1200 volts, peak, at a one-kilowatt power level. Since the large umbrella is connected to the other side of the trap, that end is assumed to be held constant at or near zero potential. The entire voltage appears across the trap.

The T-200-2 (red core) powdered-iron toroids were wound with No. 12 solid copper wire and resonated with 400 pF at 3.8 MHz. The fundamental wave shape was observed at the kilowatt level for signs of distortion and for ticks in the reflected power on the Bird wattmeter. This was done to determine whether the trap core saturates. No calculation was performed during design — an oversight.

The trap is subjected continuously to the same abuse as is a tank circuit of a kilowatt linear which is unloaded, dipped to resonance, and driven by an exciter. Any trap must be designed to withstand that treatment. Consequently, any trap in any system should be built from the same size and quality components used in the amplifier that drives them — preferably better quality.

power dissipated in the trap

With a trap-resonating capacitance of 400 pF, and a trap-inductance of 4.5 μH, both exhibit 108 ohms at 3.8 MHz, while the ten feet of No. 12 wire has an rf resistance of 0.25 ohms. This calculates to 31 watts of power, dissipated by the trap. This would prove very significant if the antenna were subjected to five or ten minutes of RTTY or a-m operation.

These considerations must be balanced by other factors. If the trap Q is increased, the loss is reduced; but so is the system bandpass. These are engineering trade-offs. The trap in this system effectively limits the 75-meter bandpass (between 2:1 VSWR points) to 86 kHz. Other methods are used to circumvent that limitation.

Another characteristic of short antennas is their very low feedpoint impedance — so low that it is sometimes hard to measure. In highly efficient systems the inclusion of even one ohm of non-radiating resistance will make a significant change in the feedpoint resistance. The equivalent series-input resistance (R_{Ω}) of the trap resistance, calculated above, may be estimated very closely if the as-built base current is known:

Given $P_D = 30.9$ *watts (dissipation in trap)*
and $I_B = 7.14$ *amperes*

then $R_{eq} = \frac{30.9}{(7.14)^2} = \frac{30.9}{51} = 0.61\ ohms$

So it is known already that the trap with its 0.25-ohm coil resistance will be reflected at the antenna base as 0.61 ohm in series with the other instrinsic resistances.

The calculated radiation resistance for the 75-meter system is 19 ohms. The measured feedpoint resistance is 19.6 ohms. It is highly probable that the 0.6-ohm discrepancy can be explained by the rf resistance of the trap, calculated in the preceding paragraphs.

The construction, measurements, and performance characteristics of verticals in general, and of a two-band trapped vertical antenna in particular, will be described in Part 2, the conclusion of this article.

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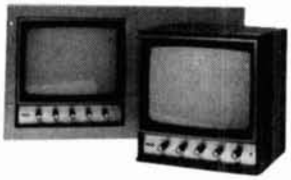

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handi-antennas

Three antenna improvements for 2-meter hand-helds — including a backpack beam!

No Amateur Radio station is better than its antenna. Most antenna articles seem to be for DXers or big-gun contesters, but this article discusses antennas for use with HT's that you can literally hold in your hand. The first is a mechanical improvement in attaching the rubber duckie to an HT; the second is an antenna with significant gain over the rubber duckie; the third is a backpack beam..

a mechanical improvement

One day I had a QSO with WD6FMG who had just finished replacing the output connector on his HT. He remarked that he had been in the habit of removing the rubber duckie every time he put the HT in his briefcase or connected the mobile whip. After removing and replacing the antenna many times, the connector had worn down and would not make a reliable contact. It was a difficult job to disassemble the transceiver and replace the output connector.

This started me thinking. Wanting to avoid the same problem, I looked for a *sacrificial connector*, an adapter that could take the wear and then be replaced easily. My first approach was to use a straight male-to-male adapter and a straight female-to-female adapter. This served the purpose, but seemed cumbersome.

Then I discovered that a BNC 90-degree elbow had one male and one female end. This could be used as a sacrificial connector, but made it necessary to hold the HT on its side, which is awkward.

It's best to use two right-angle adapters. This arrangement has several benefits in addition to the *sacrificial adapter*. It is not necessary to remove the rubber duckie to put the HT in a briefcase, because it folds down compactly. For mobile or other use with an external antenna, the two adapters act as a swivel. This allows the antenna connector to bend and rotate when the HT is picked up or set down.

a performance improvement

Despite the convenience of the rubber duckie, there are many times when an antenna with more punch is needed. This is particularly true when operating simplex, or in populous areas where repeater sensitivity must be restricted so that high-power stations do not bring up several machines at the same time.

Rubber duckie antennas are not particularly efficient; a quarter-wave whip can achieve 3 to 6 dB more radiated signal than the rubber duckie. Considering the threshold effect of fm, 3 dB can make all the difference between good copy and no copy at all.

Several more dB can be achieved over the quarter-wave whip by paying attention to the image or ground side of the antenna. There have been several articles describing the importance of a proper ground structure in achieving a low angle of radiation. After all, low angle radiation is the name of the game to increase your coverage on 20 meters or 2 meters.

The easiest way to provide the ground side of the antenna is to use another quarter-wave whip positioned down from the antenna feed point. The result is really a center-fed vertical dipole. I made this type of antenna as an experiment, and was very pleased with the improvement in signal strength for such a simple design. I have since used the dipole antenna

By Paul A. Zander, AA6PZ, 86 Pine Lane, Los Altos, California 94022

The station, ready to be assembled. The longer antenna parts are in a plastic bag. The smaller pieces and a length of coaxial cable are in the smaller pouch. (Photo courtesy N6ST.)

to make contacts that would have been impossible with only a quarter-wave antenna. The half-wave dipole seems to be competitive with a five-eighths whip without the problem of damaging the ceiling. Of course, you can reduce the half-wave to a quarter-wave when signals are strong enough.

The half-wave antenna is basically two quarter-wave whips and a BNC tee adapter. The only trick is that the two whips must be fed out of phase: one whip connects in the normal fashion to the center conductor; the other whip is electrically connected to the outside of the connector. This is just like an 80-meter dipole connected to coax cable, where one side of the antenna is connected to the cable shield.

One way to make the required connection is to modify the tee fitting so the center conductor on one end connects to the outside of the connector instead of the other center conductors. This procedure should take only a few minutes. Carefully drill a small hole, about 1/8-inch (0.32-cm) diameter, slightly closer to one end than the other. Drill through the center conductor close to where it joins the center conductor from the side arm. If you are uncertain precisely where to drill, it may be preferable to enlarge the hole in the connector shell. Then use a pointed knife blade to cut away the plastic and expose the three center conductors where they join. Next drill through the center connector going to one end. Be sure to leave the remaining two center conductors joined.

The next step is to remove the piece of center conductor from the connector. If you are lucky the piece may drop out, but the drill probably will have created enough of a burr to hold the piece in place. Insert a short length of 18-gauge wire into the center contact. This will allow a pair of tweezers to grasp the contact without damaging the contact fingers. Gently pull the cut center conductor out of the end of the connector.

The piece of 18-gauge wire can serve as a handle while you perform the next steps on the piece you just removed. Trim this piece a little bit shorter so there will be a gap when it is re-installed. Solder a short piece of flexible wire to the end of the cut piece.

You are now ready to reassemble the connector. Thread the wire and attached piece of center conductor back into the connector. Solder the end of the wire to the outside of the connector. Use an ohmmeter to verify that the rewired center conductor is connected to the outside of the connector and not to the other center conductors. Fill the hole with epoxy to provide mechanical support for the rewired center conductor. When the glue hardens you are ready to try it out.

A completely different approach is to use a standard tee fitting, one standard whip and one modified whip. The connector of the modified whip has its center pin and insulating spacer removed. The insulator is replaced by a solid metal piece so the whip connects directly to the shell of its connector.

still more gain

My next design objective was to design and build a 2-meter antenna with 10-dB gain which could be folded or disassembled into a size not more than 16 inches (40 cm) long: small enough to fit into a backpack. But what kind?

table 1. Gain of driven arrays.

number of elements	possible gain
1	0 dB (reference)
2	3 dB
4	6 dB
8	9 dB
16	12 dB

How much gain can you achieve with a driven array of dipoles? Adding a second dipole to the reference antenna can add up to 3 dB to the gain figure. Another 3 dB is achieved by adding two more dipoles to the array, for a total of four elements. **Table 1** summarizes the number of elements required for a driven array of given gain, and shows why a driven array of dipoles is not attractive for use as a portable antenna.

This brings us to another category of antennas, parasitic arrays. **Table 2** shows the gain you can expect from a properly designed Yagi or quad using a reasonable number of elements. From this, we can expect to get 10-dB gain over a dipole from either a four-element Yagi or a three-element quad. This is much more promising than a ten-element driven array. In fairness, it should be pointed out that driven arrays can generally be made to work over a broader range of frequencies than parasitic antennas. Also, a quad or Yagi will require rotation toward the station, while a colinear antenna, having an omni-directional pattern, does not.

Quads are great antennas. I used a full-size quad on 20 meters for many years. Quads can also be mechanical marvels (or monsters depending on your point of view). The challenge is to build a bigger antenna that packs smaller! Quad antennas usually have mechanical spreaders which support the elements. In contrast, Yagi antennas usually have self-supporting elements. These observations led me to expect that a cleverly designed Yagi antenna was the way to proceed.

construction details

This antenna design represents a compromise between locally available materials, package size, and antenna performance. I decided to build a four-element Yagi which is assembled something like a custom Erector™ Set. The boom and mast are each made from pieces of aluminum angle-stock. This allows the pieces to nest together when the antenna is packed. The elements are made of pieces of small diameter aluminum tubing. By making the individual boom pieces 16 inches (406 mm) long, three pieces can make a 48-inch (1220-mm) boom. This is a reasonable size for a four-element Yagi on 2 meters. Also, by making the element spacings 16 inches (40 cm), the centers of the driven element and first director will be at joints in the boom, leaving fewer places where parts have to be joined.

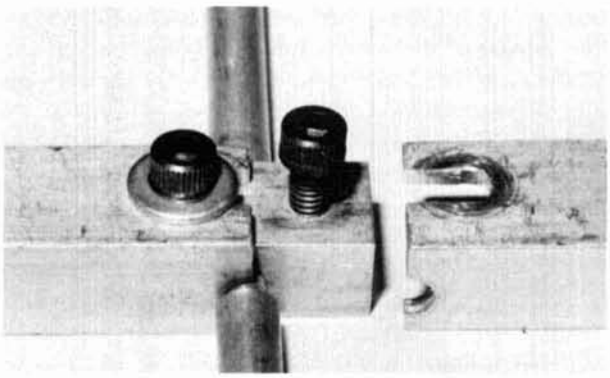
Having established the element spacings and diameters for mechanical reasons, I next needed to calculate the element lengths. Fortunately, I have a computer program for Yagi antennas. It includes an optimizer routine, which allows the computer to systematically try many combinations of antenna dimensions to find those that would give good performance.

table 2. Possible gain for Yagis and quads with different numbers of elements.

number of elements	Yagi gain		quad gain
1	0 dB	(reference)	2 dB
2	5-6 dB		7-8 dB
3	8-9 dB		10-11 dB
4	10-11 dB		12-13 dB
5	11-12 dB		13-14 dB

For this particular antenna, I was most interested in achieving gain over the entire 2-meter band. Front-to-back ratio was not considered important. There are many combinations of element spacings and lengths which could be expected to give similar performance. However, the spacings were chosen for mechanical reasons. Furthermore, by making the two directors identical in length, the possibility for errors when assembling the antenna is eliminated. These compromises probably cost a dB or so over an antenna intended for maximum gain at one frequency, but were considered worthwhile.

As mentioned, aluminum angle-stock is used for the boom and mast. The boom is made from three pieces of 1/2 × 1/2-inch (13 × 13-mm) angle. Each piece is 16 inches (406 mm) long. Hence, the assembled boom is 48 inches (1220 mm) long. Similarly the mast is made from three pieces of 1/2 × 1-1/2-inch (13 × 38-mm) angle. The pieces of the mast and boom are joined by small aluminum blocks and 8-32



Close-up of the joint between the first director and the boom. The boom is made from lengths of aluminum angle-stock which are fastened to the block by screws. The element halves screw into the sides of the same block.

The boom is assembled and the first part of the mast is added. (Photo courtesy N6ST.)

cap screws. Slots in the ends of the aluminum angle allow the pieces to slide apart when the screws are loosened, without being completely removed. Keeping the screws in the blocks reduces the effort needed to reassemble the antenna. The cap screws can be hand-tightened adequately for temporary use. I carry a small hex-wrench to tighten them more securely for longer operating periods.

The elements are made of 1/4-inch (6-mm) aluminum tubing. The eight tip sections are each 16 inches (406 mm) long. The center sections are 2 inches (50.1 mm) long for the directors, 3 inches (76.2 mm) for the driven element, and 4 inches (101.6 mm) for the reflector. Making the center sections different lengths makes it very easy to put them in the correct place on the boom. The correct tip section is always the top piece on the pile.

On each of the sixteen element-pieces, the end towards the boom has a permanently attached 8-32 thread. This was done by first tapping a screw thread inside the tubing. Next the end of a 0.5-inch (12-mm) headless set-screw was dipped in epoxy. Then the set screw was threaded into the end of the element piece until about 0.25 inch (6 mm) was exposed. After the epoxy set, the screw was permanently fixed.

The outer end of each of the center sections has an internal 8-32 thread to receive the screw from the tip section. This thread is installed by reaming the inside of the tubing to the correct diameter and putting a steel-threaded insert in the tube. These inserts are commonly sold to repair threads which have been stripped. Here the insert protects the aluminum from wear as the antenna is assembled and disassembled.

The thread size was chosen to be compatible with the tubing-wall thickness and inside diameter. You may well find that a slightly larger or smaller size is better suited to your tubing.

Assembly is begun by lining up the boom pieces and tightening the screws. Then the mast is assembled and connected to the boom. Next, the center sections of the elements are screwed into the sides of the same blocks which join the boom pieces. Finally, the element tips are put in place.

The antenna can be easily assembled or disassembled in under five minutes. At current prices, all of the material costs about $10 at the local metal supplier. The whole thing weighs under two pounds, which is certainly less than an amplifier and power supply.

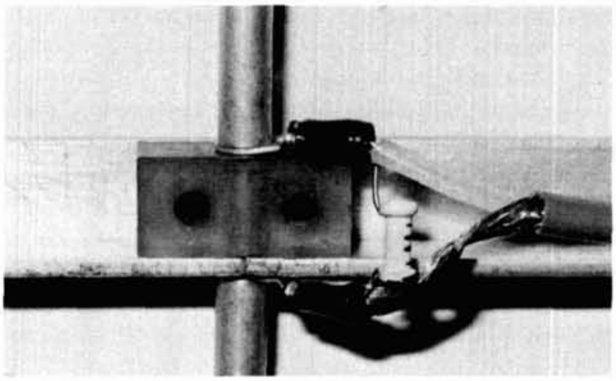
table 3. Final element lengths.

Director 1	36.5 inches	927 mm
Director 2	36.5 inches	927 mm
Driven Element	38.5 inches	978 mm
Reflector	40.5 inches	1029 mm

feedline matching

Nothing has yet been said about connecting the feedline. The center of the driven element is a Plexiglas™ block instead of the aluminum blocks used elsewhere. The driven element is fed as a center-fed dipole. With no matching circuit, the SWR is about 6:1.

The original plan was to make a small circuit board with a suitable impedance-matching circuit. This



Close-up of the driven element and matching circuit. The mechanics are the same as Photo 2 except that the block is acrylic plastic and the coax cable is connected to the two sides of the driven element. The tubular capacitor is used for impedance matching.

approach was expected to be smaller and lighter than a gamma match or some of the other impedance-matching methods. After some experimenting with different matching circuits, it turned out that a simple capacitor is all that is needed. Without matching the driven element would present an impedance consisting of a small resistance and inductance. The addition of a 10-pF capacitor across the antenna terminals provides a VSWR of 1.5 to 1 to the feedline (over the entire band).

Experiments were made with the center conductor of the coax connected to the top side and the bottom side of the driven element. The antenna seemed to work better with the top side connected to the center conductor. Possibly there is some interaction with the metal mast which is on the bottom of the antenna. Experiments were also made with and without a balun. The balun does not seem to offer any improvement, and so is not included in the final design.

The author carrying the complete station to a hilltop operating site. (Photo courtesy N6ST.)

performance measurements

Antenna gain was checked in two ways. The first way was to switch between a dipole and the beam while asking the receiving station for a comparison. This yielded reports as high as 20 dB.

More reliable measurements can be made comparing the received signal strength. A switchable attenuator should be put in the feedline. A moderately strong signal is then tuned in, and the attenuator adjusted until the signal just breaks the receiver squelch. Next, the beam antenna should be connected and the attenuator readjusted until the signal breaks the squelch. The difference (in attenuator readings) is antenna gain. For tests in clear locations, the gain measures about 10 dB, as expected.

Under conditions of multi-path propagation, results are less consistent. Small changes in the position of the reference dipole make a big difference in the received signal-strength.

However, since multi-path propagation is a common occurrence on 2 meters, let's consider it for a moment. In multi-path propagation, obstacles and reflecting objects cause the signal to reach the receiving antenna from two or more different directions. For simplicity, consider the extreme case where there are two signals of equal strength. At some antenna locations, the signals are out of phase and cancel. In this case no net signal will be picked up by the antenna. At other locations the signals will be in-phase and add. The antenna will pick up a total signal which is 6 dB stronger than if the antenna only picked up one of the signals. Under these conditions, a carefully placed vertical dipole could equal the performance of a directional antenna with 6-dB gain.

This is the type of effect which I have observed with the portable beam. Under conditions of severe multi-path propagation, it does not have the 10-dB gain over a dipole. However, the beam does have a different advantage: it is much less sensitive to position than the dipole. In trying to raise a distant repeater, aiming the beam in the right direction and making one transmission is all that is necessary. With the dipole, several attempts may be needed to find a good spot. Even then, a 10-dB beam still has an advantage in signal strength.

alternative construction ideas

I would like to suggest two other ways to build a portable beam. First, instead of tubing the elements could be made from pieces of metal measuring-tape. The tape would be strong enough to hold itself up when the antenna is in use. The elements could then be coiled up for carrying.

A more exotic scheme would be to build the antenna on a sheet of Mylar plastic with elements made of strips of aluminum foil. Such an antenna could be folded up and put in your shirt pocket. The difficulty with this design is finding a way to hold the antenna up when you wish to operate, and keeping it from blowing away in a breeze.

conclusion

I am sure that any of these three ideas will make your 2-meter portable operations more enjoyable.

ham radio

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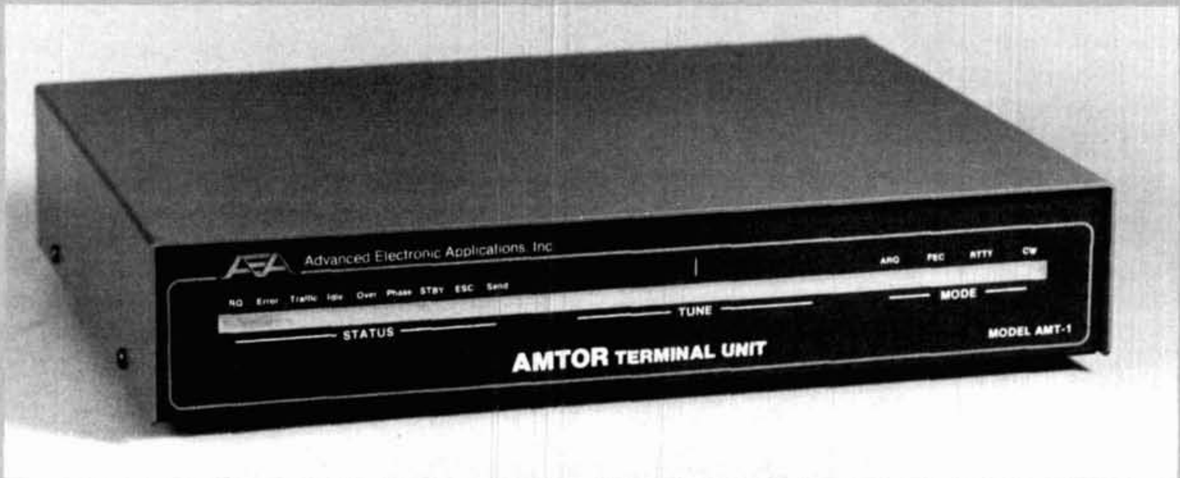

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AMTOR is the system of error correcting RTTY which has been rapidly overtaking conventional RTTY in Europe, just as its marine equivalent, SITOR, has been taking over in ship to shore communications.

It was originated by Peter Martinez, G3PLX (see June 1981 QST, p. 25). He first interpreted the international marine CCIR 476-1 specification for amateur use. Virtually all of the 400+ stations presently on AMTOR world wide are using software/hardware designs originated by Peter. The AMT-1 is a proven product which represents his latest and most highly refined design. It represents the culmination of over three years of development and on the air testing, and sets the standard against which all future AMTOR implementations will be judged.

Not only does it incorporate the latest AMTOR specification, but it gives superlative performance on normal RTTY, ASCII and CW (transmit only). As well as some fairly incredible real time microprocessor software, the AMT-1 boasts a four pole active receive filter, a discriminator type demodulator, a crystal controlled transmit tone generator, and a 16 LED frequency analyzer type tuning indicator, which is very easy to use.

Driven from a 12 volt supply, the AMT-1 connects to the speaker, microphone and PTT lines of an HF transceiver and to the RS-232 serial interface of a personal computer or ASCII terminal. All mode control is via ESCAPE and CONTROL codes from the keyboard (or computer program).

It used to be that C.W. was the ultimate mode for "getting through" when QRM and fading were at their worst. That's *no longer true* — AMTOR will get through with perfect error-free copy when all other conventional transmission modes become useless.

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achieving the perfect VHF antenna null

Principles borrowed from a-m broadcasters permit steerable nulls with theoretically infinite attenuation.

With fixed-location VHF stations, such as repeaters, a situation sometimes occurs where more than one station is received on a given channel, and one of them must be rejected. A common solution has been to use a directional antenna such as a Yagi. However, a single antenna may not provide the required signal rejection.

For years, standard a-m broadcast stations have used directional antenna systems to solve interference problems. The principles involved are applicable not only to the standard a-m broadcast band, but also to VHF antenna systems. Many problems can and have been solved using only two antennas.[1,2,3,4]

design considerations

Several factors are important in the design of an antenna system capable of peaking signals from one direction while nulling those from another. For peaking, two signals must be in phase. For signal nulling, the basic requirement is having two signals that are equal in amplitude and have a phase difference of 180 degrees.*

*Theoretically, *any* number of signals can add up to a zero amplitude result (signal). However, it rapidly becomes more difficult to null increasing numbers of independent, time-varying signals. **Editor.**

A two-antenna system that provides a peak in one direction and a null in another is shown in **fig. 1.** Signals from direction A arrive at both dipoles (horizontal or vertical) at the same time. The spacing between the two antennas cause signals from direction B to arrive at antenna 2 with a time difference equal to one-half wavelength, equivalent to a 180-degree phase shift. If both antennas are fed in phase (equal length feedlines), signals from direction A add while those from B cancel.

The equation for determining required spacing is:

$$S = \frac{5904}{f\,|\sin\alpha|}$$

where α is the angle between the desired signal and the undesired signal directions; f is the frequency in MHz; and S is the antenna separation in inches.

The nulling arrangement works well with practically any antenna — horizontal dipole, vertical dipole, and Yagi, etc. The angular displacement between the directions of the two signal sources may be anything from 0 to 360 degrees. Since the same absolute value of the sine function occurs four times over a complete rotation, any pattern is symmetrical and exhibits four separate nulls. Consequently, the required spacing for an angular displacement between signal sources of 45 degrees is the same as that required for one of 135 degrees, 225 degrees, or 315 degrees. Other antenna separations, such as odd multiples of S, can provide the same results. However, there is a limit to practical applications of this system. The spacing required for angular displacements around 0 degrees and 180 degrees becomes too large to implement.

By John J. Duda, K3ED, 4311 Sunset Blvd., Erie, Pennsylvania 16504

more practical nulling methods

Required mechanical tolerances for antenna placement can be relaxed if additional techniques, such as electronic control of phase-shift and amplitude, are employed. The exact 180-degree phase shift for the undesired signal may be set by feedline length, and variable gain preamplifiers may be used to provide two signals of equal amplitude. An adjustable feedline design[5] that provides a continuous phase shift is illustrated in **fig. 2.**

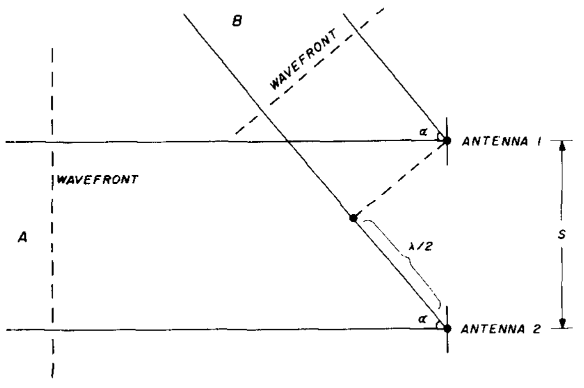

fig. 1. Example of simultaneous peaking (from direction A) and nulling (from direction B) using a two-element array.

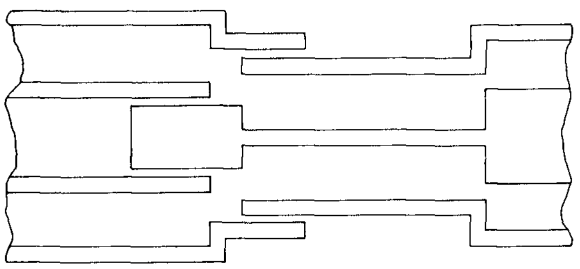

fig. 2. Adjustable-length coaxial line section with constant impedance.

Construction of this is not a simple task. However, a small amount of error is tolerable; **fig. 3** is indicative of a practical feedline design. Many hobby stores stock, or can obtain, brass tubing with a wall thickness of 1/64 inch and diameters at 1/32-inch gradations. Adjacent sections telescope together, and by proper selection of tubing size for the inner and outer conductors, the characteristic impedance of each section can be set to approximate either 50 ohms or 75 ohms at a unity velocity factor. As it works out, type F and BNC connectors are well-suited for mounting into the ends of these. For some of the smaller diameter units, however, it is necessary to file down the end of the connector for best fit.

To assure a solid assembly, the flange of each connector should be spot-soldered to the tubing. A string is clamped to each end, slightly shorter than the maximum extended length of the section, to prevent the section from separating into two pieces during adjustment. **Table 1** lists practical combinations of tubing for use with type F and BNC connectors.

Amplitude match, the second condition, is obtained using the preamplifier shown in **fig. 4.** The preamplifier uses an untuned input circuit to reduce gain variations prior to signal combining. Any preamplifier instability can be reduced by placing a low-value resistor (10-27 ohms), or ferrite bead, in the drain lead of each J310.

A complete system that uses Yagi antennas in the array appears in **fig. 5.** The phase section and preamplifier unit were adjusted using signals in the fm broadcast band. In many cases signals could be null-

table 1. Brass tubing combinations for practical adjustable-length sections using 75-ohm and 50-ohm coaxial cable.

conductor	section A	impedance (ohms)	section B	impedance (ohms)	average impedance (ohms)
outer	13/32 OD	65.9	12/32 OD	77.9	71.9
inner	4/32 OD		3/32 OD		
outer	14/32 OD	70.6	13/32 OD	83.1	76.9
inner	4/32 OD		3/32 OD		
outer	10/32 OD	65.8	9/32 OD	83.1	74.4
inner	3/32 OD		2/32 OD		
outer	14/32 OD	46.3	13/32 OD	52.4	49.3
inner	6/32 OD		5/32 OD		

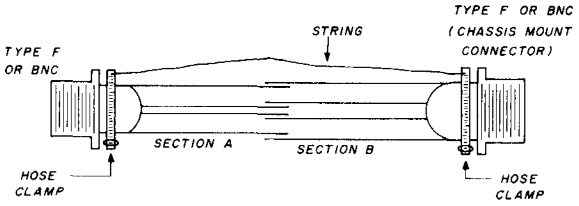

fig. 3. Adjustable-length coaxial line section using brass tubing with each half approximating impedance of associated cable.

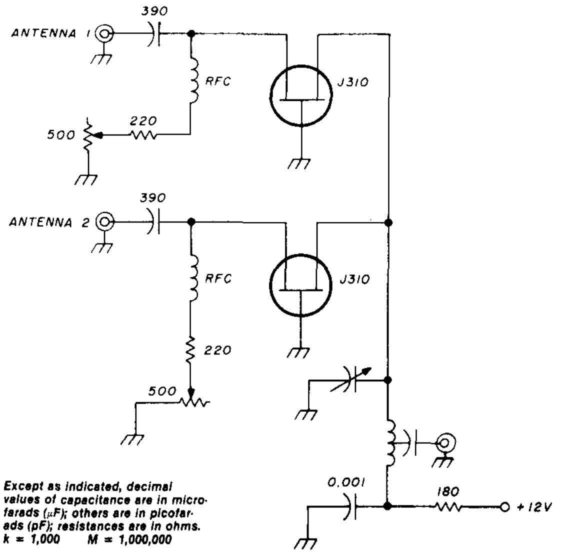

fig. 4. Diagram of preamplifier unit for adjusting signal level from each antenna.

ed down to noise level. In some cases nulling one station revealed another station on the same channel.

system limitations

The system is not totally effective in cases of multipath, where the undesired signal arrives from more than one direction. Nor is the system totally effective if the antennas are not rigidly mounted. It takes very little physical displacement to upset a perfect null setting; this means antenna rotators cannot be used as they provide too much variability in setting, as well as backlash.

Although the antennas are electronically fine-tuned for nulling the undesired signal, such care, as mentioned before, is not required for peaking. An error of as much as 10 electrical degrees from boresight reduces the gain by only about 0.3 dB.

special case: 180-degree displacement

If the signal to be rejected is coming from the direction opposite the desired signal, another configuration can be used. **Fig. 6** shows two antennas, a quarter-wavelength apart and fed 90 degrees out-of-phase. Signals from A hit antenna one 90 electrical degrees before they hit antenna two. Since the feedline from antenna one is 90 electrical degrees longer than that from antenna two, signals from direction A arrive in-phase. On the other hand, signals from B hit antenna one 90 electrical degrees after they hit antenna two. They are further delayed another 90 degrees by the long feedline to antenna one, giving a total phase shift of 180 degrees. Spacings at any odd multiple of a quarter-wave also provide nulling.

Fig. 7 shows how Yagis may be used in a system exhibiting *infinite front-to-back ratio*. Again, the peaking criteria need only be approximated, while the system is electronically fine-tuned to give total nulling of the signal off the back. Slight shifts in spacing and/or feedline length may be used to generate nulls in the vicinity of 180 degrees. The null can be slewed off the 180-degree direction by changing

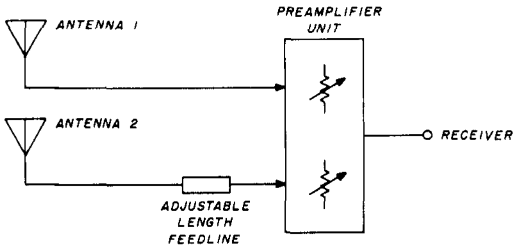

fig. 5. Practical antenna system with electronic null adjustment.

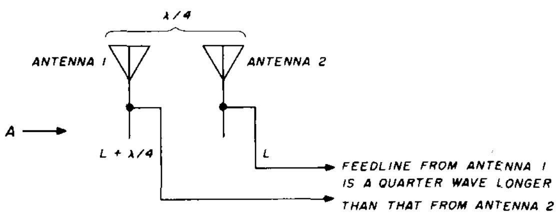

fig. 6. Dipole pair setting for peaking signals from one direction and nulling those displaced 180 compass degrees.

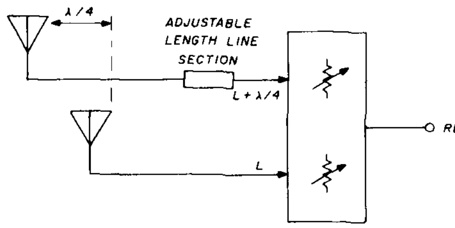

fig. 7. Practical antenna system with "infinite" front-to-back ratio.

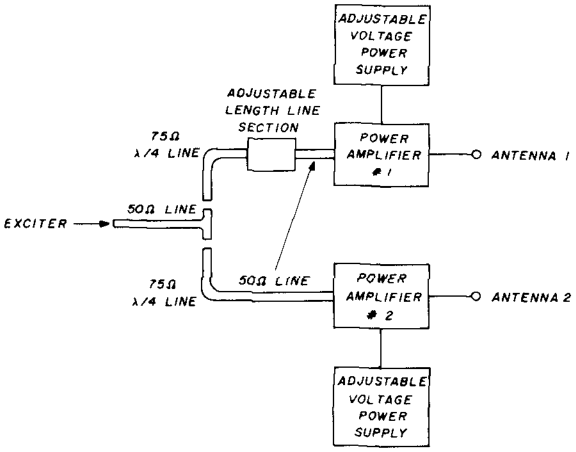

fig. 8. Null adjustment with a transmitting system.

antenna spacing, feedline length, or both. Another method is to maintain the 180-degree null point and to aim the back of the array toward the undesired signal.

the first system, or at some odd multiples of a quarter-wave in the second system, has value. The closer together two antennas are placed, the more they interact. Wide spacing effectively reduces this interaction.

transmitting arrays

Null principles can be applied to transmitting systems as well. **Fig. 8** shows how two power amplifiers and an adjustable-length line section can be used to secure a perfect null in a transmission pattern. Feedline length from each amplifier to the antenna should be equal. Amplifier input lines, as measured from their common junction, should be equal in length, or have a difference of one-quarter wavelength, depending on the system used.

temperature changes influence pattern

Another factor to consider is the effect of temperature on feedline length. This has been a problem in broadcast applications.[6] The effect may be minimized by making the outdoor portion of each feedline section equal in length. The adjustable-length line section and preamplifier unit are best located indoors near the receiver, protected from the elements. Here they can also be adjusted by observing a local field-strength meter. There should be minimal signal pick-up by the feedlines, as any direct signal pick-up by a feedline serves to mask the true antenna pattern. It has been reported that military RG cable provides about 35 dB shielding, whereas less expensive cable may provide only 20 dB. Full braid, duofoil, or double-shielded coaxial feedline may be necessary in difficult situations.[7]

Finally, the nulling criteria holds only for a single frequency. However, attenuation remains high around the set frequency. For example, if the null is set for the carrier of an fm broadcast station, which has a channel of + / − 100 kHz, the calculated attenuation decreases from infinity at the carrier frequency to about 80 dB at the channel limits.

The systems described here can solve many problems. If there is another signal on a desired repeater's frequency, it can be nulled out. Setting a null in a transmitting pattern may offer a solution to an rfi problem. Then too, the systems may be used to reduce interference in fm broadcast or TV station reception. An interesting application is nulling one of the desired signals in a multipath distortion problem. By adding two coaxial relays it is possible to expand the system to the capability of switching the null from one direction to another. For example, the addition of a half-wave section in either feedline may be used to reverse null and peak directions. The adjustable-length line section and preamplifier are also effective with circularly polarized antenna systems, since they permit total nulling of signals of one sense or the other.

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ham radio

ham radio TECHNIQUES

Antenna experimentation is one of the few fields in which an Amateur can participate armed only with enthusiasm, a tape measure, an SWR meter and inexpensive tools. No Ph.D. degree in higher mathematics or computer technology is required.

One of the best candidates for home experimentation is the quad antenna (**fig. 1**). The quad loop can be built in many configurations. The support structure can be as uncomplicated as a set of bamboo poles and the whole arrangement can be built for only a few dollars. A single loop parasitic element added to the driven loop makes a two-element quad beam. In many areas of the world where aluminum tubing is hard to find, or prohibitively expensive, the quad antenna is the best answer to the need for a high-gain, high-frequency antenna.

the single-element loop antenna

While the loop antenna has been known since the early days of radio, the use of a large loop for hf transmission was not seriously investigated until 1938 when Clarence Moore, ex-W9LZX, developed a two-element loop antenna for shortwave broadcasting. The Moore design was an instant success and the so-called quad antenna has been popular with Amateurs worldwide for the past four decades.

The simplest quad is a single loop which provides horizontal polarization when fed as shown in **fig. 1**. The loop has a bi-directional pattern similar to that of the dipole. Loop gain and feedpoint impedance are a function of the shape of the loop. The loop having the highest gain and feedpoint resistance is the circular model. This provides a power gain of about 1.13 dB over a dipole with a feedpoint impedance of 135 ohms. The square design has a gain of about 0.85 dB over a dipole and a feedpoint impedance of 120 ohms. The triangular, or "delta," loop provides a gain of about 0.55 dB over a dipole and a feedpoint impedance of 105 ohms.

An intermediate-design loop which provides a power gain of 1.5 dB over a dipole and a feedpoint impedance of 50 ohms is shown in **fig. 2**. This quad loop (while a bit unwieldy for the lower frequencies) is an excellent antenna for the higher bands, as it provides bi-directional gain and can be fed directly with a 50-ohm coaxial line. A similar design, to match a 75-ohm line, is also shown.

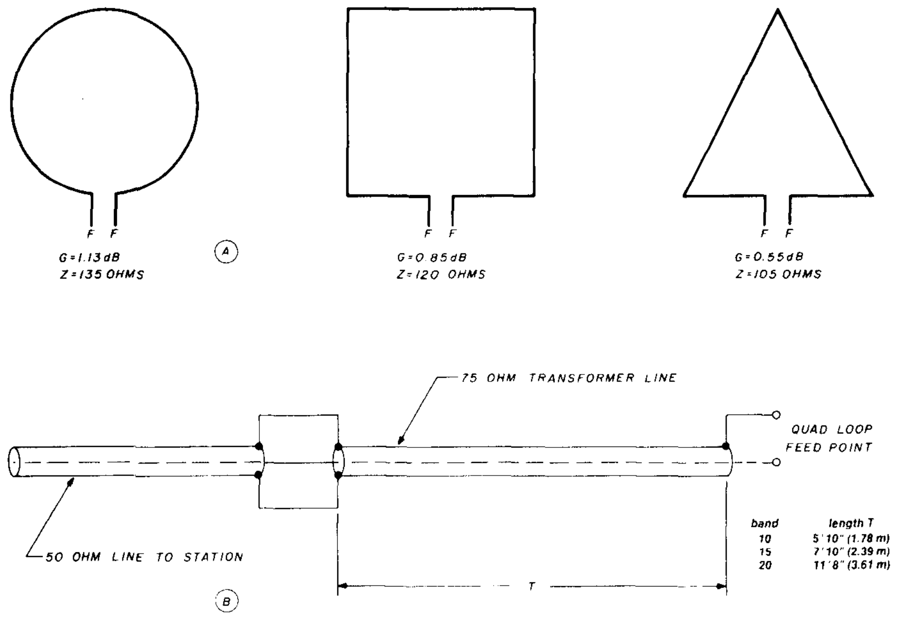
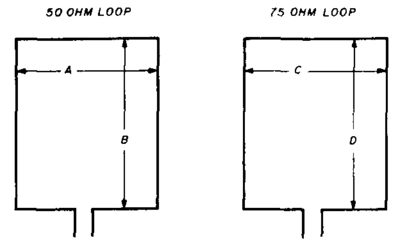


fig. 1. *(A)* The simple transmitting loop. Directivity is in and out of page. The triangular loop may be inverted, with apex at bottom and feedpoint at apex. *(B)* Quarter-wave transformer for use with quad loop antennas.



band	A	B	band	C	D
10	5'6" (1.7 m)	11'8" (3.6 m)	10	6'10" (2.1 m)	10'4" (3.1 m)
15	7'5" (2.3 m)	15'9" (4.8 m)	15	9'3" (2.8 m)	13'11" (4.2 m)
20	11'1" (3.4 m)	23'7" (7.2 m)	20	13'10½" (4.2 m)	20'10" (6.3 m)

fig. 2. Single element quad loops for 50- and 75-ohm feedlines.

The delta loop and the circular loops have a feedpoint impedance somewhat different from that of the square, but all of these designs can be nicely matched to a 50-ohm transmission line by the use of a quarter-wavelength, 75-ohm transformer between the line and the loop. Data for such a transformer is given in **fig. 1**.

The loop antenna is balanced to ground at the feedpoint and it is a good idea to isolate the outer shield of the coaxial feedline from antenna current. This can easily be done by winding the line into a four-turn coil about 8 inches in diameter directly below the loop. The plane of the coil should be at right angles to the plane of the loop.

One of the advantages of the loop antenna is that it can be supported at the midpoint by a single pole. Properly built, the loop is not obtrusive and can be used in areas where more conspicuous ham antennas are frowned upon.

The 50-ohm or 75-ohm loop can be turned on a side to provide a vertically polarized array for low-frequency operation. For 40 meters, for example, loop height is only about 22 feet, and the extensive radial system that is required for a ground plane antenna is not as necessary (see **fig. 3**).

the cubical quad beam antenna

Adding a parasitic element to the driven loop produces the famous cubical quad antenna pioneered by ex-W9LZX. The quad is a unidirectional array providing a power gain of about 6 to 7 dB with a good front-to-back ratio. Both gain and f/b ratio depend upon element separation and tuning, as is the case with the traditional Yagi beam design.

It is difficult to surpass the advantages offered by the simple two-element quad. It is light and has low wind resistance, and it provides high gain in a small package. The feed system is uncomplicated. In addition, since the elements are continuous and have no tips, rain static problems (often a headache with the Yagi beam) are nonexistent. The cubical quad beam is thus an ideal antenna for the DXer who wants to get good results with a minimum expenditure of money.

a practical two-element cubical quad

Data for a practical two-element quad are given in **fig. 4**. Boom length is about 0.12 wavelength, which provides a compact design and a good match to the coaxial transmission line, since feedpoint impedance of the quad is a function of element separation as well as tuning. The reflector loop is pre-cut to the correct dimension and requires no adjustment after assembly. Important dimensions are shown in the illustration, the length **R** being the distance from the center point of the assembly to the point of attachment of the wire to the support structure.

The crossarms for the quad should be made of insulating material. Many quad assemblers have run into problems when metal arms are used for the array. It is possible to insert insulating sections in metal crossarms, but the builder is advised to stay away from this complicated technique. Fiber glass poles, bamboo, and PVC pipe have been used successfully for quad arms.

Most homemade quads use a section of 2- or 3-inch diameter aluminum tubing for the boom. The two-element quad usually requires 2-inch tubing, but a quad for 6 or 10 meters can use a smaller diameter boom.

Boom-to-crossarm clamps are available from several manufacturers, but many builders have made their own out of a plywood sheet and galvanized-iron angle brackets. If you take this approach, make sure that the edges of the plywood are sealed against moisture penetration. Two or three coats of outdoor house paint will do the job.

A more exotic design makes use of a "spider" arrangement which employs multiple crossarms supported from a central point on the mast, at the middle of the array.

how high the quad?

Experience has proven that the quad antenna will perform well even though mounted close to the earth. As an example, the main lobe of a quad antenna mounted one-quarter

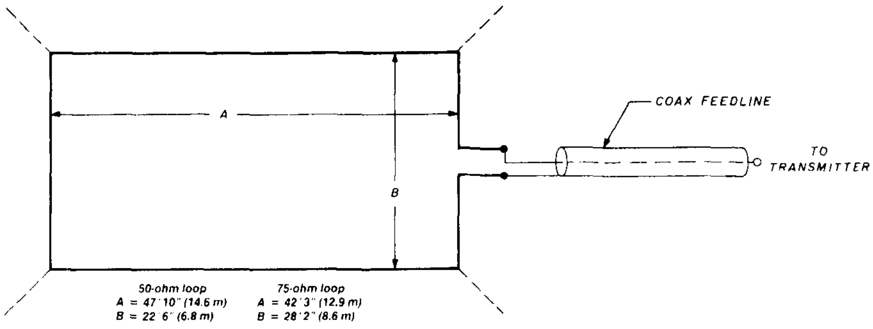
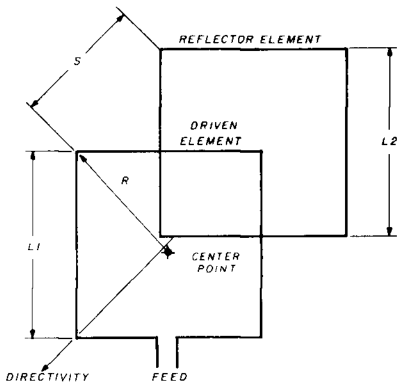


fig. 3. Vertically polarized 40-meter loop for 50- or 75-ohm feed. Mount loop in vertical plane as high above ground as possible. Bring feedline off horizontally.



band	side dimension $L_1 = \frac{250}{f(MHz)}$	side dimension $L_2 = \frac{258}{f(MHz)}$	spacing $S = \frac{118}{f(MHz)}$	dimension R
40	35′2″ (10.72 m)	36′4″ (11.07 m)	17′0″ (5.18 m)	24′8″ (7.52 m)
20	17′8″ (5.38 m)	18′2″ (5.54 m)	8′5″ (2.56 m)	12′6″ (3.81 m)
15	11′8″ (3.56 m)	12′3″ (3.73 m)	5′7″ (1.70 m)	6′4″ (1.93 m)
10	8′8″ (2.64 m)	9′1″ (2.77 m)	4′2″ (1.27 m)	6′2″ (1.88 m)

fig. 4. Design data for two-element quad. Dimension R is approximate distance from center point of loop assembly to point of attachment of wire.

wavelength above the ground is at an elevation angle of 40 degrees, whereas the angle of maximum radiation of a dipole at the same height is straight up.

At a height of three-eighths wavelength the angle of radiation of a quad is about 32 degrees below that of a Yagi or dipole at the same height. Finally, at a height of one-half wavelength, the radiation angle of the quad and the dipole (or Yagi) are about equal. (The height of the quad is measured to the bottom of the lower element, as that is the point at which the quad is usually supported).

The upshot of this is that the quad does better in terms of low elevation angles than does either the dipole or the Yagi beam. True, a height of one-quarter wavelength is not a good one as far as low-angle, long-distance DX is concerned, but if you are stuck with it, it is better to use a quad than almost any other antenna because of the lower angle of radiation.

Those Amateurs lucky enough to get the quad up in the air from 40 to 60 feet above ground will quickly find out why the quad achieved world-wide popularity in a very short time. Build a quad and enjoy!

RFI revisited — 18 MHz

The 18-MHz band (18.068-18.168 MHz) has not been opened for general use in the United States, although Amateurs in several other countries are already using it on a non-interference basis. Use of the band in the U.S. poses some interesting problems so far as RFI goes. The third harmonic of the band (54.2-54.5 MHz) falls extremely close to the video (picture carrier) frequency of television channel 2 (55.25 MHz).

This situation is unique; I can't think of another circumstance where the harmonic frequency of an Amateur band falls so close to a television video channel.

My experimental license (KM2-XDW) permits restricted operation in the 18-MHz band, and this provided the incentive to explore the question of TVI on this new ham band. One of the first experiments I ran on 18 MHz was to determine the degree of TVI that I would encounter when operating on this band. I used my regular station equipment, which included TVI suppression techniques such as a lowpass filter in the transmission line, bypassed power lines, and good equipment grounding. This sufficed to provide adequate TVI protection on all Amateur bands when the TV receiver was equipped with a highpass filter. Alas, operation on 18 MHz quickly pointed out that ordinary TVI suppression was insufficient in my case to reduce channel 2 television interference to an acceptable level. After a few false starts, however, I was able to clean up the problem, which seemed to be a combination of fundamental overload plus harmonic interference. Here's what I did:

First: I wound about five turns of the transmission line (RG-58/U) at the transmitter around an iron-powder toroid core of 2¼ inch diameter (Amidon T-225-2). This was done to "cool off" the outside of the coaxial line to the antenna. A similar toroid choke was placed at the antenna end of the line.

Second: The garden variety highpass filter on the television set was replaced with a higher attenuation unit (*J.W. Miller C-513-T3* for 300-ohm line, or *C-513-T2* for 75-ohm coaxial line). These filters provide about 60 dB of attenuation to signals below 40 MHz.

Third: The line cord of the television receiver was wrapped around a ferrite core, similar to the one used on the transmitter feedline. This was done to isolate the receiver from rf picked up by the power line.

After these three fixes were incorporated into the station, the television receiver was reasonably clear during 18-MHz operation, even at a kilowatt input level. I was transmitting into an antenna only about 18 feet away from the TV antenna.

It was interesting to note that some TVI measures actually degraded the TV picture. One brand of TV filter, for example, when placed in the ribbon line, seemed to upset the TV tuner, as it produced "sound bars" on the picture which wiggled about with the audio signal. Removing the TVI filter and replacing it with the one specified cleaned up the wiggly lines.

Grounding the TV receiver chassis (through a 0.01-μF, 1.6-kV disc capacitor for protection) increased the TVI level, possibly because the ground lead was long enough to act as an antenna at 18 MHz.

In summary, it is possible to clean up TVI at 18 MHz, but it takes special care to make sure the transmitter is "clean" for channel 2 reception. In addition, the television receiver has to have a good highpass filter in front of it to provide maximum overload protection from the transmitter.

references

1. For comprehensive data on all types of quad antennas, read: "All About Cubical Quad Antennas," available for $5.95 plus $1.00 shipping from Ham Radio's Bookstore, Greenville, New Hampshire 03048.

2. For additional information on TVI and RFI, read, "Interference Handbook," available for $8.95 plus $1.00 shipping from Ham Radio's Bookstore, Greenville, New Hampshire 03048.

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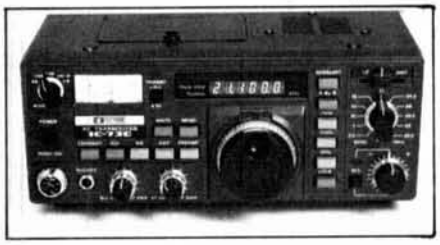

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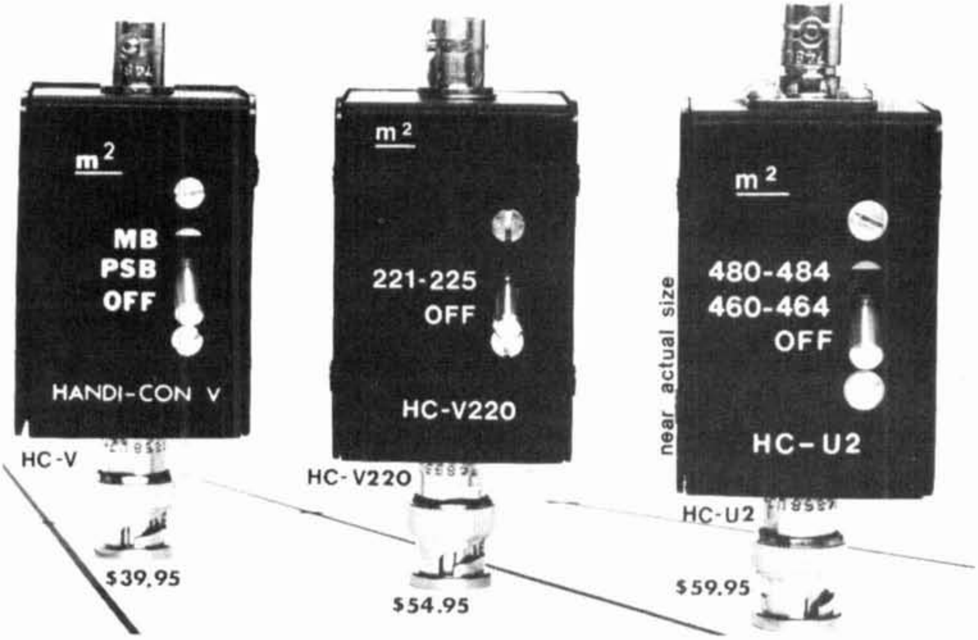

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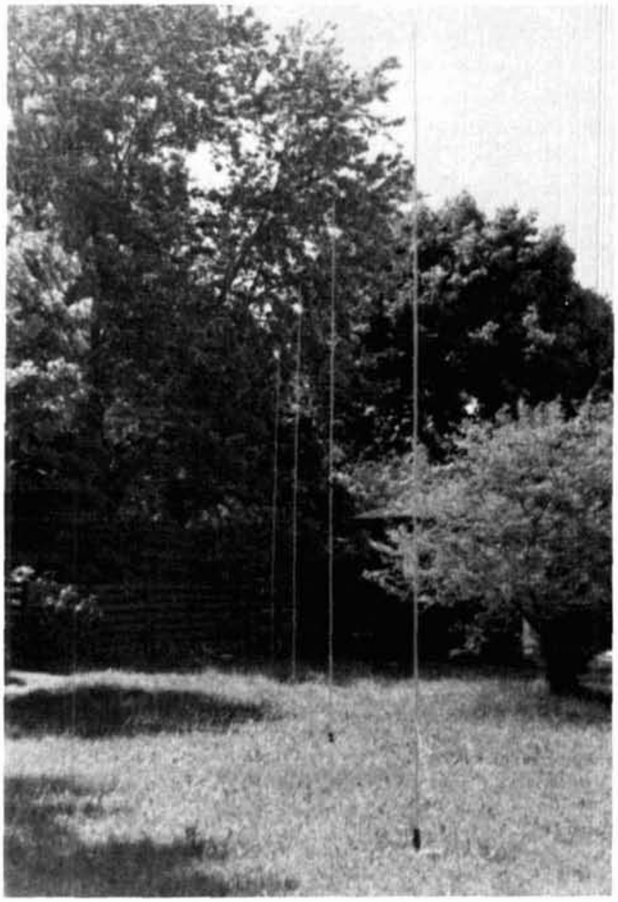

fig. 1. 20-meter phased array.

This is a 20-meter version of the 80-meter array described in *QST* in 1965. It represents one method of providing directional performance without the use of a rotator. Interconnect figure courtesy ARRL. **Editor**

I had never been impressed with vertical antennas until I phased a pair of 40-meter quarter-wave verticals a few years ago. Since the two worked so well, it seemed reasonable that four should work even better. I constructed a phasing box for four in-line vertical antennas.[1] However, not having the time to erect this system, I stored the relay box away.

A job change some time later brought me to a small ranch duplex adjacent to an open field. I erected a single 20-meter quarter-wave vertical in the middle of the field using a ground system consisting of eight 16-foot-long three-conductor radials.

four-element array construction begins

Soon after this I started gathering parts for the four 20-meter verticals. Using pieces of 1-inch (25.4-mm), 7/8-inch (22.23-mm), and 3/4-inch (19.05-mm) aluminum tubing with 0.058-inch (1.45-mm) walls, I constructed four 16-foot 6-inch radiators using stainless steel automotive hose clamps and a slit tubing

By Jim Gabriel, WA8DXB, 15 Cambrian, Tallmadge, Ohio 44278

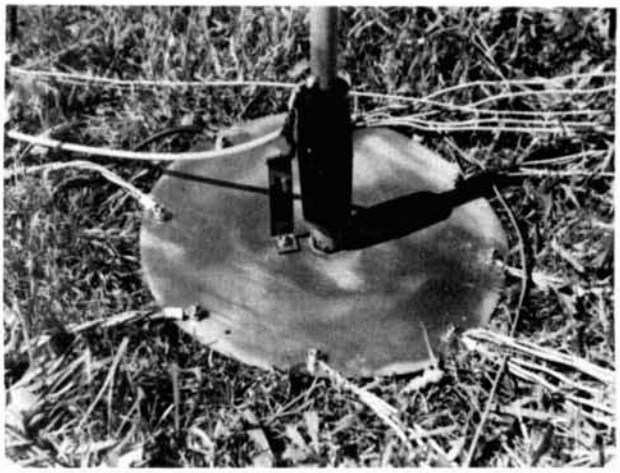

fig. 2. Basic ground system under each radiator, consisting of copper disk and No. 16 insulated ac house wire.

technique. The base insulators were old plastic spacers from a 20-meter quad. The antenna was mounted on 1-inch treated-wood dowels driven several feet into the ground (**fig. 1**).

The ground buss consists of surplus copper disks from a junk yard. A 1-1/8-inch (28.56-mm) hole was cut in the center of the disk and a series of holes drilled around the perimeter with radials attached to them by brass nuts and bolts (**fig. 2**). The radials were number 16 insulated ac house wire. Finally, each disk, as well as the antenna connections was given two coats of clear Krylon® to retard corrosion after radial wires were attached.

The verticals were laid out in line from northwest to southeast, the switchable end-fire directions. When the two broadside lobes were switched in, two squashed figure-eight lobes resulted, one on southern Europe and the other on the South Pacific. Since I was mostly interested in working into Asia, I considered this the best compromise.

The verticals were spaced 16-feet 6-inches (5.03 m) apart and each was fed by equal three-quarter wavelength RG-8X coaxial lines. The main feeder, power divider, and three phasing lines used RG-8. The ground systems consisted of four single-conductor quarter-wavelength wires under each antenna, making it difficult to work into Asia. The small ground system adversely affected the array performance. After adding eight three-conductor 16-foot 6-inch (5.03-m) radials to the original four wires, (a total of twelve radials) I noticed 4 to 6 dB difference in transmission and a bit better front-to-back ratio on receive. Knowing the importance of a good ground system and with a future 40-meter installation in mind, I laid an additional thirty 33-foot-long radials under the two outer (NW) verticals, in about the 120-degree sector. A total of forty-two radials were now connected to the outer antennas.

The VSWR using only twelve radials was NW - 1.2:1; SE - 1.4:1; broadside - 2.4:1. With the addition of thirty 33-foot-long radials under the two outer antennas, the VSWR was reduced to NW - 1.05; SE - 1.15:1; broadside - 2.01:1.

The relay phasing box, **fig. 3**, is wired as shown in **fig. 4**. Internal leads should be kept as short as possible. When constructing the relay lines, phasing harnesses, and power dividers, remember that the velocity factor of coax can be 0.66, 0.77, and sometimes 0.81. It pays to check what the VF is before you start cutting the coax. The electrical length of the phasing lines is $\frac{246 \times VF}{freq.\ in\ MHz}$ for a 90-degree or one-quarter wavelength line.* For the 180-degree or 270-degree lines, just multiply by a factor of two and three respectively. I used type-N connectors and a type-N female T-connector for the power divider since they are waterproof and constant impedance devices. I found the rubber boots for the phasing box connectors at a hamfest. The RG-8 coax and relay wire (inexpensive doorbell wire) was placed along a neighbor's fence. I used surplus 50-cycle 120-Vac large-contact relays that actuate at 35 Vdc.

The vertical array is easy to access (phasing box and antenna connections) and maintain. If a 16-foot radiator falls down as a result of heavy winds or ice loading, it can be rebuilt easily.

performance

I worked two VK stations, both running little Heathkit HW-8 QRP transceivers! On checks with UAØWAY and UA9OH running just the 100-watt

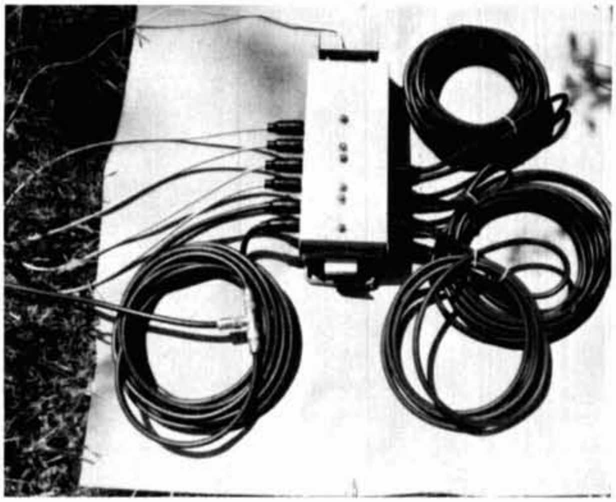

fig. 3. Relay box, phasing lines, and antenna input power divider (T-connector).

*See assumption 5 on page 20.

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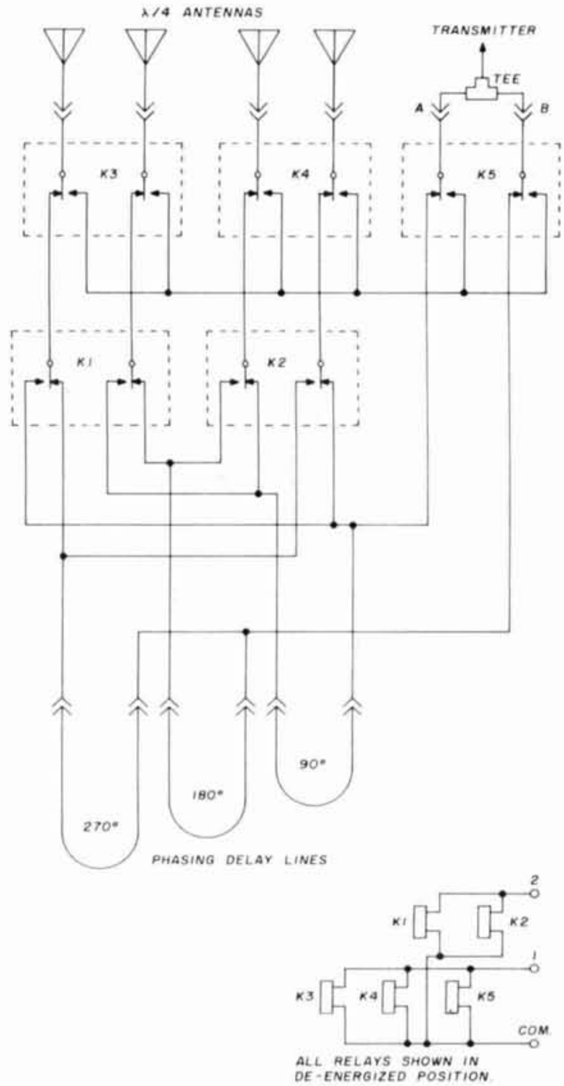

fig. 4. Relay inconnection diagram for the four-element phased array. The preferred end-fire direction is present with no dc applied. Voltage applied to terminals *2* and *COM* reverses the array (still end-fire), while dc applied to terminals *1* and *COM* provides a bi-directional broadside lobe pattern.

transceiver on SSB, front-to-back was in excess of 30 dB and sometimes as high as 40 dB. This is helpful when you're trying to reject southern QRM and looking for a weak 9V1 or 9M2 station over the North Pole.

reference

1. Dana W. Atchley, Jr., W1WKK, "A Switchable Four-Element 80-Meter Phased Array," *QST*, March, 1965.

ham radio

inexpensive connectors for hardline

Hams combine ingenuity and plumbing fittings to solve costly interface problems

A great deal of surplus hardline has recently become available from CATV companies at very low cost. The hardline has a solid aluminum outer shield with either a solid copper or copper-clad aluminum center-conductor. This high quality, low loss, VHF/UHF cable is great for repeater or home stations. There is only one problem — connectors are expensive, *if* they can be found. Once again, ham ingenuity and homebrew construction are necessary.

I needed a connector (for 1-inch cable) which would be simple and cheap to manufacture. Designing one required some thought and many hours' rummaging through local plumbing suppliers' stock. It takes only about 10 minutes to make each connector. The cost per connector is about $2.00 — far less than they could be bought new. Construction is not hard, and you may use considerable latitude choosing materials.

First check out your local plumbing stores to see what is available. The fittings I used were (1) a 3/8-inch threaded to 3/16-inch tubing (nipple) adapter (this may be called a barb); (2) a 3/4-inch threaded female to 1/2-inch copper tubing adapter; (3) an SO-239 coaxial connector. These are shown in **fig. 1**, along with a section of the 1-inch line.

construction

Some machining is required to make the center of the adapter. I have a Shopsmith Mark V that I used as a lathe. It is possible to do the same thing using a

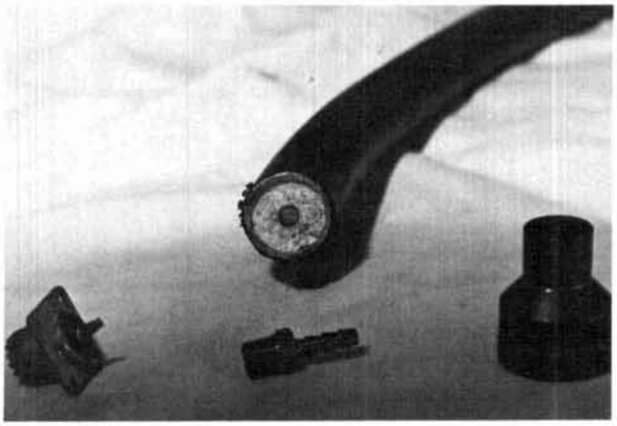

fig. 1. The 1-inch hardline, coax connector, and the plumbing fittings used to make a connector for the hardline.

By James A. Sanford, WB4GCS, 509 Forest Drive, Casselberry, Florida 32707

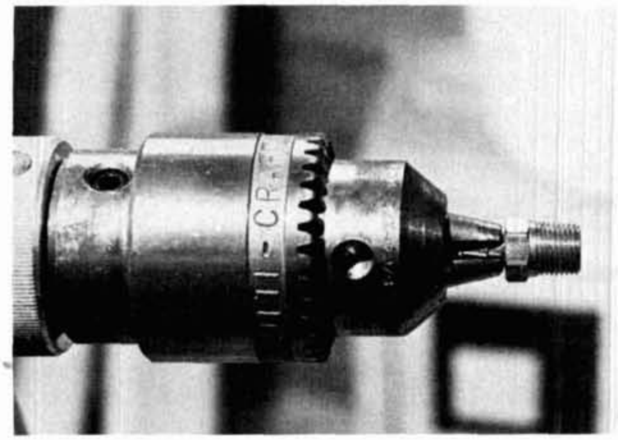

fig. 2. The Barb fitting prior to machining.

standard 1/4-inch drill mounted in a vise or stand. There is no high torque or stress involved, so either method is fine.

The first step is to chuck up the nipple adapter with the nipple end in the chuck. Make sure it is centered in the chuck! This step is shown in **fig. 2**. Start the lathe (drill) at a moderate speed. First, using a coarse and then medium file, machine away the flat surfaces. Then file down the threaded section. After a single cylinder is obtained, use a fine file to smooth the assembly. The final outside diameter should be 5/16-inch (7.94 mm). Then, very carefully, use a rattail file to taper out the inside of the fitting. The reason for this taper is to ensure a good press fit against the center conductor when the completed connector is placed on the line.

Now stop the lathe and reverse the fitting in the chuck. **Fig. 3** shows this step. You can see how the large end has been machined. Again, the adapter must be placed squarely in the chuck. Using a medium and then a fine file, smooth out this piece and round off the shoulder slightly.

The next step requires some dexterity. A small vise and some clamps help. Fit the small end of the machined adapter into or over (depending upon the exact fitting and connector you use) the center connection of the SO-239. Solder the two pieces together, making sure the fitting fits squarely on the SO-239 (**fig. 4**).

Now use some fine sandpaper to clean the small end of the large reducing-fitting and the SO-239. Apply a small amount of soldering flux to the SO-239 body and the large reducer. Remember that these are plumbing fittings and not wires you're soldering; if you omit this step you'll find out why plumbers always use flux. Press the SO-239 into the adapter. This should be a close fit, requiring only hand force to assemble. Now, carefully solder the two pieces together. I expected to need a torch, but a 56-watt soldering iron worked nicely. After a smooth bead is applied around the outside, apply a little solder to the inside of the adapter. This will result in a strong, waterproof joint. Now allow this assembly to cool. After it cools, remove any flux residue to prevent corrosion.

The next step is preparation of the cable itself. Use a tubing cutter and a hacksaw to square off the end.

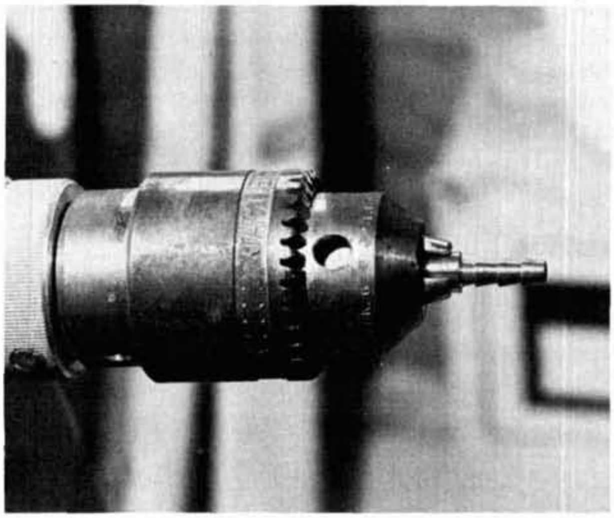

fig. 3. The Barb fitting after one end has been machined. The ribbed end is about to be machined.

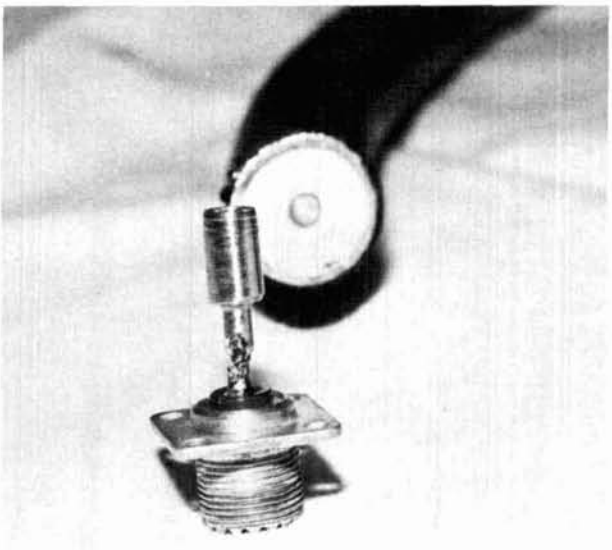

fig. 4. The inner assembly has been completed and prepared for insertion into the outer adapter.

Use the tubing cutter to remove 1 inch (25.4 mm) of the outer insulation. File down the aluminum shield to an outside diameter of 15/16 inch (23.81 mm). Cut the entire cable so that 5/8 inch (15.88 mm) of the cable extends beyond the outer insulation. Carefully square off the center conductor with a fine file. Use the tubing cutter to remove 1/8 inch (3.18 mm) of the shield. Using a sharp knife, cut away the insulation. Do this carefully to avoid nicking the center conductor. This careful order of steps prevents any aluminum filings from contaminating the dielectric. You will now have 1/2 inch (12.7 mm) of the shield extending beyond the outer jacket, and a center conductor extending 1/8 inch (3.18 mm) beyond that. **Fig. 5** shows the completed connector and the prepared cable, ready for assembly.

To place the connector on the cable, carefully start threading the fitting onto the cable. Make sure the fitting goes on square. (A pipe die of the proper size will make this easier, if you can obtain one.) Once the threads are started, you can use a pipe wrench to hold the cable, and an open-end wrench or channellock pliers to turn the connector. Do this carefully to make sure you don't kink or bend the cable. Continue screwing the connector on until you feel an increase in resistance. This will indicate that the center fitting has mated. Now carefully remove the connector. Check for stray aluminum filings and any other problems. **Fig. 6** shows the completed connector placed on the cable.

Since there are two dissimilar metals in close contact (aluminum and copper), some steps must be taken to prevent corrosion. Liberally coat the cable shield and the inside threads of the connector with Penetrox or some similar anti-corrosion compound. Now reassemble the connector to the cable. (The Penetrox will act like a lubricant.) Use an ohmmeter to verify continuity from one end of the cable to the other and make sure no shorts exist between conductors. If this test is satisfactory, tape over the connector and the line is ready for use.

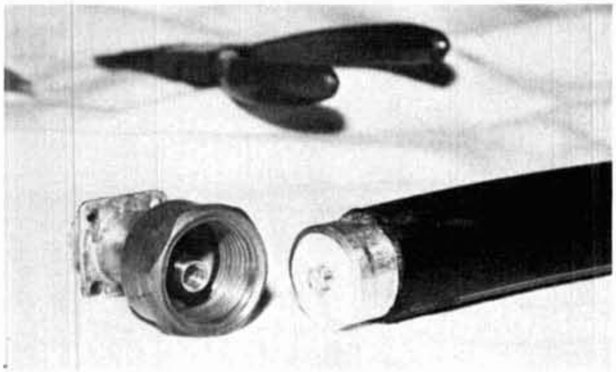

fig. 5. The completed connector and the prepared end of the hardline, ready for assembly.

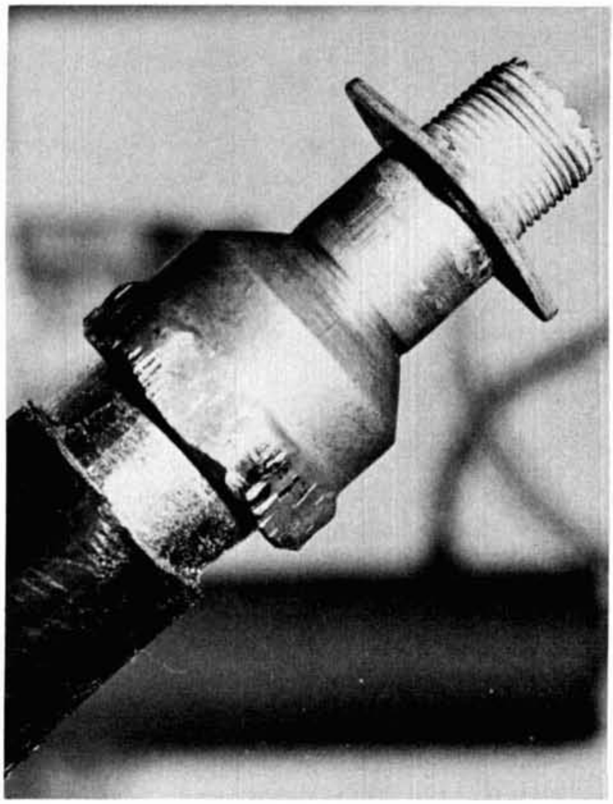

fig. 6. The finished connector installed on the line. It is ready to be protected from the elements and placed in service.

results

The best check of a connector and line assembly is to measure the rf loss through the cable. I tested a 100-foot (30.48-meter) section at 2 meters. The loss measured as 0.8 dB — exactly what the reference tables call for. In other words, the homebrew connectors *did not add any significant loss* to the system.

I have described an economical way to make connectors for 1-inch (25.4-mm) CATV hardline. They are not hard to make, and the materials and procedure can be varied to suit local supplies. Being able to use this high-quality, low-cost cable will make a significant improvement in any station.

acknowledgments

Special thanks go to Mel, W4MJJ, and George, WD4ORM, for their assistance in this project.

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*Export model includes coverage of the 10-meter Ham Band.

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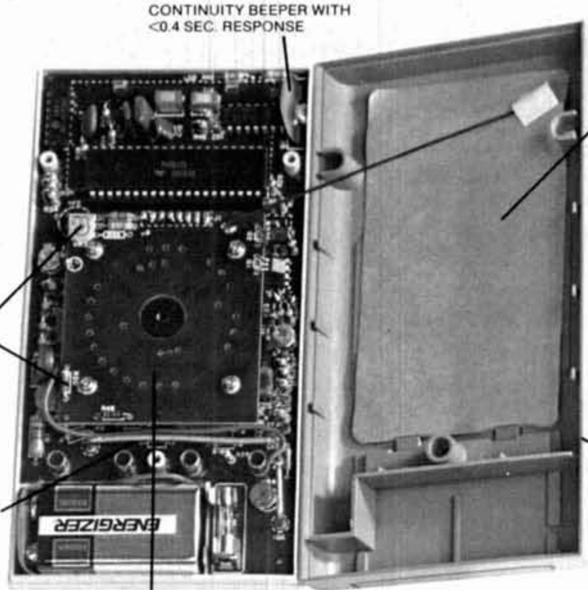

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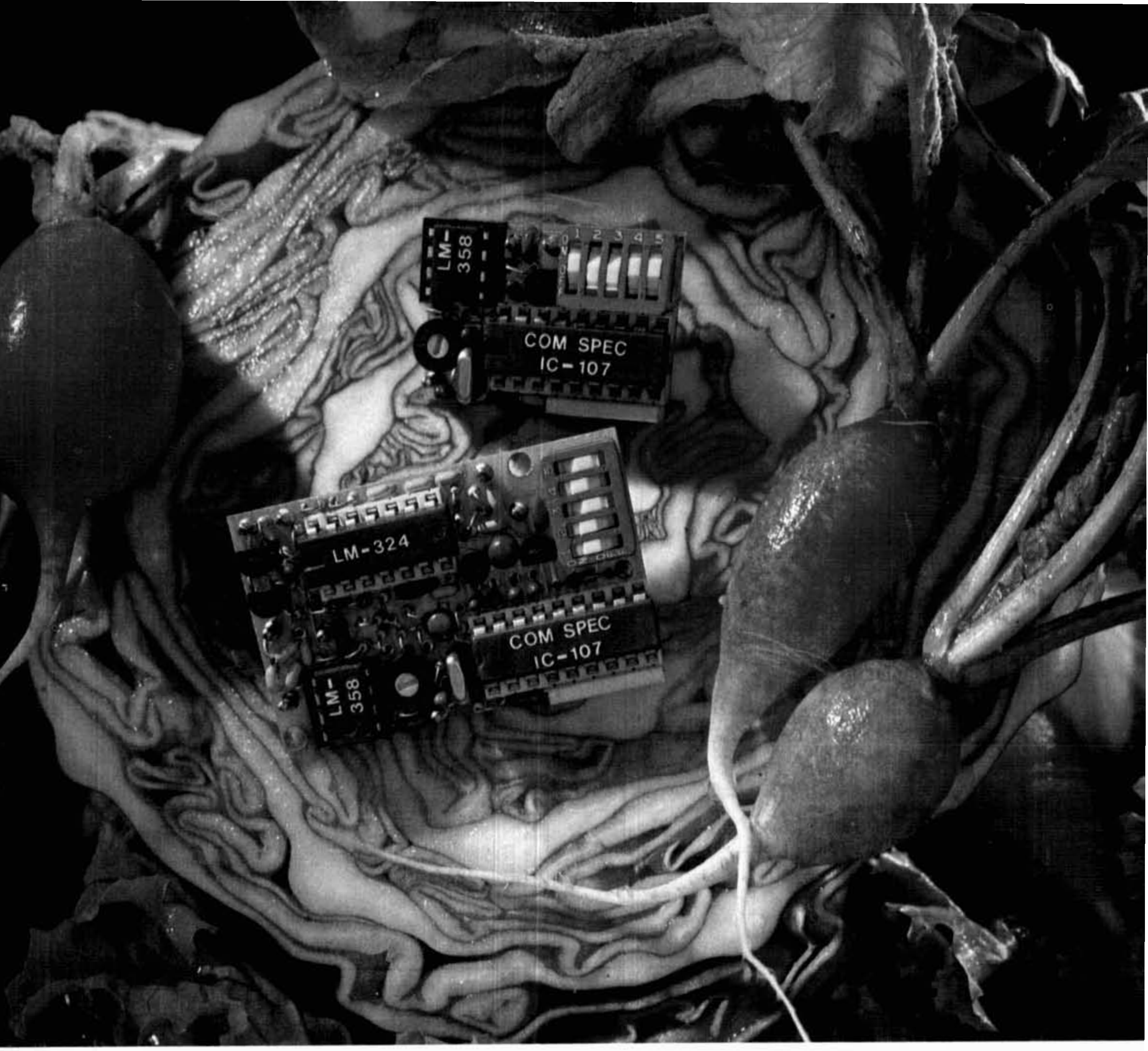

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The Explorer 14 will load solid state transceivers to maximum output with VSWR below 2:1, eliminating the need for an antenna tuner. You'll have edge to edge broadband performance on 20, 15 and 10 meters with gain and front-to-back ratio competitive to giant tribanders that cost twice as much or more. You'll be able to work stations you cannot even hear with a dipole antenna. And, the Explorer 14 handles maximum continuous legal power with a respectable safety margin.

Short Boom Save Space and Money

If your space or budget was too limited for a long boom tribander, chances are the Explorer 14 will fit both. The boom is only 14′ (4.3 m) long and the turning radius requires only 17′3″ (5.3 m). The compactness of the Explorer 14 reduces its overall weight and windload surface so you can mount it on a roof tripod, a mast or a tower. For example, the Hy-Gain CD-45II rotator and HG52 tower are a perfect match for the Explorer 14. This saves you the cost of an extra heavy-duty rotator or tower.

Superior Construction

The Explorer 14 includes passivated stainless steel hardware and heavy gauge, pre-formed element and mast brackets. High grade 6063-T832 thick wall swaged aluminum tubing is used throughout. A BN86 balun is included and a new Beta Multi-Match provides DC ground to reduce lightning hazard and precipitation static. It's a rugged, easily assembled antenna that survives winds to 100 mph (160 km/h).

Quad Band Option

You can add a fourth band, either 30 meters or 40 meters to the Explorer 14 with the QK-710 kit. A kit that attaches to the central dipole and is easily adjusted for either 30 meters (WARC) or 40 meters at minimal extra cost.

Lew McCoy, W1ICP is among the most authoritative writers in amateur radio. For over 30 years he served on the ARRL technical staff with his last position as assistant senior technical editor. Presently he is the technical editor for CQ magazine. Here is what he had to say about the Explorer 14:

"In my opinion, with Explorer 14, Hy-Gain produced a truly high gain, high performance antenna in a small package. The "para-sleeve" design provides the amateur a whole new ball game, particularly in the area of broadbanding. I was really surprised when I actually verified the gain, front-to-back and bandwidth during my recent visit to the Hy-Gain labs and antenna range in Lincoln, Nebraska. The Explorer 14 is a winner."

SPECIFICATIONS

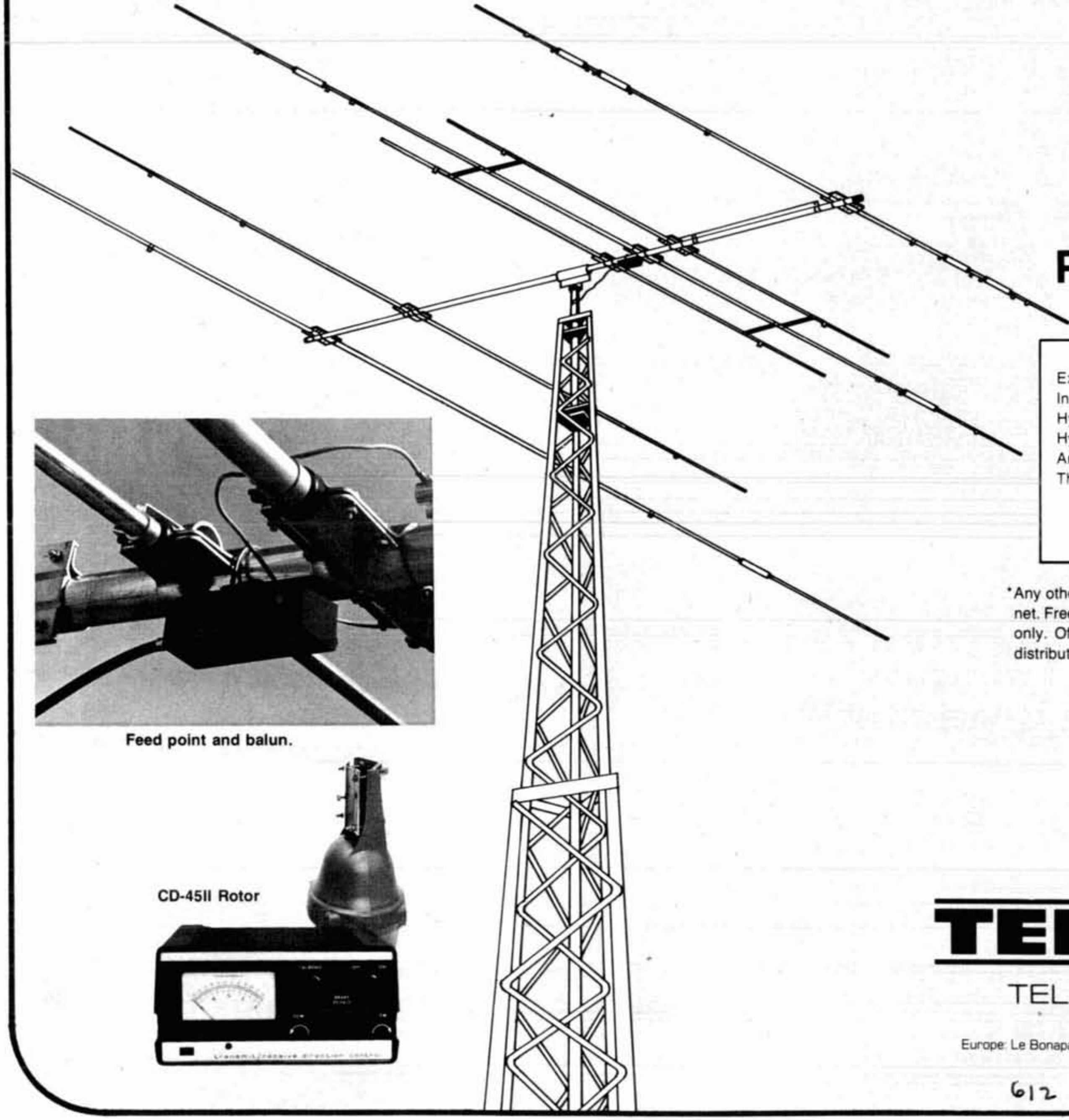
Electrical

Frequencies of operation:	20M	15M	10M
Under 2:1 VSWR (MHz)	14.0-14.35	21.0-21.45	28.0-29.7
Maximum F/B Radio (dB)	27	27	21
Maximum Gain (dB)	7.5	8.0	8.0
Maximum Power		Maximum Legal	
Lightning Protection		DC Ground	

Mechanical

Boom Length	14′1½″ (4.3 m)
Turning Radius	17′3″ (5.3 m)
Net Weight	43 lbs. (19.5 kg)
Wind Surface Area	7.5 sq. ft. (.69 m²)

More Details? CHECK—OFF Page 132



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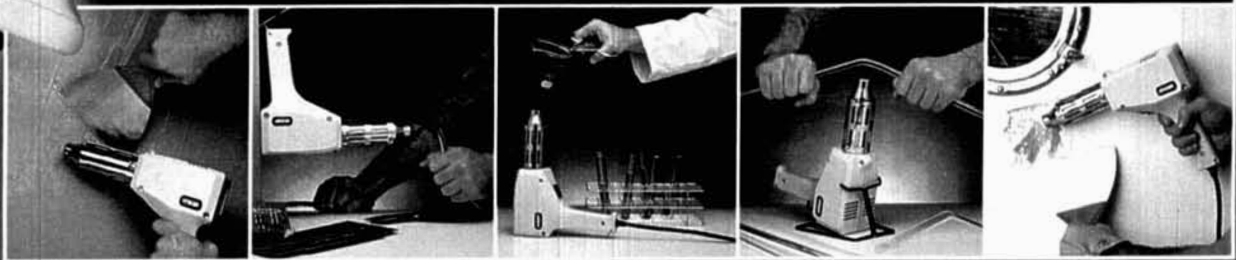

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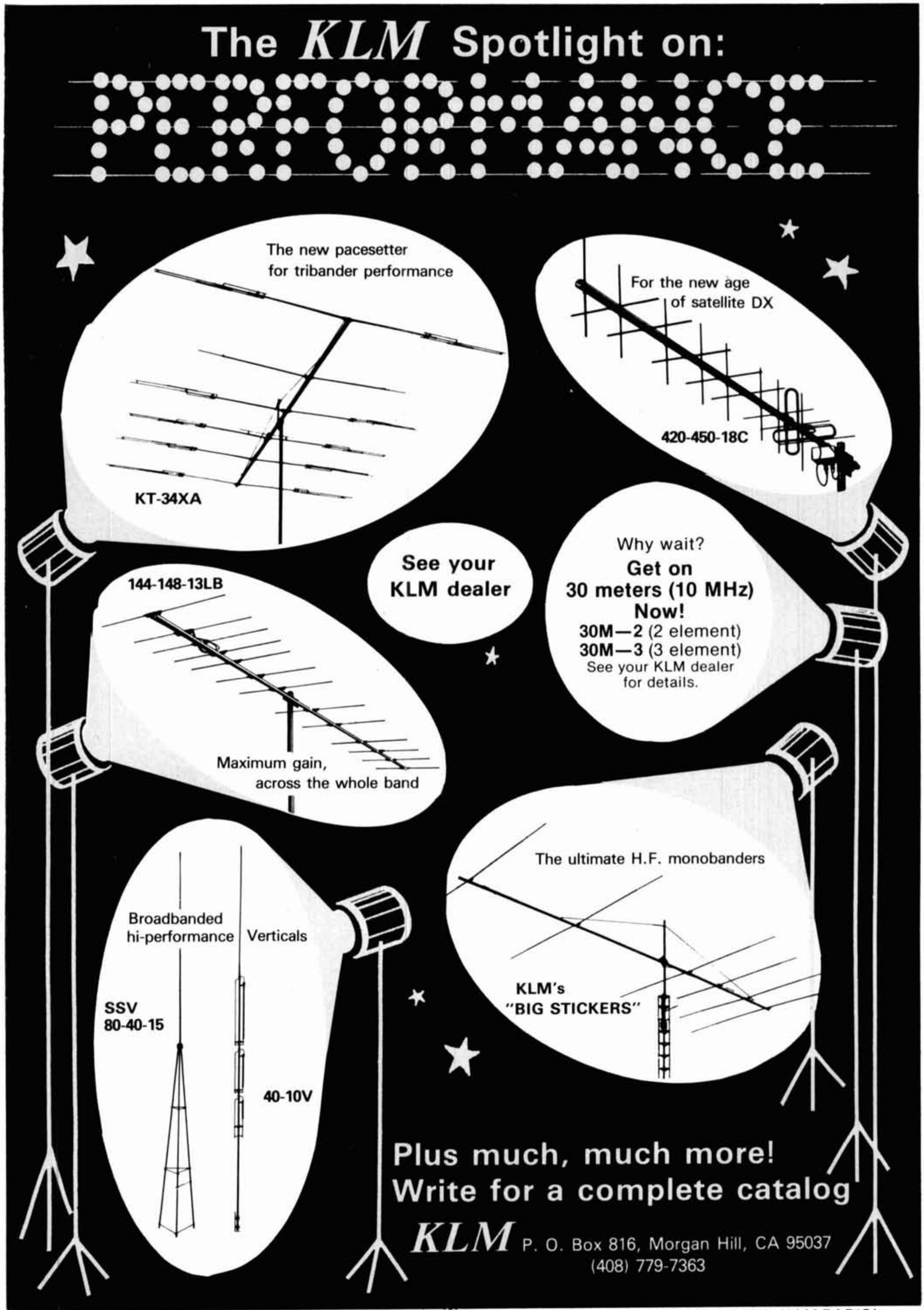

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Each month, our editors will select the best answer received to a question posed in the Technical Forum. We will send the writer a book from our Bookstore as a way of saying thanks.

helical antenna matching

In the March, 1983, Technical Forum, a question was raised as to a method of matching a 140-ohm helical antenna to a lower impedance line. A similar problem was covered in the *IEEE Transactions on Antennas and Propagation*, Vol. AP-25, No. 6, November, 1977, Page 913. The antenna design note covers the method of lowering the impedance of the helical to 50 ohms. The method described would appear to be usable at 70 ohms or any other impedance through 140 ohms. — John Belliveau.

Ed note: Most technical libraries probably have files on *Transactions on Antennas and Propagation*.

ham radio thanks Alfred Resnick, K9PXR/9, for his similar solution to the matching problem. In addition he illustrates how series section transformers can be used to transform 70 ohms to 50 ohms. Articles have appeared on that subject in many magazines. Here are some of the sources:

1. Frank Regier, "The Series-Section Transformer," *Electronic Engineering*, August, 1973, page 33.
2. Frank Regier, "Impedance Matching with a Series Transmission Line Section," *Proceedings of the IEEE*, July, 1971, page 1133.
3. B. Bramham, "A Convenient Transformer for Matching Coaxial Lines," *Electronic Engineering*, January, 1961, page 42.

mysterious spur on 160

A local (0.67-mile-distant) 1500-kHz, 50-kW, a-m broadcast station recently installed a new transmitter that uses asymmetrical modulation (95 percent down, 125 percent up). In addition to increasing an already strong rf field, the new transmitter introduced a low-level, broad spurious signal in the 160-meter band that is present on three different receivers. On a sideband receiver the signal is a broad splatter in sync with the station program. On an a-m receiver the signal is intelligible audio.

The transmitter has been cleared by the FCC in response to telephone-equipment-interference complaints. I've estimated the 160-meter "spur" at my location to be about 100 dB down from the 1500-kHz signal. The station engineer was unable to detect it three miles from the transmitting antenna. The spur is difficult to detect closer to the station, but at my location, with a quarter-wave inverted-L, an antenna tuner, and two 1500-kHz traps in the input of the Omni-D receiver, it is an interfering signal of approximately 80 microvolts.

For the first few months the spur seemed to drift randomly in the lower 25 kHz of the 160-meter band over periods of hours and days. When really cold weather occurred in January, I realized that the frequency drift was related to outdoor temperature. Since then I have been correlating the frequency of the spur and the outdoor temperature. A plot of these readings shows that as the temperature rises during the day the spur frequency decreases. The frequency in the early morning is related inversely to the low temperature reached during the night.

Has anyone experienced a similar situation, or does anyone know what is causing this effect? — Jack Geist, N3BEK.

DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The higher frequency bands (10-30 meters) are favored for the best DX the first half of the month. The solar flux is expected to be highest at that time and lowest about the 20th. Look to the lower frequency bands (40-160 meters) for the best DX the *last half* of the month. Short-duration disturbed conditions (geomagnetic-ionospheric storms) are expected around the 4th, 12th, and 30th, with a longer-duration event just prior to the 20th. Hearing and working DX will be more difficult during the disturbances, but DX from unusual locations may appear in the form of weak fading signals.

The lunar perigee and full moon, of interest to moonbounce DXers, occurs on the 16th and 26th of this month. An Aquarid meteor shower of interest to meteor-scatter and meteor-burst DXers peaks between May 4th and 6th with rates of 10 and 25 per hour for the Northern and Southern Hemispheres, respectively.

sporadic-E propagation

One of the major paths for excellent DX signals in the summer is short skip, or multiple short skips, on the higher frequency bands. In order to best use sporadic-E (E_s) short-skip propagation, which intensifies toward the end of May and ends in mid-September, a short review is in order: E_s 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 distances of 600 to 1200 miles (1000 to 2000 km). Signals remain strong for from a half-hour up to a couple of hours, on the average; they're generally stronger than long-skip. Station location also determines how strongly the present sunspot number (SSN-75) *affects sporadic*-E propagation, with mid-latitudes the least affected and equatorial and polar paths the most. The highest *frequency* propagated by E_s occurs at local noon, since it follows the sun across the sky. However, the highest probability of *occurrence* is near sunrise and again around sunset. These two characteristics of E_s affect short-skip openings differently. Openings on the higher-frequency bands occur near local noontime; the lower bands tend to have openings near sunrise and sunset.

Let's look at the best locations for these E_s openings: Since E_s is related to the summer sun, the effect is in the Northern Hemisphere from June through September and in the Southern Hemisphere during their summer, December through March. The best E_s is on either side of the geomagnetic equator; it's especially good where the geomagnetic equator is furthest 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 better of the two.

To look for E_s openings on the higher-frequency bands, monitor beacons on 6 and 10 meters 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 E_s openings (sunrise and sunset) are available most nights.

band-by-band summary

Six meters will provide occasional openings to South Africa and South America around local noontime by short-skip E_s. Monitor TV, an unused channel (2 through 5) for clues.

Ten and fifteen meters will have a few short-skip E_s openings, and long skip during high solar flux to most areas of the world during daylight. Some trans-equatorial openings associated with disturbed ionospheric conditions may occur in the evening hours.

Twenty and thirty meters will have DX from most areas of the world during daylight and into evening almost every day, either long skip to 2500 miles (4000 km) or short-skip E_s to 1250 miles (2000 km) per hop. The length of daylight is now approaching maximum, providing many hours of good DXing.

Thirty, forty, eighty, and one-sixty meters are the night DXer's bands. On many nights 30 and 40 meters will be the only usable bands because of thunderstorm QRN, but signal strengths via short-skip E_s may overcome the static when E_s is available. Although E_s is scarce in May, it should be plentiful next month.

ham radio

WESTERN USA

MAY																								
GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PDT	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
ASIA FAR EAST	20	20	20	20	—	20*	20	20	—	—	—	—	—	—	—	—	—	20	20	20	20	15	20*	20	N
EUROPE	20	20*	20*	20*	20*	20*	20	20	20	—	—	—	—	—	—	—	40	40	20	20	20	20	20	20	NE
S. AFRICA	15	15	15	15	15	15	15	15	15	20	—	—	—	—	—	20	20	20	20	30	30	20	20	20	E
S. AMERICA	10	10	10	10	10	10	15*	15*	15	15	20	—	—	—	20	20	20	15	15	15	15	10	10	10	SE
ANTARCTICA	15	15	15	15	20	—	—	—	—	—	—	—	30	20	20	20	20	20	20	20	20*	15	15	15	S
NEW ZEALAND	10	10	10	15	15	15	—	—	—	—	—	15	15	15	15	15	15	10	10	10	10	10	10	10	SW
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JAPAN	15	15	15	15	—	—	—	—	—	—	—	—	20	20	20	20	20	15	15	15	15	15	15	15	NW

MID USA

MDT	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	
ASIA FAR EAST	—	—	—	—	20	20	20	20	20	20	—	—	—	—	—	—	—	—	—	20	15	15	15	15	N
EUROPE	15	15	15	15	15	15	15	15	20	20	—	—	—	—	—	40	20	20	20	20	20	20	20	20	NE
S. AFRICA	20	20	15	15	15	15	15	15	15	15	15	—	—	—	30	20	20	20	30	30	30	20	15	15	E
S. AMERICA	10	10	10	10	10	10	10	10	15	15	20*	20	—	—	20	20	20	20*	15	15	15	10	10	10	SE
ANTARCTICA	15	15*	15	15	20*	—	—	—	—	—	—	—	—	20	20	20	20	20	20	20*	20*	20*	15	15	S
NEW ZEALAND	10	15*	15	15	15	15	—	—	—	—	—	—	20	20	20	20	15	15	15	10	10	10	10	10	SW
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JAPAN	20*	20	20	20	—	—	—	—	—	—	—	—	—	—	—	20	20	20	20*	15	15	15	15	15	NW
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EASTERN USA

EDT	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	
ASIA FAR EAST	20	20	—	—	—	—	20	20	20	20	—	—	—	—	—	—	—	—	20	20	20*	15	15	15	N
EUROPE	20	20	15	15	15	15	15	15	15	15	15	—	—	—	20	20	20	20	20	20	20*	20	20	20	NE
S. AFRICA	20	15	15	15	15	10	10	10	15	15	15	—	—	—	20	20	20	20	30	30	30	20	15	15	E
CARIBBEAN S. AMERICA	10	10	10	10	10	10	10	10	10	15	—	—	—	20	20	20	20	15	15	15	15	15	10	10	SE
ANTARCTICA	20	15	15	15	15	15	—	—	—	—	—	—	—	—	20	20	20	20	20	20	30	30	30	30	S
NEW ZEALAND	10	10	15	15	20	20	20	20	20	—	—	—	—	20	20	20	20	15	15	15	15	15	15	10	SW
OCEANIA AUSTRALIA	15*	15	15	20*	20	20	20	20	—	—	—	—	—	—	20	20	20	20	15	15	15	15	15*	10	W
JAPAN	15	15	20*	20	—	—	—	—	—	—	—	—	—	—	—	20	20	20	20	20*	15	15	15	15	NW

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

More Details? CHECK—OFF Page 132

Log-Yagis simplified

A 12-foot (boom) antenna achieves 11-dB gain on 10 meters

Several articles on the design of log-periodic dipole and Log-Yagi antennas have made the Amateur fraternity quite conscious of their excellence for long-haul DXing. Their virtues are high gain, exceptional bandwidth, and a large capture area. In order to understand the mathematical concepts, rather than just copying a design, a series of simple functions have been derived that permits any interested Amateur to design his own Log-Yagi.

reflector considerations

Relatively close spacing is employed in these Log-Yagis. Purists may be dismayed by this approach, since approximately 0.5 dB would be lost in a *Yagi* of similar size. In the case of Log-Yagis, however, if such a lost exists it is dwarfed in importance by achievement of front to back ratios of up to 30 to 45 dB. Experimenters who have tried both the wide and close-spaced reflectors report that the close-spaced reflector shows no apparent loss in gain, but that the front-to-back is terrific. Interlacing Log-Yagis does show the loss of about 5 dB F/B when compared with monobanders.

Since I could find no published curves or data for using close-spaced reflectors, I decided to provide my own data at three spacings under 0.15 wavelength. The spacings were chosen to provide easily measured intervals of inches and fractions and result in 0.0765, 0.0854, and 0.1 wavelength. Efficient reflectors are made progressively longer as they are moved closer to the driven element or cell. Simple formulas can then be used to calculate reflector lengths based on the indicated spacing. Finally, the frequencies used for computation are based on the lower band-edge where wavelength is determined by 11808 ÷ f MHz, with the result in inches.

Reflector spacing versus required reflector length is as follows:

spacing	reflector length
0.0765λ	6190 ÷ f MHz
0.0854λ	6115.2 ÷ f MHz
0.10λ	6050 ÷ f MHz

director considerations

In addition to the reflector design needed to produce the best F/B ratio, the best broadband characteristics with constant gain were also considered. Because of perturbations within the log cell, it has been found that with spacings less than 0.12 wavelength the gain is not constant over the entire band. Spacings between 0.125 and 0.150 wavelength exhibit a relatively flat response if the director is adjusted to 95 percent of the longest cell element. The use of spacings of less than 0.125 require pruning or adjusting

By Leo D. Johnson, W3EB, Route 1, Box 448, Hollywood, Maryland 20636

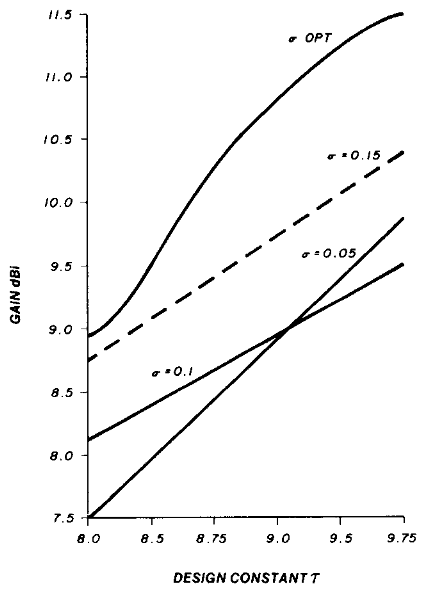

fig. 1. Gain (dBi) vs τ (from K4EWG curves).[1,2,3]

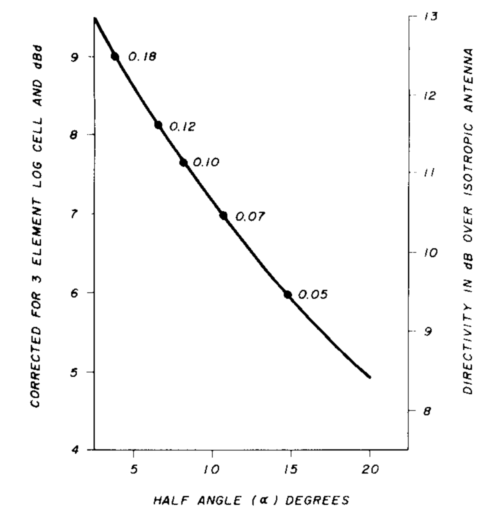

fig. 2. Extension and modification of Isbell's fig. 14.[4] [Curve for $\tau = 0.95$ only with approximate sigmas (σ).]

the director for best results in the portion of the band of interest.

average Yagi gain

Tests conducted using two Yagi parasitic elements with log-cell radiators show 4.3 to 4.6 dB gain over the cell alone. Reference in the text to average Yagi gain is based on a 4.5 dB average.

Second directors provide between 1 and 1.5 dB additional gain when spaced 0.15 to 0.2 wavelength from the first director. A third director seldom adds more than 0.5 dB gain.

the cell function

There are as many combinations of Log-Yagi configurations as imagination will allow. As this article is not a treatise on the construction of a single design, working examples are used to lead the builder through the simple design steps.

In the formulas presented, f is the frequency in MHz at the lower band edge, τ is the design constant between 0.85 and 0.97, and σ is the spacing constant between 0.05 and 0.19 used to determine cell length and gain. Half angle (α) is the angle formed between the boom and the taper formed by the element.

It should be noted that a τ near 0.95 produces higher gain, with virtually any σ, than is possible using the lower figures near 0.85, and is generally what I use. Bandwidth of the cells, even with high σ, are sufficient through 28 MHz to ensure coverage of the entire band.

Two curves are shown in **fig. 1** and **fig. 2** which enable the designer to reasonably determine cell gain. One represents the τ versus σ from K4EWG's work[1,2,3] and the other is from Isbell's[4] work using τ versus half angles. The Isbell curve has been modified by extending the curves to include half angles near 3 degrees.

Both curves are based on pure log-periodic cell design and their accuracy is not questioned. For Log-Yagi work, Isbell's curves appear to correlate closely if a correction factor of -1.3 dB is applied.

Subtraction of 2.2 dB results in dBd — or gain over a dipole. For this reason, the left-hand figures on the modified Isbell curve have been corrected by 3.5 dB and shown as dBd.

Either curve shows that cell gains over a dipole, when added to the average Yagi gain, *provide a very efficient antenna on a relatively short boom.*

designing the antenna

Having waded through the basics that are pertinent to Log-Yagi design, you can proceed with the development of the antenna shown in **fig. 3** using simple formulas.

For the cell half-lengths in inches:

$$\ell 1 = 2820 \div f$$
$$\ell 2 = 1 \times \tau$$
$$\ell 3 = 2 \times \tau$$

Spacing between the elements is calculated by first multiplying the selected σ by four and again multiplying that quantity by the length of $\ell 1$. Stated as a formula: $\ell 1(4\sigma) = \ell 1 - \ell 2$ spacing. To calculate the

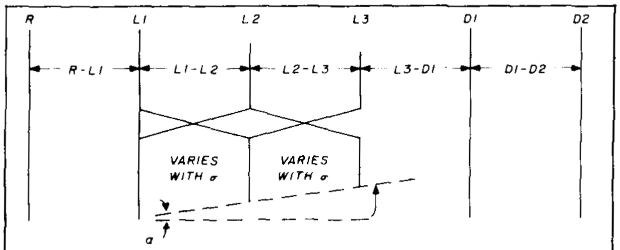

fig. 3. Log-Yagi consisting of cell (ℓ1, ℓ2, and ℓ3) and up to three parasitic elements.

$\ell 2 - \ell 3$ spacing multiply the $\ell 1 - \ell 2$ spacing by τ.

This completes the cell design and a total Log-Yagi can be designed from the data presented so far.

For example, a 28-MHz antenna with a τ of 0.95 and using a σ of 0.07 results in the following cell dimensions.

$$
\begin{aligned}
\ell 1 &= 2820 \div 28 = 100.71 \\
\ell 2 &= 100.71 \times 0.95 = 95.6786 \\
\ell 3 &= 95.6786 \times 0.95 = 90.895 \\
\ell 1 - \ell 2 &= (4 \times 0.07) \times 100.71 \\
&= 0.28 \times 100.71 \\
&= 28.1988 = (28.2) \\
\ell 2 - \ell 3 &= 28.2 \times 0.95 \\
&= 26.79 = (26.8) \\
\text{cell length} &= 55 \text{ inches}
\end{aligned}
$$

Continuing the design for the parasitic elements using 0.0765-wavelength spacing for the reflector and 0.15-wavelength spacing for the director we find:

$$
\begin{aligned}
R &= 6190 \div 28 \\
&= 221.07 \\
R - \ell 1 &= (11808 \div 28) \times 0.0765 \\
&= 421.7 \times 0.0765 \\
&= 32.26 = (32.25) \\
d &= (2 \times 100.71) \times 0.95 \\
&= 201.42 \times 0.95 \\
&= 191.349 = (191.35) \\
\ell 3 - d1 &= 421.7 \times 0.15 \\
&= 63.25
\end{aligned}
$$

The parasitic elements require 95.5 inches plus 2 inches each for mounting; when added to the cell length, this figure indicates that a boom of 154.5 inches, or 12.875 feet, is required. If the antenna was to have been designed for exactly a 12-foot boom, then this example must be changed by reworking the cell length or changing the director spacing. In the example given, reducing the director spacing to 0.125 wavelength results in a new spacing of 52.75 and the antenna fits a 12-foot long boom nicely.

The K4EWG curve indicates a cell gain of 9.2 dBi, or 7.0 dBd. To compute the half angle to check with the modified Isbell curve, we must calculate the cotangent (cot) of the half angle from the τ and σ used in our design as follows:

$$
\begin{aligned}
\cot \alpha &= (4 \times \sigma) \div (1 - \tau) \\
\cot \alpha &= (4 \times 0.07) \div (1 - 0.95) \\
&= 0.28 \div 0.05 \\
&= 5.6
\end{aligned}
$$

Cot 5.6 (5.614) resolves to a half angle (α) of 10.1 degrees.

The gain on the modified Isbell curve indicates 8.8 dBi, or 6.6 dBd, for the cell alone. Cell gain of 6.6 plus 4.5 average Yagi gain renders a figure of **11.1 dBd total** gain for the Log-Yagi, or about 0.6 dB less than indicated by the other curve.

The two methods produce little difference in cell gain figures in the region between sigmas of 0.05 and 0.12, but even the lowest of gain figures equates to a power ratio of 12.6, which makes 100 watts as effective as 1.25 kW on a dipole.

wide-spaced cells

The previous design produced a high-gain antenna on a short boom. Surely some designers will be considering whether versions with longer booms and more directors are practical, particularly for those who have the space to erect them.

If all the constants remain the same except σ, which is increased, only the spacing between cell elements will change. The spacing for $\ell 1 - \ell 2$ becomes 68.5 inches and $\ell 2 - \ell 3$ is 65.063 inches for a cell length of 133.5 inches using a σ of 0.17.

Using this cell length with 0.15-wavelength director spacing and 0.0765-wavelength reflector spacing, the boom required would be a little over 19 feet long. If, however, the reflector spacing were changed to 0.0854 wavelength, the mechanical balance would be improved and the configuration would fit nicely on a 20-foot boom.

Using the previous formulas, the $\cot \alpha$ is 13.6 and the half angle is 4.2 degrees. The modified Isbell curve shows a cell gain of 8.95 dBd and a total Log-Yagi gain of **13.45 dBd**. The 100 watts now looks like 2 kW on a dipole.

While straining for every dB possible, adding a second or third director could give a final figure of over 15 dBd.

tolerances

Two items left untouched by most other articles on this subject are the need for careful workmanship and the use of relatively finite measurement if the best results are to be attained. Inattention to detail or poor workmanship can cost you gain.

Tolerances should be held to 1/16 inch for element lengths and spacings up to 1/8 inch as high as 28 MHz. For metric measurement, 1 mm is an excellent tolerance figure (for both length and spacing).

By fastening the phase lines exactly 0.5 inch from the attachment end of the radiator, and maintaining equal lengths of each wire or strap in the phasing pairs, the builder is ensured of good electrical balance and his results will be repeatable time after time. The dimensions developed from the design effort are based on center-to-center spacing of all elements.

fine tuning the design

In many combinations of the three basic factors of design, it appears that some fractions make the measurement practically impossible. Other cases are noted where attaining the tolerance figures for construction is impossible.

Changing one or more of the factors even slightly can often resolve the problems. In the following example of a 14-MHz design, the original figures and finalized computations are explained:

original computation	final computation
$f = 14\ MHz$ $\tau = 0.95$	$f = 14.0037214$ $\tau = 0.950341403$
$\sigma = 0.1791$	$\sigma = 0.1789265$
$\ell_1 = 201.42857$	$\ell_1 = 201.375$
$\ell_2 = 191.357$	$\ell_2 = 191.375$
$\ell_3 = 181.7893$	$\ell_3 = 181.875\ (181.8716)$
$\ell_1 - \ell_2 = 144.303$	$\ell_1 - \ell_2 = 144.125$
$\ell_2 - \ell_3 = 137.088$	$\ell_2 - \ell_3 = 137.0\ (136.968)$

First, the dimensions of ℓ_1, ℓ_2, and ℓ_3 were difficult to measure. This was resolved by dividing 2820 by 201.375 for the new frequency. Although ℓ_2 and ℓ_3 could be considered within tolerance, it was desirable to see how τ would be influenced.

The figure of 191.3786 for ℓ_2 after the frequency was changed was close to 191.375, so a new τ was developed by dividing 191.375 by 201.375 for $\tau = 0.950341403$, which helped make ℓ_3 a more easily resolved figure.

Although the cell spacings were resolvable, I felt that reducing the sigma slightly would permit the use of integral inches for $\ell_2 - \ell_3$, and that the small change would not affect gain. By cut and try, I improved the dimensions and arrived at the new figure.

The results are dimensions well within the established tolerances. It is much more simple to redo the arithmetic than to try to measure uncommon fractions!

construction

I've tried various methods for mounting cell elements. Generally, the insulating material used in cell construction dictates the mounting method. When using polystyrene, Lucite, Plexiglass, or PVC tubing as insulators, strap them with stainless steel hose clamps. (If you use U-bolts, a cushioning material must be added.) With these insulators, I used 1-1/4 × 1-1/4 aluminum angle mounted to 4 × 4 plates for fastening to the boom (with muffler clamps). Most of the materials mentioned succumb to weathering of some sort in two to three years. PVC shows breakdown of insulation and the others get brittle and crack.

The best material is polycarbonate. Though this material is expensive, it has a tensile strength of 6000 psi, a breakdown characteristic of 360 volts per mil (0.001 inch), it retains its impact strength to −40 degrees F, and it has a temperature distortion point of over 260 degrees F. Polycarbonate with 1/8-inch wall can support a full-sized 14-MHz element, with two U-bolts spaced 6 inches apart, when the element is enclosed in a tube only 7 inches long with a gap between elements ends of 0.5 inch. There will be no noticeable sag at the element center.

guying

Single guy wires are satisfactory for small booms and on larger-diameter long booms with thick walls. The extra support provided by umbrella-type guying is recommended in most other cases. When the installation is close to salt water, or in areas where oxidation levels are high, stainless steel guys and turnbuckles are highly recommended. The 3/32-inch sailboat-shroud cable is adequate for most cases. For very heavy arrays, such as interlaces, 1/8-inch material is recommended. Dacron is the only rope material recommended for guys. This should be of the woven type, in diameters of 1/4 or 5/16 inch. Rope guys increase wind resistance considerably.

matching

Impedances of almost all configurations are between 35 and 48 ohms. Whether strap, rods, tubes, or wire is used for the phasing lines, their influence is small so far as matching capabilities are concerned.

K4EWG devised a matching stub for his design which is easily found by using 256 ÷ f. It is installed between ℓ_3 and a 1:1 balun. Closing up the stub spacing or adjusting 1/8 inch at a time provides the best match.

On many occasions it is difficult to make such changes easily. A preferred method is to feed the antenna through a balun and slightly shorter stub, using a transformation in the feedline. This approach uses either an odd number of quarter wavelengths of 50-ohm feedline (corrected for velocity factor) or a single 50-ohm quarter-wave section between 70-ohm feedline and the balun end. In every case, it has been possible to reduce the VSWR to 1.3:1 or less across the band.

Though the standard computation for a quarter-wavelength section is 246 ÷ f multiplied by the line's velocity factor, my figure of 240 ÷ f low end, with correction for velocity factors, appears to provide the best broadband characteristic for this transformation.

about gain figures

I will be among the first to agree that antenna models do not guarantee the gain figures attributed to the designs of these Log-Yagis. Usually as much as 2.5 dB variation is noted.

Recent antenna testing by the NRL (Naval Research Lab) and others have verified that modeled antennas are but guidelines for the development of full-scale antennas, where certain performances are required over particular paths. Recent testing has been performed with full-scale antennas to determine "apparent gain" over such paths.

The use here of the idea of apparent gain is similar to its use in the development of "gain type" antennas for mobile use. For example, a 5/8-wavelength antenna by itself cannot produce a 3-dB improvement over an antenna 1/4-wavelength long. Apparent gain is accomplished by concentration of energy in a favorable direction or takeoff angle.

Apparent gain follows the design gain quite closely in Log-Yagi arrays. On long-haul paths of over 3000 miles, a comparison with a reference dipole yields results that are quite close to those derived by computations using the curves. The large capture area and non-symmetrical vertical pattern are no doubt contributors to its ability on such paths.

credits

Thanks goes to Peter Rhodes, K4EWG, for planting the original seed and for taking the time to discuss and verify the aspects of this new design; to WA3ELE for making the first long-boom wide-spaced array; and a special thanks to the model shop-workers who manufactured the antenna hardware.

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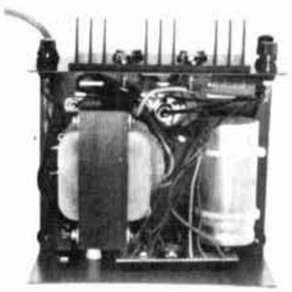

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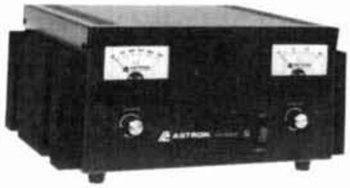

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VS-35M	25	15	7	35	5 x 11 x 11	29
VS-50M	37	22	10	50	6 x 13¾ x 11	46

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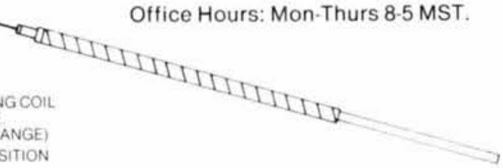

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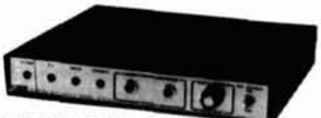

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the grounded monopole
with elevated feed

Low-takeoff-angle vertical for 10 through 80 meters

A popular multiband antenna in the 1930s was the off-center-fed or Windom. It consisted of a half-wave horizontal dipole, at its fundamental frequency, fed off-center by a single wire feeder, at a distance of about 0.36 times its length measured from one end. A later version of the off-center-fed antenna (1940s) used 300-ohm twin lead instead of a single wire feeder, fed at a point one-third of its length, measured from one end. This antenna operates satisfactorily on the fundamental frequency and on harmonics, permitting operation on the 80-, 40-, 20-, 15-, and 10-meter bands.

If this off-center-fed antenna is turned up on end and grounded at the end closest to the feed point, we now have a vertically-polarized antenna with impedance and radiation characteristics that change with frequency in such a way that this antenna can be successfully employed for multiband (multi-frequency) operation. However, it has not been used, to my knowledge, at high frequency for radio communications. The antenna is in effect a grounded vertical monopole with elevated feed. Its main lobe, which is directed toward the horizon, does not break up into a high angle lobe for heights between 3/4 and 1 wavelength.

The transfer of the feedpoint from the base upwards has been used for a different purpose, in the sleeve antenna, originally designed for VHF, but recently adapted for use at high frequency.[1] The half-sloper[2] is also a type of elevated feed antenna. In the present design, the antenna is earthed at its base, and sectioned at a height of one-third its total height. The coaxial feeder cable is brought up along or inside the earthed lower section. Its sheath is connected to the top of the lower section, and the inner conductor is connected through a 4:1 step-up transformer to the insulated upper section. This is shown in **fig. 1A**.

An antenna of this design was described by Hatch et al[3] who analyzed it by approximation, treating the antenna as a lossless transmission line of constant characteristic impedance. Since the standing wave component of the antenna current is much larger than the progressive wave component, corresponding to radiation, for thin monopoles, this treatment is a good first approximation.

On this assumption, the authors computed the current distribution on the radiator for $h = \lambda/4$, $\lambda/2$, $3/4\lambda$ and λ, (**fig. 2**). Note the elevated feed has a pronounced effect on the current distribution on the radiator, an effect which improves the radiation pattern of the antenna for $h > \lambda/2$, since for $h = 3/4\lambda$ and λ the current distribution is essentially in phase, a desirable feature for maximum gain.

radiation patterns

The radiation patterns of the monopole were also computed, and are reproduced in **fig. 3**, for $h = \lambda/2$, $3/4\lambda$ and λ. Patterns for the elevated feed differ little from those for base feed for heights up to $h = \lambda/2$, but there is a substantial improvement in low angle

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radiation for $h = 3/4\lambda$ and λ. In the case $h = \lambda$, the base-fed antenna has only a high angle lobe, whereas with an elevated feed, there is no high angle lobe, and the radiation is dominantly low angle (less than 10 degrees above the horizon). Such an antenna would be a good DX antenna since it will have gain at these frequencies. The patterns are significantly modified by the finite conductivity of the earth, and a radial ground system must be employed to reduce losses due to currents returning to the base of the antenna through the ground. This is no different from any ground plane antenna.

antenna reactance

The reactance to the source was computed, and calculated curves are reproduced in **fig. 4**. The rate of change of reactance with frequency is smaller for the elevated feed antenna, and the SWR (actually X/Z_o, where Z_o = the characteristic impedance of the antenna if considered to be an open-circuit transmission line) is particularly small at $\lambda/4$ and $5\lambda/4$. The SWR at $\lambda/2$ and λ is acceptable if an antenna tuner is used to match the antenna to the transmitter. If the antenna height is such that it is approximately quarter-wave resonant at 80 meters (3.75 MHz), it could be used on 80-, 40-, 20-, 16-meters (18 MHz) and 15 meters ($h = 3\lambda/2$).

antenna modeling

The antenna reactance versus frequency curve shown in **fig. 4** represents the ideal case, since the antenna was analyzed as a lossless transmission line, whereas a practical antenna has resistance (radiation and loss resistance) as well as reactance. The impedance of a modeled antenna over a perfectly conducting ground plane (a 30-meter diameter wire grid ground screen) is shown in **fig. 4**. The antenna was 1.96 feet (60 cm) high, and 0.25 inches (0.63 cm) in diameter. The antenna was fed at a point one-third its height above ground. The top section was fed by connecting it to a wire running inside the lower section, but insulated from it. The lower section of the mast with the feed wire inside behaved like a coaxial feeder, as well as part of the monopole antenna. The impedance (Z, θ and Γ) was measured between the lower end of the coaxial feeder wire and ground. Γ is the voltage reflection coefficient, with reference to 50 ohms:

$$\Gamma = \frac{SWR - 1}{SWR + 1}$$

If at full scale 3.5 MHz corresponds to 100 MHz, the scale factor equals 28.57, and at full scale the monopole is 56.24 feet (17.14 meters) high, and 7.4 inches (18.14 cm) in diameter. For this scale factor, the band edges for the 80, 40, 30, 20, 15, and 10 meter bands are marked. Except at 20 and 40 meters the $SWR < 4:1$.

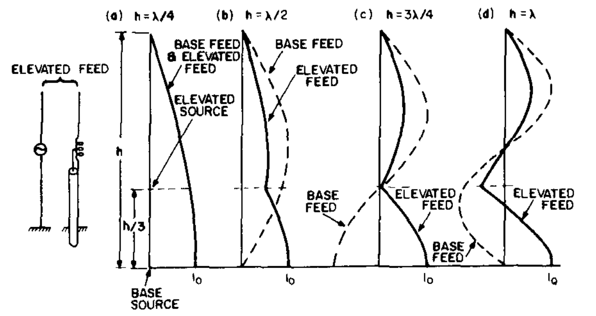

fig. 2. Current distribution for base-fed and elevated-feed monopoles.[3]

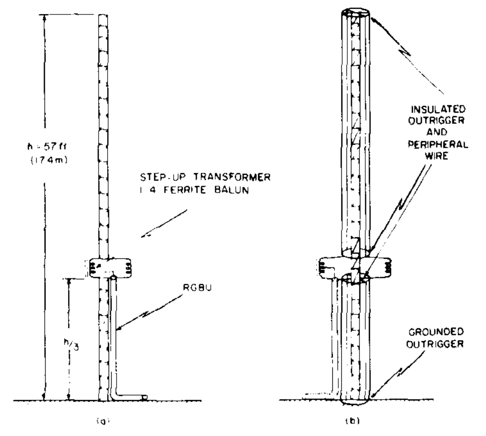

fig. 1. (A) Elevated feed grounded monopole antenna, (B) Use of a cage of wires instead of physically sectioning the antenna.

sectioning the monopole

A tower is physically sectioned by proper placement of insulating sections. This is not very practical, especially if a grounded tower is available. Broadcasters have used grounded towers for particular applications that require the tower to be sectioned, and they have devised a method to effectively achieve this without *physically* doing so. The method is sketched in **fig. 1B**.

The tower is screened using insulated outriggers which support a surrounding cage of vertical wires. Six or eight wires are required, although four wires, as sketched, might be satisfactory. The wires are joined together by a peripheral wire at the top of the tower, at the bottom of the top section, at the top of the bottom section, and at the base of the tower. The sketch shows a physical separation at the place where the tower is sectioned. In practical applications, a series strain insulator would be inserted in the vertical dropwire at that point. This arrangement effectively screens the grounded tower, sections it, and since the electrical diameter is increased, the intrinsic bandwidth of the radiator will be greater.

performance

A temporary test antenna was constructed using a 37-foot free-standing whip mounted on an 18-foot lattice tower. This antenna was erected at the author's QTH (**fig. 5**). The SWR was measured at a number of frequencies in 3-30 MHz band. These results are plotted in **fig. 6**, where the abscissa is h/λ rather than frequency.

Since the antenna is not resonant and matched at any frequency in this band, the SWR depends upon the length of the feeder transmission line, and its characteristic impedance. The SWR for lengths 30 feet and 100 feet of RG8-U (50-ohm coax) was measured, and measurements were made with 72-ohm coax. Rice and Winacott,[4] following the Marconi work, employed a 7.5 μH coil across the 4:1 step-up transformer, (**fig. 1**), which was supposed to improve the SWR at the higher frequencies. The author found that this coil increased the SWR at these frequencies, and so this inductor was not used. While there were differences in the SWR at particular frequencies for the different lengths and impedances of the feeder cable, an optimum length or impedance was not found. The results in **fig. 6** were for a 100-foot length of RG8-U. The SWR for the various present and proposed Amateur bands are in **table 1**.

The SWR was highest at 10.1 MHz, where $h/\lambda = 0.57$, it was 5.5. This is, however, of no consequence, provided the antenna can be matched employing an antenna tuning unit. Since the normal loss for $SWR = 1$ for RG8-U cable at 10 MHz is 0.45 dB,

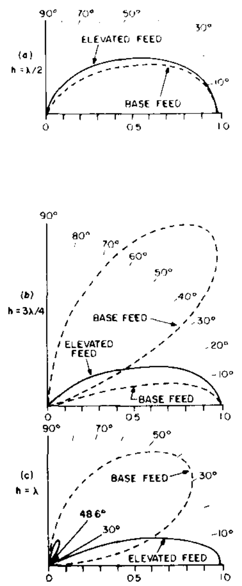

fig. 3. Vertical radiation patterns for base-fed and elevated-feed monopoles.[3]

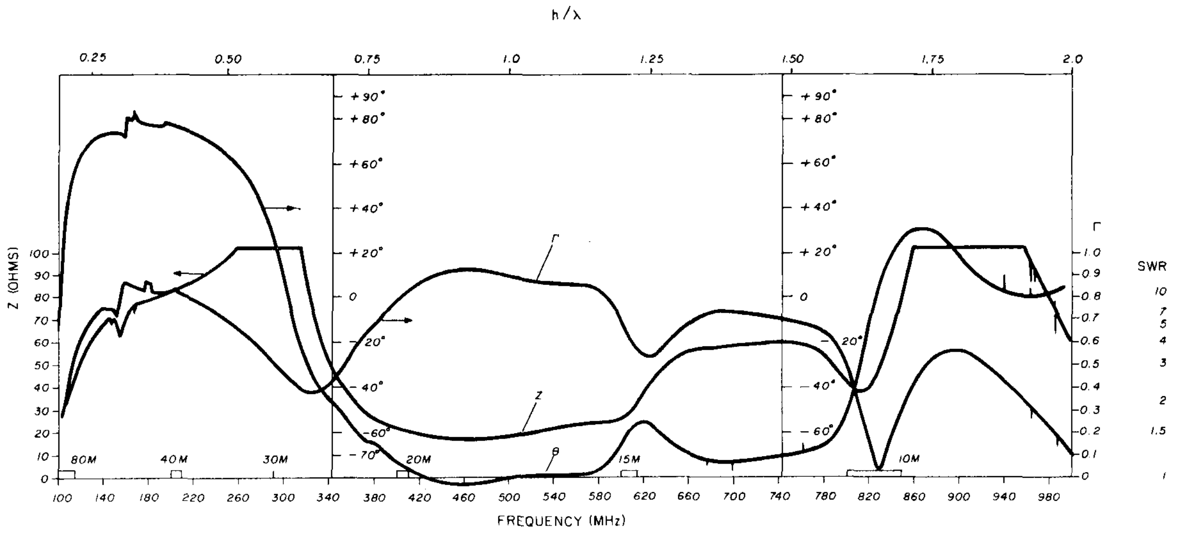

fig. 4. Curves that show the feed impedance of the grounded monopole with elevated feed versus operating frequency for the scaled model. Corresponding full-scale frequencies are noted.

table 1. Initial antenna SWR measurements are indicated together with the corresponding Drake MN-4 antenna tuner dial settings and bandwidth positions. The last column lists impedances inferred from the tuner R/X dial settings.

frequency MHz	initial SWR	antenna tuner dial R/X	antenna tuner bandswitch	antenna impedance magnitude (ohms) and phase (degrees
3.70	3.3	9/1.1	80	26 $\angle -30$
7.10	4.5	2.1/3.6	40	98 $\angle +46$
10.10	5.5	5.6/7.8	40	100 $\angle +59$
14.15	3.3	4.6/4.1	20	17 $\angle -34$
18.10	2.0	4.3/8.6	20	85 $\angle +34$
21.20	2.8	4.6/5.3	15	19 $\angle +16$
24.90	2.5	4.1/10	15	83 $\angle +15$
28.50	3.1	3.9/7	10	19 $\angle -50$

the additional loss due to $SWR = 5.5$ is about 0.6 dB, for a total loss of about 1 dB. This is hardly worth worrying about. A more important consideration is radiation from the transmission line, which should be buried, and the run above ground into the shack should be as short as possible.

Table 1 includes dial setting and bandswitch positions to tune the antenna at the various frequencies for an $SWR = 1{:}1$, employing a Drake MN-4 antenna tuner. Also shown are the antenna impedances inferred from these dial settings. That is, the transmitter input port was terminated in 50 ohms and with the tuner controls reset to the indicated value, the conjugate impedance was measured at the tuner output port. This measurement gives the correct magnitude of the antenna impedance, but the opposite sign of the phase angle. These settings and impedances would not apply to other installations, since it is hardly likely that this temporary antenna would be copied identically. They are given to indicate that the antenna can be tuned at all frequencies using an antenna tuner. A table such as this facilitates band change, the controls can be preset and require only trimming for minimum SWR.

While I had no doubt that the antenna would perform as predicted, my concern was that losses in the ferrite balun (which was used for the 4:1 step-up transformer) might be high for high SWR.[5] I do not have a Drake B-1000 balun which is supposed to be designed for such applications. For outdoor use, this balun must be mounted in a weatherproof box, with feedthrough insulators.

The first test was to measure the SWR at different power levels. It was measured at 10 watts of forward power and 100 watts of forward power. No difference was detected.

The operational performance of an antenna is difficult to measure quantitatively. The following account describes some communications tests conducted over several days in October, 1980.

Starting with 20 meters, I measured the relative gain with respect to an elevated ground plane (a Hy-Gain 14AVQ trap vertical with 16 radials, four for 40, 20, 15, and 10 meters) on the roof of my garage. A gain of 0 to 1 S units was measured (0 to 5 dB). The measured gain was obviously dependent on the distance of the station being received and the propagating mode (angle of elevation of signal received).

On 40 meters during early evening hours, I worked UK2PCR, and GW4BWK, whom I chatted with for half an hour or so. He was using a full-wave delta loop apex up, lower corner feed (vertical polarization). I was using a Yaesu FT101 (100-watt transceiver).

On 75 meters, during the same two evenings, I worked Y21UJC, EA1UU, FT7DG, and G2PU. I had not previously worked DX from my QTH on 75 meters, since my fixed antenna system is quite inadequate for working DX. If you can't hear DX, you can't work it.

I QSY'd with VE8MA from 20 meters to 15 meters late one evening. I thought the 15 meter band might be dead. My received signal report came up by an S-unit, his remained the same. He was using a tri-band beam.

On 10 meters, my brief experience is that if you can hear the station you can work him.

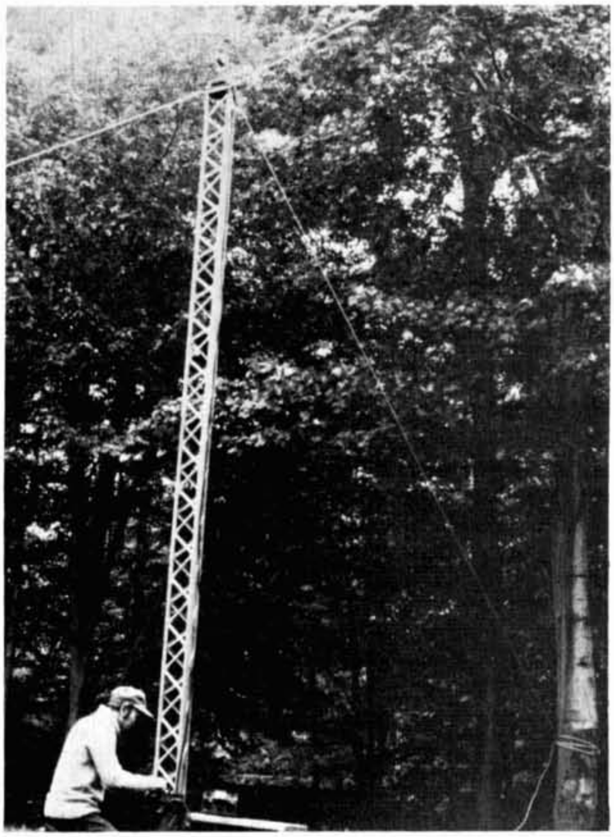

fig. 5. Photograph of a simply-constructed monopole with elevated feed (employing a free-standing Fiberglass whip for the top section).

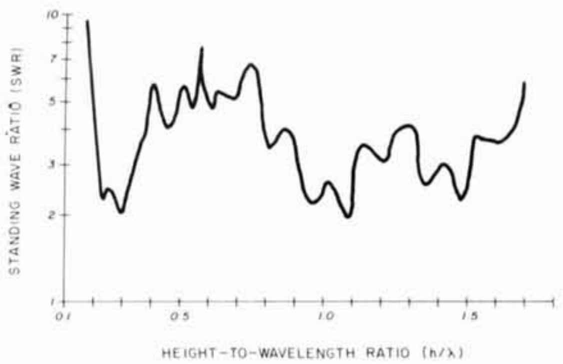

fig. 6. SWR versus height/wavelength ratio for the antenna shown in *fig. 5*, fed with 100 feet of RG8-U.

conclusions

The antenna appears to perform well. It is not a gain antenna, and beam antennas usually, but not always, outperform it. The lack of a directional pattern means that QRM can be high. However, the grounded monopole antenna with elevated feed has a pattern and impedance that changes with frequency in such a manner that the antenna can be used for DX, and it can be used on any frequency in the high-frequency band (3 to 30 MHz).

appendix

Radio Amateurs nowadays are accustomed to employing matched antennas, and some might find it difficult to match their transceiver to a reactive load. As an aid:

1. Calibrate the dial settings for your transceiver using an SWR bridge and a 50-ohm load;

2. when tuning a reactive antenna (high SWR) don't tune the transmitter PA for maximum forward power to the mismatched antenna, you will only mistune your transmitter. Set the plate tank and load capacitors to the place where the transmitter delivers maximum power at an $SWR = 1{:}1$ into the 50-ohm load;

3. with low rf drive (sufficient to measure SWR or reflected power, tune the resistance and reactance dials of the antenna tuner together for low SWR (or reflected power). Only when the antenna is matched, and the SWR seen by the transmitter is 1:1, should you tune the transmitter for maximum forward power.

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1. J.S. Belrose, VE2CV, "The Half-Wave Vertical: A 40 Meter DX Antenna Without a Radial Wire Ground System," *ham radio*, 1980.
2. J.S. Belrose, VE2CV, "The Half-Sloper-Successful Deployment an Enigma," *QST*, May, 1980.
3. J.F. Hatch, W. Struszynski, and H. Thurgood, "The Marconi Eight Aerial Adcock HF Direction Finder Type S-480," *The Marconi Review*, XXIX, 1-23, 1966.
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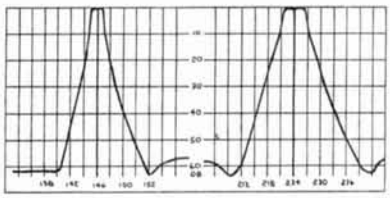

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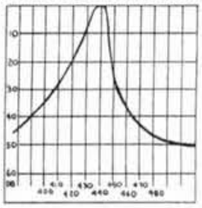

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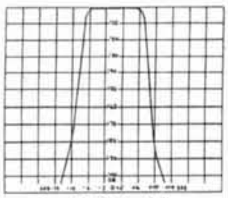

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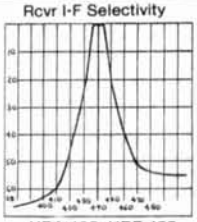

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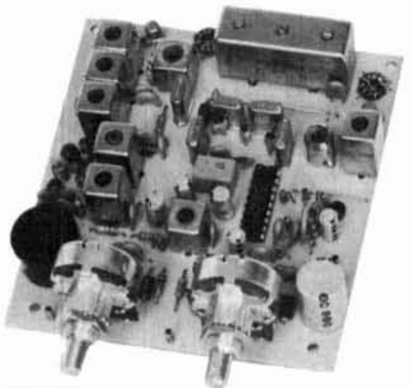

R144 Shown

- **R144/R220 FM RCVRS** for 2M or 220 MHz. 0.15uV sens.; 8 pole xtal filter & ceramic filter in i-f, helical resonator front end for exceptional selectivity (curves at left). AFC incl., xtal oven avail. Kit only $119.95
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HRF-220 for 213-233 MHz	$34.95
HRF-432 for 420-450 MHz	$44.95

(See selectivity curves at left.)

- **COR KITS** With audio mixer and speaker amplifier. Only $29.95.
- **CWID KITS** 158 bits, field programmable, clean audio. Only $59.95.
- **DTMF DECODER/CONTROLLER KITS.** Control 2 separate on/off functions with touchtones®, e.g., repeater and autopatch. Use with main or aux. receiver or with Autopatch. Only $89.95.
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- **T51 VHF FM EXCITER** for 10M, 6M, 2M, 220 MHz or adjacent bands. 2 Watts continuous. Kits only $59.95

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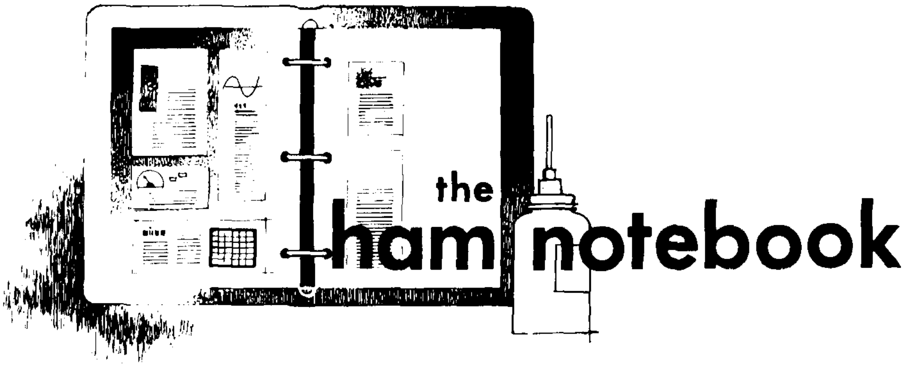

Radiokit
Box 411
Greenville, New Hampshire 03048
(Millen capacitors stock No. 19100)

Amp Supply
2071 Midway drive
Twinsburg, Ohio 44087
(Capacitors)

In all instances send SASE for reply.

Ed Marriner, W6XM

another antenna tuner

One type of antenna tuner that has not seen much use is one half of the Johnson Match Box circuit (see **fig. 1A**). The advantage of this circuit

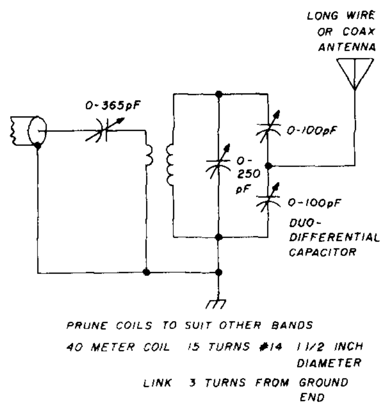

fig. 1A. Antenna tuner schematic.

over some of the more popular transmatch tuners is that it is a resonant circuit that rejects harmonics. It is very easy to adjust for either a long wire or coax-to-coax feed systems. It will not work for open-wire line because it is only half of the original circuit.

The reason it has not been used is probably the difficulty in obtaining a duo-differential capacitor. This capacitor has two stator sections and one combined rotor section. As the rotor increases in one section the other decreases. It forms a capacitance tap for the antenna across the coil in place of sliding the antenna tap around for a match. A duo-differential capacitor can be made by soldering two capacitors together or by mechanically linking two capacitors. The two capacitors are joined by remov-

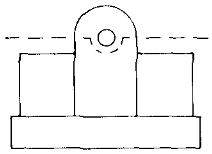

fig. 1B. Millen type 19100 was used here because the rounded top of the support made it easier to form and solder. Other types might also work.

ing the shaft of one, cutting across the middle of the hole, and enlarging the hole to fit on top of the other capacitor (see **fig. 1B**). After fitting, solder as shown in **fig. 1C**.

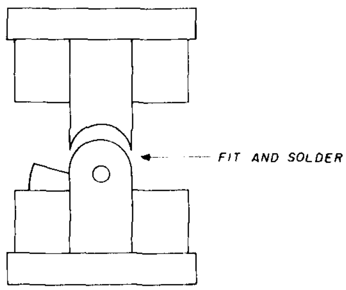

fig. 1C. Join the two capacitors as indicated.

I built my tuner in a box with a five-prong ceramic tube socket mounted on insulators by punching a hole in the top of the box. The coil, manufactured by Bud, was mounted using the five-prong socket. The small BDC type handles several hundred watts and makes a nice small tuner. The tuner controls are adjusted for minimum SWR.

sources

Fair Radio Sales Co.
P.O. Box 1105
Lima, Ohio 45802
(Bud coils, capacitors)

latching relay control

The great virtue of a latching relay is that it draws current only while it is changing states. The latching relay's built-in magnet holds the contacts in their last position until they are changed by a current flow through the relay winding. This makes the latching relay ideal for use with battery-powered or remote equipment.

When the circuit in **fig. 2** is completed through the switch, electrons flow through R1 to the negative terminal of C1, which was in a discharged state (both plates of the same polarity); the capacitor looks momentarily like a conductor. Thus the voltage appearing at the junction of C1/R1 rises to near the supply value, and this surge of electrons flows to Q1's base, causing Q1 to conduct and energize the relay, changing its state.

As C1 becomes fully charged, the electron flow ceases. Therefore Q1 no longer conducts.

The schematic diagram of **fig. 3** uses a similar principle to control a latching relay. CR1's forward resistance guarantees that Q1 will not be

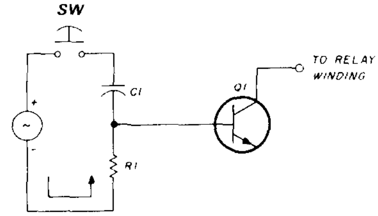

fig. 2. Block diagram of a latching-relay controller.

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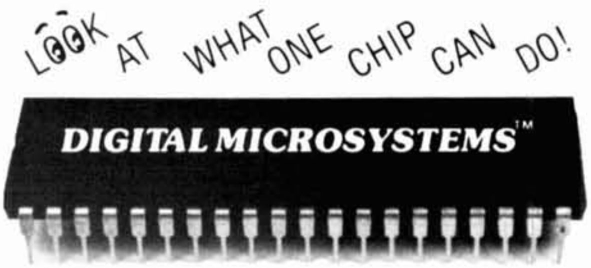
Digital Microsystems™ SCRC Chip $89.95



ASCII to MORSE CODE CONVERTER

• Turns any ASCII terminal or computer into a Morse code keyboard • When used with a computer, reduces system overhead and allows system time for disk access • When used with Morse to ASCII chip, any ASCII terminal or computer is transformed into a Morse code system • 1 to 90 words per minute transmission rate keyboard selectable. 1-30 wpm in 1 wpm increments, 32-90 wpm in 2 wpm increments • Master enable output for compatibility with Morse to ASCII converter chip • Two separate Morse outputs for easy interface to your transmitter; one high one low • Logically perfect Morse code generation • 110 and 300 baud • Automatic line feed insertion selectable by user • Selectable automatic echo back of ASCII characters • Internal 32 byte type-ahead buffer • Supports Modem control type handshaking with UARTS • Compatible with personal computer RTTY software packages • **PARALLEL ASCII TO MORSE CODE CONVERTER** • Similar to SATOM chip but for parallel strobed ASCII keyboards • 16 letter buffer for ID • Automatic test and CQ message generation

Digital Microsystems™ SATOM Chip $34.95
Digital Microsystems™ PATOM Chip $24.95

DTMF DIGITAL CONTROL

• Provides digital input and output capability under the control of a DTMF decoder • Perfect for repeater, remote base, and other homebrew control applications • 21 separate i/o pins which can be set high or low by a four digit custom sequence. Each bit may be checked by entering a digit code. The chip will respond with a Morse code 1 or 0 depending upon the logic state • Direct interface with the Mostek 5102 DTMF decoder chip • Anti-jamming mode automatically activates to prevent tampering • Five second timer for proper control sequencing and grouping • May be purchased in two different versions — version "A" for 12 digit decoding, "B" for 16 digit decoding • Each chip is different — the codes for each chip are randomly selected by computer, but custom codes are available at extra cost

Digital Microsystems™ DCC Chip $34.95

MORSE CODE to ASCII CONVERTER

• Advanced adaptive algorithm converts most hand sent and machine sent Morse code to ASCII • 110 and 300 baud • Automatic line feed insertion selectable by user • Automatic carriage return insertion selectable by user • Selectable number of characters per line before insertion of carriage return or line feed (if selected) • Master enable input for compatibility with ASCII to Morse converter chip (SATOM) • Two separate ASCII outputs for easy interface to RS232 or RS422 drivers • Designed to work with any ASCII compatible terminal or computer • Internal inverter may be selected to invert incoming Morse waveform before decoding

Digital Microsystems™ MTOA Chip $39.95

MORSE CODE MESSAGE GENERATOR

• Up to 6 separate user definable messages • Completely non-volatile memory • Will not forget your messages when power is shut off • Supports manual, continuous automatic, and timed automatic modes • User selectable transmission rate • Individual messages, or groups of messages may be transmitted • Can be wired as a beacon controller, automatically repeating any selected messages • Can be wired as a repeater/remote base ID controller: a. Automatic repeat of any selected message(s) at selectable intervals; b. Latched COR input for trigger of ID mode; c. ID holdoff mode selectable for repeater ID mode • Two separate Morse outputs available — direct audio or digital logic • Two message in-progress signals available — one high, the other low • Crystal controlled 1, 5, 6, 7, 8, 9, and 10 minute timers, useful for repeater ID mode • Perfect companion to your RTTY, ATV, or SSTV station

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GENERAL SPECIFICATIONS

• All circuitry contained on a single chip • Crystal controlled for accuracy • Requires 5 volts DC • TTL/CMOS compatible I/O pins • Chips designed with the experimenter/homebrew specialist in mind • Manual for each chip available for $5 postpaid • Deductible with order

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• All prices include shipping. Massachusetts residents please add 5% sales tax. Check or Money Order for payment. Prices and specifications subject to change without notice or obligation.

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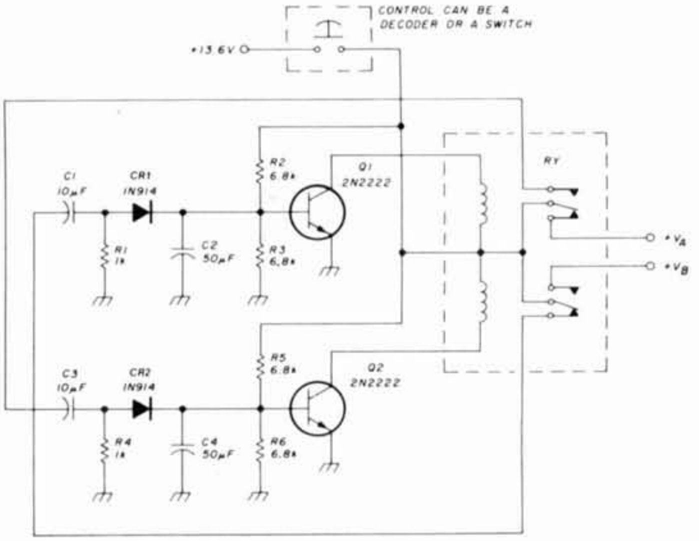
✓ 118

the ham notebook

continued



C1,C3	10-µF
C2,C4	50-µF
R1,R4	1K
R2,R3	
R5,R6	6.8K
Q1,Q2	2N2222
RY	28 volt, DPDT: Potter & Brumfield SL-7156 28 volt, DPDT: General Electric 3SAM1283A2 12 volt, 4PDT: RCA 231435/Gould-Allied Control T3ZX-10

fig. 3. Schematic diagram of the latching-relay controller.

turned on by a voltage of less than 0.6 volt. The contacts automatically complete the circuit to Q2 so that the next closing of the switch will cause the relay to again change state in the manner described.

Latching relays in the 12-volt range are hard to find, but surplus relays rated from 24 volts to 28 volts are common. They will work down to about 11 volts. Surplus relays are usually of the "crystal can" size. The RCA/Gould relay listed has a 12-volt coil and four poles, and it is larger than the others. It is a specialty item that might be obtainable only through RCA suppliers.

An ideal use for this control is an on-off power switch for a battery-operated repeater. A low-current receiver with a decoder IC connected to the control line of this circuit will allow the repeater to be turned on or off on command.

Charles G. Bird, K6HTM
Chico, California

More Details? CHECK—OFF Page 132

✓ 134

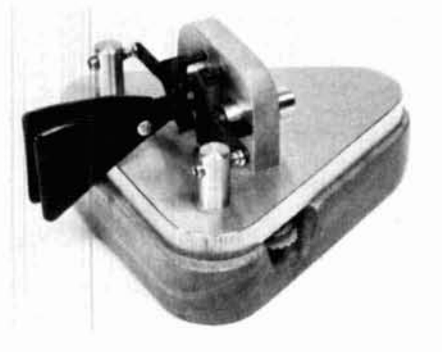
NEW products

Vibroplex electronic keyer

When you think of speed keys, one of the first that comes to mind is the Vibroplex "Bug." Years before the advent of electronic keyers, they were the only alternative to the "cootie key" for sending semi-automatic code. In those days, you could actually tell who was sending well before signing of calls by the sender's fist. Dahs were drawn out longer than they should. Dits came in a rapid-fire "bruuup." Now, however, with keyboards and other forms of electronic keys, everyone sounds somewhat the same.

Vibroplex has introduced a new Iambic key and keyer that will be of great interest. Their new Brass Racer, based on the FYO design, is attractively built and is rock solid. The Vibroplex treatment of this design does not use springs to adjust paddle tension. A clever use of magnets controls the paddle tension.

Another twist is that Vibroplex took the Brass Racer base, hollowed out the center and inserted an electronic keyer that uses the Curtis 8044 chip. This makes for a very nice, compact, self contained keyer (a big plus for field day and other portable operations).



There are no power cords to clutter up the operating desk. Power comes from a self-contained 7.5-volt battery. The EK-1 is limited in that it does not have a memory like so many of the newer electronic keys. But not everyone feels that this is necessary and many will find the EK-1 a nice, simple package.

For more information, contact Vibroplex Company, Attention Bruce Palmer, P.O. Box 7230, Portland, Maine 04112; Reader Service Number 301.

tri-band vertical

Hustler, Incorporated, has announced a three-band vertical antenna for 10, 15, and 20 meter operation. A unique two-in-one trap design allows excellent bandwidth while maintaining an overall height of only twelve feet.

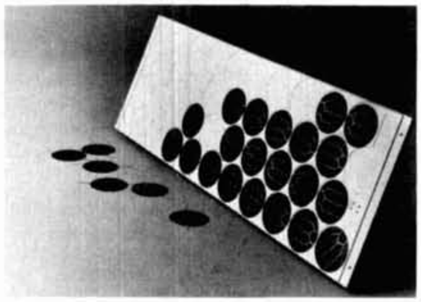
The antenna, 3-BTV, is designed for permanent ground mounting or for portable use on travel trailers, condo balcony railings, or anywhere exhibiting a sufficient groundplane.

The antenna is made of high quality aluminum with stainless steel hardware, supplied with a heavy duty bracket for pipe or bulkhead mounting.

For additional information, contact Hustler, Incorporated, 3275 North B Avenue, Kissimmee, Florida 32741. Reader Service Number 302.

photovoltaic panel kit

Encon announces solar panel kits for the Amateur that enable you to build your own solar electric panel for less than $6.00/watt.



Molded high-strength plastic base has forty 4-inch recesses and thirty-six 4-inch diameter cells. One panel should produce approximately 17-volts, between 1.2 and 2 amps. Cover glass, silicone potting, wire, and solder, not included.

These kits are ideal for demonstrators and schools seminars. Good working panels have been constructed in less than two hours each. Instructions are included; it is recommended that you have basic soldering skills.

For more information, contact Encon Corporation, 27584 Schoolcraft Road, Livonia, Michigan 48150; Reader Service Number 303.

TH5Mk2 tribander

The TH5Mk2 is a five-element broadband tribander for 20, 15, and 10 meters. The TH5Mk2 will load tube-type or solid state auto-tuned rigs from band edge to band edge on 20 and 15 meters. On 10 meters there is a choice of 28.0 to 29.4 or 28.3 to 29.7 MHz, all below 2:1 VSWR. The Hy-Q traps for each band are the most efficient technique for multibanding a Yagi antenna. Factory assembled and pre-tuned traps are mechanically superior, and provide reliable all-weather performance. With four active elements on each band, the average forward gain is an impressive 8.5 dB, and average front-to-back ratio is 20 dB.

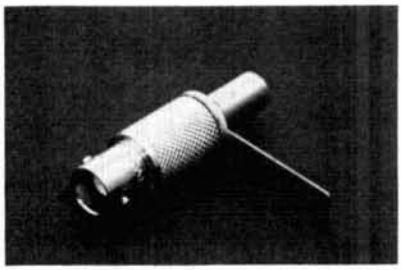
The antenna assembles on a 19 foot (5.8 meter) boom. With a maximum element length of 31.5 feet (9.6 meters), the tuning radius is only 18.4 feet (5.6 meters). The assembled antenna weighs 59 pounds (26.8 kg).

The antenna includes stainless steel hardware, the BN86 balun and a sophisticated matching dual-driven element feed system as also used in the larger TH7DX. The antenna provides dc grounding for lightning protection. The suggested price is $459.95. For more information, contact Hy-Gain, 9600 Aldrich Avenue, South, Minneapolis, Minnesota 55420.

BNC adapters

Centurion International, Inc., has introduced a new line of BNC adapters designed for antenna connection to two-way portable radios that require threaded connectors.

The adapters are available in nine different styles and feature a grounding strap for use with portable gain antennas that require ground potential. The adapters may also be used with mobile antennas, mobile amplifier chargers, and a variety of other applications.



For more information, contact Centurion International, Box 82846, Lincoln, Nebraska 68501. Reader Service Number 304.

receive-only RTTY/CW terminal

HAL Communications Corp. announces the new CWR6750 receive-only RTTY/CW terminal. The CWR6750 is the ideal companion to a shortwave receiver for printing Amateur and commercial Morse code and RTTY transmissions. Its small size, the built-in green video monitor screen and its 12-volt operation make the CWR6750 truly portable. The CWR6750 will receive all standard radioteleprinter speeds from 60 words per minute (45 baud) to 300 wpm (300 baud). Both the standard press "Baudot" RTTY code and the computer ASCII RTTY code can be received.

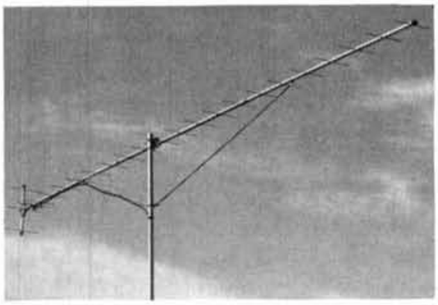
Stations using Morse code can be received at speeds from 4 to 50 wpm. A computer-style ASCII printer may be connected to the CWR6750 to provide a full printed copy of all received text.

The CWR6750 measures only 10¼ × 6½ × 11 inches, and weighs only 9 pounds. It operates from any 11 to 14.5 Vdc source, drawing 1.6 amperes. The CWR6750 is easily installed in a camper, boat, or home station.

For more information, contact Hal Communications Corp., Box 365, Urbana, Illinois 61801; Reader Service Number 305.

Boomer antenna

The 424B is the newest Cushcraft Boomer antenna. It is a twenty-four element, 70 cm Yagi, exhibiting 18.2 dB forward gain. A 424B



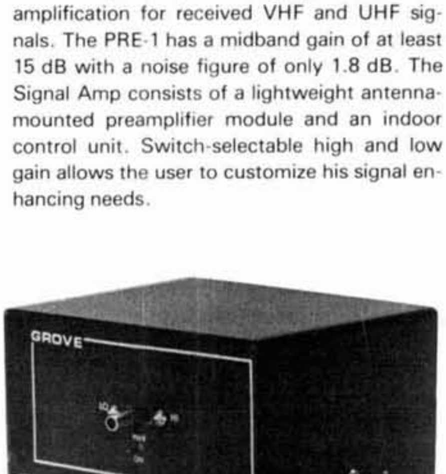
NEW products

won the 70 cm antenna gain measuring contest at the 1982 Central States VHF Conference. The antenna's features include insulated elements, stainless steel hardware, N-type connector, T-match feed and trigon reflector.

For more Boomer information, contact Cushcraft Corporation, P.O. Box 4680, Manchester, New Hampshire 03108; Reader Service Number 306.

wideband antenna preamplifier

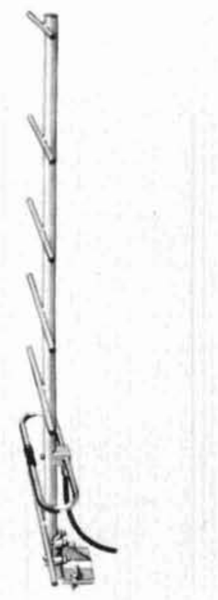
The PRE-1 Signal Amp masthead preamplifier is designed to provide high gain, low-noise amplification for received VHF and UHF signals. The PRE-1 has a midband gain of at least 15 dB with a noise figure of only 1.8 dB. The Signal Amp consists of a lightweight antenna-mounted preamplifier module and an indoor control unit. Switch-selectable high and low gain allows the user to customize his signal enhancing needs.



Guaranteed to outperform competitive indoor preamplifiers, the PRE-1 Signal Amp comes with all necessary hardware, connectors, and instruction. PRE-1 costs only $69.00 plus $2.00 UPS shipping, from Grove Enterprises, 140 Dog Branch Road, Brasstown, North Carolina 28902; Reader Service Number 307.

heavy-duty SRL-307 UHF Yagi antenna

Sinclair Radio Laboratories' rugged seven-element 10 dBd gain antenna will shrug off 113 mph (181 km/h) winds while carrying a 1/2-inch radial ice load, or 187 mph (301 km/h) winds without ice. This unit is useful for point-to-point links or for repeater applications in

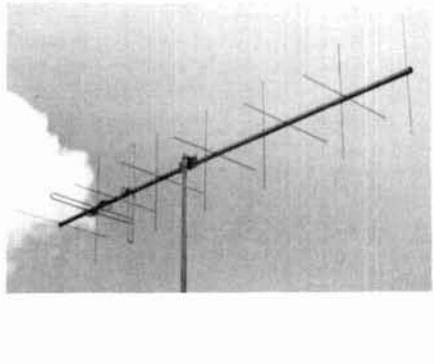


highway mobile radio systems. Reflector and director elements are 3/8-inch diameter aluminum rods welded to the boom, reducing the risk of damage and misalignment. The antenna clamp allows easy orientation for either vertical or horizontal polarization. A higher gain can be achieved by using dual (SRL-307-2) or quad (SRL-307-4) arrays with gains of 12.5 dBd and 15 dBd respectively.

For further information, contact Mr. Dan Roszelle, Sales Manager, Sinclair Radio Laboratories Inc., 14614 Grover Street, Suite 210, Omaha, Nebraska 68144; Reader Service Number 308.

circular satellite technology

The new KLM 143-150-14C circularly polarized antenna not only provides optimum reception of OSCAR satellite signals but can also dramatically improve 2-meter terrestrial communications. Linearly polarized signals (any mode, fixed or mobile) are frequently affected by buildings, mountains, and movement and, as a result, circular wavefronts develop. Reception with the 14C reduces flutter, fading, and multipath distortion, and often improves



S/N ratios. Benefits of circular polarity on transmit are similar, regardless of the polarization of the receiving antenna.

Since circularity may have a right-hand or left-hand twist, the 14C antenna kit includes a feedpoint mounted switcher, keyed by +9 to +15 Vdc. For a single-feedline convenience, a special matching harness is included. If desired, the 14C can also function as two separately fed antennas, one vertical and one horizontal. Each set of feedpoints is equipped with a 2-kW balun ready for direct coax feed.

With seven elements in each plane, the 14C produces 11-dB gain at better than 1.5:1 VSWR. Circularity is maintained within 3 dB. Virtually unbreakable 3/16 inch rod parasitic elements, anchored through the 1-1/2 inch boom, help reduce weight to 7-1/2 pounds, and windload to 1.2 square feet.

For more information, contact KLM Electronics, Inc., P.O. Box 816, Morgan Hill, California 95037; Reader Service Number 309.

R-2000 communications receiver

Trio-Kenwood has just introduced the R-2000, a highly sophisticated, all-mode communications receiver that covers 150 kHz-30 MHz in thirty bands. Designed to answer the needs of the short-wave listener as well as the Radio Amateur, this new radio is capable of receiving signals on a-m, USB, LSB, CW, and fm. Among the more interesting features to be found on this model are digital VFOs, ten memories that store frequency, band, and mode data, memory scan, programmable band scan, and dual 24-hour quartz clocks with a timer that can be programmed to turn the radio on and off on a pre-selected schedule.

Additional features include a built-in lithium battery memory back-up (estimated 5-year life), fluorescent tube digital display, three built-in i-f filters with switch, manual UP/DOWN band scan, squelch, S-meter, noise blanker, and rf step attenuator. The R-2000 operates on 100/120/220/240 Vac or it may be operated on 13.8 Vdc using an optional DCK-1 cable kit. Suggested retail price is $599.95.

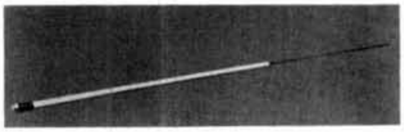
For additional information, write Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220. Reader Service Number 310.

NEW products

vertical mobile antennas

dB-Gain Antennas announces its new line of antenna products with the introduction of its dB-Gain vertical mobile antenna.

The antennas are available for 450 MHz, 220 MHz, 2, 6, 10, 15, 20, and 40 meters with a power rating of 250 watts. Although these antennas were designed primarily for mobile use, they can be used for a fixed station.



Antenna whips and set screws are made of 17-7 stainless steel for longer life and extra protection. Heavy-gauge fiberglass coil housings (0.031 wall/spiral finish) add extra strength and durability in extreme weather conditions. Each coil is wound with No. 16 copper and remaining hardware is chrome-plated brass. A standard mounting ferrule is compatible with most mobile mounts.

For more information, contact Tom Adams, W4MTW, dB-Gain Antennas, 2308 NE 20th Avenue, Ft. Lauderdale, Florida 33305; Reader Service Number 311.

smallest manual encoder

The Model 340 Thin-Coder, by CES, measures 2-1/2 × 3-1/8 × 3/4 inches. It effectively dials the user into private networks, computer access, or dimension systems. Its rugged white case features a brown faceplate and white digit blocks. A convenient normal/high switch allows flexible volume control. Up to 10,000 long distance calls are possible with the Thin-Coder's long-life 9-volt battery. CES encoders use single-contact tactile keyboards for extra reliability.

For more information on the Thin-Coder Model 340 Encoder, contact Ron Hankins, CES, Inc., P.O. Box 507, Winter Park, Florida 32790; Reader Service Number 312.

160-10 m transceiver

The FT-980 is a full-featured 160-10 meter transceiver which includes a general-coverage receiver section. Providing a nominal 100-watts rf output from a low-distortion, high-voltage final amplifier, the FT-980 is set up for full QSK with silent solid-state switching. The receiver section is designed for wide dynamic range and versatility in filter selection. An audio peak filter, i-f notch filter, variable pulse width noise blanker, variable i-f bandwidth with i-f shift (passband tuning), and an audio shaping control round out the receiver features.

The FT-980 is controlled by an 8-bit microprocessor, which allows storage of frequency and mode in memory, and programming sub-band limits for Novice, Technician, General, or Advanced Class operators. Direct keyboard entry of frequencies provides instant QSY without the need to rotate the main tuning dial.

For more information, contact Yaesu Electronics Corp., P.O. Box 49, Paramount, California 90723. Reader Service Number 313.

indoor antenna

Contemporary Electronic Products announces the new NXL-1000 indoor shortwave antenna. Unlike other active indoor antennas, the NXL-1000 employs a Faraday shield for maximum rejection of manmade noise, so often a problem. In addition, the NXL-1000 has a built-in crystal calibrator with selectable 1-MHz and 100-kHz markers. This is a great help with uncalibrated or poorly calibrated receivers.

The NXL-1000 covers the range 1.5 through 30 MHz in three ranges. A high-Q selective circuit provides excellent rejection of unwanted frequencies, valuable for receivers with poor front-end selectivity or marginal image rejection. Internally generated noise, a problem with some active antennas, has been substantially reduced in the NXL-1000.

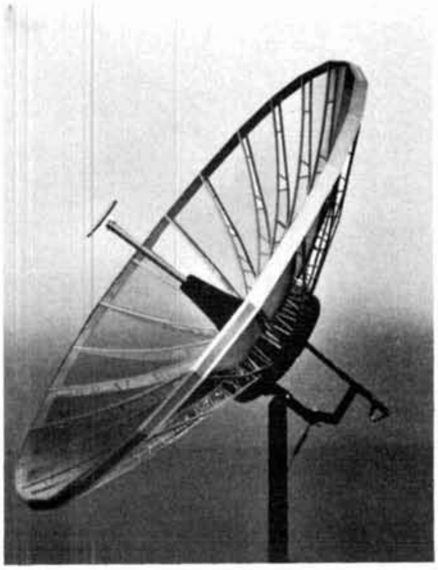
The NXL-1000 can provide performance comparable to that of a long-wire antenna, and makes possible even better reception than an outdoor antenna in high-noise environments. By adjusting the orientation of the loop via the AZ-EL mount, local signals and noise can be almost totally nulled out.

The NXL-1000 can be conveniently placed on a desktop. The cabinet measures just 3 × 5-1/4 × 5-7/8 inches, and the loop is only 12 inches in diameter. The NXL-1000 indoor antenna is available from Contemporary Electronic Products, P.O. Box 570549, Miami, Florida 33157; Reader Service Number 314.

satellite TV antenna

A new satellite television antenna has been announced by Total Television, Inc., of Roseburg, Oregon. Designed for rapid assembly and installation, this 12-foot-diameter dish is suitable for every part of the U.S.A.

Special attention has been given to the appearance of the antenna. The Newtonian feed permits housing the receiving/amplifying electronics in the waterproof hub at the center of the dish. This also helps prevent theft and vandalism of these components. Featuring a true polar mount, the dish is balanced to make satellite changing easy. The reflective surface of



NEW products

the antenna is made from heavy-duty expanded aluminum screen or optional solid aluminum panels.

Named "Next Generation," this model is constructed with aircraft-style riveted aluminum framework and a single steel support for strength and light weight. It comes with a fully illustrated, step-by-step installation manual. Compatible with all popular brands of supporting electronics, the antenna is also available in colors to match the predominant local background.

For more information, contact Total Television, 17537 N. Umpqua Highway, Roseburg, Oregon 97470. Reader Service Number 315.

Eurocard racks

Designed specially for the growing interest in Eurocard-based systems, a new high-capacity rack allows placement of both single- and double-size VME-bus compatible boards in the same enclosure. The Model CCKE2, from Vector Electronic Company, also has abundant space in the rear for mounting large power supplies.

The VME bus was developed by Motorola, Mostek, Signetics, and its parent, N.V. Philips, to provide a combined sixteen-bit and thirty-two-bit standard. It employs the Eurocard format of 6.30 inches by 3.94 inches (160 mm by 100 mm) for the single card and 6.30 inches by 9.19 inches (160 mm by 233.4 mm) for the double card. Bus interconnections are made with one ninety-six-position connector on the single card and two connectors on the double card.

The CCKE2 takes advantage of the 1.3-inch (33.4-mm) difference between two single-size Eurocards and one double-size card. A simple fixture places groups of single boards one on top of another, adjacent to double boards. Appropriate system partitioning permits access to signals on either of the two VME-bus connectors.

The 19-inch (482.6-mm) EIA Std. cage holds up to twenty-seven double-size Eurocards or up to fifty-four single-size cards on 0.6-inch (15.24-mm) centers. Alternatively, the CCKE2 may be configured as a combination of Eurocard sizes; twenty-six single and thirteen double, for example.

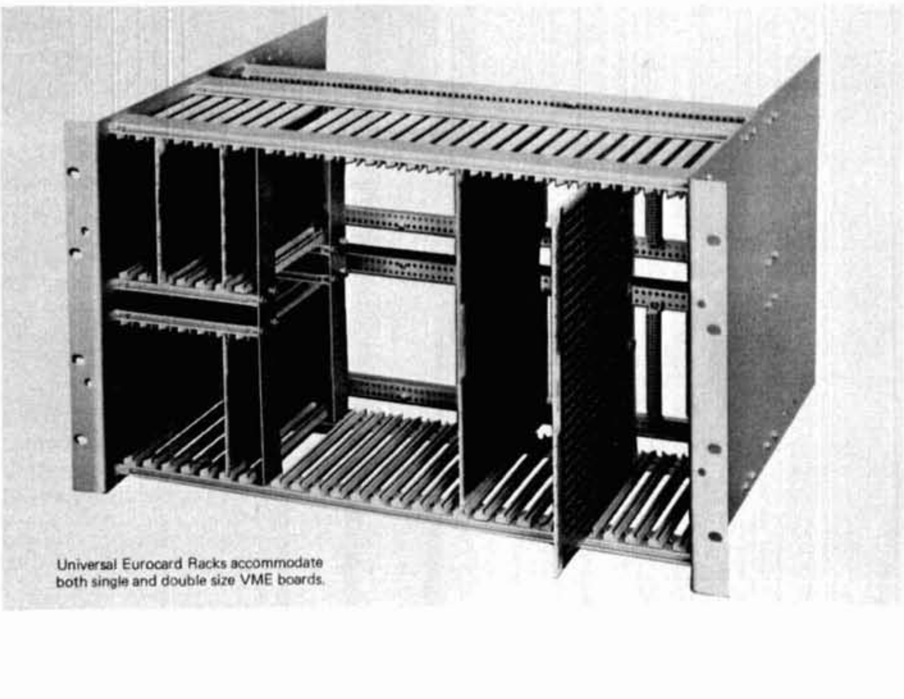
Card-guide and connector-mounting holes are spaced on 0.20-inch (5.08-mm) centers, so cards with varying component and lead heights may be installed in any position. Snap-in card guides are made of Underwriter-Laboratories-rated flame retardant grey nylon. Connectors are mounted on the pre-drilled struts with 3-48 machine screws and nuts.

At the rear of the rack, a space 10.5 inches by 16.8 inches by 5.5 inches (259.1 mm by 426.7 mm by 140 mm) is available for power supplies with 1-inch (25.4-mm) clearance for backplane wiring.

In single quantities, the fully assembled CCKE2 is priced at $68.18 each. An unassembled version, CCKE2U, is priced at $56.82 each. For more information, contact Vector Electronic Company, 12460 Gladstone Avenue, Sylmar, California 91342. Reader Service Number 316.

RTTY/CW computer interface

The new MFJ-1220 RTTY/CW computer interface is a terminal unit that provides TTL/CMOS and RS-232 levels for computer inter-



Universal Eurocard Racks accommodate both single and double size VME boards.

facing. Unlike phase-lock loop demodulators, this is an optimum design using individually tuned active bandpass filters. It has separate

mark and space channel filters, CW filter, and post detection lowpass filter for excellent weak-signal and high-interface RTTY/CW performance.

The MFJ-1220 takes received RTTY/CW audio from your transceiver, demodulates it, and provides TTL/CMOS and RS-232 levels for interfacing with nearly any computer. A program (not included) is used to provide RTTY/CW text.

For RTTY transmission, your computer drives the AFSK generator to provide FSK transmission using the microphone or phone patch input of your SSB transmitter, or it can directly key the FSK input of your transmitter. For CW transmission, your computer drives the high-voltage keying currents of the MFJ-1220, which then provides grid block or direct keying for your transmitter.

The RTTY/CW interface transmits and receives all standard RTTY shifts of 170, 425, and 850 Hz to cover all Amateur, commercial, and military traffic to over 100 WPM. It uses the standard space tone of 2125 Hz and marks tones of 2295, 2250, and 2975 Hz.

The MFJ-1220 RTTY/CW Computer Interface is available from MFJ Enterprises, Inc., for $179.95 plus $4.00 for shipping and handling. For more information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762. Reader Service Number 317.

receiving converter kits

Lunar Electronics announces a new line of high-performance receiving converter kits. The initial line-up of available kits includes crystal controlled models for VHF frequencies and ultra-stable tunable oscillator models for UHF. The crystal-controlled UHF models are due out in the spring of 1983.

Easy-to-read illustrated instructions with each kit ensure the builder will achieve maximum performance from his unit. Complete factory back-up assistance, if needed, is also available. Typical specs for complete unit: input frequency 144 MHz; crystal frequency 144 MHz; image rejection −65 dB; noise figure (tune max. gain 18 dB); LO specs +7-10 dBm output; output frequency 28 MHz; conversion gain 15 dB; noise figure (tune min. NF 1.75 dB) 2.4 dB; and harmonics −50 dBc.

The highest quality components are used throughout, including double-sided, plated-through-hole PCB, gold alodined box for greatest circuit integrity, provisions for crystal netting, DBM for best performance.

NEW products

For more information, contact Lunar Electronics, 2775 Kurtz Street, Suite 11, San Diego, California 92110; Reader Service Number 318.

two antenna tuners

Encomm, Inc., announces two antenna tuners from Tokyo Hy-Power Labs, the 2000 watt HC-2000 and the 200 watt HC-200. The HC-2000 is a 2000 watt PEP (500 watts max on 1.9 MHz) hf antenna coupler with a power/SWR meter and a versatile twelve-position antenna switch (six through the tuner and six bypass). It will tune coaxial fed antennas, balanced line antennas (balun included), or end fed wires. It is band switched for 1.9, 3.5, 7, 10, 14, 18, 21, 24.5 and 28 MHz (all WARC) bands, so you don't have to experiment to find your inductor setting, plus it has 6:1 vernier dials on the capacitors for easy fine tuning. Scales on the dual meters include SWR, 2 kW, 200W, and 20W. Connectors are SO-239s and Johnson terminals. Suggested retail for the HC-2000 is $329.95.

The HC-200 is a combined 200-watt hf antenna coupler with a power/SWR meter and a six-position antenna switch (three coaxial/wire positions through the tuner and three bypass). It will tune end-fed wires, coax, or balanced line antennas (with optional balun). The HC-200 is band switched for 3.5, 7, 10, 14, 18, 21, 24.5, and 28 MHz (includes new WARC) bands. Scales on the meter include SWR, 20W, and 200W. Connectors are SO-239s and Johnson terminals. Suggested retail for the HC-200 is $99.95.

Both antenna tuners have high-quality ceramic coil forms, well damped and shielded meter circuits, as well as first-class design and layout. There are no ferrite cores in the main inductor to saturate!

For more information, contact THL Sales Department, Encomm, Inc., 2000 Ave. G, Suite 800, Plano, Texas 75074. Reader Service Number 319.

80-MHz multifunction counter

A new 80-MHz, eight-digit multifunction counter that provides frequency, period, and totalize measurements has been introduced by the B&K Precision Test Instrument Product Group of Dynascan Corporation. Designated Model 1805, this lightweight unit measures frequencies from 5 Hz to 80 MHz. Resolution may be selected from 0.1 Hz for frequencies below 10 MHz to 1 Hz for frequencies above 10 MHz. The period mode can be used to measure low frequencies from 5 Hz to 2 MHz more accurately. The totalize mode counts individual events from 0 to 99,999,999 with an overflow LED. This model is helpful in applications where a specific number of cycles occurs, such as gated tone bursts.

The B&K-Precision Model 1805 utilizes a 10-MHz time base generated by a crystal controlled oscillator for good stability with regard to temperature (< 0.001 percent ± 10 ppm at 0 degrees C - 50 degrees) and line voltage variations (< ± 1 ppm with ± 10 percent line voltage regulation). For lessened susceptibility to noise and undesirable high-frequency components, a front-panel-switchable 100-kHz low-pass filter is incorporated in the counter. All operating modes, resolution ranges, and functions are front-panel selectable. The Model 1805 incorporates a switchable X10 attenuator, **HOLD** switch to freeze the display at the present reading, and a **RESET** switch to clear the display and initiate a new measurement.

The Model 1805 is available from B&K-Precision Electronic distributors. Suggested price is $290.00. For further information, contact B&K-Precision Test Instrument Product Group, Dynascan Corporation, 6460 W. Cortland Street, Chicago, Illinois 60635. Reader Service Number 320.

TIDBITS

MORSE CODE, BREAKING THE BARRIER

by Phil Anderson, WØXI

Learning the Morse Code does not have to be the painful experience many folks make it out to be. This little booklet is chockfull of helpful and highly recommended hints and tips on how to learn the Morse Code. Uses the high/low method to eliminate the dreaded 10 wpm plateau. © 1982, 1st edition.

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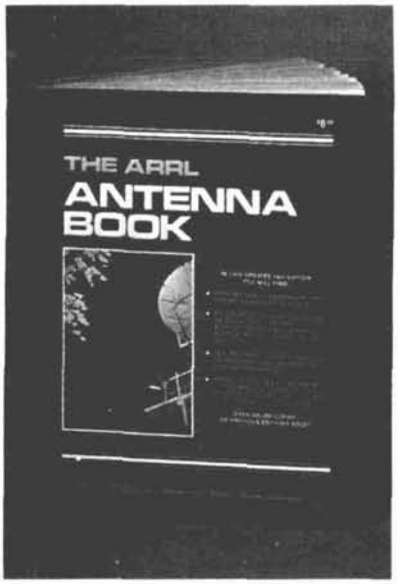
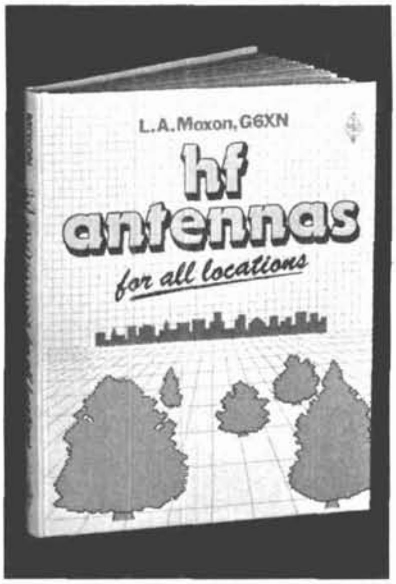
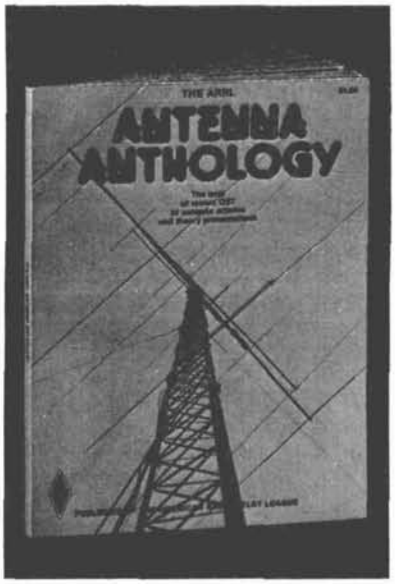
BOOKS

"A STATION IS ONLY AS EFFECTIVE AS ITS ANTENNA SYSTEM"







THE ARRL ANTENNA BOOK The best and most up-to-date antenna information around. The just revised 14th Edition contains in its 328 pages propagation, transmission line and antenna fundamentals. You can update your present antenna system with practical construction details of antennas for all amateur bands - 160 meters through microwaves. There are also antennas described for mobile and restricted space use. Tells how to use the Smith chart for making antenna calculations and covers test equipment for antenna and transmission line measurements. Over 600,000 copies of previous editions sold. Paperbound. Copyright 1982. **$8.00** in the U.S., **$8.50** elsewhere.

HF ANTENNAS FOR ALL LOCATIONS by L.A. Moxon, G6XN. An RSGB publication. Contains 264 pages of practical antenna information. This book is concerned primarily with small wire arrays, although construction information is also given on a small number of aluminum antennas. Chapters include: Taking a New Look at hf Antennas; Waves and Fields; Gains and Losses; Feeding the Antenna; Close-spaced beams; Arrays, Long Wires, and Ground Reflections; Multiband Antennas, Bandwidth; Antenna Design for Reception; The Antenna and Its Environment; Single-element Antennas; Hortizontal Beams; Verticle Beams; Large Arrays; Invisible Antennas; Mobile and Portable Antennas; What Kind of Antenna: Making the Antenna Work; Antenna Construction and Erection. Copyright 1982, 1st Edition, Hardbound **$12.00**.

ANTENNA ANTHOLOGY The best *QST* hf antenna articles and theory presentations. Verticals: 2 and 4 band verticals for the novice, Cheapie GP, High Performance system for 20, 40 and 80, other loaded systems. Yagis: Short antennas, and The Log-Yag Array. Quads: Wire quads for 80 and 40, 2-Element Quad for the Novice, Miscellaneous Antennas: Loops, Delta-loops, Antennas for travel trailers and campers, plus matching devices and antenna test accessories. Copyright 1978, 148 pages. **$4.00** U.S., **$4.50** elsewhere.

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UHF PROGRAMMABLE DIVIDERS ÷10/11

SP8640A & B 200 MHz

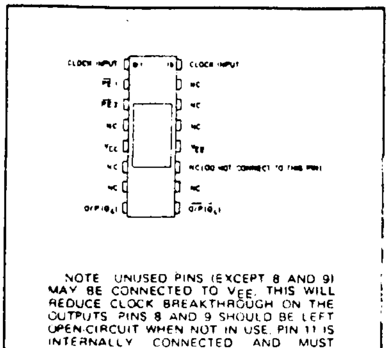
In frequency synthesis it is desirable to start programmable division at as high a frequency as possible, because this raises the comparison frequency and so improves the overall synthesiser performance.

The SP8640 series are UHF integrated circuits that can be logically programmed to divide by either 10 or 11, with input frequencies up to 350 MHz. The design of very fast fully programmable dividers is therefore greatly simplified by the use of these devices and makes them particularly useful in frequency synthesisers operating in the UHF band.

All inputs and outputs are ECL-compatible throughout the temperature range: the clock inputs and programming inputs are ECL III-compatible while the two complementary outputs are ECL II-compatible to reduce power consumption in the output stage. ECL III output compatibility can be achieved very simply, however (see Operating Notes).

The division ratio is controlled by two $\overline{PE}$ inputs. The counter will divide by 10 when either $\overline{PE}$ input is in the high state and by 11 when both inputs are in the low state. Both the $\overline{PE}$ inputs and the clock inputs have nominal 4.3k Ω pulldown resistors to V_{EE} (negative rail).

$7.12 each



NOTE UNUSED PINS (EXCEPT 8 AND 9) MAY BE CONNECTED TO V_{EE}. THIS WILL REDUCE CLOCK BREAKTHROUGH ON THE OUTPUTS. PINS 8 AND 9 SHOULD BE LEFT OPEN-CIRCUIT WHEN NOT IN USE. PIN 11 IS INTERNALLY CONNECTED AND MUST ALWAYS BE LEFT OPEN-CIRCUIT.

Fig. 1 Pin connections (top)

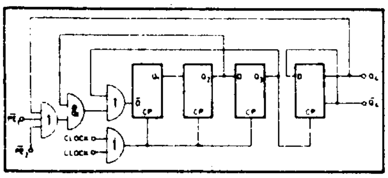


Fig. 2 Logic diagram (positive logic)

FEATURES

- Military and Industrial Variants.
- 350 MHz Toggle Frequency
- Low Power Consumption
- ECL Compatibility on All I/Ps & O/Ps
- Low Propagation Delay
- True and Inverse Outputs

ABSOLUTE MAXIMUM RATINGS

Supply voltage $\lvert V_{CC} - V_{EE}\rvert$	8V
Input voltage V_{in} (d.c.)	Not greater than the supply voltage in use.
Output current I_{out}	20mA
Max. junction temperature	+150°C
Storage temperature range	−55°C to +175°C

PLESSEY Semiconductors

SP4550/1

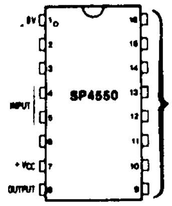
1 GHz ÷ 256

The SP4550/1 are part of the new range of Plessey Consumer high speed dividers which offer improved input sensitivity and higher input impedance.

The devices are intended for use in television frequency synthesis systems. They have a division ratio of 256 with a single, (SP4550) or complementary, (SP4551) ECL output and incorporate an on-chip preamplifier with a differential input. The input pins may be used as UHF and VHF inputs, with only a slight loss of sensitivity, if suitable drive circuitry is employed.

FEATURES

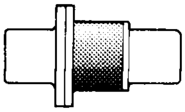
- On-chip wideband amplifier
- High input sensitivity
- High input impedance
- Low output radiation
- Single (SP4550) or complementary (SP4551) ECL output



$19.67 each

Gunn Effect Diode

Type	Peak Power Output (mW)	Frequency Range (GHz)	Typical Operating Current (A)	Typical Operating Voltage (V)
TE O3	10	8–12	110	7.5



$33.00 each

SW300

VESTIGIAL SIDEBAND FILTER

The SW300 is a two-channel Vestigial Sideband Filter which uses Surface Acoustic Wave (SAW) technology and is designed for use in TV Game circuits, or other applications where it is necessary to eliminate unwanted sideband radiation. Operation is specified for U.S. TV Channels 3 and 4 (61.25MHz and 67.25MHz respectively); the filter has one input for each channel and a common output intended to drive 75Ω loads. No tuning is required, and the device is supplied in a TO-8 type metal package for ease of shielding.

$9.44 each

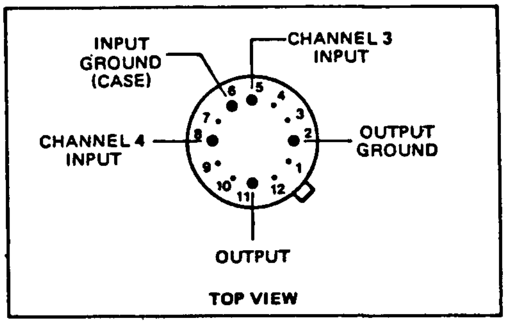


Figure 1. Pin Connections

FEATURES

- Surface Acoustic Wave (SAW) technology
- U.S. TV Channel 3 (61.25MHz) and 4 (67.25MHz) Operation
- Low-loss at Intended Fc
- High Unwanted Sideband Rejection
- No Tuning Required
- High Stability
- No Additional Components Required
- Easily-shielded TO-8 Type Metal Package

SL1626C

AUDIO AMPLIFIER AND VOGAD

FEATURES

- Constant Output Signal
- Fast Attack
- Low Power Consumption
- Simple Circuitry

APPLICATIONS

- Audio AGC Systems
- Transmitter Overmodulation Prevention
- Speech Recording
- Level Setting Systems

The SL1626C is a silicon integrated circuit combining the functions of audio amplifier with voice operated gain adjusting device (VOGAD).

It is designed to accept signals from a low-sensitivity microphone and to provide an essentially constant output signal for a 60dB range of input.

The encapsulation is an 8-lead plastic dual-in-line package and the device is designed to operate from a 6V ±0.5 volt supply, over a temperature range of −30°C to +70°C

$4.04 each

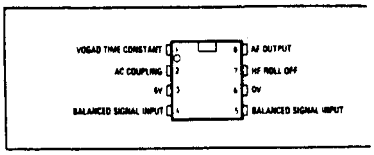


Fig. 1 Pin connections (top)

ELECTRICAL CHARACTERISTICS

Test conditions (unless otherwise stated):

Input frequency	1kHz
Supply voltage	−6V
Temperature	+25°C

DIPPED SILVER MICA CAPACITORS

1pf	300V	$ .32	56pf	300V	$ .28	560pf	300V	$ .49
5pf	500V	.32	75pf	300V	.30	620pf	300V	.52
10pf	500V	.32	75pf	500V	.30	680pf	300V	.59
12pf	300V	.34	100pf	500V	.30	820pf	50V	.68
12pf	500V	.40	110pf	500V	.30	820pf	300V	.70
15pf	300V	.34	120pf	500V	.32	910pf	500V	.59
15pf	500V	.40	150pf	300V	.32	1120pf	500V	.70
18pf	500V	.34	180pf	500V	.38	1200pf	100V	.70
20pf	500V	.26	200pf	500V	.40	1300pf	500V	.70
22pf	500V	.26	210pf	500V	.42	2200pf	500V	1.00
24pf	500V	.26	250pf	500V	.44	2700pf	500V	1.50
30pf	300V	.26	330pf	500V	.44	3300pf	500V	2.00
33pf	500V	.26	360pf	300V	.46	5600pf	500V	2.00
39pf	500V	.34	470pf	500V	.45	6800pf	500V	2.00
47pf	500V	.28	500pf	500V	.47			

HIGH VOLTAGE DOOR KNOB CAPACITORS

1pf	5KV	$ 4.99	14pf	5KV	$ 4.99	120pf	2.5KV	$ 4.99	
2pf	5KV	4.99	25pf	5KV	4.99	330pf	2.5KV	4.99	
3pf	5KV	4.99	25pf	7.5KV	5.99	470pf	15KV	6.99	
4pf	5KV	4.99	40pf	5KV	4.99	500pf	20KV	10.99	
4.5pf	5KV	4.99	40pf	7.5KV	5.99	500pf	15KV	8.99	DUAL
5pf	5KV	4.99	45pf	5KV	4.99	680pf	6KV	3.99	
6pf	5KV	4.99	47pf	4KV	4.99	800pf	15KV	8.99	
7pf	5KV	4.99	50pf	7.5KV	6.99	1000pf	30KV	30.00	
8pf	5KV	4.99	60pf	4KV	4.99	1500pf	3.5KV	6.99	
9pf	5KV	4.99	67pf	7.5KV	5.99	2700pf	40KV	40.00	
10pf	5KV	4.99	80pf	5KV	4.99	6800pf	3KV	9.99	
10pf	7.5KV	5.99	100pf	5KV	4.99				

GIMMICK CAPACITORS (Axial Lead Construction like a Resistor)

0.2pf	500WVDC	1.2pf	500WVDC	3.9pf	500WVDC
0.16pf	"	1.5pf	"	4.7pf	"
0.22pf	"	2.4pf	"	100pf	"
0.33pf	"	3.3pf	"	2200pf	"
0.68pf	"	3.6pf	"	4/$1.00	

TELONIC ATTENUATOR
Model TC50A, has BNC connectors for input and output, 0-1db, 50 Ohm $39.99 each

MICROELECTRONICS BROADBAND AMPLIFIER, TRW CA602/CA2601BV, 15-270 MHz, 30db gain max., 30 VDC supply voltage $39.99 each

MICROWAVE ASSOCIATES, INC.
MA41482 & MA41482R, 10GHz to 12GHz, similar to 1N21 & 1N23 series
$2.99 each

50 WATT ZENERS
1N3313B 5% 14VDC $3.00
1N4554 10% 6-2VDC 2.50

BUSS FUSE #HB035
35 Amp $1.99 each

SPRAYON #703 GENERAL PURPOSE ELECTRICAL CLEANER, 16 oz. can $2.99 each

ALCO PROXIMITY SWITCH
Magnetic Reed Type #RS-11
N.O. Type $2.59 each

RF POWER TRANSISTORS

MRF449/A	30Watts	3-30MHz	$12.65
MRF450/A	50	3-30	14.37
MRF454/A	100	3-30	20.12
MRF455/A	80	3-30	16.00
2N5589	3	175	9.77
2N5590	10	175	10.92
2N5591	25	175	13.80
2N6081	15	175	12.07
2N6080	4	175	10.35
2N6082	25	175	12.65
2N6083		175	13.00
2N6084	40	175	15.00
MRF901	Microwave RF Amp		2.00
BFR91	Microwave RF Amp		1.00

VARIABLE CAPACITORS

Cambion #563-7625-03 1.5 to 30 pf
¼" shaft, ½" long

#80-526/ARCO 425	30-150pf
#B7311369/CVR-5	390-580pf
#80-527/ARCO 426	45-232pf
#80-528/ARCO 406	20-115pf
#80-529/ARCO 462	5-90pf
#E281001/ARCO 421	2-25pf
#2222-808-44121	2.1-120pf
#3L1-0003-03	.9-50pf
#3731259-228	.9-50pf

$1.00 each or 2/$1.50

FIELD EFFECT TRANSISTORS

2N4416	400MHz	10 TPS. db. min.	4 MF/db	$1.50
MPF102	100			.40
3N140	200	16	4.5	2.80
3N128	200	High power gain 18db		
	200	Low noise figure 4db		2.05
J-310	VHF/UHF Amplifier, mixer, & oscillator			.75
40673	Dual Gate			1.40

Rockwell International/
Collins #526-9963-040
Disc-Wire Mechanical Filter
Center Freq. 450KHz
3.4/3.0 Typical P/B (KHz/db)
Typical stopband 6.0/60 (KHz/db)
Source & Load 5K - Ohms
Res. Cap. (pf) 360 $39.99 NEW

FULL WAVE BRIDGES

W04M	1 Amp	50V	$ .89
5P4	2 Amp	200V	.99
MDA204/3N256	2 Amp	400V	1.28
SS-4	4 Amp	600V	1.39
VH148	6 Amp	100V	1.00
75KBP005	1.5 Amp	50V	1.00
MDA100A/3N246	1 Amp	50V	1.00
MDA104A/3N249	1 Amp	400V	1.69
VJ648X	10 Amp	600V	2.69
MDA990-6	27 Amp	600V	3.50
506342	25 Amp	200V	2.69
MDA801	8 Amp	100V	2.00

Grigsby-Barton, Inc. #GB-604
12.5KVDC HIGH VOLTAGE RELAY
Maximum Contact Ratings: 12.5KVDC @ 50VA
Coil: 24VDC, 230 Ohms
SPST Contacts
High Voltage Probe Wire leads
onw is 8 inches, one is 10 inches
Quick Disconnect Coil Leads
Relay Size: 3¼" X 3/4" X 1 3/4"
$19.95 each

E. F. JOHNSON

#189-504-5	1.5 to 11.6	
#189-505-5	1.7 to 14.1	
#189-507-5	2 to 19.3	
#189-508-5	2.2 to 21.9	Any number
#189-509-5	2.4 to 24.5	$1.00 each
#187-0103-005/T3-5	1.3 to 5.4	
187-0106-005/T6-5	1.7 to 11pf	
274-0113-015	1.5 to 15pf	
274-0040-025	2.5 to 40pf	
274-0009-025	2.5 to 9pf	

VARIABLE CAPACITORS

ARCO 423	7 to 100pf	$1.00 each or 2/$1.75
ARCO PC464	25 to 280pf	$1.00 each
ARCO PC402	1.5 to 20pf	$1.00 each or 2/$1.50
CO10ZZ/10	.7 to 46pf	79¢ each or 2/$1.10

DUAL VARIABLE CAPACITORS

075-014 Atlas	1.2-30pf & 1.2-15pf	$3.99
075-013 Atlas	9-55pf Dual	$3.99
075-012 Atlas	1.1-175pf Dual	$3.99

VARIABLE CAPACITORS

272-1341 Archer	8.5-365pf	$1.99
ARCO 464X	25-280pf	$1.00
2222-804-20024	2-25pf	2/$1.00

LINEAR IC's	DESCRIPTION	PRICE
LM301H		$1.25
LM301N	Operational Amplifier	.48
LM324N	Quad Operational Amplifier	.71
LM555N	Timer	.33
LM339	Quad Comparator	.69
LM380N-14	Audio Power Amplifier	.90
LM1889N	TV Video Modulator	3.20
CA3028H/AH	Communications Amplifier	1.90
CA3130E	FET Operational Amplifier	1.50
MC1306P	½ Watt Audio Amplifier	1.30
MC1330P	Low Level Video Detector	1.50
MC1350P	IF Amplifier	.98
MC1358P	IF Amplifier, Limiter, FM Detector, Audio Driver, Electronic Attenuator	1.30
MC1590G	RF/IF Audio Amplifier	6.99
MC1723P	Voltage Regulator	.62
MC1709P	14 pin Operational Amplifier	.73
MC1741	8 pin Operational Amplifier	.56
MC3302P	Quad Comparator	.80
Data Sheets Available, price per page		.25

IC SOCKETS

Solder Tail

8 pin	$0.10
14 pin	0.10
16 pin	0.14
18 pin	0.18
20 pin	0.20
24 pin	0.22
28 pin	0.25
40 pin	0.50

Wire Wrap

10 pin	0.35
14 pin	0.35
16 pin	0.40
40 pin	0.99

Voltage Controlled Multivibrator
MC4024P $4.49

Phase Detector
MC4044P $4.49

VOLTAGE REGULATORS	DESCRIPTION	PRICE
7805/LM340T-5	5 Volt	$ .69
7808/LM340T-8	8 Volt	.69
7812/LM340T-12	12 Volt	.69
7815/LM340T-15	15 Volt	.69
78M05	½ Amp, 5 Volt	.33
7912/LM320T-12	12 Volt	.79
79M05	½ Amp, 5 Volt	.49
79M15	½ Amp, 15 Volt	.49
LM317T	1.2 to 37 Volt	2.00
78H05CK	5 Amp, 5 Volt	5.00
78H12CK	5 Amp, 12 Volt	6.00

SILICON RECTIFIERS

1N4001	50V	1Amp
1N4002	100V	1Amp
1N4003	200V	1Amp
1N4004	400V	1Amp
1N4005	500V	1Amp
1N4006	800V	1Amp
1N4007	1000V	1Amp

10 for $1.00

TO-3 Transistor Sockets
A must for the TO-3 power transistor or regulator 5/$1.00

Fairchild VHF, 300MHz
Prescaler with a 2N5179
$5.69

Ferranti AM Receiver IC
ZN414 $2.00

C-MOS Bit Rate Generator
MC14411P $10.00

C-MOS Touchtone Encoder
MC14410P $10.00

TO-3 Mica Insulator 10/$1.00

TO-3 Case Transistor Pair
NPN & PNP Audio Power
2N3055 & 2N2955 $2.00/pair

DPDT Slid Switch 5/$1.00

Black Rubber Feet
1" round x ½" high 12/$1.00

Two Wire 18 Awy Line Cords
Black, 5 Feet 2/99¢

Spacer Assortment of all Types
25/$1.00

Variable Trimmer Cap Special
of all Types 20/$2.00

USED FEATHER FANS 115VAC
7" Dia. x 2½" $7.99

Compact Water Heater Tank
120VAC, 500 Watts, Copper Tank
Size: 3 5/8" x 3" x 7½" $10.00

BUSS #2448 Fuse Holder for 3AG type 4/$1.00

Ferrite Beads 12/79¢

SILICON POWER TRANSISTORS *Germanium, °Darlington

BU208	VCEO 1500	5 Amps	NPN	TO-3	$3.00
2N6307	VCEO 300	5 Amps	NPN	TO-3	2.00
MJ10005	VCEO 400	20 Amps	NPN	TO-3	6.00
MJ10006	VCEO 350	10 Amps	NPN	TO-3	4.00
2N3055	VCEO 60	15 Amps	NPN	TO-3	.88
2N5886	VCEO 80	25 Amps	NPN	TO-3	2.00
2N6569	VCEO 40	12 Amps	NPN	TO-3	.88
MJ2955	VCEO 60	15 Amps	PNP	TO-3	1.25
2N5302	VCEO 60	30 Amps	NPN	TO-3	2.00
MJ15012	VCEO 250	10 Amps	PNP	TO-3	2.00
2N5880	VCEO 80	15 Amps	PNP	TO-3	2.00
°MJ4000	VCEO 60	4 Amps	NPN	TO-3	2.00
2N5240	VCEO 350	6 Amps	NPN	TO-3	1.25
2N4898	VCEO 40	4 Amps	PNP	TO-66	1.25
2N3767	VCEO 80	4 Amps	NPN	TO-66	1.25
2N3713	VCEO 80	10 Amps	NPN	TO-3	1.25
2N3235	VCEO 60	7.5 Amps	NPN	TO-3	1.25
2N3442	VCEO 140	10 Amps	NPN	TO-3	1.25
°MJE802	VCEO 80	4 Amps	NPN	TO-126	1.00
2N6487	VCEO 60	15 Amps	NPN	TO-220	1.00
*2N301	VCB 40		PNP	TO-3	2.00
*2N2140	VCB 75	2 Amps	PNP	TO-3	3.99
*2N1099	VCB 80	12 Amps	PNP	TO-36	6.99
°PDM10K40/2N6057	VCEO 60	12 Amps	NPN	TO-3	1.50
°PDM12K40/MJ1000	VCEO 60	8 Amps	NPN	TO-3	1.00
MJE2955T	VCEO 60	10 Amps	PNP	TO-220	.75

CERAMIC FILTERS

Murata CF260H		260KHz	$ 7.50
" CFU455HZ		455KHz	2.90
" SFB455D		455KHz	2.50
" SFD455D		455KHz	5.00
" SFE10.7MA	Orange	10.7MHz	2.50
" CFW455H6		455KHz	2.90
" SFE10.7MA	Black	10.7MHz	2.50
" SFE10.7MA	Red	10.7MHz	2.50
" SFE10.7MA	Blue	10.7MHz	2.50
" SFE10.7MA	White	10.7MHz	2.50
Matsushira EFC-L455K41B		455KHz	2.50
" EFC-L455K40B2		455KHz	2.50
PTI 1479 10.7MHz			20.00

10 WATT ZENERS

10V	36V
11V	39V
14V	40V
20V	56V
22V	62V
24V	68V
27V	100V
33V	

99¢ or 10/$7.50

MOTOROLA SP1801 PNP
POWER TRANSISTOR
SP1801 will replace the 2N1529 thru 2N1560 in most cases. $4.95 each or 10/$35.00

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New & Used in Mixed Sizes
$1.25 each or 10/$9.00

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#123-0210-001
Used for 811A, 8005, 3B28, etc.
$6.99 each

HIGH CURRENT 25Amp SCR
Stud Mount
2N687 400 Volt $2.97
2N690 600 Volt $5.03

LED DISPLAYS
TIL 305/745-005 RED
.3" 5x7 array
Alphanumberic Display
$3.85

NARROW BAND CRYSTAL FILTER 10.7MHz
Bandwidth 13KHz
Type 2194F
Input & Output
Impedance 2700 Ohms
$4.95 each

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115VAC
4½" x 1½" deep
USED $5.00 NEW $10.00
3/8" x 3/8" x 1½"
USED $7.00 NEW $12.00

SUBMINIATURE POWER SUPPLY
5VDC @ 300mA
2¼" x 1 3/4" x 1"
NEW $8.00
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TV COAX CONNECTOR FOR CABLE F-59 16¢ each

TV COAX CABLE CONNECTOR
F-61 25¢ each

NEC NTM2222A
General Purpose Amplifier
High Speed Switching
NPN Silicon Epitaxial
Transistor "Mini Mold Type" 79¢ each

TRW TD1021J
Monolithic Video
A/D Converter, 4 Bit
30 MSPS $30.00 each

MINI-CIRCUIT RF TRANSFORMERS
Model T16-1,
Ratio 16 Ohms,
Frequency .3-120MHz
$3.95
Model TM05-T1
Ratio 5 Ohms
Frequency .3-300MHz
$6.75

MICROWAVE ASSOCIATES Inc.
#MA4815 Point Contact
Detector Diode
Test Freq. .1GHz
$1.00 each

VARADYNE CHIP RESISTORS
.05" x .05" 75MW 10%

12 Ohm	680 Ohm
15 Ohm	820 Ohm
27 Ohm	1K
82 Ohm	1.2K
100 Ohm	2.2K
120 Ohm	3.3K
150 Ohm	3.9K
180 Ohm	4.7K
390 Ohm	5.6K
550 Ohm	

99¢ each or 10/$7.50

EIMAC 4CW800F
VHF/UHF POWER TUBE 800 Watts
Plate Dissipation. Heater 26.5V
@ 1.1Amps Tube comes with
bypass capacitor $309.99

MALLORY CAPACITORS Type CGX
500 mfd @ 250 VDC
1 3/8" x 3 1/8" $3.00 each
740 mfd @ 250 VDC
1 3/8" x 4 1/8" $3.00 each

VARIABLE CAPACITORS
Dynatronics 1.5 to 23 pf 2/$1.00
Swallow CV05E300 2.3 to 27pf 2/$1.00

MR510 RECTIFIER
3 Amp @ 1000 Volt
10/$2.99 100/$20.00
1000/$150.00

THERMAL GLASS WARMING PLATE 120VAC or DC @ 120 watts 130° C to 135° C ± 3% (266°-275°F) 10 3/8" wide x 5 3/8" deep. $3.00 each

NICKEL CADMIUM 12VDC PACK, GE AA BATTERIES Pack of Ten USED, AS IS $3.99/pack

NICKEL CADMIUM 12VDC PACK, GE C CELLS Pack of Ten USED, AS IS $5.99/pack

HIGH SPEED SWITCHING DIODES 1N4148/1N914 30/$1.00 or 120/$3.00

POTTER & BRUMFIELD/AMF RELAY DPDT #KUP11D15 28VDC Coil, ¼ HP @ 120VAC or 10 Amps @ 240 VAC. Size: 1¼" x 2" x 1½" $3.99 each

SIGMA STEPPING MOTOR #20-22350-28175 (Similar to Superior MO-62 Series) 4VDC, 1.8° or 9° per step. 120oz/in. holding torque. $31.99 each

NEW AVANTEK GPD403 General Purpose Thin-Film Amplifier Modules Four pin, TO-12 package 5-400MHz, 9db gain, 7.5db noise, 20db reverse isolation, +15db power output $19.50 each

VOLTAGE REGULATORS

78L05	+5V	4/$1.00
78L09	+9V	4/$1.00
78L15	+15V	4/$1.00
7905/LM320T-5		
-5V @ 1Amp		$0.69

STUD TRIACS T6410N 40Amps, 800VDRM Case 263-03 $8.99 each

MAC15-6 TRIAC 15Amps, 400V, TO-220 $1.29 each

2N4442 SCR Case 90-05 8Amps @ 200V $1.25

MCR3918-3 SCR STUD 20Amps, 100V Case 175-02 $3.00

MOTOROLA MOC3011 TRIAC DRIVER OUTPUT LED Trigger Current 5mA Peak Blocking Voltage 250 Isolation Voltage 7500 V $1.00 each

GLOBE RECHARGEABLE GEL/CELL BATTERY #GC-280 2VDC @ 8 Amp-HR 3 3/4" high x 2" deep 2" wide NEW $5.99 each or 6/$27.00 #GC1260 12VDC @ 6 Amp-HR. 3 3/4" high x 3 1/8" deep x 6" long NEW $29.99 each

MOTOROLA MD3251 DUAL PNP SILICON ANNULAR TRANSISTOR. Especially designed for low-level, differential amplifiers VCB 50, VCEO 40, VEB 5, IC 50madc, 250MHz, Case 32 $4.50 each

2N2894 PNP SILICON ANNULAR TRANSISTOR, designed for low-level, high speed switching, VCEO 12, VCB 12, VEB 4, IC 200madc, 400MHz, TO-18 Case, House numbered $1.00 each

MOTOROLA MMT3960 MICRO MINIATURE NPN SILICON TRANSISTOR, high speed switching, designed for high speed current mode logic switching, 2250MHz, VCEO 8, VCB 15, VEB 3 $3.00 each

TO-3 GERMANIUM POWER TRANSISTOR IR TR-01A/ECG121, PNP, AF power output, BVCBO 65, BVCEO 45, BVEBO 15, IC Amps 7.0, 30 Watts, 22KHz, gain 80 $1.29 each

EIMAC PLATE CAPS HR Type, 1" high X 11/16" diameter, 3/8" I.D. $6.99 each or 10/$40.00

CERAMIC PLATE CAPS Type 1 for 3/8" plate cap Type 2 for 5/8" plate cap $1.99 each

NEW MONSANTO MAN4640A READOUT $1.00 each

1 WATT ZENER DIODES 1N4728 thru 1N4755 Four of same part number $1.00

TO-220 MICA INSULATOR 20/$1.00

HIGH VOLTAGE CAPACITOR Plastic Capacitors Inc. #LQ80-203YA .02 mfd @ 8000 VDC Size 2½" x 1" $2.99 each

CONCAVE GLASS MAGNIFYING MIRROR 19" Focal Length, 8.5" diameter 99¢ each

TEN TURN POTS removed from equipment. ¼" shaft ½" long. Model 534 Spectrol 2K Ohm, type 8400/2053A TRW 2K Ohm, model 534 Spectrol 100K Ohm, type 8400/2053A TRW 100K Ohm $2.99 each

TURNS COUNTING DIALS FOR TEN TURN POTS $4.99 each

E.F. JOHNSON TUBE SOCKETS AND CAPS #124-0311-100 for 8072, etc. $10.99 #124-0113-001 and #124-0113-021 capacitors for sockets #124-0107-001 $12.99 each

UNDELCO CAPS

8.2pf	36pf
10pf	47pf
12pf	160pf
13pf	240pf
20pf	360pf
24pf	470pf
33pf	1000pf

1-10	$1.00
11-50	.90
51-up	.80

MOTOROLA TIP49, 1Amp NPN POWER TRANSISTOR VCEO 350, VCB 450, VEB 5, 40 Watts, TO-220 Case $1.00 each or 10/$7.50

MOTOROLA RF AMP MODULES #544-4001-002 Similar to MHW401-2. 1.5Watts output. .047 Watts input 440-512MHz, 15 db gain, 7.5VDC $39.99

1.1VDC Lamps 3/16" round 10/$1.00

CRYSTALS (Odd) Each value $2.00 each

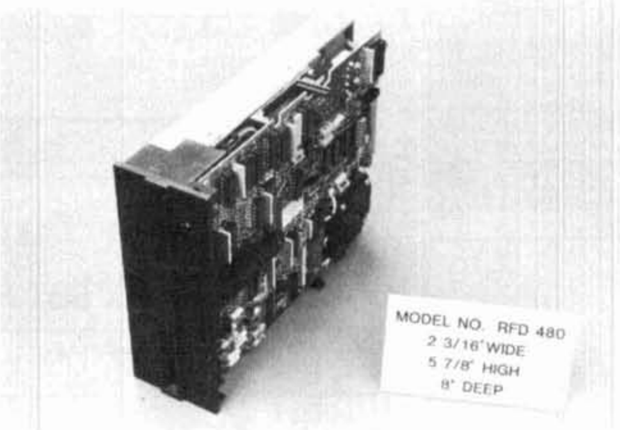
1.68960	9.565	10.180	12.6	37.650
3.579545	9.575	10.240	17.015	37.700
4.8384	9.585	10.605	17.065	37.750
7.4625	10.010	10.615	17.115	37.800
7.4725	10.020	10.625	17.165	37.850
7.4825	10.030	10.635	17.215	37.900
7.4925	10.040	10.695	17.265	37.950
7.5025	10.130	11.750	17.315	65.714286
7.8025	10.140	11.955	17.365	65.7143
9.545	10.160	12.050	24.8832	
9.555	10.170	12.100	37.600	

CRYSTALS (EVEN)

100KC	$3.99
2.0MHz	3.00
4.0MHz	3.00
6.0MHz	3.00
10.0MHz	3.00
12.0MHz	3.00
16.0MHz	3.00
38.000	3.00
60.0	3.00

R.F. CONNECTORS

SO-239	UHF Female	$ .69
PL-259	UHF Male	.69
2-330830-2	UHF Male Crimp	.69
225398-9	BNC Female Crimp	1.29
UG273/U	BNC Female to UHF Male	2.99
UG914/U	BNC Female to BNC Female	2.99
UG1094/U	BNC Female	.79
UG260/U	BNC Male	1.69
UG175/U	ADP	.39
M23329/3-05	BNC Female Crimp	1.69
M23329/3-21	BNC Female Crimp	$1.69
18225	BNC Female	1.99
UG23B/U	N Male	3.99
18750	N Male	3.99
UG216/U	N Male	4.99
94375-301-N1800D	N Male	4.99
142-0261-001	SMA Male	3.99
142-0221-001	SMA Male	3.99
142-0299-001	SMA Female	3.99
UG705/U	C Female	4.99



NEW EX-CELL-O CORPORATION, Remex Division 5¼" Model RFD480, DISK DRIVE, 2 3/16" Wide, 5 7/8" High, 8" Deep $299.99 each

COMMUNICATION EQUIPMENT & ENGINEERING CO.
#C-152-A1 Loading Coil, Type C656
66MH $6.99 each

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PRO-SEARCH™
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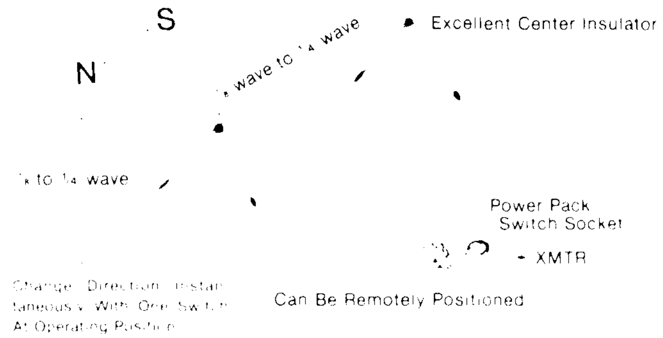
BIG SIGNAL.......LITTLE EFFORT......

INTRODUCING.........THE HJ-SERIES COAXIAL DIPOLES AND PHASING KIT.........

Specifications: 5.0 DBD 10-22DB F/B

Example
Antenna Tested ON 7.2mc. 1/4 wave spacing
at 18' at APEX.
ENDS AVERAGE HGT. 6'
SWR-FLAT or BELOW 1.5 to 1 over Phone Band

* When Testing just one of
2 Antennas - SWR was Flat
or Below 1.5 to 1 over Entire Band...
7.0 to 7.3 MHZ



FOR THE HAM WHO WANTS
A BETTER SIGNAL ON THE BAND.
BUT IS LIMITED BY SPACE OR ZONING....

HJ-DIPOLE*

Strong Weather Proof

Tuned Short

100' RG8X

- BROADBANDED
- PORTABLE
- REQUIRES ONLY ONE SUPPORT
- CAN WORK INDOORS

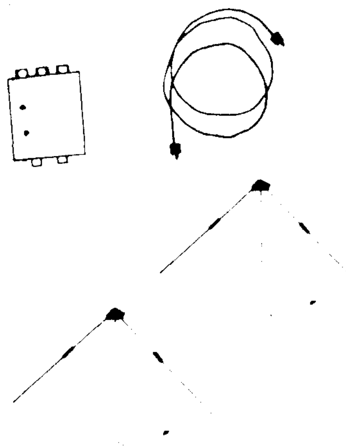
"The Coaxial Dipole is a very quiet antenna with slightly stronger signal punch than a conventional dipole" This quote is from The Giant Book of Electronic Projects by the Editors of 73 Magazine.

PL-259

* THE SINGLE HJ-DIPOLE CAN BE UPGRADED TO A PHASED ANTENNA SYSTEM AT A LATER DATE. NO TUNER REQUIRED HOWEVER, WITH A TUNER ANTENNA CAN BE LOADED UP ON A HIGHER FREQUENCY...

THE HJ-PHASING KIT...CONTAINS EVERYTHING YOU NEED, BUT A PLACE TO HANG THEM...*

Contents
9-PL-259
2-Coax Tees
1-Barrel Connector
5-Female Connectors
2-Male Phono Plugs
2-Female Phono Sockets
1-Cabinet
1-Power Pack
4-Short Covers
2-Center Insulators
5-Stainless Steel 10/32 Screws
5-Stainless Steel 10/32 Nuts
1-Relay
3-Sets of 1/4 wave coax lines
2-100' lengths of coax feedline
2-Antennas Cut and Tuned



* ALL ANTENNAS ARE ASSEMBLED-PHASING LINES CUT AND HAVE PL-259S INSTALLED...LEAD-IN CABLES PL-259 ARE INCLUDED BUT NOT ATTACHED FOR USER CONVENIENCE...PHASING BOX IS ALSO ASSEMBLED AND READY TO USE...

PRO-SEARCH™ has designed quality into simplest of antennas...Center insulator is made up of high quality material that is virtually unaffected by heat, cold or impact...will withstand rugged use and extreme environments...RG-8X has 93% shield...Antennas are very flexible and very portable...good for vacation or field day...apartment dwelling...Tuned shorts are weather-proofed with gripping covers which also add strength to this area of the antenna...Stainless steel hardware, of course...Antennas can be made for any frequency...The most important part, we stand behind our products...That's a Promise...

FREQUENCY	SINGLE ANTENNA	TUNED PAIR OF ANTENNAS	PHASING KIT	TOTAL
1.8	$139.95	$251.91	$110.95	$362.36
3.5	96.95	174.51	110.95	285.46
7.0	73.95	133.11	110.95	244.06
10.0	68.95	124.11	110.95	235.06
14.0	64.95	116.91	110.95	227.86
18.0	61.95	111.51	110.95	222.46
21.0	59.95	107.91	110.95	218.86
24.0	57.95	105.91	110.95	216.85
28.0	56.95	102.51	110.95	213.46

U.S. and Foreign Patents Pending

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For more information on this and other products Write or Call Pro-Search Electronics Co. Suite 305 10411 Clayton Rd. St. Louis, Mo. 63131 1-314-994-7872 Missouri 1-800-[illegible]

SATELLITE TELEVISION RECEIVER KITS

Rainbow makes a top-of-the-line Receiver affordable

The Electronic Rainbow Receiver consists of a receiver with an external down-converter that mounts at the antenna, feeds the voltage to the LNA through the coax cable. The 4GHz signal is down converted to 70 MHz and is fed through the RG59/U coax to the receiver.

Rainbow Kits are supplied with simple step by step instructions. All the circuits that you need expensive test equipment to do are pre wired and tested. All printed circuit boards have the outline of each part printed on them.

RECEIVER FEATURES
Built in RF modulator • Detent Tuning-3.7 to 4.2 GHz • Variable Audio-5.5 to 7.5 MHz • Invert Video • Channel Scan • Voltage monitoring • Meter output • Remote Tuning
SPECIFICATIONS:
Single Conversion Image Rejection Downconverter • Threshold 8 db CNR • IF Bandwidth 24MHz • Output IV Audio and Video • IF Frequency 70MHz • Video Bandwidth 4.5MHz • Size 3½"Hx8½"Dx11¼"W

Complete Satellite TV Receiver

KIT #1 — Contains:
- Mainboard • Tuning Board • Downconverter Board • Modulator Board
- All parts needed to complete receiver
- Down Converter built in case.
- Cabinet, attractive black brushed anodized metal with silk screened front and back for a professional look
- 70 MHz Filter is pre-wired and tested.
- Complete instruction Manual.

$395.00

KIT #2 — Board Kit Contains:
- Main Board • Tuning Board • Downconverter board • Modulator Board
- Parts List, assembly and alignment manual
- 4GHz local oscillator and 70MHz filter is pre-wired and tested.

$129.00

Instruction manual. Contains printed circuit board layouts, parts placement, and alignment instructions. **$25.00**

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ELECTRONIC RAINBOW INC

Homebrew Headquarters

PROJECT PACKS*

DIRECT from ENGLAND

2 Meter Converter R & EW 10/81
Low noise 144-146 to 28-30 MHz MOSFET Converter

2 Meter Pre-Amp. R & EW 4/82
Gain 22 db, BW 6 MHz, NF < 1.5 db, Z_i/Z_o 50 Ω

2 Meter GaAs Pre-Amp. (Mast Head Mount w R/T relay) R & EW 10/82
Gain 17 db, BW 6 MHz, NF < 1.0 db, Z_i/Z_o 50 Ω

UHF (70 CM) Converter. R & EW 11/81
Low noise 432-434 to 28-30 MHz MOSFET Converter

UHF (70 CM) Pre-Amp. R & EW 3/82
Gain 13 db, BW 20 MHz, NF < 2 db, Z_i/Z_o 50 Ω

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ENGINEERING DATABOOKS, electronic design magazines, radio magazines, some from 1930's, manuals, electronics books, machine shop magazines, porcelain insulators, many other parts and equipment on large list, 5 pages. SASE please. Joseph Cohen, 200 Woodside, Winthrop, MA 02152.

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WANTED: Schematics-Rider, Sams or other early publications. Scaramella, P.O. Box 1, Woonsocket, RI 02895-0001.

RETIRING to Florida. Must sell 30-year accumulation of Ham gear, parts, Ham and technical books immediately. Sacrifice prices. Send SASE for list. Dino Mastrojohn, 10 Madeleine Pl., Parsippany, NJ 07054. W2UII.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

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ACTIVITIES

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ARKANSAS: The Northwest Arkansas Amateur Radio Club's 3rd annual Hamfest/Swapmeet, Saturday, May 21, Rogers Youth Center, 315 West Olive Street, Rogers, 8 AM to 4 PM. Free admission. Commercial exhibitors and flea market tables/space $2.00. Setup 6 AM. Free parking. Refreshments nearby. Snack bar on premises. Talk in on 146.16/.76 or 146.52 simplex. For more information: Mary Webb, KA5HEV, PO Box 338, Prairie Grove, AR 72753.

CALIFORNIA: The North Hills Radio Club's 11th annual Sacramento Valley Hamswap, May 1, 9 AM to 3 PM, Placer County Fairgrounds, Roseville. Free admission. Tables $6 to $8. Tailgate sites $5.00. Talk in on K6IS repeater (144.59/145.19). For information: Doug Long, KB6ZR, 8810 Swallow Way, Fair Oaks, CA 95628. (916) 961-0728.

CALIFORNIA: West Coast VHF/UHF Conference sponsored by W6GD UHF Society, May 7 and 8, Sunnyvale Hilton Inn, 1250 Lakeside Drive, Sunnyvale. $8 pre-registration by April 27, 1983. $10 door. Displays, programs, DX and contest operating, computers, swap and flea market. Saturday evening banquet. For information: West Coast VHF/UHF Conference, PO Box 4101, Fremont, CA 94539.

COLORADO: The Rocky Mountain VHF Society's annual Swapfest, Sunday, May 22, 9 AM to 4 PM, Colorado National Guard Armory, 4750 North Broadway, Boulder.

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FLORIDA: When visiting Florida, stop in at a Welcome Center and get a complimentary 2-meter directory and a refreshing glass of juice. Cloverleaf Farms Amateur Radio Club and Cloverleaf Farms Manufactured Homes Community have cooperated to bring this service to hams traveling in Florida.

GEORGIA: The Anderson, Hartwell and Toccoa Amateur Radio Clubs' 5th annual Lake Hartwell Hamfest, May 21 and 22, Lake Hartwell Group Camp, Hartwell. Free admission, free camping and free flea market space. A left-footed CW contest, horseshoes, fishing, swimming and more for the whole family. Campgrounds open 6 PM Friday evening. Talk in on 146.19/.79, 147.93/.33 and 146.895/.295. For further information: Ray Pettit, WB4ZLG, Rt. #1, Dooley Drive, Toccoa, GA 30577.

IDAHO: Kootenai Amateur Radio Society's Hamfest '83, Saturday, June 11, North Idaho Fairgrounds, Coeur d'Alene, 8 AM to 4 PM. Free swap tables, large RV parking area. Food available. Talk in on 146.38/98 or 146.52 simplex. For further information: Vladimir J. Kalina, South 1555 Signal Point Road, Post Falls, ID 83854.

ILLINOIS: The Six Meter Club of Chicago is having their 26th annual Hamfest, Sunday, June 12, Santa Fe Park, 91st and Wolf Road, Willow Springs, southwest of Chicago. Gates open 6 AM. Advance registration $2.00. $3.00 at gate. Large swapper's row, picnicking, pavilion displays, refreshments, AFMARS Meeting. Talk in on K9ONA 146.52 or K9ONA/R 37-97. For advance tickets: Val Hellwig, K9ZWV, 3420 South 60th Court, Cicero, IL 60650.

INDIANA: The 4th annual MAARC Hamfest, May 22, Delaware County Fairgrounds, 8 AM to 3 PM. All activities inside. Fla market tables $5.00. Tickets $2.00 advance, $3.00 at door. Free parking. Food, forums, computer displays. Talk in on 146.13/73, 146.52, 223.10/224.70. For further information: Craig Graham, WD9EHF, RR 12, Box 86, Muncie, IN 47302.

INDIANA: The Wabash Valley Amateur Radio Association's 37th annual Hamfest, Sunday, June 5, Vigo County Fairgrounds, Terre Haute. For more information SASE to W.V.A.R.A., PO Box 81, Terre Haute, IN 47808.

INDIANA: The Tristate Amateur Radio Society's annual Hamfest, Sunday, May 15, Vanderburgh County 4H Center, Evansville. Admission $2. Open 6 AM CDT. Indoor tables available. Outdoor flea market. Talk in on 147.75/.15 and 146.19/.79. For information and table reservations: Hal Wilson, WB9FNN, RR #8, Box 427B, Evansville, IN 47711.

KANSAS: The Central Kansas Amateur Radio Club's 3rd annual Kansas State ARRL Convention, June 4 and 5, Red Coach Inn Convention Center, West Crawford and I-135, Salina. Programs for Hams, non-Hams and ladies. Free flea market adjacent to Center. Saturday evening banquet and entertainment. For further information SASE to Bill Ringquist, KAØCUF, RR #1 Box 155, Gypsum, KS 67448.

KANSAS: The Pittsburg Repeater Organization's annual Hamfest, May 15, 10 AM to 5 PM, Lincoln Center, Lincoln Park, Pittsburg. Covered dish dinner, flea market. Admission $1.00 at door.

KENTUCKY: Northern Kentucky Amateur Radio Club's annual Ham-A-Rama, Sunday, June 5, Burlington Fairgrounds, Burlington. Tickets $5.00 at gate. Flea market space $3.00. Vendors, nets and group meetings. Refreshments available. Talk in on 147/86 and 375/975. For information: Dick Johnston, WA4KUB, 3113 Brookwood Dr., Edgewood, KY 41017. (606) 341-8759.

MARYLAND: The Maryland FM Association's annual Hamfest, Sunday, May 29, Howard County Fairgrounds, West Friendship. 8 AM to 4 PM. Donation $3.00. Tailgating $3.00. Inside tables in advance $6.00 each, at door $10.00 each. Talk in on 146.16/76 and 146.52. For information and table reservations: MFMA HAMFEST COMMITTEE, c/o John Elgin, WA3MNN, 5495 Apt 2, Harpers Farm Road, Columbia, MD 21044. (301) 596-3741.

MICHIGAN: The Chelsea Communications Club is sponsoring a Swap 'N Shop, Sunday, June 5, Chelsea Fairgrounds, 8 AM to 2 PM. Gates open for sellers 5 AM. Donation $2.50 advance; $3.00 door. Children under 12 and non-ham spouses admitted free. Talk in on 146.52 simplex and 147.855 Chelsea repeater. For information: William Altenberndt, 3132 Timberline, Jackson, MI 49201.

MICHIGAN: The Independent Repeater Association of Grand Rapids will hold its annual Hamfestival, Saturday, June 4, 8 AM to 4 PM, Wyoming National Guard Armory on 44th St. east of US-131. Dealer setup 6 AM. Free table space to all sellers. Admission $3.50. ATV, satellites, contests, computers, MARS and schack photo contest. Huge swap area. Talk in on 147.165/147.765. For information and table reservations: John Knoper, KC8KK. (616)

534-5501 or I.R.A., 562 - 92nd Street S.E., Byron Center, MI 49315.

MINNESOTA: NARA is again sponsoring the state's largest swapfest and exposition of personal computers and software, June 4, Minnesota State Fairgrounds, Snelling Avenue, north of I-94. Large indoor commercial exhibits and booths. Giant outdoor flea market. Admission $4.00. For more information or dealer inquiries: Amateur Fair, PO Box 857, Hopkins, MN 55343 (612) 420-6000.

MISSOURI: The Indian Foothills Amateur Radio Club's 8th annual Hamfest, Sunday, May 15, Saline County Fairgrounds, Marshall. Tickets $2.00 each, 3/$5.00 at door, 4/$5.00 advance. Registration 8 AM. Free flea market tables, registration required. Talk in on 52, 147.84/.24. For information and tickets: Fred Fellers, WØABW, 703 N. Main, Carrollton, MO 64633. (816) 542-0223 or 542-2655 or (816) 886-2837.

NEW ENGLAND: The Hosstraders will hold their tenth annual Tailgate Swapfest, Saturday, May 7, sunrise to sunset, at Deerfield, NH, Fairgrounds. Admission $1.00, including tailgaters and commercial. Friday night camping for self-contained rigs at nominal fee. None admitted before 4 PM Friday. Profits benefit Boston Burns Unit of Shriners' Hospital. Last year's donation $2622.75. Questions or map to northeast's biggest ham flea market? SASE to Norm, WA1IVB, RFD Box 57, West Baldwin, ME 04091 or Joe, K1RQG, Star Route, Box 56, Bucksport, ME 04416 or Bob, W1GWU, North Walton Road, Seabrook, NH.

NEW HAMPSHIRE: The 9th annual Eastern VHF/UHF Conference, May 13-15, Sheraton Tara, Nashua. Friday night hospitality room. Saturday night banquet, $14, payable prior to May 9. Registration $13.50 from K1LOG, Rick Commo, 3 Pryor Rd., Natick, MA 01760 before May 9. Registration at door $20.00

NEW JERSEY: The Jersey Shore Chaverim are sponsoring the Jersey Shore Hamfest and electronic flea market, June 12, 9 AM to 3:30 PM, Jewish Community Center, 100 Grand Avenue, Deal. Admission $3 per person. Children under 12 and XYLs free. Refreshments available. Table $5. Tailgating $2.50. Reserve spaces by SASE and advance payment to Jersey Shore Hamfest, PO Box 192, West Long Branch, NJ 07764 by May 15. Talk in on 147.045 + .6; 146.52 simplex.

NEW YORK: The Rochester Hamfest combined with ARRL New York State and Atlantic Division Conventions, May 20 and 21, Marriott Thruway Hotel and Monroe County Fairgrounds. Tickets $4 advance and $5 at gate. Flea market tickets $2 per space. FCC exams given. Send Form 610 to FCC, 1307 Federal Building, 111 W. Huron St., Buffalo, NY 14202 by May 1 marked "administered at Rochester Hamfest." Friday evening banquet (instead of Saturday). Flea market open 6 AM Saturday, commercial exhibits 8:30 AM. Closing time 6:00 PM. Talk in on 146.28/88 and 144.51/145.11. Advance tickets from K2MP, 737 Latta Road, Rochester, NY 14612. For more information: Rochester Hamfest, 300 White Spruce Blvd., Rochester, NY 14623.

NEW YORK: The Putnam Emergency Amateur Repeater League (PEARL) will have its 2nd annual indoor Hamfest, Saturday, May 7, 9 AM to 4 PM, JFK Elementary School, Foggintown Road, Brewster. General admission $1.00. Exhibitors $4.00. Talk in on 144.535/145.135 and 52. For advance table registration and information: Frank Konecnik, WB2PTP, RD 1 - 244 C, Carmel, NY 10512.

NEW YORK: The 24th annual Southern Tier Amateur Radio Club's Hamfest, Saturday, May 7, Treadway Inn, Owego. Flea market opens at 8 AM. Vendor displays and sales. Tech and non-tech talks. Refreshments. Advance tickets only for the dinner at 6:30. Talk in on 22/82, 16/76 or 146.52 simplex. For further information SASE to KF2X, C. England, RD #1, Box 144, Vestal, NY 13850.

NEW YORK: The Ebonaire Amateur Radio Society's 2nd annual Hamfest/Flea Market, Sunday, June 5, 9 AM to 3 PM, 119-09 Merrick Blvd., Queens. Contact WA2VYG (212) 523-2319 or KA2CPA (212) 528-0416.

NEW YORK: The Rome Radio Club's 31st Rome Ham Family Day, Sunday, June 5, Beck's Grove in Rome. Games, contests, technical presentations and a giant flea market are some of the features. Refreshments available throughout the day. The Club's "Ham of the Year" award will be presented at the buffet dinner. Talk in on 146.28/88 and 146.52 simplex.

NORTH CAROLINA: Durhamfest sponsored by the Durham FM Association, Saturday, May 14, South Square Shopping Center, Durham. Flea market, dealers, tables available for rent. Admission $4.00. Talk in on 147.825/.225 and 146.52 simplex. For information: DFMA, PO Box 8651, Durham, NC 27707.

OHIO: The Fremont Radio Club in cooperation with the Ottawa County Radio Club is sponsoring their 6th annual Hamfest, May 22, Fremont Fairgrounds. Gates open 8 AM. Dealer setup 7 AM. Advance tickets $2.50. $3.00 at door. Flea market tables $3.00 per 8 ft. space. For tickets and table reservations SASE to John Dickey, W8CDR, 545 N. Jackson Street, Fremont, OH 43420. (419) 332-8066.

OHIO: The Lancaster and Fairfield County Amateur

Radio Club's annual Fathers' Day Hamfest, Sunday, June 19, Fairfield County Fairgrounds, Lancaster, 8 AM to 4 PM. Admission $2.00 advance; $3.00 at gate. Refreshments available. Free parking. Many covered tables. Talk in on 147.03/63 or 146.52 simplex. For more information: Box #3, Lancaster, OH 43130.

PENNSYLVANIA: The 29th annual Breeze Shooters Hamfest, Sunday, May 22, 9 AM to 5 PM, White Swan Amusement Park, PA, Rt. 60 near the Greater Pittsburgh International Airport. Free admission. Free flea market. Registration $2.00 or 3/$5.00. Covered vendors tables by advance registration. Talk in on 146.28/.88 or 29.0 MHz. Contact Don Myslewski, K3CHD, 359 McMahon Road, North Huntingdon, PA 15642. (412) 863-0570.

PENNSYLVANIA: The Warminster Amateur Radio Club's annual Hamfest, Sunday, May 15, Middletown Grange Fairgrounds, Penns Park Road, Wrightstown (Phila. area) 7 AM to 2 PM. Admission $3.00 per ham. Sellers $2.00 additional per 8 ft. space. Inside spaces available. No power. Registration prior to May 1, $2.00 per ham. Talk in on 147.69/09 and 146.52 simplex. For information: WARC, Box 113, Warminster, PA 18974. Or call Frank, AK30 (215) 968-3133 after 2300 UTC.

ROCHESTER HAMFEST: Atlantic Division/New York State Convention. Saturday, May 21, Monroe County Fairgrounds. Hotel headquarters, Rochester Marriott Thruway. More info? Write or call Rochester Hamfest, 300 White Spruce Blvd., Rochester, NY 14623 (716) 424-7184.

SOUTH CAROLINA: The Blue Ridge Amateur Radio Society's Hamfest, Saturday, April 30 and Sunday, May 1, at the American Legion Fairgrounds, White Horse Road, Greenville. Admission $3.00. Talk in on 146.01/61 and 223.46/224.06. For information: Phil Mullins, WD4KTG, Hamfest Chairman, PO Box 99, Simpsonville, SC 29681. For advance sales: Mrs. Sue Chism, Rt. 6, 203 Lanewood Dr., Greenville, SC 29607.

TENNESSEE: The Radio Amateur Club of Knox County will hold its 17th annual Hamfest, Saturday, May 28, 9-5 and Sunday May 29, 10-4, Kerbella Temple Auditorium, east of US 441 behind Vol Inn Motel. Admission $2.00 advance, $3.00 at door. Radio and computer forums, dealers, indoor and tailgate flea markets. Free parking. Talk in on 147.90/30. For tickets, dealer or flea market information: Mark Nelson, AJ2X, 4317 Foley Drive, Knoxville, TN 37918. (615) 687-9656.

TEXAS: The YL International Single Sidebander's 1983 Convention, June 16-19, Dallas. Activities include the DX Roundup, the System Awards banquet Saturday night with a country-western band for dancing. Preconvention activities begin June 13. For detailed information: Joe, W5UJO and Mary, KC5UO, Parsons, 1639 Evergreen Drive, Mesquite, TX 75149.

VIRGINIA: Mayfest '83 presented by the Roanoke Valley Amateur Radio Club, Sunday, May 29, 0900 to 1600, Roanoke Civic Center Exhibit Hall. Advance registration $3.00, $3.50 at door. CW contest, ARRL forum YL, XYL and kiddie functions. Nearby motels, camping and sightseeing. Talk in on 146.385/.985 and 146.52 simplex. For information, tickets and tables: Bill Johnson, W4NLC, 5129-D Overland Rd., Roanoke, VA 24014. (703) 989-5374.

WASHINGTON: The Tri-Cities Hamfest Council 4th annual Hamfest, May 21 and 22, starting 9 AM, Benton-Franklin County Fairgrounds, Kennewick. Admission $3.00 advance, $4.00 at door. Children under 12 free. Vendors, swap tables, Bunny Hunt on Sunday morning. Camping and RV space at site $6.00. For reservations and information: (509) 586-9375 or (509) 967-2358. Inquiries to Tri-City Hamfest Council, PO Box 1181, Richland, WA 99352.

OPERATING EVENTS

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MAY 14: Ling Submarine Expedition. The Meadowlands Amateur Radio Association will be aboard the USS Ling (SS297) docked in Hackensack, New Jersey, and will operate under club station N2BMN, starting Saturday at 1500Z through 2100Z. 20 Meters: CW 14.060, SSB 14.310. 40 Meters: CW 7.115, SSB 7.250. 2 Meters: CW 144.100, SSB 144.160, FM 146.550. 6 Meters: CW 50.095, SSB 50.125. For an 8½ × 11 certificate to confirm QSO send large SASE with 37¢ U.S. Postage to PO Box 324, Little Ferry, NJ 07643.

MAY 16-21: Jimmy Stewart's Birthday. The Indiana (PA) County ARC will help the community of Indiana, PA, celebrate this native son's 75th birthday. Club members will be on all General and Novice frequencies at various times and frequencies. SASE with QSL card to W3FVU for a commemorative QSL card.

MAY 21: ARMED FORCES DAY military-to-Amateur cross band operations will be conducted from 21/1300 UTC to 22/0245 UTC May 1983. East coast stations commence operations at 21/1300 UTC and west coast stations commence operations at 21/1600 UTC. Military stations will transmit on selected military frequencies and listen for Amateur stations on the specific frequency to

which she/he is listening. Entries must be postmarked no later than 28 May 1983 and submitted to the respective military commands. Stations copying AIR send entries to: Armed Forces Day Test, 2045th CG/DONJM, Andrews AFB, DC 20331. Stations copying NAM, NAV or NPG send entries to: Armed Forces Day Test, HQ, Navy-Marine Corps MARS, 4401 Massachusetts Ave., N.W., Washington, DC 20390. Stations copying WAR send entries to: Armed Forces Day Test, Commander, 7th Signal Command, Att: CCN-PO-OX, Fort Ritchie, MD 21719.

MAY 21 AND 22: The Clark County Amateur Radio Club, W7AIA, is pleased to announce the third annual Mount Saint Helens QSO party to mark the third anniversary of the explosion of nearby Mt. Saint Helens. 0001 UTC May 21 through 2359 UTC May 22. Look for W7AIA on: SSB 3.895, 7.230, 14.280, 21.360, 28.505. CW 3.705, 7.105, 21.105, 28.105. VHF — various Vancouver and Portland area repeaters. To apply for the award send log information or QSL card and $2.00 (or 8 IRCs) to: Award Manager, W7AIA, PO Box 1424, Vancouver, WA 98668.

MAY 28 AND 29: The Northwest Amateur Radio Club will operate W9LM from 1700Z May 28 to 1700Z May 29 to commemorate their 50 years in Amateur Radio. Frequencies: Phone 10 kHz from lower General 40, 20, 15, and 10. CW 25 kHz from lower edge of Novice bands and 2 meter simplex on 146.52. QSL with SASE for commemorative certificate to: NARC, PO Box 121, Arlington Heights, IL 60006.

JUNE 2, 3 AND 4: S.P.A.R.C., the Southern Piedmont Amateur Radio Club, will operate a special event station, the 10th annual "Helen to the Atlantic Ocean" hot air balloon race, held under the direction of the "Free Spirits of Helen, Inc." The station will be operating SSB between 7200-7250 and 3865-3915 on 40 and 80 meters using club call WD4NHW. For an 8 × 10 certificate SASE to John Anthony, PO Box 28, Sautee, GA 30571.

JUNE 4: The Pennyroyal Amateur Radio Society announces the annual Jefferson Davis QSO party, Saturday, 1500 to 2400 Z. Suggested frequencies: 3.940, 7.260, 14.310, 21.410 and 28.610 MHz phone and 3.730 MHz CW. For an attractive certificate send $1.00 and 3/20¢ stamps with QSL card to P.A.R.S., PO Box 1077, Hopkinsville, KY 42240.

JUNE 10 AND 12: The Wireless Institute of Northern Ohio (W.I.N.O.) will operate a special events station (KO8O) from a winery in Madison, Ohio, to commemorate Ohio Wine Week. Friday 2300Z to 0300Z on 3900 MHz and 7235 MHz. Sunday 1500Z to 2000Z on 7235 MHz and 21360 MHz. For a special QSL certificate send legal SASE with 40¢ postage or coin to above address.

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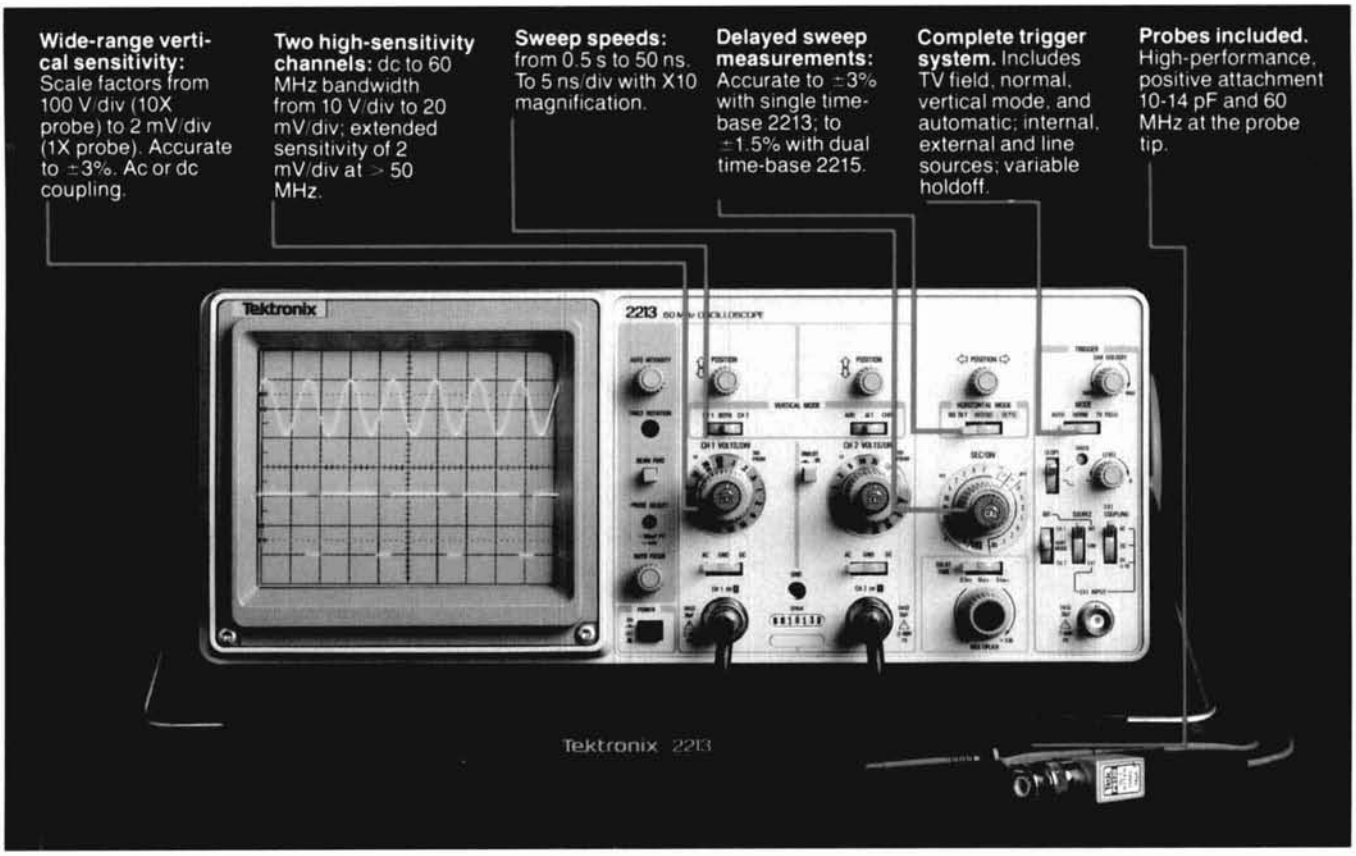

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MEET THE NEW YAESU FT-102

The FT-102 is factory equipped for operation on all present and proposed Amateur HF bands. An extra AUX band position is available for special applications. Equipped for SSB, CW, and AM (RX), the FT-102 may be activated on FM and AM (TX) via the optional AM/FM-102 Module.

The all-new receiver front end utilizes a low-distortion RF preamplifier that may be by-passed via a front panel switch when not needed. Maximum receiver performance is yours with this impressive lineup of standard features: IF Notch Filter, Audio Peak Filter, Variable IF Bandwidth Control, IF Shift, Variable Pulse Width Noise Blanker, Independent SSB and CW Audio Channels with Optimized Audio Bandwidth, and Front Panel Audio Tone Control. Wide/Narrow filter selection is independent of the Mode switch.

The celebrated transmitter section is powered by three 6146B final tubes, for more consistent power output and very low distortion. An RF Speech Processor, Mic Amp Audio Tone Control, VOX, and an IF Monitor round out the transmitter lineup.

Futuristic panel design and careful human engineering are the hallmarks of the FT-102. Convenient pop-out controls below the meters may be retracted when not in use, thus avoiding inadvertant mistuning. Abundant relay contacts, rear panel phono jacks for PTT, microphone/patch input, and other essential interface connections make the FT-102 extremely simple to incorporate into your station.

SPECIFICATIONS

TRANSMITTER

Power Input: (1.8-25 MHz) (28-29.9 MHz)

	(1.8-25 MHz)	(28-29.9 MHz)
SSB, CW	240W DC	160W DC
AM	80W DC	80W DC
FM		160W DC

RECEIVER

Image Rejection:
Better than 70dB from 1.8-21.5 MHz
Better than 50dB from 24.5-29.9 MHz

IF rejection:
Better than 70 dB

Selectivity (−6 dB/ −60 dB):
SSB, CW, AM; 2.7/4.8 kHz (with no optional filters)
Width adjusts continuously from 2.7 kHz to 500 Hz (−6 dB)

Spurious Radiation: Better than −40 dB

SP-102

The SP-102 External Speaker/Audio Filter features a large, high-fidelity speaker with selectable low- and high-cut audio filters. The front panel A-B switch allows selection of two receiver inputs for maximum versatility. Also available is the SP-102P Speaker/Patch.

See your Authorized Yaesu Dealer today for a hands-on demonstration of the rig that everybody's talking about. It's the FT-102, The Transceiver of Champions!

FV-102DM

The FV-102DM Synthesized External VFO tunes in 10 Hz steps. Keyboard entry of frequencies, UP/DOWN scanning, and 12 memories make the FV-102DM a "must" for serious DX or contest work.

FC-102

The FC-102 Antenna Coupler is capable of handling 1.2KW of *transmitter power, with an in-line wattmeter, separate SWR* meter, and A-B input/output selection expanding your station's capability. The optional FAS-1-4R allows remote selection of up to four antennas via one coaxial cable connected to the FC-102.

Price And Specifications Subject To Change Without Notice or Obligation

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YAESU ELECTRONICS CORP. 6851 Walthall Way, Paramount, CA 90723 • (213) 633-4007
Eastern Service Ctr., 9812 Princeton-Glendale Rd., Cincinnati, OH 45246 • (513) 874-3100

NEW

"DX-traordinary."

Superior dynamic range, auto. antenna tuner, QSK, dual NB, 2 VFO's, general coverage receiver.

TS-930S

The TS-930S is a superlative, high performance, all-solid state, HF transceiver keyed to the exacting requirements of the DX and contest operator. It covers all Amateur bands from 160 through 10 meters, and incorporates a 150 kHz to 30 MHz general coverage receiver having an excellent dynamic range.
Among its other important features are, SSB slope tuning, CW VBT, IF notch filter, CW pitch control, dual digital VFO's, CW full break-in, automatic antenna tuner, and a higher voltage operated solid state final amplifier. It is available with or without the AT-930 automatic antenna tuner built-in.

TS-930S FEATURES:

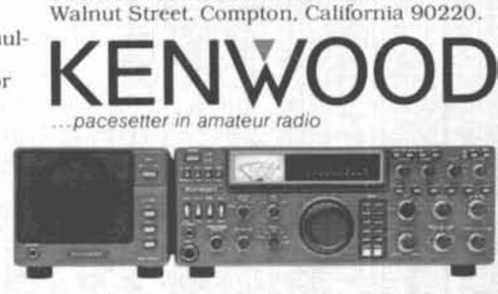
- **160-10 Meters, with 150 kHz-30 MHz general coverage receiver.**
  Covers all Amateur frequencies from 160-10 meters, including new WARC bands, on SSB, CW, FSK, and AM. Features 150 kHz-30 MHz general coverage receiver. Separate Amateur band access keys allow speedy band selection. UP/DOWN bandswitch in 1-MHz steps. A new, innovative, quadruple "UP" conversion, digital PLL synthesized circuit provides superior frequency accuracy and stability, plus greatly enhanced selectivity.
- **Excellent receiver dynamic range.**
  Receiver two-tone dynamic range, 100 dB typical (20 meters, 50-kHz spacing, 500 Hz CW bandwidth, at sensitivity of 0.25 μv, S/N 10 dB), provides the ultimate in rejection of IM distortion.
- **All solid state, 28 volt operated final amplifier.**
  The final amplifier operates on 28 VDC for lowest IM distortion. Power input rated at 250 W on SSB, CW, and FSK, and at 80 W on AM. Final amplifier protection circuits with cooling fan, SWR/Power meter built-in.
- **CW full break-in.**
  CW full break-in circuit uses CMOS logic IC plus reed relay for smooth, quiet operation. Switchable to semi-break-in.
- **Automatic antenna tuner, built-in.**
  Covers Amateur bands 80-10 meters, including the new WARC bands. Tuning range automatically pre-selected with band selection to minimize tuning time. "AUTO-THRU" switch on front panel.
- **Dual digital VFO's.**
  10-Hz step dual digital VFO's include band information. Each VFO tunes continuously from band to band. A large, heavy, flywheel type knob is used for improved tuning ease. T.F. Set switch allows fast transmit frequency setting for split-frequency operations. A=B switch for equalizing one VFO frequency to the other. VFO "Lock" switch provided. RIT control for ±9.9 kHz.
- **Eight memory channels.**
  Stores both frequency and band information. VFO-MEMO switch allows use of each memory as an independent VFO, (the original memory frequency can be recalled at will), or as a fixed frequency. Internal Battery memory back-up, estimated 1 year life. (Batteries not Kenwood supplied).
- **Dual mode noise blanker ("pulse" or "woodpecker").**
  NB-1, with threshold control, for pulse-type noise. NB-2 for longer duration "woodpecker" type noise.
- **SSB IF slope tuning.**
  Allows independent adjustment of the low and/or high frequency slope of the IF passband, for best interference rejection. HIGH/LOW cut control rotation not affected by selecting USB or LSB modes.
- **CW VBT and pitch controls.**
  CW Variable Bandwidth Tuning control tunes out interfering signals. CW pitch controls shifts IF passband and simultaneously changes the pitch of the beat frequency. A "Narrow/Wide" filter selector switch is provided.
- **IF notch filter.**
  100 kHz IF notch circuit gives deep, sharp, notch, better than -40 dB.
- **Audio filter built-in.**
  Tuneable, peak-type audio filter for CW.
- **AC power supply built-in.**
  120, 220, or 240 VAC, switch selected (operates on AC only).
- **Fluorescent tube digital display.**
  Six digit readout to 100 Hz (10 Hz modifiable), plus digitalized sub-scale with 20-kHz steps. Separate two digit indication of RIT frequency shift. In CW mode, display indicates the actual carrier frequency of received as well as transmitted signals.
- **RF speech processor.**
  RF clipper type processor provides higher average "talk-power," improved intelligibility
- **One year limited warranty on parts and labor.**

Other features:
- SSB monitor circuit, 3 step RF attenuator, VOX, and 100-kHz marker.

Optional accessories:
- AT-930 automatic antenna tuner.
- SP-930 external speaker with selectable audio filters.
- YG-455C-1 (500 Hz) or YG-455CN-1 (250 Hz plug-in CW filters for 455-kHz IF.
- YK-88C-1 (500 Hz) CW plug-in filter for 8.83-MHz IF.
- YK-88A-1 (6 kHz) AM plug-in filter for 8.83-MHz IF.
- SO-1 commercial stability TCXO (temperature compensated crystal oscillator). Requires modifications.
- MC-60A deluxe desk microphone with UP/DOWN switch, pre-amplifier, 8-pin plug
- TL-922A linear amplifier (not for CW QSK)
- SM-220 station monitor (not for pan-adapte
- HS-6, HS-5, HS-4, headphones.

More information on the TS-930S is available from all authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

KENWOOD
...pacesetter in amateur radio



Specifications and prices are subject to change without notice or obligation.