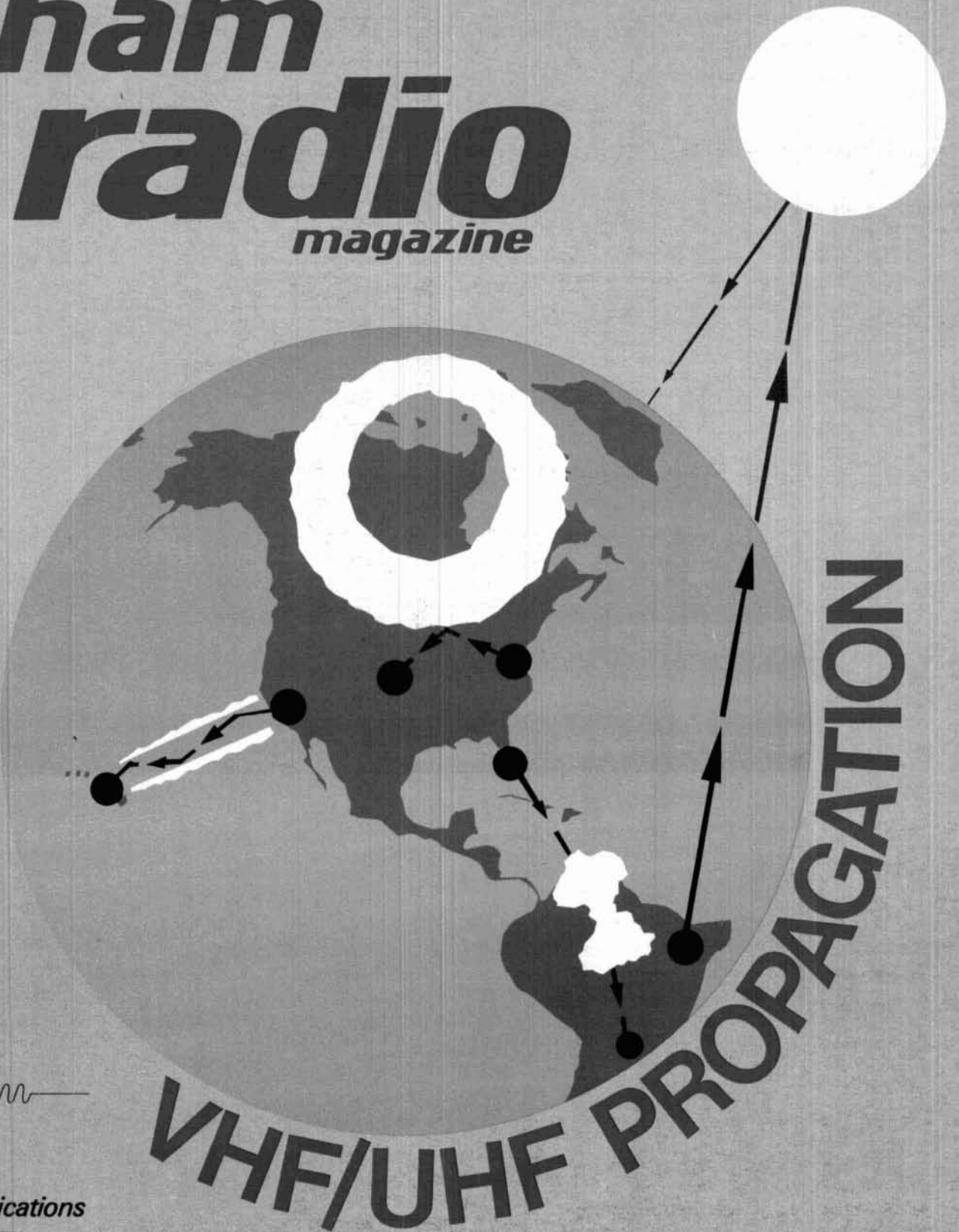
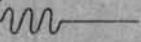


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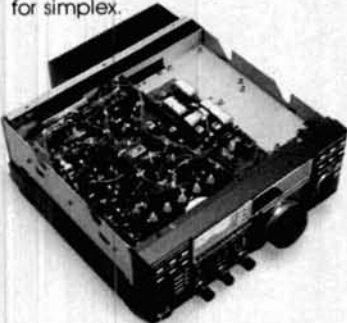
IC-271H

Now a 100 Watt, 2 Meter Base!



For the ultimate in two-meter communications, ICOM presents the IC-271H transceiver with a high dynamic range receiver and a 100 watt transmitter. Operating from the IC-PS30, IC-PS15, or the internal IC-PS35 (optional), the IC-271H brings all the advanced functions of the latest CPU controlled radios to your shack.

100 Watts. Now a two-meter base station with 100 watts of internal power! The IC-271H provides all the power required for operation from remote places to repeaters, or for simplex.



IC-PS30
Power Supply

Subaudible Tones.

Included as a standard feature are 32 built-in subaudible tones which are easily selected by rotating the main tuning knob. PL tones may be stored into memory.

32 Full-Function Memories.

Each tunable memory holds frequency, offset, offset direction, mode and subaudible tone. Each parameter is selected by rotating the main tuning knob in conjunction with the switches on the front panel.

PLL Locked at 10Hz.

An extremely low-noise, professional receiver and a good signal-to-noise ratio PLL allows the IC-271H's synthesizer to lock to 10Hz providing receiver performance unparalleled by any other VHF receiver.

Fluorescent Display. ICOM's high-visibility, multicolor display gives easy-to-read display of all information necessary for logging a contact. Frequency, mode, duplex, offset direction, RIT frequency, memory channel and PL tone can be displayed.

Scanning. The IC-271H can scan memories and programmed sections of the band or modes. Mode-S scan can be used to scan only memories with a particular mode or lock out frequencies continuously busy so the receiver will not stop at that memory channel while scanning.

Other Standard Features.

To facilitate the operation of the IC-271H, ICOM has incorporated a duplex check switch, all-mode squelch, receive audio tone control, S-meter, center meter, seven-year lithium battery memory backup, accessory connector and microphone.

Optional Features. IC-271H options are: switchable preamplifier, CTCSS encoder/decoder (encoder is standard), computer interface and voice synthesizer.

Size. Only 11¼ inches wide by 4¾ inches high, the IC-271H is styled to look good and engineered for ease of operation.



IC-271H
Shown with internal
power supply, IC-PS35

The IC-271A. The IC-271A with 25 watt output is available and has the same features as the IC-271H, plus an optional IC-PS25 internal power supply to make it a compact, go-anywhere two-meter base station. See the IC-271A(H) and other fine ICOM equipment at your ICOM dealer today.



ICOM

The World System

CLEAR CHOICE



For a crystal clear picture, choose a Lowrance System 70 Satellite Receiver

Lowrance System 70 receivers truly have no equal for picture quality. Colors are true and vibrant — not that washed-out look so common in other receivers. Lines are clear and distinct — not fuzzy. Low threshold makes 1000-foot runs a snap. And the audio is crystal clear. No wonder that Lowrance, one of the world's finest electronics companies, is proud to put its name on the new System 70 models.

Look over the multitude of easy-use features. With detent tuning, you click right to the channel you want — no fishing around. A polarity push-button with separate skew adjustment makes polarization changes easy and works with the Polarotor 1, Omni polarizer, or a Ferite device. Fixed and variable audio tuning with wide or narrow filter selection makes audio tuning extremely versatile. The System 70 models are equipped with scan tuning, 125 feet of pre-made cables, built-in modulator, AFC defeat and signal strength meter, so installation and antenna positioning are a breeze.

Two Models to Choose From

The System 70^s has all the remarkable features of the standard 70^s, plus superb stereo reception with *discreet and matrix capability*. The stereo reproduction will please the most discriminating listener, and it's easy to tune with independent subcarrier A and B tuning capabilities.

For System 70 dealers, we provide outstanding support with product brochures, posters, the popular customer question-and-answer brochures AND the best warranty service in the industry.

Lowrance System 70^s and 70^s. They're the clear choice in satellite receivers and downconverters.

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KENWOOD

pacesetter in amateur radio

TS-830S

TS-830S... a "top notch" field proven performer.

The TS-830S is the HF transceiver that delivers the performance the others can only talk about.

Kenwood's TS-830S offers you every conceivable operating feature built-in for 160-10 meters, including the WARC bands. Key operating features

such as wide receiver dynamic range, variable band width tuning, notch filter, adjustable noise-blanker, IF shift (pass-band tuning), and receive capability of WWV on 10 MHz, have established the TS-830S as the first choice of the serious Amateur.

Two 6146B's in the final assure you of rugged, reliable service. The fluorescent tube digital display, RF speech

processor, narrow/wide filter selection on CW/SSB monitor circuit and receiver (RIT) and transmitter (XIT) incremental tuning, add to the operating ease and enjoyment of the TS-830S.

Yes, all these features along with unprecedented reliability have made the field-proven TS-830S truly "top notch".

Optional accessories:

- SP-230 external speaker.

- VFO-230 remote digital VFO with five memories, digital display.
- VFO-240 remote analog VFO.
- AT-230 antenna tuner.
- YG-455C (500 Hz) or YG-455CN (250 Hz) CW filter for 455 kHz IF.
- YK-88C (500 Hz) or YK-88CN (270 Hz) CW filter for 8.83 MHz IF.
- KB-1 deluxe heavyweight knob.



TS-530SP

TS-530SP... "Cents-ational" in performance and value.

No other HF transceiver gives you all these features at such an affordable price.

The TS-530SP covers 160-10 meters, LSB, USB, CW, including WARC bands and it also receives WWV on 10 MHz.

When you turn on your TS-530SP, the IF shift tunes

out interfering signals, and the tunable audio notch filter also helps eliminate QRM. Your frequency is displayed in six digits by the fluorescent tube display, with an analog dial for added convenience. Other key features include wide receiver dynamic range, narrow/wide filter selection for CW and/or SSB, built-in speech processor for extra talk power, adjustable noise-blanker and RIT/XIT to allow independent fine-tuning

of receive or transmit frequencies. All this along with two 6146B's in the final to allow for lasting, dependable operation.

The TS-530SP, solid dependability at a price everyone can afford!

Optional accessories:

- SP-230 external speaker with selectable audio filters.
- VFO-240 remote analog VFO.
- VFO-230 remote digital VFO.
- MC-50 desk microphone.

- AT-230 antenna tuner/SWR/power meter.
- KB-1 deluxe VFO knob.
- YK-88C (500 Hz) or TK-88CN (270 Hz) CW filter.
- YK-88SN (1.8 kHz) narrow SSB filter.

More information on the TS-830S and TS-530SP is available from authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

Specifications and prices are subject to change without notice or obligation.



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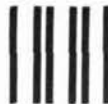
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THE NUMBER 1 QUESTION

I've recently discovered that if I connect two framastans in parallel, water-cool them, operate them in Class E, and drive them with my 2N5109 solid-state QRP transmitter, I can achieve the legal output power level and cover 160 meters through 40,000 GHz without retuning. Would you be interested in seeing a manuscript on this subject?

Every time I read a question like this from a prospective author my interest is definitely aroused. Editors constantly receive telephone and mail inquiries about possible articles covering a wide range of subjects. We at *ham radio* are no exception, because every day we receive proposals for manuscripts ranging in size from quarter-page ham notes through six-part series of epic proportions. In order to encourage you to contribute your wisdom and experience to the pages of *ham radio*, I'd like to tell you what I'd like to see coming through the transom.

If you'll look at a magazine — any magazine — you'll notice that there are a number of realities associated with it. One is the number of pages allocated to editorial content. Ah, but what's editorial content? you ask. Basically, "editorial" content is anything that isn't advertising — technical articles, ham notes, columns, letters, *Presstop*, new product announcements, and even the front cover, as well as (ahem) this editorial. If you were to view each page as if it were a parcel of extremely valuable land, you'd understand the dilemma (and the joy) an editor faces when reviewing manuscripts. So many good ideas . . . and so little space!

We have a mandate from our readers, consistent with our charter and clearly reaffirmed by the Reader Survey of September, 1983, that directs us to provide high quality *technical* material. For my part, I'm more than willing to meet this demand. For those of you who are thinking of proposing an idea for an article, please keep the following guidelines in mind:

Length. Don't worry about it. With very few exceptions (and this editorial may be one of them), the subject will dictate the length of the article. It's difficult to write more than a paragraph or two about how to insert 6146s into sockets (with a hammer, of course), so if you're going to write on a small, limited topic, keep your article short. But if you're going to deal with a larger topic in a more comprehensive way, then give your subject the room it needs; consider, for example, K2BT's series on vertical phased arrays, which ran in six installments spread over a year's time.

Style. Yours is *fine*. Just keep it simple; the point is, after all, to convey information. Don't worry about grammar; we'll worry about that. It may help to remember this rule of thumb: *write to inform, not impress*.

Accuracy. Here's where we all get into trouble now and then. "In conclusion, my superduper loudenboomer metal noodle, described herein, works on the principle of thermoquality of non-homogeneous turf." It very well might. But please prove it. If you've discovered some fabulous new technique that promises to revolutionize the world's understanding of antennas, propagation, or anything else, we want to hear about it . . . but please present your idea in a logical sequence of facts and build your case. If you decide to compare your method to a standard, make sure your setup is carefully designed and that it generates reproducible results.

Subject. This I leave to you. However, you might want to ask yourself one question before taking pen in hand. How many readers will be interested? Three, three thousand, or thirty thousand? This is especially true in regard to conversions. Not too many readers are interested in converting a BC610 to 11 meters. However, a simple circuit that adds the three WARC bands to an older transceiver will generate substantial interest. How about a short article on receivers, or on some particularly exciting aspect of future technology? I'll be glad to consider your idea. Just pick up the phone or send a one-page outline of your proposed manuscript. (I can't, by the way, consider simultaneous submissions.)

A final word. Please double space your manuscript. Don't hide or crowd your words . . . let them sing out and tell your story. For this — and more — I thank you.

Rich Rosen, K2RR
Editor-in-Chief

FREE MFJ SOFTWARE

Free MFJ RTTY/ASCII/CW software for VIC-20 or C-64 with purchase of MFJ-1224, MFJ-1225 or MFJ-1228 from MFJ. Send/receive Baudot, ASCII, CW. Type ahead buffer. 24 hour clock. Supports VIC printer. Menu Driven. MFJ-1224/1225 cable. On tape. Available separately for \$29.95.

RTTY/ASCII/ AMTOR/CW INTERFACE CARTRIDGE

FOR
VIC-20/C-64 MFJ-1228 \$ 69⁹⁵



FREE MFJ RTTY/ASCII/CW Software
INCLUDES MFJ-1228, SOFTWARE ON TAPE. ADD
VIC-20 OR C-64 AND RIG TO ENJOY COMPUTER-
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Most versatile RTTY/ASCII/AMTOR/CW interface cartridge available for VIC-20 and Commodore 64. Gives you more features, more performance, more value for your money than any other interface cartridge available.

Same interface cartridge works for both VIC-20 and Commodore 64. Plugs into user's port.

Choose from wide variety of RTTY/ASCII/CW, even AMTOR software. Not married to one on-board software package. Use MFJ, Kantronics, AEA plus other software cartridge, tape or disk.

850 Hz and 170 Hz shifts on receive and transmit. Has mark and space outputs for scope tuning.

Normal/Reverse switch eliminates retuning. True dual channel mark and space active filters and automatic threshold correction gives good copy when one tone is obliterated by QRM or selective fading.

Easy, positive tuning with twin LED indicators.

Narrow 800 Hz active CW filter. Automatic PTT.

Exar 2206 sine generator for AFSK output.

Shielded XCVR AFSK/PTT interface cable provided. Plus or minus CW keyed output. FSK out.

Powered by computer (few ma.), no power adapter to buy or extra wire to dangle or pick up/radiate RFI.

Glass epoxy PCB. Aluminum enclosure. 4 1/2 x 4 1/2 x 1 1/2".

UNIVERSAL SWL RECEIVE ONLY COMPUTER INTERFACE FOR RTTY/ASCII/AMTOR/CW

MFJ-1225
\$ 69⁹⁵



FREE MFJ RTTY/ASCII/CW Software
TAPE AND CABLE FOR VIC-20 OR C-64. ORDER MFJ-1225/
MFJ-1264 FOR VIC-20 OR MFJ-1225/MFJ-1265 FOR C-64.

Use your personal computer and communications receiver to receive commercial, military and amateur RTTY/ASCII/AMTOR/CW traffic.

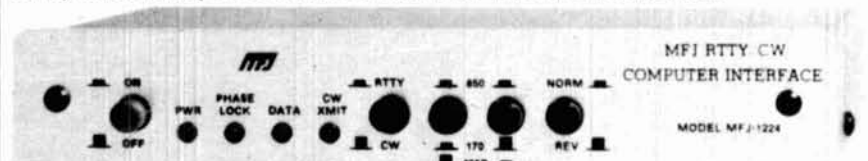
Plugs between receiver and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most other personal computers. Requires appropriate software.

Use MFJ, Kantronics, AEA and other RTTY/ASCII/AMTOR/CW software.

Copies all shifts and all speeds. Twin LED indicators makes tuning easy, positive. Normal/Reverse switch eliminates tuning for inverted RTTY. Speaker out jack. Includes cable to interface MFJ-1224 to VIC-20

UNIVERSAL RTTY/ASCII/AMTOR/ CW COMPUTER INTERFACE

Lets you send and receive computerized RTTY/ASCII/AMTOR/CW. Copies all shifts and all speeds. Copies on both mark and space. Sharp 8 pole active filter for 170 Hz shift and CW. Plugs between your rig and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 or other personal computers. Uses MFJ, Kantronics, AEA software and other RTTY/CW software.



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CABLES. YOU NEED ONLY VIC-20 OR C-64 AND RIG TO ENJOY COM-
PUTERIZED RTTY/ASCII/CW. ORDER MFJ-1224/MFJ-1264 FOR VIC-20,
MFJ-1224/MFJ-1265 FOR C-64.

MFJ-1224
\$ 99⁹⁵

New MFJ-1224 RTTY/ASCII/AMTOR/CW Computer Interface lets you use your personal computer as a computerized full featured RTTY/ASCII/AMTOR/CW station for sending and receiving. Plugs between rig and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most others.

Use MFJ software for VIC-20, Commodore 64 and Kantronics for Apple, TRS-80C, Atari, TI-99 and most other software for RTTY/ASCII/AMTOR/CW.

Easy, positive tuning with twin LED indicators. Copy any shift (170, 425, 850 Hz and all other shifts) and any speed (5-100 WPM RTTY/CW and up to 300 baud ASCII).

Copies on both mark and space, not mark only or space only, to improve copy under adverse conditions.

Sharp 8 pole 170 Hz shift/CW active filter gives good copy under crowded, fading and weak signal conditions. Automatic noise limiter suppresses static crashes for better copy.

Normal/Reverse switch eliminates retuning. +250 VDC loop output drives RTTY machine. Speaker jack.

Automatic tracking copies drifting signal. Exar 2206 sine generator gives phase continuous AFSK tones. Standard 2125 Hz mark and 2295/2975 Hz space. Microphone line: AFSK out, AFSK ground, PTT out and PTT ground.

FSK keying output. Plus and minus CW keying. CW transmit LED. External CW key jack.

Kantronics compatible socket.

Exclusive general purpose socket allows interfacing to nearly any personal computer with most appropriate software. Available TTL lines: RTTY demod out, CW demod out, CW-ID input, +5 VDC, ground. All signal lines are buffered and can be inverted using an internal DIP switch.

Use Galfo software with Apple, RAK with VIC-20, Kantronics with TRS-80C, TI-99, N4EU with TRS-80 III, IV. Some computers with some software may require some external components.

Metal cabinet. Brushed alum. front. 8x1 1/4x6 in. 12-15 VDC or 110 VAC with adapter, MFJ-1312, \$9.95. MFJ-1223, \$29.95, RS-232 adapter for MFJ-1224.

SUPER RTTY FILTER

MFJ-725
\$ 39⁹⁵



Super RTTY filter greatly improves copy under

crowded, fading and weak signal conditions. Improves any RTTY receiving system. 8 pole bandpass active filter for 170 Hz shift (2125/2295 Hz mark/space). 200 or 400 Hz bandwidths. Automatic noise limiter. Audio in, speaker out jacks. On/off/bypass switch. "ON" LED. 12 VDC or 110 VAC with optional AC adapter, MFJ-1312, \$9.95. 3x4x1 inch aluminum cabinet.

or Commodore 64. 4 1/2 x 1 1/4 x 1/4 inches. 12-15 VDC or 110 VAC with optional adapter, MFJ-1312, \$9.95.

CW INTERFACE CARTRIDGE FOR VIC-20/C-64

High performance CW interface cartridge. Gives excellent performance under weak, crowded, noisy conditions. Works for both VIC-20 and Commodore 64. Plugs into user's port.

4 pole 100 Hz bandwidth active filter. 800 Hz center frequency. 3 pole active lowpass post detection filter. Exclusive automatic tracking comparator.

Plus and minus CW keying. Audio in, speaker out jacks. Powered by computer.

Includes Basic listing of CW transmit/receive program. Available on cassette tape, MFJ-1252 (VIC-20) or MFJ-1253 (C-64), \$4.95 and on software cartridge, MFJ-1254 (VIC-20) or MFJ-1255 (C-64), \$19.95.

You can also use Kantronics, AEA other software. Also copy RTTY with single tone detection.

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*Apple, Atari, TI-99/4A, TRS-80C,
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Computers*



Suggested Retail Price 269.95

Interface II is the new Kantronics transceiver-to-computer interface. Interface II features a highly sensitive front end with mark and space filtering. Even the most discerning operator will be surprised with the Interface II's ability to dig out signals in poor band conditions. Our unique tuning system even displays signal fading.

X-Y scope outputs and dual interface outputs for VHF and HF connections make Interface II compatible with almost any shack. All three standard shifts are selectable, and Interface II is AMTOR compatible. Interface II is designed for use with Kantronics software.

Kantronics Software — The Industry Standard

Hamsoft

Our original program for reception and transmission of CW/RTTY/ASCII. Features include Split Screen Display, Message Ports, Type-ahead buffer, and printer compatibility. Apple Diskette \$29.95, VIC-20 cartridge \$49.95, Atari board \$49.95, TRS-80C board \$59.95, TI-99/4A cartridge \$99.95.

Hamtext

All the features of Hamsoft with the following additional capabilities: text editing, received message storage, variable buffer sizes, diddle, word wraparound, time transmission, and text transmission from tape or disc. The program is available on cartridge for the VIC-20 or Commodore 64, and diskette for the Apple. Suggested Retail \$99.95.

Hamsoft/Amtor

This program has Hamsoft features with the added ability of communicating in the newest coded amateur format-AMTOR. AMTOR offers error free low power communication. Hamsoft Amtor is available for the Atari, TRS-80C, VIC-20, and Commodore 64 computers. Suggested Retail \$79.95.

Amtorsoft

For the serious AMTOR operator using a VIC-20, Commodore 64, or Apple computer. This program is similar to Hamtext in capabilities, but can only be used for AMTOR. The Apple version includes both Hamtext and Amtorsoft on one diskette (\$139.95), while the Vic-20 and Commodore 64 cartridge is just Amtorsoft (\$89.95).

Kantronics UTU

The Universal Terminal Unit For Everyone Else



Suggested Retail Price 199.95

KANTRONICS SETS A NEW STANDARD WITH THE KANTRONICS UNIVERSAL TERMINAL UNIT.

UTU allows any computer with an RS232 port and a terminal program to interface with any transceiver. Additional software isn't necessary with UTU, as an internal microcomputer gives the unit data processing capabilities to send and receive in four coded amateur formats; Morse code, Radioteletype, ASCII, and AMTOR.

Sample terminal programs for IBM, TRS-80 Model III and IV, Kaypro, and other computers are included in the manual. Enhanced features can be user defined by altering the terminal program, giving you

flexibility to program for your specific needs.

The Kantronics Universal Terminal Unit can send and receive CW at 6-99 WPM; RTTY 60, 67, 75, 100, and 132 WPM; ASCII 110, 150, 200, and 300 baud; and AMTOR. Dual tone detection and our unique bargraph tuning system make tuning fast and easy. Additional LEDs indicate Lock and Valid status during AMTOR operation. The RS232 port is TTL or RS232 level compatible.

If you've been waiting for a Kantronics system for your computer, the wait is over.

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OWN THE WORLD WITH THE R3 NO RADIAL VERTICAL 10, 15, 20 METERS

The R3 half wavelength design eliminates the ground radial system required by other verticals. Optimum current distribution gives more efficiency and low angle radiation for DX communications.

R3 brings high performance antenna features to those living in apartments, condominiums or on small city lots. Even if you have plenty of space, R3's combination of neat appearance and DX capability make it ideal for your station. The R3 includes an integral tuner to give a perfect match across 10, 15, and 20 meters. The remote tuning feature allows easy fingertip control as you operate your station.

R3 is a complete antenna system ready to install in virtually any location from ground level to roof top.

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Can Be Easily Stored and Set Up For
Portable or Temporary Operation

Add up the features—you'll find that you can have ALL OF THIS PERFORMANCE without the need to buy tower, rotator and associated hardware. *R3 IS ANOTHER PRODUCT CREATED FOR THE ENJOYMENT OF YOUR HOBBY BY THE WORLD RENOWNED CUSHCRAFT ENGINEERING DESIGN TEAM.*

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TELEX 953-050 CUSHSIG MAN

AVAILABLE THROUGH DEALERS WORLDWIDE

OSCAR 11 IS BACK ON THE AIR AFTER 10 WEEKS OF FRUSTRATING SILENCE. UOSAT OSCAR 11, the University of Surrey's scientific satellite, finally responded to signals from its parent command station May 14 and is now being tested to uncover its post-launch problem.

Launched March 1 From Vandenberg AFB in California, the English Amateur satellite had gone off the air after only three orbits and then staunchly resisted all attempts to bring it back to life. The key to its resuscitation was provided by a crew in Greenland, who used a 100-foot dish to hear signals leaking from its 1.2 GHz command receiver that both confirmed its actual orbital position and provided clues to unlocking the command hangup!

OSCAR 11's Three Beacons Can Now Be Heard Again on 145.825, 435.025, and 2304.5 MHz.

Another Sophisticated Amateur Satellite Could Be In The Offing, with a projected early 1986 launch date. This possible launch opportunity would permit a large payload, at least as heavy as OSCAR 10, opening the door for still another multi-function Amateur bird.

A World-Spanning Set Of Geostationary Amateur Satellites is also currently under consideration by AMSAT. Operating in the 1.3 or 2.3 GHz bands and stationed at suitable intervals around the equator, these satellites could provide a round-the-clock worldwide communications capability far beyond that of present orbiting Amateur satellites. Such a project would be expensive, however, so before proceeding too far with it AMSAT would like to hear expressions of interest and support. Write AMSAT, Box 27, Washington, D.C. 20044.

VOLUNTEER EXAMINER COORDINATORS ARE NOW IN PLACE IN 10 of the 13 areas designated by the FCC. The sixth district now has a VEC, the Greater Los Angeles Amateur Radio Group (GLAARG), a grouping of area clubs; the San Diego Amateur Radio Council (SANDARC), should also have FCC acceptance before this sees print. Two additional VECs are on board in the fourth district, VE-administered exams have already been given in Alaska and the second, eighth and ninth call areas as this went to press, and GLAARG was hoping to start giving exams in the LA area in conjunction with Field Day. This leaves only the first and zero call areas, and the Pacific, without at least one acceptable VEC, though Wayne Green, W2NSD, has told Westlink that he intends to apply for first district VEC through the radio club at his recently established Wayne Green University.

The Proposal To Permit Exam Expense Reimbursement will probably be considered by the Commissioners by mid-July, and if there's no hitch, exam fees could be in place before Labor Day. If so, expect the ARRL to submit its long-awaited VEC proposal very quickly. Just how soon a League-sanctioned program could get under way is questionable, however. The experience of those VECs already up and running is that both the necessary paperwork and the exam process itself are sufficiently complicated to require some formal VE training. Dayton, for example, gives its VEs two three-hour training sessions. The League, however, expects to prepare its VE corps by simply distributing a "training manual!" Another factor to be resolved is whether the League can build an adequate "Chinese Wall" between its VEC role and its Amateur training and training publications activities, a problem that will also be a potential obstacle to any proposal from a Wayne Green enterprise.

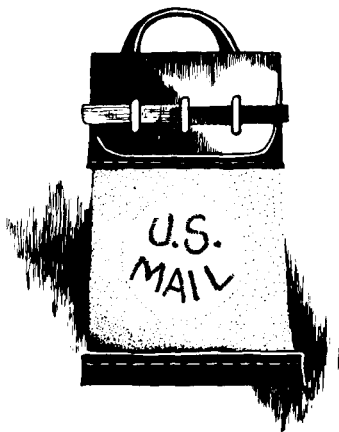
THE 1984 SUMMER OLYMPIC TORCH RUN KICKED OFF MAY 8 in New York City and passed through Chicago two weeks later. The torch bearers each run a four-mile segment, with their efforts coordinated by teams of 16 Amateur volunteers from AT&T's Telephone Pioneers of America. Two meters is used for the bulk of their communications, using both simplex and area repeaters when available. By the time the run ends in Los Angeles in late July, the runners (and their Amateur Radio support teams) will have covered over 9000 miles.

ADDITIONAL EXPANSION OF PHONE BANDS COULD BE DECIDED before the end of July. Unlike the earlier FCC action on phone band expansion, which concerned only 20 meters, this time all other bands in the NPRM—75, 40, 15, and 10 meters—will be considered. However, just which phone bands will be changed and by how much is still an open question. Canada's Department of Communications has proposed doing away with mandated subbands in its Amateur service!

Amateur Access To The New 902 MHz Amateur Allocation may also be relatively imminent. IRAC (the Interdepartmental Radio Advisory Committee) seems to have no objection to giving Amateurs the band on a secondary basis, though RCA is protesting that its video disc players are susceptible to 902 MHz RFI. In the HF spectrum, 24 MHz may also see Amateur occupancy soon as well, but problems with existing users make access to 18 MHz a more distant hope.

Getting New Bands From WARC Has A Negative Aspect, as well. Along with the gains come losses, the first of which will be a severe cut in the 1215-1300 MHz band. Amateurs along the Canadian border will also lose access to 420-430 MHz, and eventually (when AM broadcast expands upward) radiolocation will again lay claim to 1900-2000 MHz.

FURTHER EXPANSION OF 20-KHZ CHANNELIZATION TO TWO METER'S TOP HALF will be a major topic at the Texas VHF-FM Society's August 11 meeting in Austin. Heading up the forum on this controversial change is Joe Jarrett, K5FOG, who seeks inputs from concerned Amateurs across the country. Papers (from those unable to attend in person) and outlines of oral presentations on the subject should go to Joe at 8501 Spring Valley Drive, Austin, Texas 78736.



comments

on the VHF/UHF challenge

Dear HR:

I am especially pleased to see Joe Reisert's VHF/UHF column and have written a personal note of thanks to him. I've been an avid V/UHF'er for over 20 years and try to communicate the excitement and challenge of operating on the VHF/UHF bands to other hams whenever I can. That's why I'm glad to see you giving someone of Joe's stature and expertise a chance to reach a large "lay" audience on a monthly basis!

Jack C. Parker, KC0W
Bismarck, North Dakota

Dear HR:

The January, 1984, issue came today, and I'm very pleased to be able to look forward to Joe Reisert's "VHF/UHF World" every month.

I'm one of a handful of Amateurs in Montgomery who operate 2-meter SSB and plan to be on 432 soon. I am NCS of the Central Alabama 2-meter SSB net each Wednesday night at 0200 (Thursday) UTC on 144.250 MHz.

I also really liked the January "Ham Notebook." There have been many repeater controllers published in various publications, but this is the first time I have seen a repeater-to-phone schematic. This is a circuit I have been looking for — thanks.

Alton L. Erdman, W4CNO
Montgomery, Alabama

Timex/Sinclair newsletter

Dear HR:

A specialized newsletter is available for Amateurs with Timex-Sinclair computers. *QZX* is a monthly publication that includes programs and news features pertaining to Sinclair computers. At \$12 per year, I think it's a great resource for Sinclair computer owners; one recent issue, for example, was dedicated to RTTY applications.

For more information, contact *QZX* at 2025 O'Donnell Drive, Las Cruces, New Mexico 88001.

Tom Hart, AD1B
Westwood, Massachusetts

new MSO for RTTY

Dear HR:

A new MSO (Message Storage Operation) system has been established in the New York metropolitan area by N2CKA. The frequency of operation is 145.680 MHz-FM, using 100 WPM (74 baud) Baudot Code.

All Amateurs in the New York-New Jersey-Connecticut area (for that matter, anyone who can "hit" the MSO from elsewhere) are encouraged to leave items of interest, bulletins, or just "mail."

The MSO uses standard DS 3100 type format. The access code, "MSOCKA.HELP" will bring a list of commands to assist the new user. "EXIT" is used to "close" or deactivate the system.

N2CKA or I will be glad to help users unfamiliar with MSO operation to get off on the right foot.

Rich Tashner, N2EO
Whitestone, New York

can you help?

Dear HR:

I am in possession of a 6-channel HF-SSB marine transceiver made by Maritek — Model No. SB6-80, approximate date of manufacture, 1973.

I have been able to trace the company to the following address: 1819 South Central, Kent, Washington, 98031, but letters have been stamped "Not known" and returned. No phone number is listed.

I would like very much to have a copy of the workshop service handbook and/or circuit details, a copy of the operations handbook, and any other information — but specifically that which applies to the settings of the taps of the output stage.

I can arrange to have these photocopied in either the U.S. or Canada, or here in the U.K., and the original returned. I am willing to reimburse any expenses incurred.

Kris Partridge, G8AUU
6 Blagdon Walk,
Teddington, TW11 9LN,
United Kingdom

While the HI MANUALS catalog doesn't list the Maritek SB6-80, it's often a helpful source of hard-to-find manuals and schematics. For a copy, write to HI MANUALS, P.O. Box 802HR, Council Bluffs, Iowa 51502; enclose \$1.00.

Editor

operating etiquette

Dear HR:

I'm delighted when editors speak out about the selfish operating practices prevalent on the HF bands (Reflections, *ham radio*, February, 1984). On the accidental occasions when I work DX, I want to get to know the other guy and find out interesting things about his country. I would never insult a foreign ham by implying that I am interested in him only for his QSL. If I naively try to converse for more than a couple of minutes, however, the vultures pounce.

I'm also dismayed by hams who hog frequencies, claiming they are participating in phantom "nets" or handling nonexistent "overseas phone-patch traffic." I've heard better operating

practices on the frequencies between 10 and 11 meters! CB isn't to blame; some of the most rules-conscious hams I know are ex-CB'ers who hoped to find something better in Amateur Radio.

These things, plus the obnoxious proliferation of contests, cause me to confine most of my activity to experimental modes of communication where contacts are rare but always stimulating.

There are two kinds of hams — operators and experimenters. Both are necessary, but the operators vastly outnumber the experimenters. Bravo for *ham radio* for supporting us underdogs!

Frank Reid, W9MKV
Bloomington, Indiana

short circuit filter design

In fig. 6 of W6NRW's article, "Graphic Filter Design," (April, 1984, page 37), the resistor labeled 528.2 should be labeled 582.2. This nominal 7 percent error in value results in some peaking and a general tilt to the filter's passband.



Building a current *ham radio* project? Call the Short Circuit Hotline any time between 9 AM and Noon, or 1 to 3 PM — Eastern time — *before* you begin construction. We'll let you know of any changes or corrections that should be made to the article describing your project.

(See "Publisher's Log," April, 1984, page 6, for details.)



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the VHF/UHF primer: an introduction to propagation

To really work DX,
try a new mode

One of the most interesting aspects of the world above 10 meters is radio wave propagation. Sure, we've all heard about F2, tropo, meteor scatter, ducting, EME, and perhaps auroral propagation. But are these the prime or only ways of working DX on VHF/UHF? No way!

In preparing my monthly column for *ham radio*, I've noticed that I'll occasionally identify a propagation mode without providing any explanation about how that mode works. Sometimes it's difficult to readily identify a particular mode of propagation on the VHF/UHF frequencies because not all modes are well understood. And different propagation modes are frequently combined, making identification difficult at best.

Over the years, the many articles written about VHF/UHF propagation have only rarely covered more than a few modes at a time. Lesser known modes have been hidden away and almost forgotten. In this article, I'll identify and explain the most common modes of radio propagation, discuss some newly discovered, less common ones, and try to provide some insight into how you can exploit them and perhaps discover some new modes yourself. Wherever possible, references will be listed for those interested in pursuing the individual subjects further.

Before we proceed, remember that communications on any frequency is limited not only by the propagation mode and path length, but by several other factors such as transmitter power, receiver sensitivity, and antenna gain, among others. A full discussion of the latter parameters would fill an entire article, if not a book; hence, I'll limit this discussion to a basic introduction and a review of most of the identified

VHF/UHF propagation modes, as well as the operating techniques that make use of these modes. I'll begin with the propagation modes on the lowest VHF frequencies and move on upward through SHF, adding some of my own observations and suggestions about how to use each mode to its best advantage.

line-of-sight

Line-of-sight, surely the most common form of VHF/UHF propagation; is easily understood.^{1,2} At one time it was thought to be the *only* reason to use VHF/UHF; even now, the idea of QRM-free local communications is appealing.

Light and radio signals usually travel in relatively straight lines. If the antenna height is known, a simple formula can be used to determine the distance to the horizon:

$$D \text{ (miles)} = \sqrt{1.5H} \quad (1)$$

where H is in feet,

$$D' \text{ (km)} = \sqrt{12.75H'} \quad (2)$$

where H' is in meters.

Because of changes in air pressure, temperature, and humidity along the path, the refractive index of the atmosphere may change and bend or refract signals over a greater distance than the normal line-of-sight. Generally speaking, this refractive index averages 1.33, meaning that we can normally communicate over a distance 33 percent further than the normal line-of-sight. To account for this we can modify eqs. 1 and 2 as follows:

$$D \text{ (miles)} = \sqrt{2H} \quad (3)$$

or
$$D' \text{ (km)} = \sqrt{17H'} \quad (4)$$

For example, station "A" has a 50-foot (15.24 meter) tower. It has a horizon of approximately 8.66 miles (13.94 km) and a radio horizon of 10 miles (16.09 km).

By Joe Reisert, W1JR, 17 Mansfield Drive,
Chelmsford, Massachusetts 01824

table 1. Claimed 2-meter (and up) terrestrial DX records.

frequency band	record holder	date	mode	DX	
				miles	km
144-148 MHz	I4EAT-ZS3B	30 March 1979	Trans. Eq.	4840	7788
220-225 MHz	KP4EOR-LU7DJZ	9 March 1983	Trans. Eq.	3670	5906
420-450 MHz	KD6R-KH6IAA	28 July 1980	Tropo. duct.	2550	4103
1240-1300 MHz	VK5MC-VK7KZ/P	23 Jan. 1980	Tropo. duct.	1422	2290
2300-2450 MHz	VK5QR-VK6WG/P	27 Jan. 1978	Tropo. duct.	1190	1883
3300-3500 MHz	G3LQR-SM6HYG	11 July 1983	Tropo.	576	927
5650-5925 MHz	G3ZEZ-SM6HYG	12 July 1983	Tropo.	610	981
10-10.5 GHz	I0SNY/EA9-I0YLI/IT9	18 July 1983	Tropo. duct.	1034	1663
24-24.5 GHz	DJ2UH/P-DJ4YJ/P	21 Feb. 1982	Tropo.	152	244
48 GHz and up:	none reported				

Note: EME hasn't been included since it would distort the records significantly. EME DX of over 11,000 miles (17,699 km) has been accomplished on 2 meters, 70 cm and 23 cm. 220 MHz is only limited by the lack of frequency allocations worldwide. 13 cm is the highest band where Amateur EME QSOs have been claimed.

Station "B" has a 100-foot (30.48 meter) tower. It has a horizon of approximately 12.25 miles (19.71 km) and a radio horizon of 14.14 miles (22.76 km). If stations "A" and "B" are on opposite ends of a straight line between the same point on the horizon, the distances can be added to find the maximum path length. In this example the line-of-sight distance would be 20.91 miles (33.65 km) and the radio horizon would be 24.14 miles (38.85 km). If two stations are attempting to communicate, any obstructions or trees at the common point on their respective horizons may attenuate signals!

path loss attenuation

Space does not permit me to discuss path loss attenuation at length; see reference 2 for a detailed summary of this phenomenon. In brief, it may be useful to know that typical line-of-sight attenuations for a 10-mile (16 km) unobstructed radio path are 90.5 dB at 50 MHz, 109.3 dB at 432 MHz, 123.8 dB at 2304 MHz and 136.6 dB at 10 GHz. Due to the inverse square law, attenuation increases or decreases by 6 dB every time you either double or half the path length or frequency, respectively. Hence, if you try to double the path length (providing you have line-of-sight), the path loss will be 6 dB greater.

F2 propagation

The supreme propagation mode for DX and the workhorse of the HF bands is F2 propagation. Once it was thought that ultraviolet radiation from the sun would never be sufficient to ionize the ionosphere sufficiently to support communications on 50 MHz via the F2 layer (approximately 150 to 250 miles or 250 to 400 km above the earth), but the experts were proven wrong when W1HDQ contacted G6DH crossband (6 to 10 meters) via this mode on November 26, 1946. Only hours later a transcontinental 6-meter two-way

QSO using the same mode between W4GJO in Florida and W6QG in California occurred. Six-meter F2 was not too common during solar cycle 18, and the sun "cooled down" by November, 1947.

The International Geophysical Year (1957-1958) helped numerous stations obtain 6-meter permits where operation was normally forbidden. In October 1957 W4UMF worked SM5CHH, signaling what may have been the start of the greatest F2 openings ever recorded on 6 meters. Later that year K6GDI submitted the QSLs to qualify for the first WAC above 10 meters, showing the worldwide participation. In 1957, solar cycle 19 hit a tremendous peak, the highest recorded in history, when on December 24 to 25, the sunspot count reached 355 and worldwide propagation, even via the long path, became commonplace on 6 meters. But by early 1960, this cycle was on the decline, and unfortunately, solar cycle 20 displayed a more normal solar activity peak level with some 6-meter F2 contacts reported between November, 1967, and February, 1970. Most were single-hop contacts. It began to look as if we'd never see F2 on 6 meters again in our lifetime.

However, in the fall of 1978, during cycle 21, solar activity increased dramatically and F2 propagation began anew on 6 meters. The mean sunspot count in December, 1979, was 164.5, the highest for cycle 21. Unfortunately, many countries no longer permitted Amateur operation on 6 meters because of TV and other frequency allocations. As a result, many VHFers outside the United States had to be satisfied with SWLing or 6 to 10 meter crossband QSOs. 1980 saw a big F2 dip in the United States, but surprisingly, propagation returned for a strong second session in November, 1981, slowly diminishing in late 1982. (As I wrote this column, in March of 1984, F2 returned, with some USA areas working VK's and ZL's. No guess on how long it will last, but enjoy!)

F2 propagation requires a very high sunspot count, typically greater than 125, which is roughly equivalent to a 2800 MHz solar flux of 175 (as broadcast at 18 minutes after each hour on radio station WWV). Generally speaking, in the continental United States, openings start first at the southern latitudes, slowly working up to the northern latitudes over a period of days to weeks as the ionosphere gets "pumped up." Hence the solar activity has to be sustained for at least several days in a row. In the continental USA, openings usually occur between late October and March, favoring southern latitude stations.

At the first appearance of F2, single hop distances are right at the MUF and very long (typically 2500 miles or 4000 km), getting shorter as the ionization builds for several days. As the ionization increases, the MUF slowly rises, permitting operation above 52 MHz. Six-meter communications with low power (10 watts or less) become possible even with dipole antennas. If conditions remain favorable, multiple hops become possible.

The best propagation between two points usually occurs when the sun is about halfway between the stations and almost always requires that the entire path be in sunlight. At times the path can be rather selective, especially on multiple hops; this means that stations as few as 10 miles (16 km) apart may not be able to hear the same distant station. F2 can also link up with sporadic E (more on this later) and extend the path. When solar disturbances occur, the north-south paths show little or no change and often become enhanced soon after the storm subsides. However, the east-west paths drop off quickly and are usually good only during undisturbed solar periods.

Although several crossband 50-70 MHz QSOs were reported during cycle 21 between VE1ASJ and the United Kingdom, the 70 MHz signals were almost certainly not propagated by F2 but rather by sporadic E, since sporadic E propagation was in evidence on 6 meters during these openings.

Much of the success during cycle 21 can be attributed to improved gear, propagation beacons, monitoring of commercial paging and television stations (such as the BBC on 48.25 MHz), and the various liaison nets, especially those on 28.885 MHz (this frequency is still used whenever 10 meters is open). Most of the 6 to 10 meter crossband operation takes place near this frequency. Solar bulletins on radio station WWV at 18 minutes after each hour are also helpful because they report solar flux, an indication of sunspot count, and disturbance warnings via the "A" and "K" indices. Much more information on F2 can be found in "The World Above 50 MHz" column in *QST* during the appropriate years. It's doubtful that any widespread F2 propagation will occur on 6 meters again until about the year 2000, but it sure was great while it lasted!

backscatter

This mode of propagation, a form of radar, often precedes sporadic E and F2 openings. It is most prevalent on 10, 15, and 20 meters and sometimes occurs even on 40 meters. Its presence indicates that the MUF is very high. In backscatter operation, what happens is that an area of the ionosphere is so highly charged that signals traversing the E or F2 layer path strike the earth at some distant point and are scattered. If two stations running reasonable power and antenna gain aim at this common scattering point, communication is made possible by reflection. Because signals arrive from several different directions at the same time (multipath), they are usually weak and distorted. A good time to look for 6-meter backscatter is when propagation is good on 10 meters; even then, it may be difficult to spot unless there is lots of activity. This mode is primarily limited to 6 through 40 meters and can be used for DX even up to 3000 miles (4825 km).

midlatitude intense sporadic E

This is truly the workhorse mode for DX on 6 meters. Propagation is typically from ionized clouds located in the E layer and usually approximately 60 miles (100 km) above the earth in the midlatitudes (25 to 55 degrees north latitude). There is also equatorial and polar sporadic E, but they are slightly different in nature and of little value for continental USA stations since they are too far south or north to be of any use.

In the continental USA, sporadic E propagation usually peaks near the summer solstice (June 21). Typical limits are from May to early August but can occur any time of year. Typical DX limits are about 300 to 1300 miles (485 to 2100 km) per hop but two and even three hops are not uncommon on 6 meters. A lesser peak occurs approximately within plus or minus one month of the winter solstice (December 21) but this peak is considerably shorter, weaker and usually limited to single hop. It is worthwhile noting that the peaks also occur in the southern hemisphere in reverse order. Although sporadic E propagation can start at any time of the day, it is most prevalent in the late morning, the late afternoon and into the early evening. There is some speculation that sporadic E occurrences are more common and stronger when sunspot activity is low. Hence propagation via this mode may improve in the next few years.

The exact mechanism that triggers sporadic E is still not known. Some people attribute it to weather-related phenomenon, especially wind shear and lightning storms. The late Mel Wilson, W1DEI/W2BOC, devoted much of his Amateur career to the study of sporadic E and wrote several very interesting articles on the subject.^{3,4} He pointed out that the clouds that produce the propagation originate at a location he

called the "birthplace" and usually travel in relatively straight lines at approximately 180 miles (290 km) per hour from southeast to northwest (fig. 1). For best propagation, he said, the cloud should be on or nearly on a line drawn between the two stations at the half-way point. Clouds ± 5 degrees off the path can be used and up to ± 10 degrees at the extreme. A single cloud will be usable for up to 5 minutes. The size of the cloud has been estimated to be in the order of tens to hundreds of feet (5 to 100 meters) vertically. Multiple clouds are often being formed in the same birthplace so they will pass by as they are generated. The best sporadic E propagation seems to occur when no major high pressure areas are present. (Mel's work will be carried on by his son Steve, W2CAP/1.)

Midlatitude sporadic E is also usable on 2 meters with the first reported contacts made between northern Texas and southern California on July 10, 1951, for a distance of approximately 1300 miles (2090 km). At first, other 2-meter openings were rare, probably due to lack of activity, and weren't recorded again until July, 1956 and June, 1959. Nowadays 2-meter con-

tacts are usually reported yearly and tend to occur between late June and early August, but can occur on the winter peak as described above. Strong lightning activity, especially the type that occurs above 60,000 feet (18,288 meters), is often present near the midpath of big 2-meter openings.⁵ Tornadoes and hail storms are often present at the mid-point of the path during 2-meter openings. Typical 2-meter QSOs using sporadic E are shown in fig. 2 from data given to me by the late Mel Wilson. Although we have had some very long DX (over 1600 miles or 2575 km) 2-meter openings in the United States, I have never heard of a documented double-hop QSO over 2000 miles (3218 km) such as has been recorded in Europe. The greater number of reported 2-meter openings "caught" in recent years is probably due to better monitoring and improved equipment as well as the new common 2-meter calling frequency, 144.2 MHz. The frequency limits for sporadic E are believed to extend above 220 MHz and W1JR and W0VB have both been heard on this frequency by other stations but in each case equipment problems at one end of the path prevented

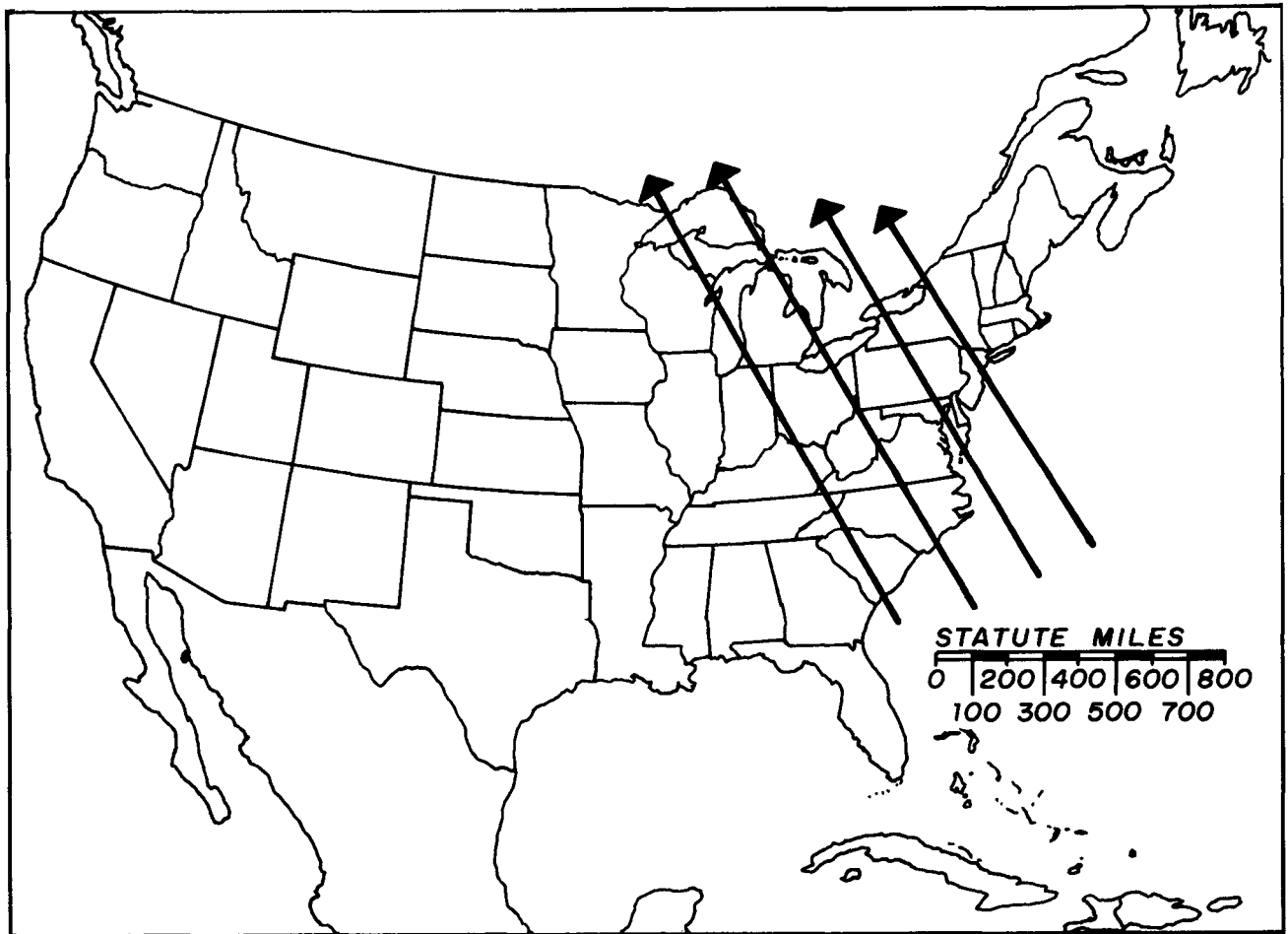


fig. 1. Clouds producing sporadic-E propagation generally travel from southeast to northwest at approximately 180 miles (290 km) per hour, moving in a relatively straight line.

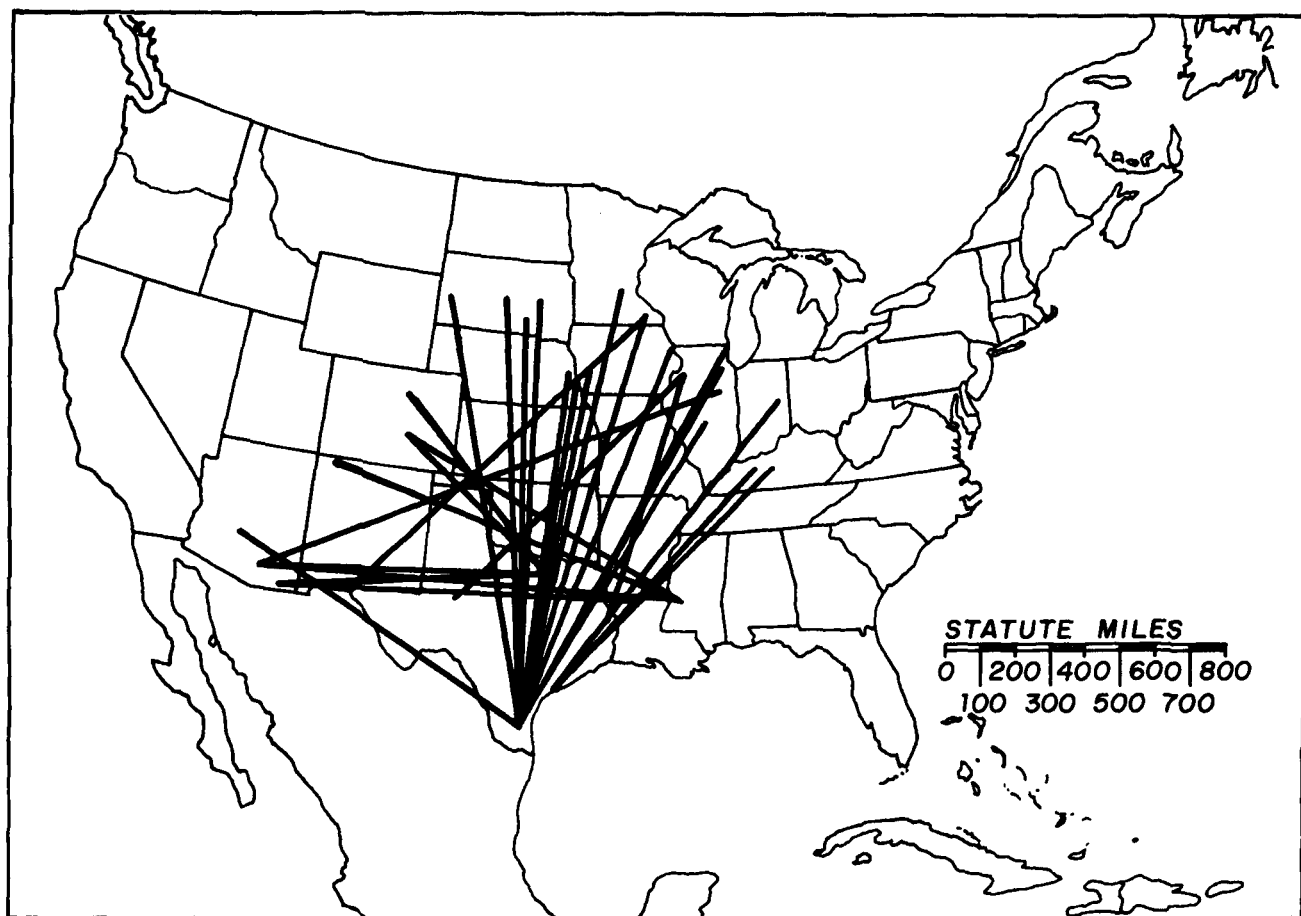


fig. 2. A typical 2-meter sporadic-E opening shows paths between stations in QSO on February 3, 1977, on 144 MHz (0000-0229 UTC).

completed QSOs! (I've noticed, by the way, that all the good east-to-west 2-meter sporadic E openings I've heard from the New England area in the past eight years have occurred within two weeks on either side of July 20th. Any comments?)

The best way to "catch" sporadic E openings is to listen on 10 meters for short skip conditions. When the 10-meter path gets down to 300 to 500 miles (483 to 805 km), the 6-meter band is probably ready to pop or is already open. Similarly, when the path on 6 meters gets very short (perhaps 400 to 500 miles or 645 to 805 km) and intense, try putting out a call on the 2-meter calling frequency. Remember that the reflection from the cloud will usually be different on 2 meters than on 6 meters. The distance will generally be much longer on the higher frequency, so judge accordingly if you're making schedules. Backscatter, especially from a local, is an indication that there are lots of clouds and a big opening is about to begin. You can't have a QSO without making some noise to alert others of an opening. W4WD has noticed that whenever WWV forecasts a "strat-warm," a sporadic E opening usually occurs within the following 12 to 24 hours.

TE (transequatorial) scatter

This was truly an Amateur Radio first when long-distance (5000 miles or 8000 km) propagation was established across the equator on 6 meters in August, 1947. It is significant that tests have verified that the signals first enter a bell-shaped ionized area midway between the station and the geomagnetic equator and then are ducted to the opposite ionized area without intermediate reflection from the earth.⁶

For best results, stations should be located about 1500 to 2500 miles (2400 to 4000 km) north and south of the geomagnetic equator and signals should cross the geomagnetic equator at close to right angles. However, deviations of up to ± 20 degrees have been known to occur. It is also significant that propagation may not necessarily be present at the same time at lower frequencies. These contacts usually improve during the equinoctial periods, especially when solar activity is high, as occurs near the peaks of the solar cycles. Openings may start in the late afternoon with clear sounding signals but early evening (at the midpoint on the path) signals often have a flutter with up to a 15 Hz rate. Signals may last until midnight, long

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Quality	304 Stainless Steel	Beamwidth	B = 1.7°
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after F2 has disappeared. The frequency usable is typically 1.5 times the MUF maximum that occurred earlier in the same day.

Unfortunately for stations in the continental United States, the geomagnetic equator runs about 15 degrees south of the true equator in this hemisphere. Consequently only stations in very southerly latitudes of the continental United States are optimally located. Stations in South Africa to the Mediterranean as well as Japan to Australia are in more favorable locations for this mode of radio propagation.

equatorial FAI (field aligned irregularities)

There was always the hope that someday there would be propagation as high as 2 meters across the equator. Then on October 29, 1977, it happened, when YV5ZZ/6 in Venezuela made a 2-meter contact with LU1DAU (in Argentina) at a distance of about 3135 miles (5045 km).⁷ After this initial success, openings kept occurring and distances kept improving, and by February, 1979, contacts were established between Puerto Rico and Southern Argentina, Australia and Japan as well as between Rhodesia and Greece.

Often the signals had an auroral sound (more on this later). Stations with elevation control noticed that signals were optimized at 5 to 8 degrees elevation. And while 70 cm (432 MHz) signals could be heard no QSOs were made on that frequency. Finally, in 1983, a successful 220 MHz QSO was completed between KP4OER and LU7DJZ (see **table 1**). Some Amateurs speculated on the existence of a new propagation mode,⁷ possibly one using a scatter mechanism and FAI from ionized bubbles. Others suggested ducts. At this time no one agrees except to say that more time and study is required.

We now know that propagation between stations equally spaced north and south of the geomagnetic equator can occur up to 70 cm. The best times and seasons for these contacts seem to be those most frequently observed for TE, as explained above. There is much more to be done in this important area — another Amateur Radio *first*.

ionospheric scatter

This mode of propagation,⁹ a form of forward scatter, is believed to be due to scattering in the lower D region (30 to 55 miles or 50 to 90 km) of the ionosphere. Typical distances are 800 to 1300 miles (1300 to 2100 km). Signals are usually continuous, but weak and wavy with a broad peak around midday at the midpath and during the summer months. Signal attenuations are approximately 90 dB greater than free-space loss at 6 meters and 115 dB at 2 meters. Hence this mode of propagation is definitely within the capability of two well equipped stations with 2-meter EME capability and deserves more attention.

aurora

Aurora, caused by magnetic disturbances on the sun,¹⁰ is called *aurora borealis* (or "northern lights") in the northern hemisphere and *aurora australis* in the southern hemisphere. Aurora borealis are most common around the equinoxes in March and September and usually begin in the late afternoon or early evening, though they can occur at any time of the year and are sometimes active in the early afternoon as well as all through the night and even into morning! The number of auroral occurrences tends to peak at the beginning and at the end of a solar cycle peak (e.g. 1978-79 and 1982-83) and decrease significantly when sunspot activity is low. They usually occur 24 to 48 hours after a major solar flare. A WWV "A" index of 30 or greater or a "K" index of 4 or more is a good warning of impending aurora. Weak or "watery" sounding HF signals are an excellent indicator of aurora presence although their presence does not guarantee that the openings will extend to VHF/UHF.

Typical auroral propagation occurs in a region between 47 to 84 miles (75 to 135 km) above the earth. If you were to look down on the earth from directly over the magnetic pole, an aurora would appear to be shaped like a halo or doughnut. (See satellite photograph shown in reference 11.) From a vantage point on the earth, auroras appear to be thin sheets or columns of light that are not quite vertical but tipped at the local dip angle of the magnetic field. Those in the far north are usually green, while those that extend further south may be red. The further south the aurora extends, the greater the DX possibilities; they are, after all, a superb reflector of radio waves.

The auroral reflection occurs when the angle of incidence equals the angle of reflection, but incidence and reflection paths need not lie in the same plane. Propagation via auroral reflection has been verified up to about 3000 MHz, but no known Amateur contacts have been reported above 70 cm (432 MHz). The best reported DX is about 1336 miles (2150 km). High power (several hundred watts or greater) is beneficial, but even 10-watt stations have had confirmed 70 cm QSOs. Occasionally the aurora extends far enough south so that even stations in Florida, Texas, New Mexico, and Arizona can establish auroral contacts.

For communications via auroral propagation, both stations should aim their antennas at the same "hot" spot. The cross-section of reflection decreases with increasing frequency. The angle of perpendicularity with respect to the earth's magnetic field also decreases with frequency. Typical accuracies required are ± 12 degrees at 220 MHz, ± 9.5 degrees at 432 MHz and ± 6 degrees at 780 MHz.¹² Since typical antenna installations have beamwidths that usually decrease in both the horizontal and vertical planes with

increasing frequency, the path becomes more difficult and would definitely be improved above 220 MHz if both stations could also change antenna elevation. This is particularly true when trying to contact a station that is either several degrees of latitude north or south of you. Hence, higher power is definitely preferable to increased antenna gain.

Auroral signals usually sound like a "buzz" or white noise because of the Doppler spreading caused by the rapidly changing ionization. CW is preferred, but SSB is usable, though hard to understand and lacking high pitched sounds, if you are operating on the lower VHF bands and the aurora is strong. I've noticed that if a CW signal is narrow (1 to 2 kHz) on 2 meters, there is usually sufficient ionization to permit 220 MHz and maybe even 70 cm contacts. I've also noticed that the MUF usually peaks shortly after the onset of the aurora, perhaps in 15 to 30 minutes, and then slowly decreases as time passes. *Hence it is advisable to take advantage of the higher VHF/UHF bands as soon as the aurora gets going rather than discover later that the MUF has dropped.*

"Watery" or wavy sounding signals on HF (10 to 160 meters) are an excellent indication that aurora is present and can be a tip-off to look for VHF/UHF auroral propagation. Auroras can be easily detected using a TV video carrier monitor on channel 12 (205.25 MHz) or 13 (211.25 MHz), similar to the one I described in last month's column.¹³ Just point your beam north and listen for the "buzz" on the carriers. This is also a good system for finding where the aurora is peaking and whether the MUF is high. I've noticed that the "hot" spot may be in a slightly different place at 220 MHz than on 6 or 2 meters (perhaps due to antenna patterns or other variables). This is invaluable information when trying to find 220 MHz and 70 cm signals.

Another observation I've made is that the Doppler shift may vary when you swing your beam back and forth while listening to an auroral signal. I've measured up to ± 1 kHz shift on 2 meters on locals and considerably more on 220 MHz and 70 cm. Consequently it's advisable to tune \pm several kHz when listening for answers to a CQ. If you're using a modern transceiver, tune with your RIT so you don't transmit back on a new frequency! Lately I've noticed this happening more often — but doing so can be disastrous on aurora, since you may land on top of another signal and be completely unreadable in the QRM, causing confusion to the operator you've answered, who is no doubt wondering where you went! Likewise, be careful where you zero-beat your own signal if you want an answer.

Finally, look for activity on or near the VHF/UHF calling frequencies. During auroras, this is usually 50.100, 144.100, 220.100 and 432.100 MHz on CW and with 50.110 and 144.2 on SSB. By all means, call CQ.

When you hear a reply, try to peak your beam quickly in order to optimize the path, since each station will come in at a slightly different direction depending on latitude and longitude.

artificial auroras

Attempts have been made to generate artificial auroras by using rockets to inject barium clouds into the ionosphere; in recent years, scientists in both the United States and the Soviet Union have created yet another form of artificial radio aurora.¹⁴ This propagation mode is similar to the natural auroras described except in that it is generated by radiating very high amounts (typically 40 Megawatts of ERP) of HF (typically 3 to 10 MHz) CW power vertically into the ionosphere. The scattering center is directly above the transmitter. The principal tests have been conducted in Platteville, Colorado, with a 1-Megawatt transmitter and a large antenna array, and at Arecibo, Puerto Rico, with 100 kilowatts, using the 1000 foot (305 meter) spherical dish. Operations have been successful as high as 430 MHz, and the signals are usually narrower than those generated by natural aurora.

auroral "E_s"

This is a much sought after mode of propagation on 6 meters. According to WAØIQN,¹⁵ ionospheric sounders have verified that sporadic E may be present just below an aurora, but the reasons for this are not known. When particle precipitation becomes strong enough, sufficient electrons collect at the bottom of the field line and form a "puddle" which can spread horizontally. It may then appear like sporadic E after the effects of the aurora wear off and thus yield DX in the northern regions of the United States and Canada. This may explain why some 6 meter auroras sound almost like sporadic E propagation. Auroral E_s usually occur within a few hours after an aurora fades out.

meteor scatter

Meteor scatter is one of the prime modes for DXing on VHF/UHF. Every day 50 to 100 million particles randomly enter the earth's atmosphere, where they burn up in the E region (50 to 150 km high) and leave ionized trails capable of reflecting radio signals. Due to the orbital characteristics of the earth, these random particles tend to increase slowly after midnight, reaching a broad peak at 6 AM and slowly decrease as the morning wears on, reaching a minimum at about 6 PM local time. The best months for random meteors in the continental United States are between June and August, with a minimum occurrence in February.

Even more important to the VHF/UHF DXer are meteor showers. They can occur at any hour of the day, and while they may be short in duration (any-

where from a few hours to a day or two long), they do occur on predictable dates. The better known showers are the Perseids (approximately August 11) and the Geminids (approximately December 11). DX, typically 500 to 1400 miles (805 to 2250 km) is accomplished by reflecting signals off these meteor trails.¹⁶

Most meteor scatter operation is on 6 and 2 meters, but 220 MHz and occasionally 70 cm (although there have been only about a half dozen reported contacts on this frequency to date) can be used in the higher speed showers. A recent article¹³ described how to optimize the use of this mode; readers who wish to know more should refer to that article.

FAI

The authors of reference 7 speculated that FAI similar in nature to that which produces the great TE FAI may be present in the midlatitude regions, and that signals in this mode would probably have an auroral quality. At the same time this article was published, K4GFG was conducting a nightly over-water tropo schedule in an attempt to QSO KP4EOR, who was also involved in the TE FAI experiment. What transpired was a QSO, not by tropo propagation, but by FAI with weak and "watery" signals peaking about 10 to 20 degrees north of the great circle path.¹⁷

During the following summer (1979), signals appeared over the United States and FAI-type QSOs were made from Florida to Texas and Alabama again, with auroral-type signals peaking north of the great circle path. Occurrences seem to be in the late evening, following sporadic E openings. Typical path loss is in the area of 218 to 230 dB at 2 meters and 248 dB at 220 MHz, meaning that fairly large setups (kW and modest gain antennas) are required to take advantage of this mode. Reference 17 provides charts for pointing antennas and speculates that this mode may be possible as high as 70 cm, although no known QSOs have taken place above 2 meters as of this writing. It is a fascinating possibility for VHFers and a nice way to work real DX when the band would otherwise be quiet!

EME

Earth-Moon-Earth, or "moonbounce" is one of my favorite subjects because it's *the* ultimate DX for the Radio Amateur. When you bounce your signal off the moon and listen for the returning signal, the path is up to 500,000 miles (804,500 km) in length and it takes the signal over 2.5 seconds to traverse the distance! Hence EME allows you to monitor your own signal after it is sent — and if you hear your own echoes, you know that your signal got where it was supposed to go, not like the dead-band syndrome on HF. You also know your equipment is operating successfully; by listening to the strength of the echo you can also

tell how well it's working and whether your most recent improvement actually works.

While EME is not for the faint-hearted, it can be achieved by the typical VHF/UHFer. The first EME stations were highly experimental and results were marginal at best. However, with the advances in the state-of-the-art (such as good low-noise transistors and GaAs FETs, high performance Yagis and parabolic dishes as well as efficient amplifiers), EME really took off in the late 1960s. Nowadays, when conditions are good on 2 meters, you have the capability of hearing your own echoes; WAS as well as WAC are possible with 500 watts of output power and four 3.2 wavelength NBS-type Yagis. Even a single-Yagi station with a good low-noise antenna-mounted preamplifier can hear the larger EME 2-meter and 70 cm stations off the moon when conditions are good. Over 50 DXCC countries are now or have been active on EME in the last few years and EME expeditions are no longer uncommon.

Typical path losses for EME range from 251 dB on 2 meters to 276 dB on 13 cm (2300 MHz), the highest frequency band on which Amateur contacts have been claimed.¹⁸ A few EME QSOs have been made on 6 meters, but the antenna systems were *very* large, and noise was a limiting factor. EME is now commonplace on 2 meters, 220 MHz, 70 cm, and 23 cm, where contacts are made almost daily and even SSB QSOs are not uncommon. Typical EME operating and calling frequencies are listed in **table 2**.

table 2. Typical EME operating and calling frequencies.

band	frequencies used	calling frequencies
2 meters	144.000-144.110	144.003-144.010
220 MHz	220.0-220.080	220.020
70 cm	432.000-432.070	432.010
23 cm	1296.000-1296.060	1296.010
13 cm	2304-2304.1 and 2320-2320.2	2304.050 and 2320.150*

*Most Europeans can no longer operate below 2320 MHz in the 13 cm band. The USA Amateurs may soon lose the frequencies between 2310-2390 MHz. Therefore, cross band operation may be required.

13 cm is now being tried, and DFØEME has reported several QSOs using a 9-meter dish. The interesting thing about 23 and 13 cm is that the power levels and antenna systems are small in comparison to 2 meters and 220 MHz. For example, some stations on 23 cm have been making QSOs rather routinely with dishes as small as 8 to 13 feet (2.5 to 4 meters) in diameter and with power as low as 100 watts at the feed. They're making good use of the new low-noise GaAs FET preamplifiers mounted right at the feed and of the

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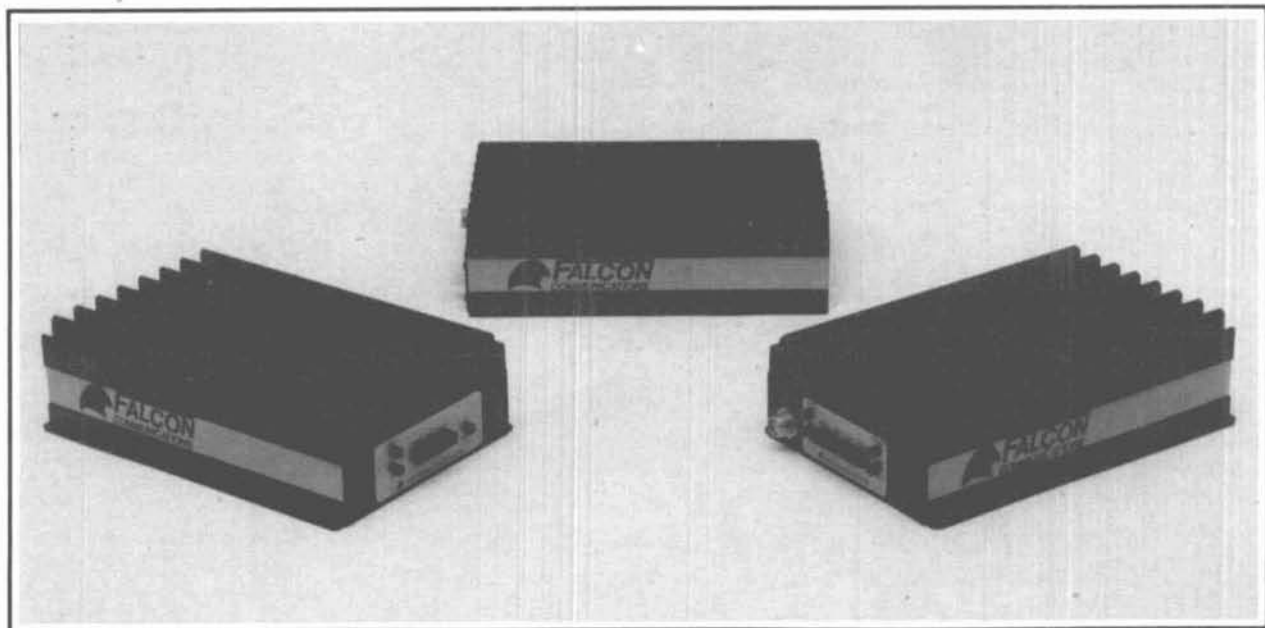
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very low sky noise above 400 MHz. All things being equal, path loss and antenna gain increase directly with frequency. However, since the antenna gain is added twice (once on receive, and once on transmit), the overall signal-to-noise ratio increases with increasing frequency. Another advantage of EME is that you don't have to wait for a band opening!

The EIMAC EME notes¹⁹ are a great help for the newcomer to EME. Reference 20 describes the requirements for 70 cm EME as well as helpful hints to improve your station and equipment both on EME and terrestrial. (A later column will describe 220 MHz requirements. See you off the moon!)

tropospheric scatter

This mode of propagation uses the reflections off dust particles, clouds and the refractive index variations that occur in the troposphere (1000-50,000 ft. or 305-15,250 meters above sea level) to provide reliable VHF/UHF propagation up to 1000 miles (1609 km) between well equipped stations.^{21,22} For several years starting in 1953 Chisolm et al²² conducted interesting tropo scatter tests over 98-830 mile (158-1335 Km) paths from Massachusetts to North Carolina. They proved that with adequate equipment, 70 cm signals could always get through with path loss varying from 190 dB at 98 miles (158 km) to 258 dB at 618 miles (994 km) and 300 dB at 830 miles 1335 km).

Both stations should aim their antennas at each other on the great circle path and their signals will scatter from the common volume of the atmosphere somewhere near the mid point in the path. For best long haul DX, a low angle of radiation is essential making it desirable to have your antenna fairly high (10 wavelengths minimum but greater than 20 wavelengths is unnecessary), in the clear, and a good low-angle horizon. Antenna gain is not fully realized since the power is not from a point source but from a volume in the atmosphere.

Typical path attenuations for the long DX (greater than 300 miles or 483 Km) are such that an EME type setup is desirable. However, many EME stations are now using their EME arrays with mast mounted pre-amplifiers so DX is no longer a problem on the VHF/UHF frequencies. Recent work in the U.K. on 3 cm (10 GHz) shows that troposcatter is a very reliable mode.²¹ They predict that a 440 Km range is possible using 1 watt and 4 foot (1.22 meter) dishes by each station. This propagation mode deserves more attention especially on 70 cm and above!

tropospheric bending

Tropospheric communication utilizes weather-related changes in the atmosphere to propagate VHF/UHF signals over much greater than line-of-sight distances. Under normal weather conditions, the tem-

perature of the atmosphere decreases in a more or less linear fashion with increasing altitude. However, if the temperature should abruptly increase with increasing altitude, the conditions are right for long haul DX. This usually happens between 3000 and 6000 feet (915 to 1930 meters) above local terrain and causes the refractive index to significantly increase beyond 1.33 as started earlier in the line-of-sight discussion. If you are at an elevated QTH, you could get above the temperature inversion and be unable to propagate through this layer!

Best tips are to look for increased cloudiness following a period of fair and calm weather. Best periods occur after a long (two or more days) high steady barometer (greater than 30.3 inches or 1025 millibars) starts to drop due to the approach of a slow moving low pressure area from a few hundred miles away, especially when moist air masses are approaching such as from the Gulf of Mexico. Signals are usually strongest in the late evening and especially in the early morning around sunrise. For advanced warning watch weather maps especially on TV. Remember that weather maps in the newspapers may be 24-48 hours old and hence may be after the fact! The late Ross Hull wrote several interesting articles on this subject.²³

I have also noticed that the really good overland tropospheric bending generally occurs in the winter months in the states bordering or near the Gulf of Mexico and between mid-August and late November in the central, northern and northeastern continental USA. Openings are also prevalent when there are large inversion layers with uncomfortably high humidity. The eastern USA should look for enhanced north to south DX when a weather condition called a "Bermuda High" is present. The best DX, especially east to west, seems to occur when a hurricane is bearing down on the area. Fortunately or unfortunately, the hurricanes that used to come roaring across the eastern half of the USA have been few in numbers since the early 1970s.

tropo ducting

This form of propagation is quite similar to the tropospheric bending just discussed but is more prevalent on the over water paths. In contrast to the normal tropospheric bending caused by an abrupt temperature change with increasing altitude, this form of propagation usually has two abrupt changes, one very low (maybe only a few meters above the surface) and the other one above it by perhaps 1000 feet (300 meters) or so. The net result is that a sort of waveguide is formed, the thickness of which determines the best frequencies of radio propagation. If you are in the duct, signals will propagate almost unattenuated until the duct deforms. If you are outside, take up another pastime!

Those who have studied ducting of radio signals tell me that at the onset of the duct, the optimum frequency is often quite high, typically 1500 MHz, and may slowly decrease as the duct stabilizes often going up again as the duct starts to disappear. During the great tropospheric ducting conditions between Hawaii and California in July, 1973, the openings were first heard on 70 cm and then slowly shifted to 2 meters. Two days later even 6-meter signals (viz. KH6IJ) were making the grade. It is noteworthy that this duct took place while two tropical (hurricane type) storms were traversing the path between Baja, California, and Hawaii just to the south of the path.

There are other peculiarities about tropo ducting. If you are above or below the duct (as in tropospheric bending), you will not be able to couple sufficiently into the duct to take advantage of it. Seldom does an over-water duct extend very far inland. Instead, the duct may abruptly become elevated as it passes over land. Hence, if you are over 10 to 40 miles (16 to 64 km) inland, the only effective way to use the duct will be if you are elevated or have a reflection assist (more on this later).

Let me elaborate on the later point. Researchers in the United States Navy and others have studied the California to Hawaii ducting with aircraft and often found that the duct was elevated 1 to 2 miles (1.6 to 3.2 km) as it approached Hawaii. The Amateurs active in Hawaii frequently drove up and down the side on Mauna Loa to optimize this path. After several years of observing this path, they installed the 24-hour-a-day warning beacons well up the side of Mauna Loa to take advantage of this phenomenon. Unfortunately, if an opening takes place (as seen by monitoring the beacon from California), there has to be an able body to drive up to the sight as soon as possible to catch the opening, and this hasn't always been possible!

The farthest inland ducting I know of is the KD6R to KH6IAA QSO. Ironically, both stations were elevated. KD6R was about 38 miles (61 km) inland, but at an elevation of almost 6000 feet (1828 meters) on the side of Mount Palomar. Likewise, the Bermuda-to-USA path where coastal stations can often access the duct but inland stations can't except K2RIW who is about 10 miles (16 km) inland but elevated on one of the highest spots (400 feet or 121 meters) on Long Island. K1PXE, at sea level in Connecticut, has never heard Bermuda, perhaps because the signals have to first traverse Long Island and are thereby elevated beyond reasonable altitudes.

The best ducts observed and used for long DX are the "Great Australian Bight" off southern Australia, the Gulf of Mexico, the Mediterranean Sea, the North Sea, Bermuda to the United States, the Atlantic Ocean between the United Kingdom and the Canary

Islands, and of course the California-to-Hawaii path. In fact, rumor has it that a 5 GHz microwave signal from the Philippines was intercepted in Southern California in the mid 1970s but that the news was suppressed because no one would believe the story! There is still much to be learned about tropospheric ducting and perhaps someday the United States-to-Europe path will finally be conquered using this mode.

super refraction

With a few exceptions, this mode is really an extension of tropospheric ducting. These ducts are usually very intense, over warm water, close to the surface and probably not as thick as the usual tropospheric ducts. Hence they are primarily good at 23 cm and above. The British were the first ones I know to really exploit this mode. In their somewhat casual manner (as we see it!) they would go to the beach for a Sunday outing with a pair of "GunnPlexers" or similar 3 cm gear. During the day they would occasionally go down to the beach and try to communicate with a station on another beach over an all-water path. By trial and error they would often find an optimum height and time for a QSO.

Another interesting story I've heard also comes from the UK. The English Channel is an ideal spot to try UHF between England and the European continent. As the story goes, an English station was in 3 cm communications across the channel with a French station, when communications abruptly ceased and then returned just as quickly a few moments later. Upon observation of the path with binoculars, it was discovered that a larger ship had apparently passed between the stations and momentarily broken up the duct!

Not to be outdone, the Italians and Yugoslavians used the Adriatic and Mediterranean Seas. They had many successes, the greatest DX being the 3 cm QSO between I0SNY/EA9 and I0YLI/IT9 (see table 1). This was an incredible DX record of 1034 miles (1663 km), using only 50 milliwatts of power and 1 meter dishes.²⁴ Once again, there is much to be learned about super refraction, but what is clear is that UHF/SHF ducts do appear on over-water paths during warm weather, especially during the summer months.

lightning scatter

The first known QSO via this mode took place on 70 cm between W0DRL (KS) and W5RCI (MS) on September 16, 1968, over a 449 mile (722 km) path. They noticed that signals peaked 15 to 18 degrees off the great circle path at an area which turned out to be a storm cell over Texas. Enhancements were up to 40 dB, some with durations of 25 seconds, with extremely rapid QSB and lots of Doppler shift. Since then, other observers have noticed the same phenomenon. This is a mode worth looking into, especially

when severe lightning storms are in progress. I have observed this same type of propagation on 70 cm on somewhat shorter paths between New Jersey and Massachusetts when severe lightning was over the central Connecticut area. Since most VHFers tend to shut off their rigs during stormy weather, it may be well to rethink our operating habits — but only if the storm *isn't* nearby!

aircraft scatter

Few VHF/UHFers give this mode a thought or even are aware of its capabilities. While in California, I discovered (undoubtedly as others did), that aircraft make fine reflectors for radio signals, especially on 70 cm and above. Since commercial aircraft often fly as high as 40,000 feet (12,192 meters), they can be used for propagation via line-of-sight out to 500 miles (805 km) reflections on a regular basis. The best paths are over the central USA, since many aircraft are available and usually fly at high altitudes. Coastal QTHs are not as favored because these aircraft usually fly low or are in takeoff or landing patterns. But don't rule them out; the California coast and the eastern seaboard of the United States have lots of traffic though these areas aren't quite as good for the long DX via aircraft scatter.

All you have to do to work via aircraft scatter is to be alert, know when the flights are in between and set up a schedule! Don't use long transmissions: at the longer DX, the mutual location for best scatter may last only a minute or less! Beware also of the Doppler shift which can be as much as 100-300 Hz on 70 cm and up to 1.5 kHz on 2304. When I QSO'd Harley, WA6HXW, on 2304 MHz from W6FZJ, a path of 310 miles (500 km), I copied Harley on two different frequencies separated by almost 1.5 kHz, one via tropo and the other via aircraft. At times the aircraft-reflected signal was up to 5 degrees off the great circle path!

table 3. Typical selected aircraft reflection sizes and figures of merit (original source of data is unknown but was sent to me via K9MHR and WB0YSG). Intermediate sized aircraft can be easily estimated.

type of aircraft	reflecting area (square meters)	relative reflection (dB)
Cessna 336 Skymaster	1.3	1
Lear Jet	2.0	3
McDonald Douglas DC 9	8-10	9-10
Douglas DC 3	12.6	11
Boeing 707	16.0	12
McDonald Douglas DC 8	20.0	13
Boeing 747	63.0	18

Some relative data on aircraft sizes and figures of merit are listed in table 3. This data, which may be

of use to those who want to make radar path loss calculations, show why larger aircraft are preferred. I have also noticed that aircraft scatter can often assist with another mode for a sort of link-up. For instance, on both the Bermuda to USA and the California to Hawaii paths, my 70 cm signals have been coupled into the duct and copied, probably via aircraft scatter at my end, but I was unable to complete the QSO due to insufficient access time before signals disappeared. This is an entertaining mode that deserves more attention since it is available 365 days a year as long as you have a reasonably good station. The possibilities for long DX on 3 cm and above are fascinating.

knife-edge diffraction

This mode of propagation, used for many years for Gigahertz microwave communications by commercial stations, is well documented. It is based on the theory that if a sharp peak or hill lies between two stations, signals can be diffracted over them. Losses of only 10 to 20 dB over the typical free space path loss are possible.² The sharper the peak, the better. Lack of foliage or reflecting objects is preferred at the peak; 3 cm signals do not go through tree leaves! Although this is a specialized propagation mode and is primarily for moderate DX, it is nevertheless interesting, especially to the UHFer who is in a low lying area or surrounded by hills or mountains.

rain scatter

This mode of propagation was discovered in 1978 by G3JVL and G3YGF/A when operating on the 3 cm band over a 110 km path during a rain squall.²⁵ They found that if two stations both aimed their antennas at the storm center, they could communicate at distances greater than 100 km. They were unable to reproduce this mode at lower Amateur frequencies. The signals are highly distorted and have an auroral quality with some noticeable Doppler. Signals tend to peak very broadly in-azimuth and elevating the antenna can improve signals if the storm is nearby. 10-20 dB enhancements are typical. Other British Amateurs also participated and verified this phenomenon, even with low power stations. This mode is especially interesting when one or both of the stations have obstructed views or a poor VHF/UHF QTH since the scattering center may be well above the horizon at one or both ends of the path. Hopefully this mode will soon be more fully utilized here in the USA.

conclusion

VHF/UHF radio propagation is a fascinating subject to which every Amateur can contribute. All it takes is time, patience, good notes, and of course some reasonably good equipment. The records listed in table 1 are good goals to pursue.

To review, VHF/UHF radio propagation is basically divided into four categories:

1. *Natural* (line-of-sight, tropo/ionospheric scatter),
2. *Weather-related* (tropospheric bending, ducting, sporadic E, precipitation scatter),
3. *Celestial* (EME, meteor scatter, F2, aurora), and
4. *Manmade* (satellite, aircraft scatter, artificial aurora).

A basic knowledge of all these types of radio propagation will show that the VHF/UHF bands are hardly a quiet and uninteresting place!

To predict radio propagation conditions we can use several sources of data such as: HF/VHF or satellite nets, propagation beacons, TV video carriers monitoring or the warning sounds on HF signals as well as alerts such as weather maps/reports and WWV forecasts at 18 minutes after each hour.

table 4. These are the typical United States VHF/UHF calling frequencies. It is common courtesy to QSY up or down after establishing contact to allow other stations to use the calling frequency.

band	frequency	mode
6 meters	50.110	SSB
2 meters	144.100	CW
2 meters	144.200	SSB
220 MHz	220.100	CW/SSB
70 cm	432.100	CW/SSB
23 cm	1296.100	CW/SSB
13 cm	2304.100	CW/SSB

Calling frequencies listed in **table 4** are also helpful. Sometimes there just aren't enough signals to go around and congregating on special frequencies can increase the probability of observing good conditions. However, you must put out an occasional call because silence doesn't convey much activity! Above all, when you do establish contact on a calling frequency, move off so that someone else can use it. Activity nights are also helpful. In the northeast, we concentrate 2 meter activity on Monday evenings, 220 MHz on Tuesdays, 70 cm on Wednesdays, and 23 cm on Thursdays.

acknowledgements

I want to thank all those who helped contribute information for this article, and in particular G3WDG, VE1YX, W4WD, WA4MVI, WB5LUA, W6ABN, and K6FV — it takes lots of cooperation to gather so much material. I hope that some of this information will be new or helpful to you and that you too will be able to help in the future.

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VHF/UHF coming events

July 3: EME perigee

July 20 (± 2 weeks): look for 2-meter E openings

July 27: (21:15 UTC) peak of Delta Aquarids Meteor Shower

July 27-29: Central States VHF Society Conference, Cedar Rapids, Iowa. (Contact W0OHU for further information.)

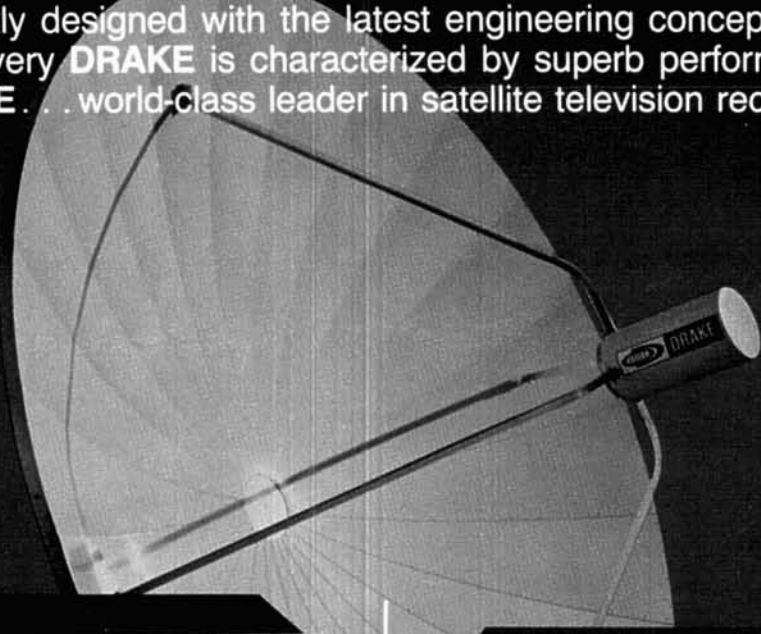
July 31: EME perigee

If you have any VHF/UHF events or contests planned, let me know at least 2 to 3 months in advance so I can let others know through this column. — W1JR

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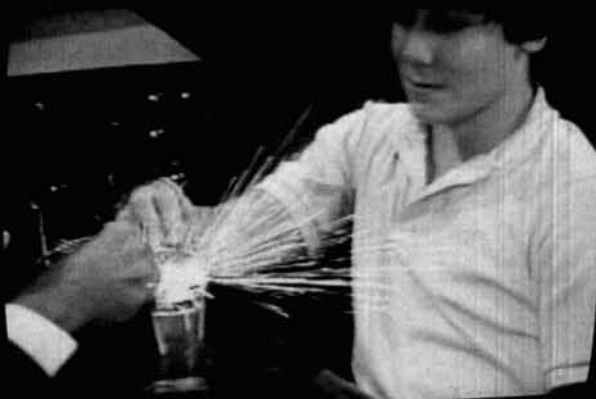
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cooling semiconductors part 1: designing and using heatsinks

Can't stand the heat?
dissipate it!

What effect does heat have on semiconductors?

How can that heat be dissipated? And what are the implications, for designers of electronic equipment, of the answers to these questions? Part one of this series will cover the design and use of heatsinks; part two will address other means, both novel and conventional, of monitoring and cooling semiconductors *without* the use of semiconductors — for example, by using a fan with flapping blades that operates on the piezoelectric crystal principle.

It is crucial for transistors, ICs, or thyristors (triacs and SCRs) to remain within their safe operating junction temperature ranges. Semiconductor junctions can withstand temperatures between 85 degrees C and 200 degrees C. Germanium withstands from 85 degrees C to 100 degrees C maximum temperature, while silicon withstands from 150 degrees C to 200 degrees C maximum temperature. However, semiconductors operated at these high temperatures show reduced performance. For example, low-input bias op amps require twice as much bias current for every 10-degree C rise in junction temperatures. (Note the typical power derating curve in **fig. 1** for a power transistor.)

Both junctions in a transistor give off heat; however, since the collector-base junction is reverse biased, it has higher resistance and produces more heat. In fact, the collector-base junction produces so much more heat than the transistor's forward-biased emitter-base

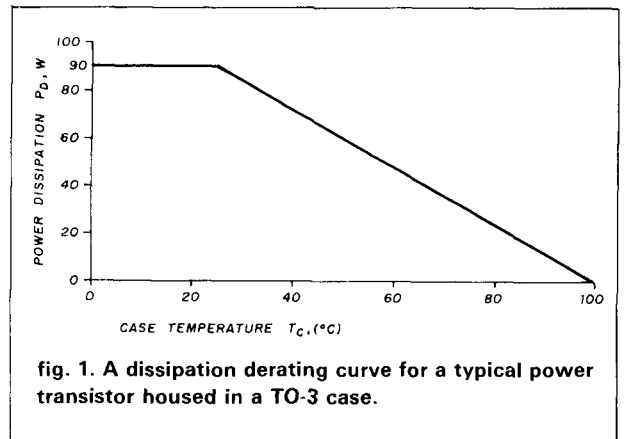


fig. 1. A dissipation derating curve for a typical power transistor housed in a TO-3 case.

junction that the heat generated by the later junction is usually ignored. As a result, the power dissipation equation is simplified and can be defined as follows:

$$P_D = I_C \times V_{CE} \quad (1)$$

where P_D = power dissipation
 I_C = collector current
 V_{CE} = voltage from collector to emitter

electrical-thermal analogies

Analogies can be helpful in visualizing abstract phenomena. For example, high school science teachers will often compare electricity to water flowing from a tower. In this comparison, voltage is defined as the "push" or potential (height) of the water within this tower. Current is equated with flow of water, and resistance is compared to the action of the tower's faucet, which impedes or constricts flow.

By Vaughn D. Martin, 114 Lost Meadows,
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Table 1. Unit symbols in electrical and thermal models.

electrical			heat		
quantity	unit	symbol	quantity	unit	symbol
voltage	V	V	temperature	°C	T
current	A	I	heat flow	W	P_D
resistance	Ω	R	thermal resistance	°C/W	θ

An analogy can also be drawn between heat transfer and electrical parameters (fig. 2). The flow (transfer of heat) corresponds to current. The heat differential between the hottest object (the transistor's junction) and the coolest object (the free-standing ambient air) is seen as voltage, and each thermal resistance — from the resistor's junction to its case, to the heatsink, and eventually to the free-standing ambient air — is compared to electrical resistances in series. Therefore, thermal resistances are added together to determine the total thermal resistance.

In fig. 2, the dual subscript on a thermal resistance, such as θ_{SA} , means resistance of the sink (S)-to-ambient air (A). Table 1 illustrates the unit symbols in both the electrical and thermal models.

The basic thermal relationship is:

$$T = P_D \theta \quad (2)$$

where T = temperature rise
 P_D = power dissipation
 θ = thermal resistance

It becomes obvious from this equation that thermal resistance θ must be minimized. This is what a heat-sink does.

how heatsinks work

Power transistors and voltage regulators with 1A or greater ratings are usually installed in large metal cases so that they can radiate more heat. Because the case size may still be inadequate for the amount of power to be dissipated, a heatsink or similar metal fitting is added to the case to increase thermal mass, lower thermal resistance, and provide additional surface area to allow heat to radiate from the surface more effectively.

The purpose of a heatsink is to transfer heat away from the semiconductor, causing it to flow from one medium to another by means of one or more of the three heat transfer methods: conduction, convection, and radiation.

Conduction is the most effective means of moving heat from the semiconductor junction to the case and from the case to the heatsink. *Convection* — which is merely surface conduction from a surface to a fluid or to air — is the most effective means of moving heat

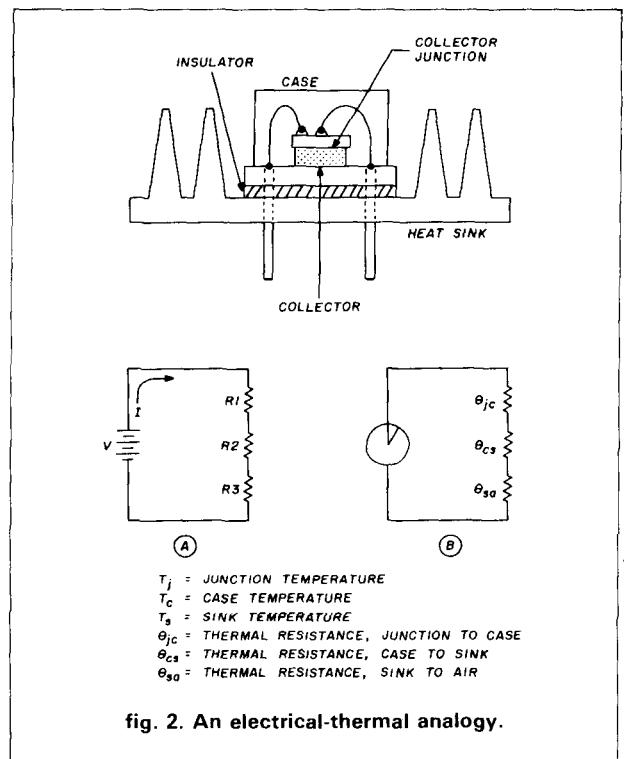


fig. 2. An electrical-thermal analogy.

from case or heatsink to ambient air. *Radiation*, the most effective means of transferring heat from radiating heatsink fins, depends on the existence of a difference in temperature between radiating and adjacent objects or space. *Emissivity* is a term used to describe this effect; table 2 illustrates some typical emissivities of various common surfaces. (The greater the emissivity, the better the ability to radiate heat.) Note that black oil-painted heatsinks radiate most effectively; this is why commercially available heatsinks (fig. 3) are almost always painted black.

heatsink materials

The two most common materials for heatsinks are copper and aluminum. Copper has a thermal conductivity four times that of aluminum, but is much more expensive. Aluminum, therefore, is the most commonly used heatsink material. In applications in which weight is a concern, magnesium can be used. If insulation is necessary, beryllium oxide (BeO), an excellent electrical insulator, can be used.

Very often, power transistors such as the ones packaged in TO-3 or TO-66 cases ("TO" stands for "transistor outline"; the number identifies the shape and size of the case) have their collectors soldered directly to the cases. Unless the collector is to be electrically grounded, the case must be isolated from the chassis.

Three other materials (used in electrical insulating washers) are also effective heat conductors: mica,

anodized aluminum, and beryllium oxide. Mica is the most common. Although anodized aluminum is fairly widely used, an electrical short will result if its surface is scratched. Beryllium oxide performs better than mica or anodized aluminum, but both its powdered form and its fumes are toxic.

custom made heatsinks

For the homebrew enthusiast in electronics who wants to make his or her own heatsinks, the nomographs of metal types and shapes and fin effectiveness, shown in **figs. 4** and **5**, will aid in the selection of appropriate materials and forms. Perhaps you have access to some surplus extruded copper or aluminum, or just want to attach a single flat square or rectangular piece of metal to a voltage regulator or power transistor and wonder whether it will do the job. A good question!

Before making any calculations, identify the semiconductor's case. If its case is a TO-220 to TO-202 metal tab, look at the accompanying data sheet to see whether the metal tab is the collector on a transistor or the output pin on a voltage regulator, or if it is the emitter (which might be grounded) or the ground pin on a voltage regulator. If the metal surface of the semiconductor's case had *any* voltage indicated on it, paint the heatsink — or chunk of metal you are about to fashion into a heatsink — so that it will be electrically insulated. A mica insulating wafer or washer may also be used, but will add a small thermal resistance.

Will a heatsink be necessary? Is the one you have in mind adequate? Use this typical heatsink calculation to be sure. A generalized equation of temperature differential (rise), power dissipation, and thermal resistance is:

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_{A(MAX)}}{\theta_{JA}} \quad (3)$$

where $T_{J(MAX)}$ = maximum junction temperature in degrees centigrade
 $T_{A(MAX)}$ = maximum ambient air temperature in degrees centigrade
 θ_{JA} = junction-to-air thermal resistance

This equation states that the maximum power dissipated is equal to the maximum junction temperature of the transistor or regulator minus the maximum ambient or outside free-standing air temperature divided by the thermal resistances from the junction (*J*) to the ambient air (*A*). These thermal resistances, analogous to electrical resistances in series, are added together. Stated mathematically, $\theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA}$; the thermal resistance from junction to air (θ_{JA}) equals the sum of the thermal resistances:

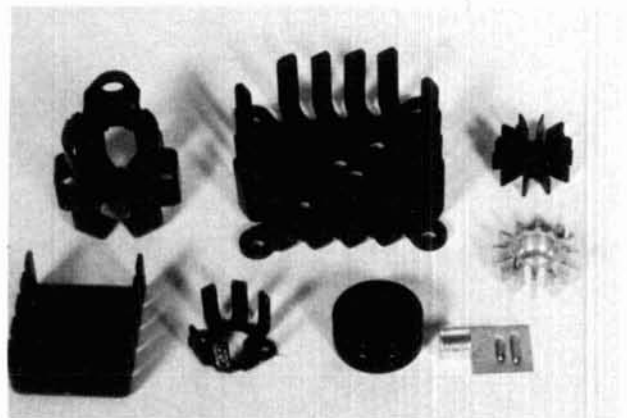


fig. 3. Commercially-available heatsinks vary in form, but are almost always painted black.

junction-to-case (*JC*), case-to-heatsink (*CS*) and heatsink-to-air (*SA*). Quite simply, if the $P_{D(MAX)}$ of the preceding equation is exceeded, then a heatsink is required. Typically, a TO-3 case will withstand 2.8 watts, and a TO-220 power tab with a flat rectangular body and three parallel leads coming out of the end, separated by 0.1 inch each, will withstand 1.8 watts, while the very small TO-39 and TO-92 packages will handle only about 0.66 watts.

Assume the following in our heatsink calculations:
 maximum ambient temperature: 60 degrees C
 maximum junction temperature: 125 degrees C
 maximum output current: 800 mA
 maximum input-output differential: 10 volts

If we use a 7800 series voltage regulator with a TO-220 case, $\theta_{JC} = 5^{\circ}\text{C}/\text{W}$ (this is obtained from the data sheet). The θ_{CS} and θ_{SA} must be solved for by:

$$\begin{aligned} \theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA} &= \frac{T_J - T_A}{P_D} \\ &= \frac{125^{\circ}\text{C} - 60^{\circ}\text{C}}{0.8 \text{ A} \times 10 \text{ V}} = \frac{65^{\circ}\text{C}}{8 \text{ watts}} = 8.13^{\circ}\text{C}/\text{W} \end{aligned} \quad (4)$$

where θ_{JC} = junction-to-case thermal resistance

θ_{CS} = case-to-heatsink thermal resistance

θ_{SA} = heatsink-to-air thermal resistance

T_J = junction temperature

T_A = ambient air temperature

Let us solve the far right side of the equation first, $T_J - T_A = 65^{\circ}\text{C}$. The denominator is the 800 mA output current times 10 volts, the input-output voltage differential. The three thermal resistances, then, sum to $8.13^{\circ}\text{C}/\text{W}$. From the data sheet we already know that the junction-to-case thermal resistance is $5^{\circ}\text{C}/\text{W}$, so the other two remaining resistances must add up to $3.13^{\circ}\text{C}/\text{W}$. With the use of silicon thermal grease (**table 4**), we can approximate with some assurance from **table 1** that the case-to-sink resistance is

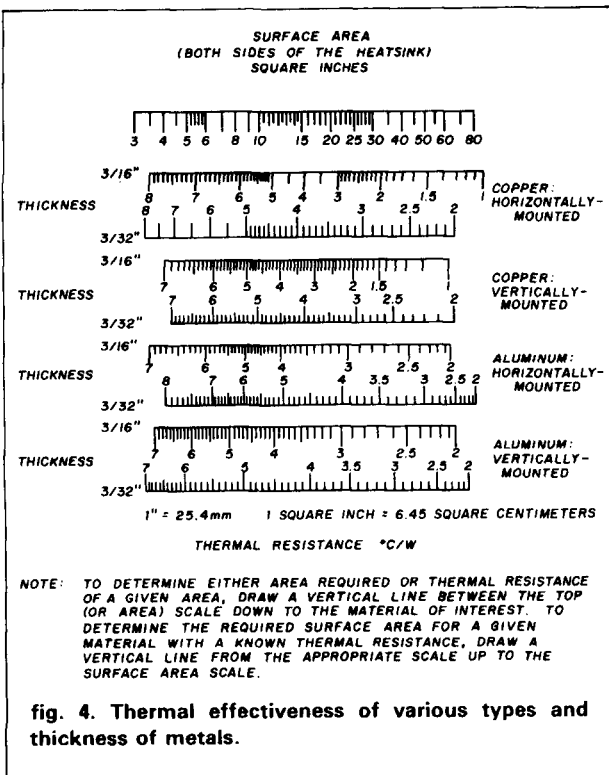


fig. 4. Thermal effectiveness of various types and thickness of metals.

Table 2. Emissivity of selected common heatsink surfaces.

Surface	emissivity (E)
polished aluminum	0.05
polished copper	0.07
rolled sheet steel	0.66
oxidized copper	0.70
black anodized aluminum	0.7-0.9
black air drying enamel	0.85-0.91
dark varnish	0.89-0.9
black oil paint	0.92-0.96

0.13°C/W, so this leaves the $\theta_{SA} = 3^\circ\text{C/W}$. Refer again to fig. 4 and note that a 22 square-inch piece of aluminum 3/16-inch thick with vertically bent ends will meet this requirement. The note at the bottom of the figure explains how to use the nomograph.

Calculating the effectiveness of a heatsink with fins is much more involved than calculating the effectiveness of a heatsink of square or rectangular metal as was just done. The heatsink-to-ambient air thermal resistance is expressed as:

$$\theta_{SA} = \frac{1}{2H^2\eta(h_c + h_r)} \text{ } ^\circ\text{C/W} \quad (5)$$

- where H = vertical height of fins in inches
- η = fin effectiveness factor
- h_c = convection heat transfer coefficient
- h_r = radiation heat transfer coefficient

$$h_c = 2.21 \times 10^{-3} \left(\frac{T_S - T_A}{H} \right)^{1/4} \text{ W/in}^2\text{ } ^\circ\text{C} \quad (6)$$

$$h_r = 1.47 \times 10^{-10} E \left(\frac{T_S + T_A}{2} + 273 \right)^3 \text{ W/in}^2\text{ } ^\circ\text{C} \quad (7)$$

where T_S = temperature (°C) of heatsink at regulator mounting

T_A = temperature (°C) of ambient air

E = surface emissivity (refer to table 2)

H = vertical height of fins in inches

do it yourself

Using fig. 5 and the formulas shown, let's design a finned heatsink for a 5-volt regulator. Assume that we are using a 1/16-inch thick piece of black anodized aluminum and want to have symmetrical square heat-sink fins. Our desired heatsink will have a thermal resistance of 4°C/W. An LM340T-5 is used under the following realistic conditions:

$$\begin{aligned} T_J &= 125^\circ\text{C} & V_{OUT} &= 5\text{V} \\ T_A &= 60^\circ\text{C} & I_{OUT} &= 800\text{mA} \\ V_{IN} &= 15\text{V} \end{aligned}$$

We find T_S by $I \cdot V \cdot \theta_{JS} = T_J - T_S$. V equals $V_{IN} - V_{OUT}$ or $(15\text{V} - 5\text{V}) \cdot 800\text{mA} \cdot 4^\circ\text{C/W} = 125^\circ\text{C} - T_S$. Solving for T_S we obtain T_S equals 93°C. Next h_c is solved for using a 4-1/4 inch high fin.

$$h_c = 2.21 \times 10^{-3} \left(\frac{93^\circ\text{C} - 60^\circ\text{C}}{4.25\text{in}} \right)^{1/4} = 3.7 \times 10^{-3}$$

and h_r is solved for with $E = 0.9$, which is found in table 2.

$$\begin{aligned} h_r &= 1.47 \times 10^{-10} \times 0.9 \left(\frac{93^\circ\text{C} + 60^\circ\text{C}}{2} + 273 \right)^3 \\ &= 5.6 \times 10^{-3} \end{aligned}$$

Next, add h_c to get $h = 9.3 \times 10^{-3}$. Now we find η from fig. 5. Draw the first line on the nomograph in fig. 5 from h through the fin thickness (remember, we are using 0.0625-inch (1/16-inch) aluminum to find

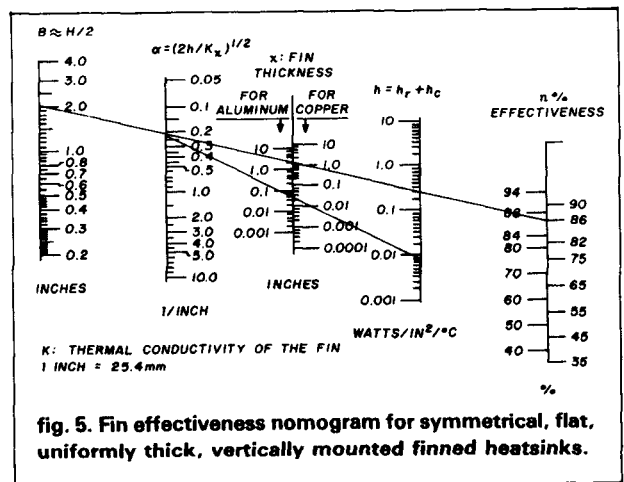


fig. 5. Fin effectiveness nomogram for symmetrical, flat, uniformly thick, vertically mounted finned heatsinks.

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Pre-load Function: The buffer memory can store the messages written from the keyboard instead of sending them immediately. The stored messages can be sent with a keyboard command.

"RUB-OUT" Function: You can correct mistakes while writing messages in the buffer memory. Misspellings can also be erased while the information is still in the buffer memory.

Automatic CR/LF: While transmitting, CR/LF automatically sent every 64, 72 or 80 characters.

WORD MODE operation: Characters can be transmitted by word groupings, not every character, from the buffer memory with keyboard instruction.

LINE MODE operation: Characters can be transmitted by line groupings from the buffer memory.

WORD-WRAP-AROUND operation: In receive mode, WORD-WRAP-AROUND prevents the last word of the line from splitting in two and makes the screen easily read.

"ECHO" Function: With a keyboard instruction, received data can be read and sent out at the same time. This function enables a cassette tape recorder to be used as a back-up memory, and a system can be created just like telex which uses paper tape.

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Table 4. Use of silicon grease or adhesive decreases thermal resistance.

insulator	thermal resistance, °C/W	
	dry	silicon grease
none	0.20	0.10
Teflon	1.45	0.80
mica	0.80	0.40
anodized aluminum	0.40	0.35

With the values used thus far, η has been graphically determined to be 0.86. Substituting our numbers in eq. 5 we obtain the following:

$$\theta_{SA} = \frac{10^3}{2 \times 18 \times 0.86 \times 9.3} = 3.47^\circ\text{C/W}$$

Incidentally, the 10^{-3} was changed to 10^3 by moving it to the numerator and changing the sign of the exponent. The value of 3.47°C/W is not exactly the desired 4.00°C/W we initially sought, but gives a margin of safety. Remember, when doing it yourself, these formulas apply to both round and square symmetrical fins. Rectangular 2:1 aspect ratio (length-to-height) fins may also be used with the appropriate deratings used. Table 3 shows some typical θ_{SA} values per case size in commercially available heat-sinks; by following figs. 4 and 5 you can build your own, and know it will do the job!

guidelines for use

Avoid placing voltage regulators next to heat-generating components like power resistors. When using smaller package regulators like the TO-5, TO-39, or TO-92 cases, keep the lead lengths to a minimum and use the largest possible printed circuit board copper connector runs to provide a heat dissipation path for the regulator. Make sure that the heatsink-to-case surfaces mate. With larger heatsinks, this is more difficult, so for good thermal conduction, use a thin layer of silicon thermal grease such as Dow Corning 340, General Electric 662, or Thermalloy's "Thermacote" or a thermal adhesive. Metallic-oxide-filled silicon grease placed between two surfaces eliminates air gaps and fills in scratches on the two metal surfaces. (A typical transistor mounted dry with a 0.2°C/W resistance will exhibit half this resistance after a layer of thermal grease or adhesive is applied.)

Negative voltage regulators, in particular, require that the heatsink and metal voltage regulator case be electrically insulated from each other. To accomplish this, use either a fiberglass or mica 0.003 to 0.005-inch thick insulating washer. While the presence of the washer will naturally increase thermal resistance, this effect can be partially offset by applying thermal grease

to each side of the washer. When mounting a regulator on a heatsink with fins, orient the fins in the vertical plane. And be *very* careful when bending the regulator's leads, should such action ever be necessary.

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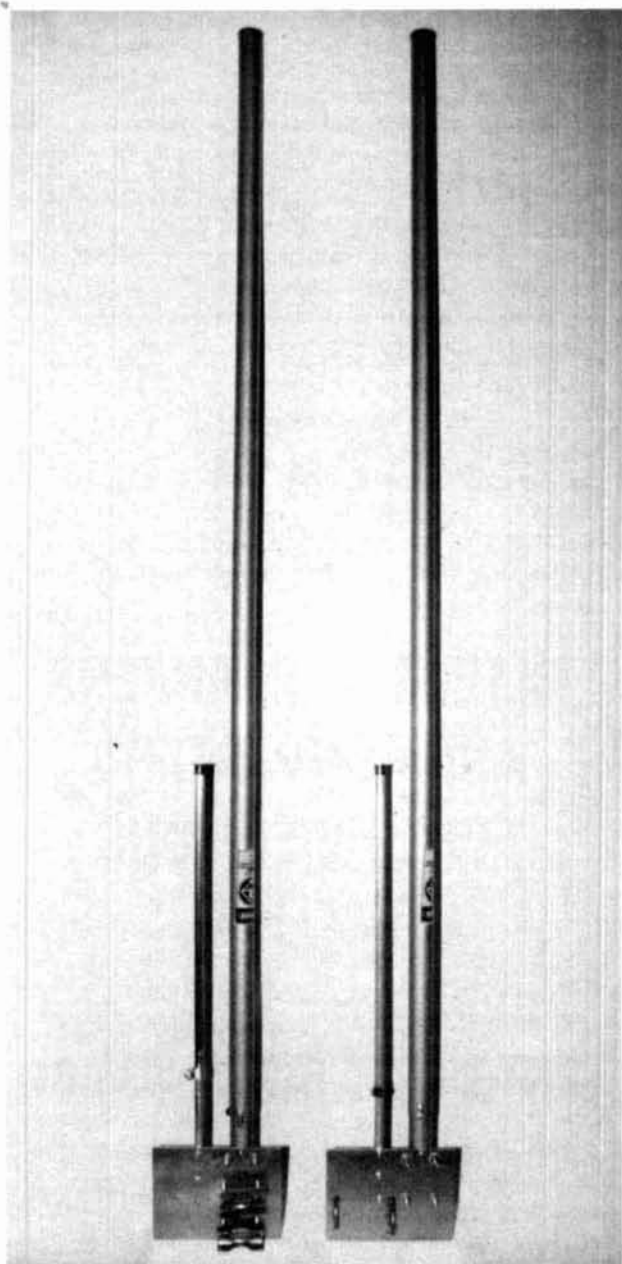


fig. 1. J-pole antenna: for upright mast mounting (left) and mounting to horizontal boom on tower (right).

While the J-pole antenna shown in fig. 1 is by no means a new design,¹ it doesn't seem to be used often. Basically it's a 5/8-wave radiator with a 1/4-wave matching section. The matching section is positioned 1-1/4 inch from and parallel to the 5/8-wave element.

I've built two of these antennas; one is for mounting to a conventional upright mast, as shown by the unit on the left in fig. 1; the other is for mounting to a horizontal boom on a tower. No significant problems were experienced in either installation.

The advantages of the J-pole design are its omnidirectional radiation pattern, characteristic of vertical antennas, and its small-diameter installation area. It lacks the radials common to ground plane antennas, and does not require driven elements to be cut in order to tune for best match.

Advantages less readily apparent, but equally important, are the elimination of the need to insulate the radiating element from the ground system, making possible an all-metal unit of rigid construction. With the whole antenna effectively grounded and installed atop a tower or mast which is grounded at the base, there is very little static noise buildup. The additional gain possible over the quarter wave ground plane because of the increased length is considered yet another advantage.

construction

A list of materials is provided in table 1; dimensional information is shown in fig. 2. The mounting plate is shown in fig. 3. The extra set of four holes in the plate allows the J-pole to be mounted in either of two different planes, depending on the location of the final installation.

The total length of the longest piece of tubing is 57 inches (144.8 cm) from the tip to the mounting plate. This piece can be made from a 5-foot (152-cm) section of lightweight (20 gauge) mast available from Radio Shack. There is no reason to spend more for the heavier gauge mast because it doesn't support anything other than its own weight. (If you really want to spend more money on this antenna, put the money to good use and buy better coax, or stainless steel assembly hardware, or both.)

By Michael Hood, KD8JB, 849 Dickinson S.E.,
Grand Rapids, Michigan 49507

hexnuts (see **fig. 5**). Inserting the dowel permits the 6-32 hardware to be tightened without unduly distorting the tubing, which would allow hairline cracks to form and cause premature element failure.

The clamp used to attach the coax center conductor (**fig. 4**) is an aircraft-type Adel clamp with the rubber sleeve removed. This clamp was originally intended for 5/16-inch (0.79 cm) tubing, but with the rubber removed and the clamp installed as shown, a tight fit is maintained around the matching section. Any such device can be used as long as a good mechanical connection is maintained.

As shown in **fig. 4**, the shield of the cable is attached to the larger diameter element at a point 1-1/2 inches (3.8 cm) away from the mounting plate. Two different methods of attaching the shield to the 5/8-wave section were used; both are satisfactory, though I feel more confident about the No. 10 through-bolt in the 5/8ths section than I do about the No. 6 sheet-metal screw and lockwasher. This is a matter of personal preference. A No. 14 AWG terminal lug was used to terminate the shield as shown, but both lug ends were replaced with a solderable lug and then silver soldered on the completed installation.

If a certain amount of hardware "overkill" seems apparent in this project, it's because in the case of antennas, too much is usually better than too little, particularly where weather conditions are severe. It's a good idea to invest in stainless steel hardware and to protect the mounting plate assembly with a polyurethane coating or spray varnish, following the directions and precautions on the spray can. Do this *after* tuning the matching section.

tuning

To tune the matching section, start at a point about 2 inches (5 cm) from the mounting plate and apply RF at the frequency most likely to be used, for example, 146.52 MHz. Note the SWR at that frequency and adjust the clamp, sliding it as necessary to produce minimum SWR. The antennas in the photographs tuned at approximately 2-1/2 to 4 inches (6.4 to 10 cm) from the mounting plate. They did not tune to identical points on the respective matching sections. In both cases, the antennas tuned to an indicated SWR of 1.2:1 at 146.52 MHz. If you've worked with antennas before, you probably know that any SWR reading depends on so many factors that tuning for minimum SWR is, more often than not, sufficient for most purposes.

installation

Figure 6 shows the antenna mounted to a horizontal boom off the side of a mast. Convention dictates that the antenna point upward when installed, but there is no reason that it cannot be pointed downward.

If high winds are a problem, or if the clamps used to attach the assembly to the boom are not of the gripper variety, pointing the antenna downward can help maintain its vertical position. As long as the antenna is mounted one or more wavelengths away from any large reflective or RF absorbent surface, fear of upside-down mounting is completely unfounded.

Conventional mounting to a vertical mast is accom-

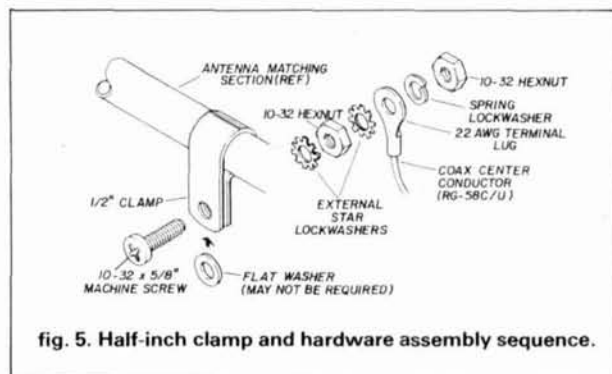


fig. 5. Half-inch clamp and hardware assembly sequence.

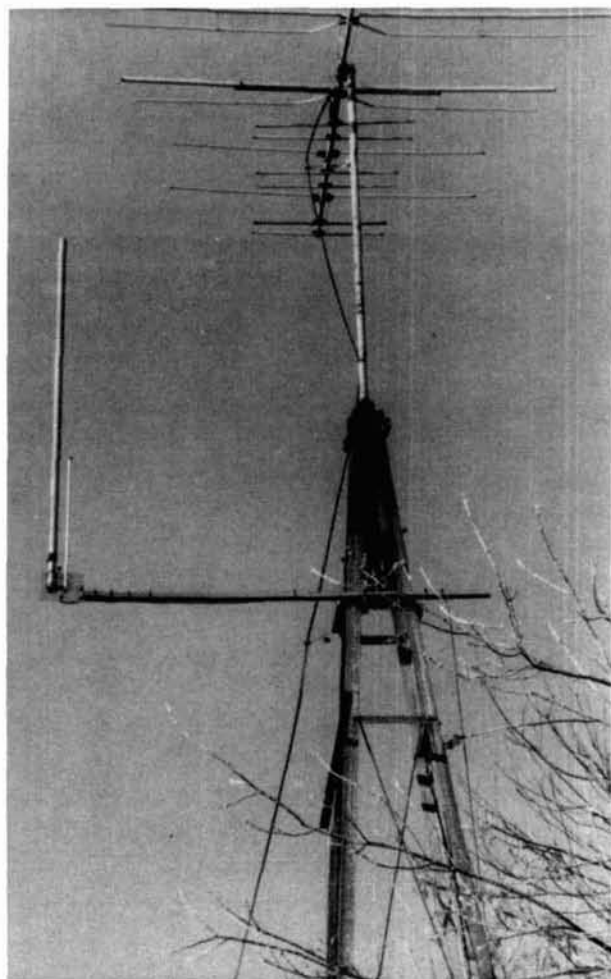
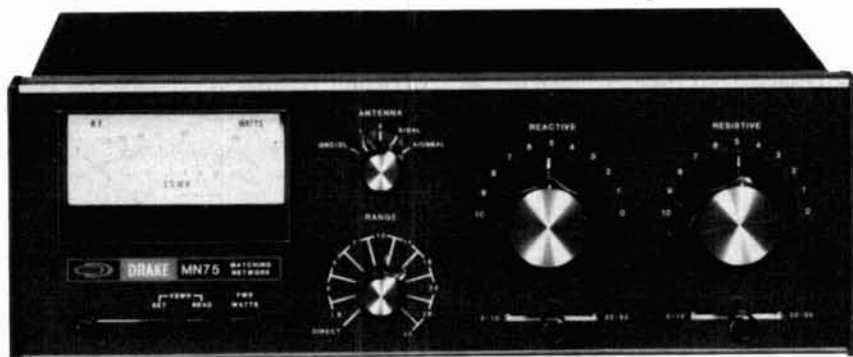


fig. 6. Horizontal mounting on a windmill tower.

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	30 W output	MML432-30-LS	179.95
144 MHz	100 W output	MML144-100-LS	249.95
	50 W output	MML144-50-S	199.95
	30 W output	MML144-30-LS	109.95
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plished by using the other set of mounting holes in the antenna mounting plate. No special problems were noted with this arrangement.

variations

As with any project, several additional ideas came to mind after the antennas were completed. For instance, the coaxial shield attachment to the 5/8th's element could certainly be made to be adjustable. Doing this might result in a better SWR reading, or perhaps allow the coax terminations to be physically matched more evenly at the antenna. If I were to build another, I would try this approach. Should you decide to make both connections adjustable, remember to remove the paint from the portion of the mast the clamp will rest against when tuned.

It may also be possible to make the 5/8th's element diameter smaller. The 1-1/4 inch tubing is convenient because it can be purchased at the proper length, but if you have stock left over from other antenna projects, it would be less expensive to use what you have. If you do, remember that antennas built from different stock may tune at positions other than those indicated in this article. I'd be delighted to hear from anyone who attempts this alternative approach.

reference

1. *FM and Repeaters for the Radio Amateur*, American Radio Relay League, Newington, Connecticut, 1978, page 70.

bibliography

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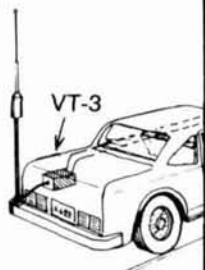
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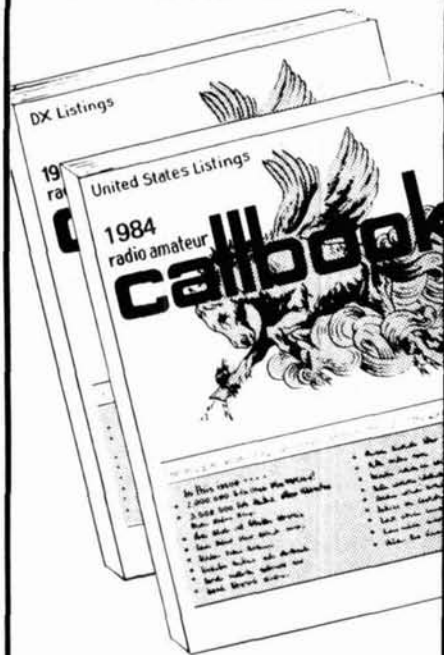
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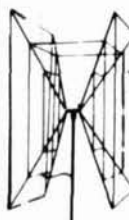
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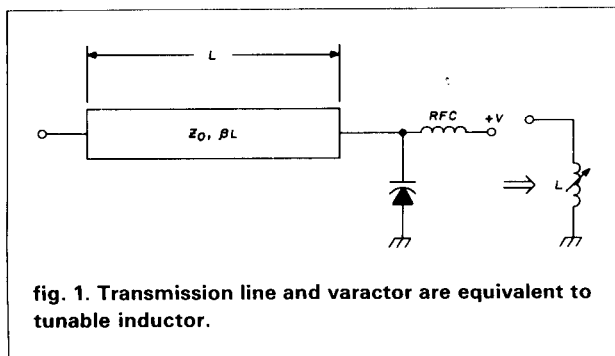
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wideband VCO design

Use this low-noise near-octave source in your HF receiver or VHF/UHF exciter

This article discusses the design and construction of a wideband voltage controlled oscillator (VCO). It can be used as an LO in a broadband receiver or spectrum analyzer, as a low-noise phase locked source in a VHF or UHF exciter, or alone as a basic signal generator.

This particular design is used in an HF communications receiver. When phase locked to a low-noise reference, it demonstrates excellent signal-to-noise performance — greater than 130 dBc/Hz at 20 kHz offset from the carrier. As mentioned in previous articles^{1,2,3} this noise performance, or spectral purity of the oscillator, is quite important if the receiver is to perform well in the presence of strong adjacent channel signals.



design concept

The oscillator design uses a resonator or tank circuit which consists of a transmission line terminated by a voltage variable capacitor or varactor. A transmission line of correct length looks like a variable inductance as the varactor voltage is varied (fig. 1). The oscillator uses the Colpitts configuration, and takes advantage of the feedback capacitor voltage divider plus any parasitic capacitance present. If the Colpitts configuration is operated with a fairly high C to L ratio, then this condition tends to improve the oscillator operating Q and consequently the oscillator signal-to-noise ratio. To assist in the design of the VCO a BASIC computer program routine has been included. Some examples, as well as actual designs and performance data, are also provided. Finally some interesting applications are highlighted.

equations developed

The input impedance of a lossless transmission line, Z_s , is equal to:

$$Z_s = \frac{Z_\ell \cos \beta L + j Z_0 \sin \beta L}{\cos \beta L + j (Z_\ell / Z_0) \sin \beta L} \quad (1)$$

If Z_ℓ is zero (the line is shorted at the end) from the preceding equation, $Z_s = j Z_0 \tan \beta L$ and the line has an inductive reactance of Z_0 ohms times the electrical length of the line. This is true provided the value of βL ($\beta = 2\pi/\lambda$) is less than 90 degrees or the line is less than a quarter wavelength long. If the line is precisely a quarter wave long (electrically), then from eq. 1 we have:

$$Z_s = Z_0^2 / Z_\ell \quad (2)$$

By Alan Victor, WA4MGX, 8758 SW 51st Place, Cooper City, Florida 33328

In this case, if Z_ℓ were a capacitive reactance of $-jX_{C_v}$ then

$$Z_s = jZ_0^2/X_{C_v} \quad (3)$$

and the capacitive reactance of the termination is reflected to the input of the line as an inductive reactance of $j/X_{C_v} = Z_s/Z_0^2$ and an inductance of

$$L = C_v Z_0^2 \quad (4)$$

For example, an oscillator that tunes 135 MHz to 145 MHz requires the electrical length to remain a quarter wavelength or less at the maximum frequency of 145 MHz. If a 50-ohm transmission line is used, then the physical length of a quarter wave is calculated using:

$$\text{length (feet)} \approx 246/f_0(\text{MHz}) \sqrt{\epsilon_r} \quad (5)$$

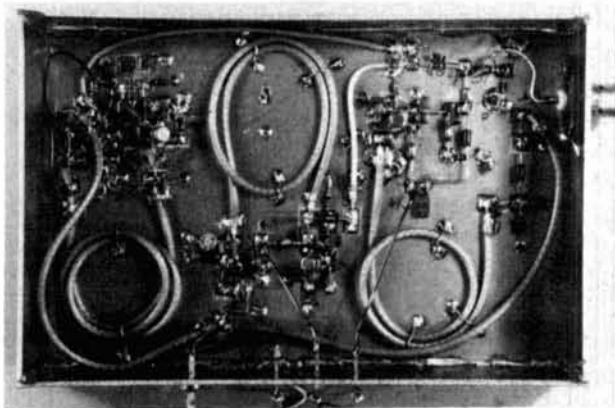
where ϵ_r is the relative dielectric constant of the line. The ϵ_r for a 50-ohm line using a Teflon[®] dielectric is 2.2; therefore, the physical line length is 13.7 inches. If our oscillator includes device shunt capacitance,

feedback capacitance, and parasitics totaling 20 pF, then the required inductance to achieve resonance is 60 nH at 145 MHz and 70 nH at 135 MHz. Consequently, the required variation in the varactor capacity is calculated from eq. 4 as 24 pF to 28 pF or 4 pF. If a lower Z_0 line were chosen, and the total capacitance remained the same, an increase in the varactor capacitance change would be required.

The equations developed so far allow us to choose a value for the transmission line impedance Z_0 and obtain a value of inductance L for a given varactor capacity, C_v . This equivalent inductance then becomes part of our oscillator tank. Since a transmission line and capacitor are readily controlled, it becomes very attractive to construct VHF and UHF oscillators in this manner since small fixed inductances are difficult to control. Furthermore, the resonator or tank is a shielded structure and therefore quite immune to outside disturbances, such as, microphonics, which can lead to hum and modulation effects.

three parameters affect frequency

Now consider what happens if the transmission line length, impedance, or the oscillator shunt capacitance is varied. Under these conditions, any value of inductance necessary to resonate the oscillator tank can be developed. Given these three variables, an oscillator frequency change of 50 percent can be achieved for a given value of transmission line length and impedance Z_0 . With careful design, even an octave is possible. The necessary design equations are presented in the **appendix**, and a BASIC program is included to solve for the transmission line impedance, Z_0 , electrical length, and required varactor capacitance change. Finally, the transmission line *physical* length is calculated, with the dimensions given in both inches and metric units. Because the program is in-



Switched transmission line injection oscillators as shown in fig. 2.

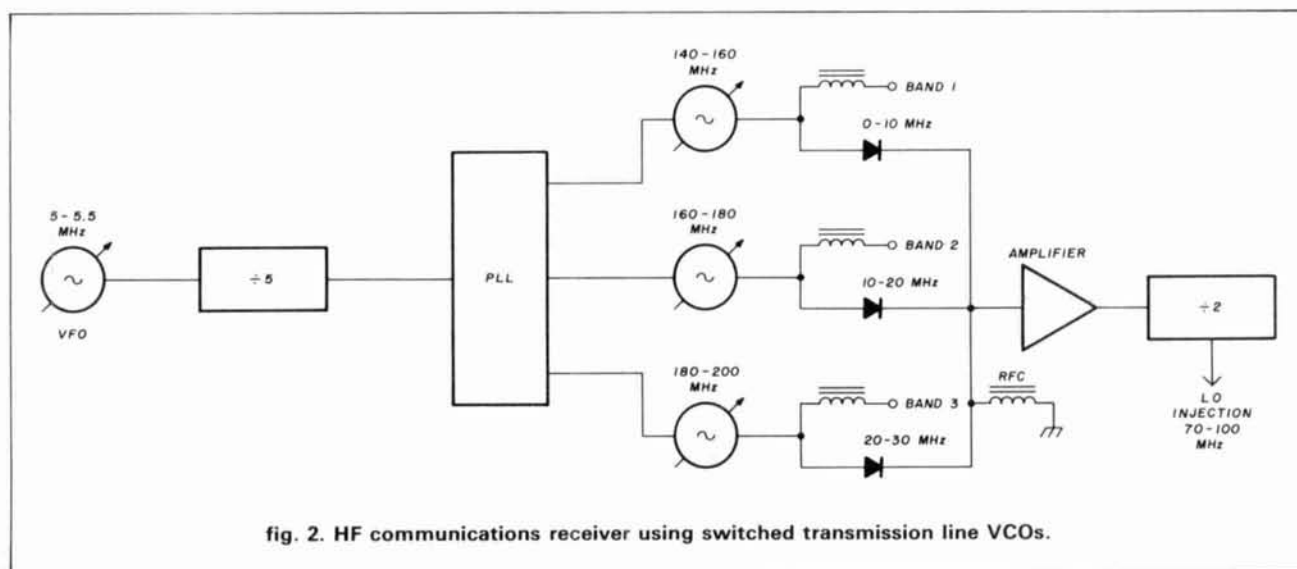


fig. 2. HF communications receiver using switched transmission line VCOs.

Program 1. Varactor oscillator design program listing.

JLIST

```

10 HOME: REM CLEARS THE SCREEN
20 PRINT " VARACTOR TUNED WIDEBAND"
30 PRINT " OSCILLATOR DESIGN"
40 PRINT " A.M.VICTOR"
50 PRINT " 1.1 9/9/84"
60 PRINT: PRINT: PRINT
70 PI = 3.1415926
80 PRINT "WHAT IS THE MIN AND MAX TUNE": PRINT "RANGE IN MHZ ";; INPUT
  F1,F2
90 W2 = 2 * PI * F2 * 1E6
100 W1 = 2 * PI * F1 * 1E6
110 PRINT: PRINT "ENTER TRANSMISSION LINE ZO,": PRINT "AND STARTING LI
  NE LENGTH": PRINT "IN DEGRESS";: INPUT ZO,ITHETA
120 STHETA = ITHETA
130 PRINT: PRINT "ENTER LINE LENGTH INCREMENT";: INPUT DL
140 PRINT: PRINT "ENTER THE DEVICE CAPACITANCE": PRINT "PLUS ANY PARAS
  ITICS IN PF";: INPUT CIN
150 HOME: REM BEGIN CALCULATIONS
160 XIN = 1 / (W1 * CIN * 1E - 12)
170 X2IN = 1 / (W2 * CIN * 1E - 12)
180 PRINT: PRINT "DELTA XCV "; TAB( 12);"LENGTH"; TAB( 20);"CVMIN"; TAB(
  30);"CVMAX"
190 FOR THETA = ITHETA TO 180 STEP DL
200 RTHETA = THETA / 57.29578
210 A = (ZO * TAN ((W2 / W1) * RTHETA)) - (W1 / W2) * XIN
220 B = 1 + (XIN * TAN (RTHETA) / ZO)
230 C = 1 + ((W1 / W2) * (XIN / ZO) * TAN ((W2 / W1) * RTHETA))
240 D = ZO * TAN (RTHETA) - XIN
250 XQUOT = (A * B) / (C * D)
260 XCVW1 = (ZO * TAN (RTHETA) - XIN) / (1 + (XIN / ZO) * TAN (RTHETA)
  )
270 Y2CVW2 = ((ZO * TAN ((W2 / W1) * RTHETA) - X2IN)) / (1 + (X2IN / ZO
  ) * TAN ((W2 / W1) * RTHETA))
280 CMAX = 1 / (2 * PI * F1 * XCVW1 * 1E6)
290 CMAX = CMAX * 1E12
300 X = CMAX
310 GOSUB 450
320 CMAX = H
330 YCMIN = 1 / (2 * PI * F2 * Y2CVW2 * 1E6)
340 YCMIN = YCMIN * 1E12
350 X = YCMIN
360 GOSUB 450
370 YCMIN = H
375 REM: NEXT 4 LINES CHECK FOR VALID TRANSMISSION LINE LENGTHS AND CAP
  ACITOR VALUES.
380 IF XQUOT < 0 THEN 430
390 IF YCMIN < 0 THEN 430
400 IF CMAX < 0 THEN 430
410 IF YCMIN > CMAX THEN 430
420 PRINT XQUOT; TAB( 13);THETA;"DEG"; TAB( 20);YCMIN;"PF"; TAB( 30);CM
  AX;"PF"
430 NEXT THETA
440 GOTO 530
450 G = INT (X)
460 H = G - X
470 H = ABS (H)
480 H = 100 * H

```

```

490 H = INT (H)
500 H = H / 100
510 H = H + G
520 RETURN
530 PRINT "ANOTHER RUN WITH NEW PARAMETERS Y/N ";: INPUT R$
540 IF R$ = "N" THEN 740
550 HOME : PRINT : PRINT "EDIT WHICH PARAMETERS?"
560 PRINT "FREQUENCY RANGE (1)?"
570 PRINT "TRANSMISSION LINE (2)?"
580 PRINT "DEVICE CAPACITANCE (3)?"
590 PRINT "OR DO TRANSMISSION LINE LENGTH CALCULATION (4)?"
600 PRINT "START NEW CALCULATION (5)"
610 PRINT "OR (6) TO END"
620 INPUT T
630 ON T GOTO 640,680,700,750,150,850
640 PRINT "ENTER TUNING RANGE MIN,MAX";: INPUT F1,F2
650 W1 = 2 * PI * F1 * 1E6
660 W2 = 2 * PI * F2 * 1E6
670 GOTO 550
680 PRINT "ENTER TRANSMISSION LINE Z0";: INPUT Z0
690 GOTO 550
700 PRINT "ENTER DEVICE CAPACITANCE PLUS ANY PARASITICS IN PF";: INPUT
    CIN
710 GOTO 550
720 HOME : ITHETA = STHETA
730 GOTO 160
740 HOME
750 PRINT "TRANSMISSION LINE LENGTH CALCULATION"
760 PRINT : PRINT "ENTER REL.DIELECTRIC CONSTANT OR": PRINT "VELOCITY F
    ACTOR, (E) OR (V) AND VALUE";: INPUT K$,ER
770 IF K$ = "V" THEN ER = 1 / ER ^ 2
780 PRINT "ENTER TRANSMISSION LINE": PRINT "LENGTH IN DEGREES";: INPUT
    FTHETA
790 LM = (FTHETA / 360) * (300 / F1) * (1 / SQR (ER))
800 IM = (LM * 100) / 2.54
810 PRINT "METRIC LENGTH"; TAB( 30);"INCHES"
820 PRINT LM; TAB( 30);IM
830 PRINT "ANOTHER RUN Y/N";: INPUT R$
840 IF R$ = "Y" THEN 550
850 END

```

teractive, you can try various combinations of line impedance, line length, and oscillator shunt output capacitance, which can be altered by shunting the oscillator device with an external capacitance. The program is arranged to automatically increment the transmission line length by a specified amount. During the program operation you'll notice that a particular line length exists which minimizes the required varactor capacitance change. Depending on the oscillator's tuning range and the line impedance, the required capacitance change of the varactor is affected and changes. For a large percentage tuning bandwidth, a high Z_0 is needed to keep the varactor capacitance change within practical limits.

VCO circuit

Several versions of the oscillator were tried. The

VCOs shown in **fig. 2** and in the photograph work well in an HF receiver using up-conversion. Each of the three VCOs covers 20 MHz in the 140-200 MHz range. The oscillators are phaselocked to a 1 MHz reference and their outputs are divided by 2. The final output is then tunable from 70 to 100 MHz in 500 kHz steps and provides injection for an up-conversion receiver with a 70 MHz first IF. U310 J-FETs and MV109 varactors are used. Trimmer capacitor values, varactor capacitance swing, and transmission line dimensions were determined by using the computer program. Each oscillator uses clamp bias to help regulate oscillator feedback as it is tuned and to prevent the FET gate-source junction from becoming forward-biased. This appears to help the oscillator noise performance as evidenced by measured values of better than 135 dBc/Hz, measured 25 kHz away from the car-

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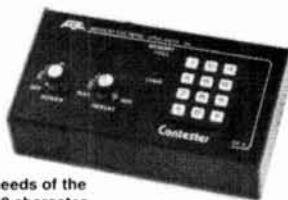
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WHAT IS THE MIN AND MAX TUNE
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ENTER TRANSMISSION LINE ZO,
AND STARTING LINE LENGTH
IN DEGRESS?50,10

ENTER LINE LENGTH INCREMENT?5

ENTER THE DEVICE CAPACITANCE
PLUS ANY PARASITICS IN PF?40

DELTA XCV	LENGTH	CVMIN	CVMAX
62.3339054	40DEG	9.82PF	1225.29PF
22.0994892	45DEG	6.33PF	279.89PF
23.7659259	50DEG	3.29PF	156.62PF
114.03646	55DEG	.47PF	107.54PF

ANOTHER RUN WITH NEW PARAMETERS Y/N ?Y

EDIT WHICH PARAMETERS?
FREQUENCY RANGE (1)?
TRANSMISSION LINE (2)?
DEVICE CAPACITANCE (3)?
OR DO TRANSMISSION LINE LENGTH CALCULATION (4)?
START NEW CALCULATION (5)
OR (6) TO END

?2
ENTER TRANSMISSION LINE ZO?75

EDIT WHICH PARAMETERS?
FREQUENCY RANGE (1)?
TRANSMISSION LINE (2)?
DEVICE CAPACITANCE (3)?
OR DO TRANSMISSION LINE LENGTH CALCULATION (4)?
START NEW CALCULATION (5)
OR (6) TO END

DELTA XCV	LENGTH	CVMIN	CVMAX
28.0326343	30DEG	10.55PF	591.88PF
11.6044757	35DEG	7.38PF	171.5PF
10.1093855	40DEG	4.91PF	99.38PF
12.2899117	45DEG	2.81PF	69.17PF
29.0553268	50DEG	.9PF	52.38PF

rier frequency (see fig. 3). Each VCO output is combined through switched pin diodes and the VCO is enabled by switching DC power from a bandswitch control logic board. The tuning line voltage of each VCO is tied together through shielded coax and 400 nH RF chokes. A small series resistor is used in line with the chokes to provide for a lower choke Q . Note that a small resistor is used; large decoupling resistors

add excessive amounts of thermal noise and can ruin an otherwise low-noise design.

digital VFO applications

The octave-tuned oscillator presented in fig. 4 covers 100-200 MHz. The layout is more critical since any additional parasitic capacitance present tends to reduce the achievable tuning range. The circuit does

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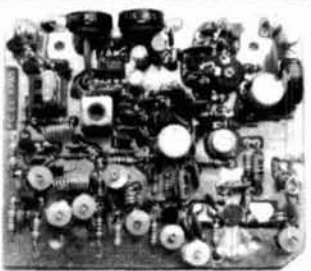
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provide octave coverage and requires a varactor voltage change from 1 to 20 volts. The noise performance was less impressive (115 to 120 dBc/Hz). However, if used in a low-noise phase lock loop and followed by frequency division, it provides the basis for a low noise synthesizer or digital VFO with 10 Hz resolution.

Another example of a digital VFO is shown in fig. 5. How about a continuous-tuning HF receiver with 1 kHz steps, using a single phase lock loop and the popular 9 MHz IF? The approach outlined uses a single 200 to 400 MHz VCO. Despite the coverage of the VCO, which is only an octave, appropriately dividing down the VCO frequency provides for frequency coverage in excess of an octave! If the first IF is 9 MHz, then an LO injection frequency from 10 to 40 MHz will provide reception from 1 to 31 MHz. Using the 200 to 400 MHz VCO with a divide by 10/20 circuit following it yields the needed coverage. The VCO is locked to a 10 kHz reference and programmed in 1 kHz steps.

Steps smaller than 1 kHz could be provided for by tuning or synthesizing the BFO.

A 200 to 400 MHz VCO was constructed and the measured noise performance varied from 110 dBc/Hz to 115 dBc/Hz at 25 kHz offset from the carrier. Division by 10 or 20 improves the noise by at least 20 dB or 130 dBc/Hz, which is quite adequate for most receiver applications. Signal generation is handled in a similar fashion, using a cascade of binary dividers. Our 200 to 400 MHz VCO, could provide the basis of an HF through UHF source by using successive division of the VCO and bandpass filtering. A number of commercially available signal sources use this approach.

summary

A design technique which allows the construction of wideband tunable oscillators with excellent noise performance is presented. The technique uses a trans-

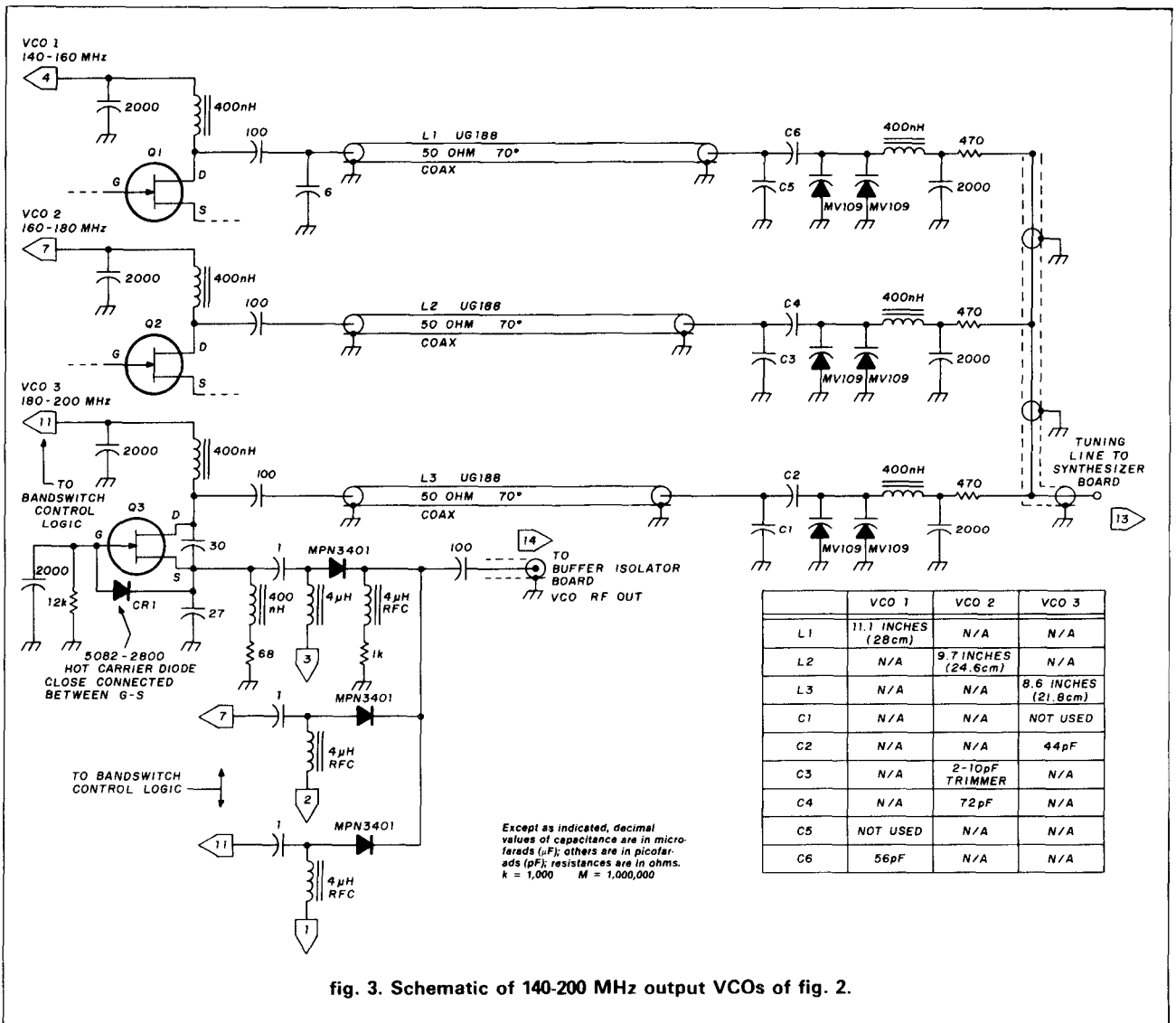


fig. 3. Schematic of 140-200 MHz output VCOs of fig. 2.

mission line and voltage variable capacitor that simulates an inductive change. A BASIC program which aids in the design of this configuration is included. Oscillators which exhibit broadband and low-noise performance have many applications. I would be very interested in hearing from readers who have similar applications.

references

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3. D.B. Leeson, "A Simple Model of Feedback Oscillator Noise Spectrum," *Proceedings of the IEEE*, February, 1966, page 329.
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appendix

determination of the transmission-line resonator parameters

The transmission line formula (eq. 1) can be rearranged to solve for Z_0 . Note that βL is not restricted to an electrical length of 90 degrees or a quarter wavelength.

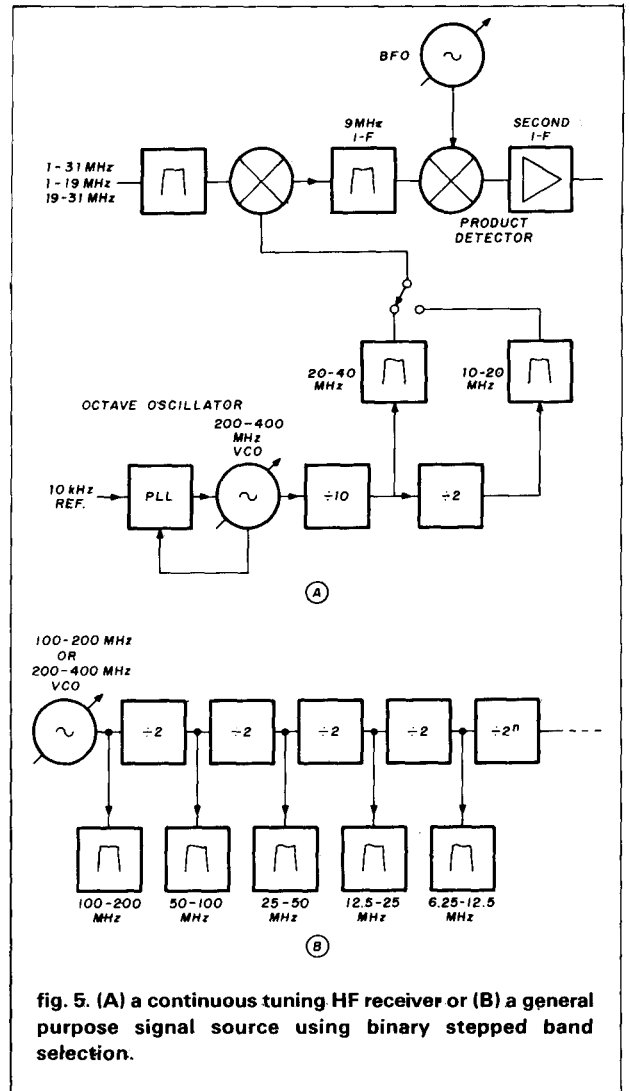
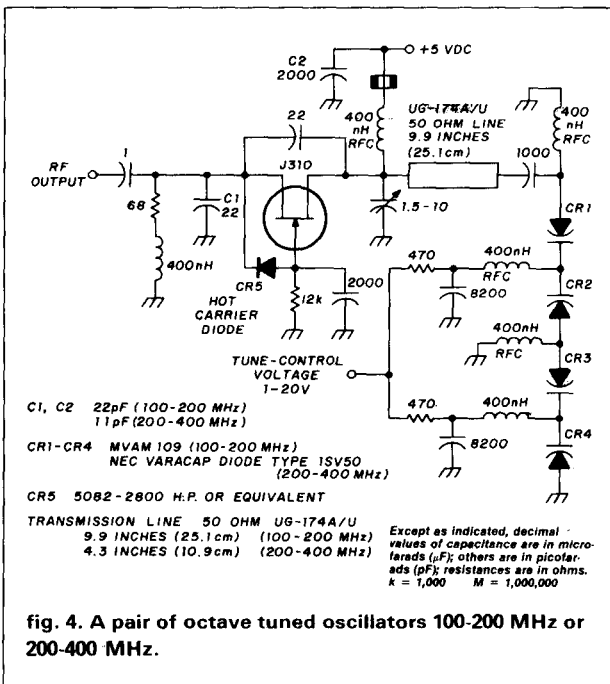
$$Z_0 = \frac{jZ_0 \tan \beta L - Z_s}{j(Z_s/Z_0) \tan \beta L - 1} \quad (A1)$$

Now $Z_s = +jX_{in}$ and resonates with $-jX_{in}$ of the device at resonance. Therefore, substituting for Z_s in eq. A1 gives:

$$Z = \frac{-j(Z_0 \tan \beta L - X_{in})}{1 + \frac{X_{in} \tan \beta L}{Z_0}} \quad (A2)$$

and the reactance of our tuning varactor is:

$$X_{C_v} = \frac{Z_0 \tan \beta L - X_{in}}{1 + \frac{X_{in} \tan \beta L}{Z_0}} \quad (A3)$$



Simplify by setting $\beta L = X$ at frequency f_1 , and $\beta L = \frac{f_2}{f_1} X$ at frequency f_2 . Since the oscillator shunt capacitance remains constant, X_{in} at f_2 equals (f_1/f_2) times X_{in} at f_1 . This information is now used to obtain the following reactance change needed to tune the VCO from f_1 to f_2 . The following reactance expression can be solved using the BASIC computer program or even a hand-held calculator. The equation is:

$$\frac{X_{C_v}(f_2)}{X_{C_v}(f_1)} = \frac{\left[Z_0 \tan \left(\frac{f_2}{f_1} X \right) - \frac{f_1}{f_2} X_{in}(f_1) \right] \left[1 + \frac{X_{in}(f_1) \tan X}{Z_0} \right]}{\left[1 + \frac{f_1}{f_2} \frac{X_{in}(f_1)}{Z_0} \tan \left(\frac{f_2}{f_1} X \right) \right] \left[Z_0 \tan X - X_{in}(f_1) \right]} \quad (A4)$$

where $X_{in}(f_1)$ = oscillator total shunt reactance at frequency f_1
 $X_{in}(f_2)$ = oscillator total shunt reactance at frequency f_2
 $X_{C_v}(f_1)$ = varactor reactance at frequency f_1
 $X_{C_v}(f_2)$ = varactor reactance at frequency f_2

Using the BASIC program and eq. A4 values of X , Z_0 , X_{in} will yield the required tuning ratio.

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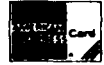
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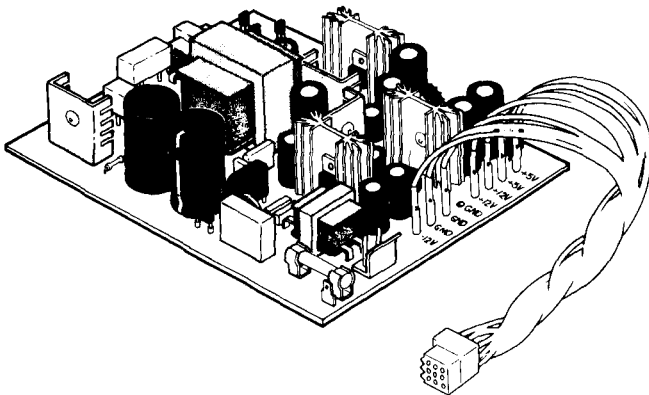
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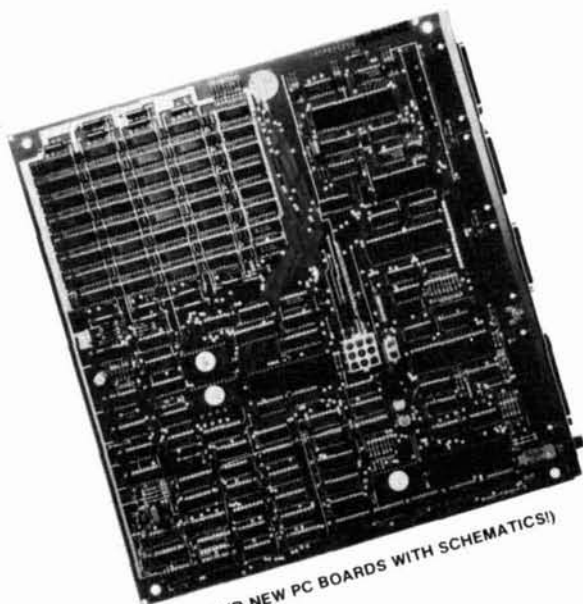
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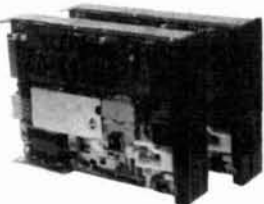
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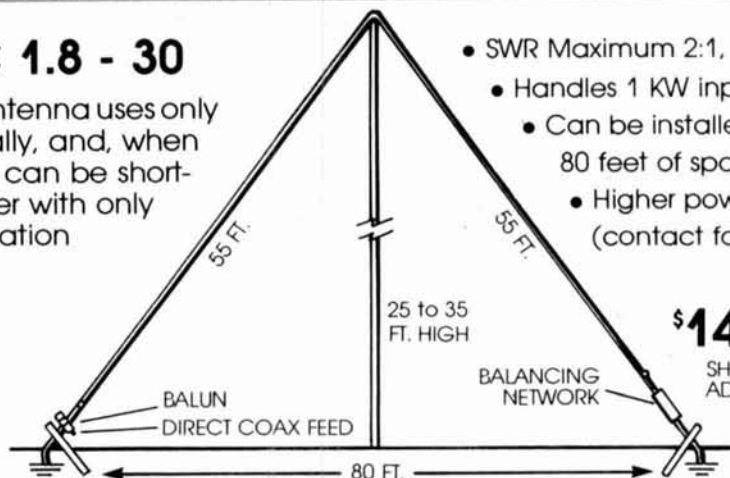
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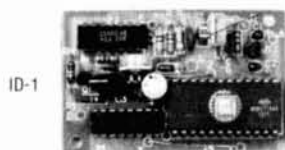


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the weekender

reflected power limiter



Most of the newer transistorized transceivers have circuits that limit output power if a high SWR or reflected power condition is encountered. But because many earlier rigs — and also linears — do not have such protection, the following unit was designed and built to automatically shut down equipment if a pre-set value of reflected power is exceeded. As some of us already know through sad experience, high reflected power, even if only for a few seconds, can be both damaging and costly.

operation

The idea is to sample a small amount of RF voltage from your SWR or reflected power meter, rectify it, and feed it through a sensitivity control to the base input of a Darlington transistor. At the proper triggering level, a relay in the collector circuit will close two of its contacts, locking itself in. At the same time another set of relay contacts will open the AC input power to your transceiver, shutting it off. The RF voltage selected by switch S2 is either REFLECTED or FORWARD, which makes it easy to initially set up the unit. A switch, S3, provides an override circuit which simplifies initial setup.

A Darlington transistor was chosen because it has a Beta (current gain) of more than 5000, which pro-

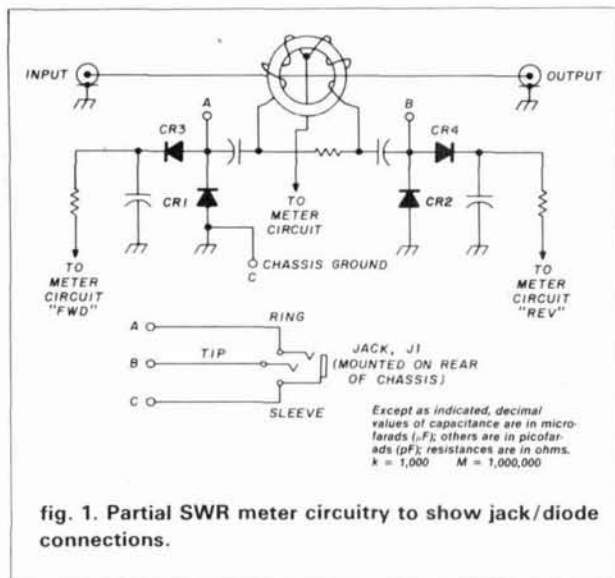


fig. 1. Partial SWR meter circuitry to show jack/diode connections.

vides more than sufficient sensitivity. The LED is useful in setting the bias control, and also indicates when the relay is locked in. During the breadboard development of the unit, some troublesome RF and 60 cycle pickup was encountered. This was readily cured by adding capacitors C1 and C2 as shown. They were incorporated into the final finished unit, as a precaution to eliminate such problems.

My own RF wattmeter is a SWAN WM-1500, and is generally representative of how SWR meters and wattmeters are constructed. The partial schematic is shown to indicate how the FORWARD and REFLECTED voltages are picked off and rectified by the added diodes CR1 and CR2. A stereo jack, J1, grounded to the meter chassis is a neat, easy way to transfer the voltages to the unit. Fig. 1 shows the schematic of the pick off voltages. At first glance it might seem that the DC voltage required for the unit could be picked off directly at the outputs of CR3 and CR4, thus eliminating the need for the added diodes CR1 and CR2. This worked well, except that under certain circumstances, a small amount of DC voltage from the unit would feed back into the wattmeter and cause the indicating meter of the wattmeter to read downscale by a few microamperes. The addition of the two diodes as shown eliminated that problem.

By William Vissers, K4KI, 1245 South Orlando Avenue, Cocoa Beach, Florida 32931

Without any RF voltage being fed into the unit, the bias control, if turned up sufficiently in the clockwise position, will turn on the transistor, locking in the relay. The bias control is a screwdriver adjustment on the rear of the unit. (It could also have been more conveniently mounted on the panel, using a conventional knob.) It is normally set somewhat below the turn-on point of the LED and relay lock in. The lower the bias control is set, the lower the standby current will be; I found that for normal operation, the standby current is less than a half a milliamper, which makes for long battery life. Switch S1 performs two functions, turning the power to the unit on, and when in the off position, isolating the unit from the wattmeter. Actually, the loading effect is so small as to be almost undetectable; the circuit was added more as a precaution than as a necessity.

The easiest way to set up the unit is to first determine the level of reflected power at which you want your transmitter to turn OFF. With the override switch, S3, on, and the bias properly set as just described, turn your sensitivity control counterclockwise. Set switch S2 in the FORWARD position. Then load up your transmitter until the forward power is the amount at which you want your reflected power level to trip the relay. Now turn the sensitivity control (clockwise) until the LED lights and the relay locks in. Throw S2 to the REFLECTED position, reset the relay by momentarily turning switch S1 OFF and then ON, and turn the override switch S3 OFF. The unit is now calibrated and ready to go. Now, if your reflected power in your system reaches the preselected level already set up, your LED will light up, your relay will lock in, and contacts DE of the relay will open, turning off your transmitter almost instantaneously and automatically protecting your equipment.

The required level of reflected power can be easily determined by knowing that if it is one tenth of the maximum forward power, then your SWR will be slightly below 2:1. Naturally, each operator may want to determine the maximum SWR at which the equipment will be shut off. When the unit is set up for its most sensitive condition, it actually will trip at about 3 to 4 watts of reflected power, which I have found is more sensitivity than you will normally need. Although the unit and the circuit shown in fig. 2 turn off my transceiver input power, the relay contacts could instead easily be used to reduce your drive, increase your bias, reduce your plate voltage, or any one of the many different ways to reduce power output. The unit shown was built for my Yaesu FT-101-B transceiver. Its relay contacts have a current capacity of 3 amperes. Some experimentation was also done using an NPN Darlington transistor TIP 120, (Radio Shack™ part number 276-2068), which has a power

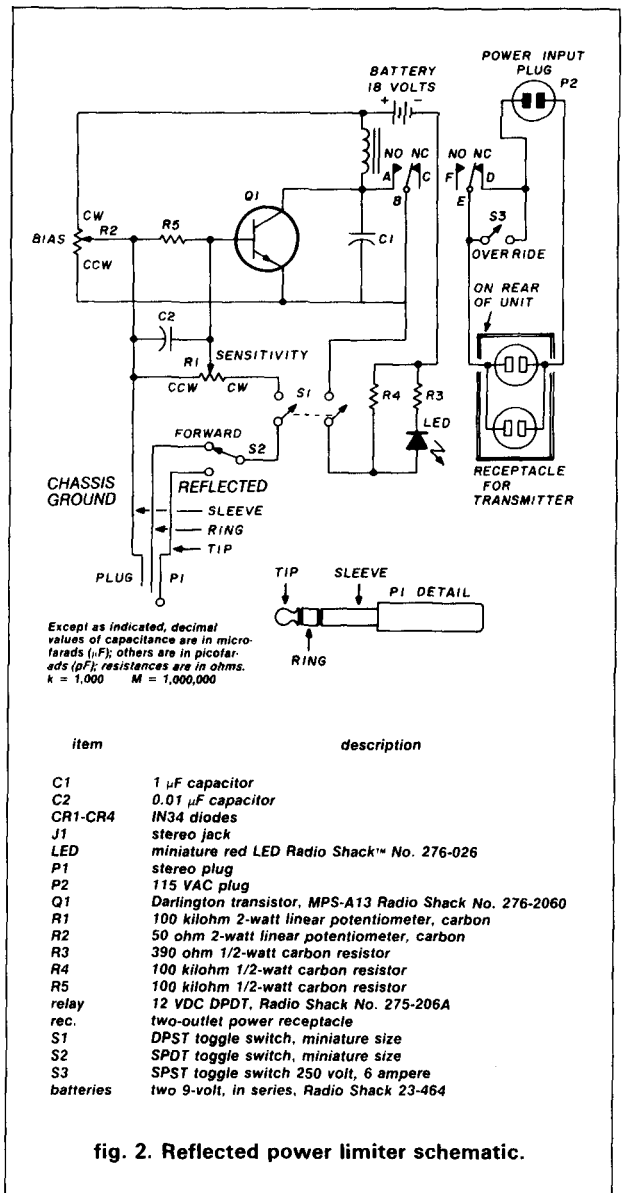


fig. 2. Reflected power limiter schematic.

dissipation of 65 watts, and would therefore be suitable for a high power linear control, in which a larger relay with heavier current contacts would be needed. It works in the circuit shown, but is slightly less sensitive. None of the parts listed were critical in any way; most of them came from my collection gathered over more than fifty years of hamming. The unit is housed in a metal box measuring 4 x 5 x 3 inches (10 x 12.7 x 7.6 cm). Any similar metal box will do.

I'd be interested in hearing from others who have built or experimented with a similar unit, and will be glad to answer any questions I can. Just include an SASE with your letter, addressed to me at the address provided.

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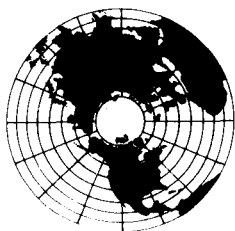
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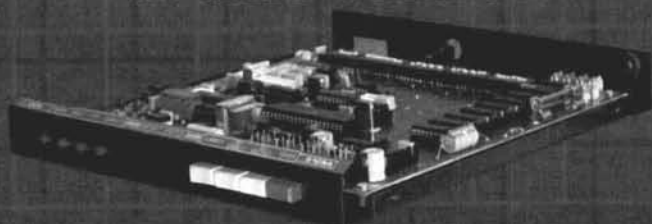


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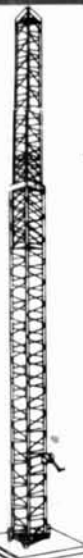
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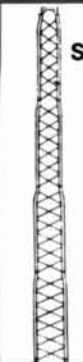
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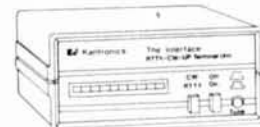
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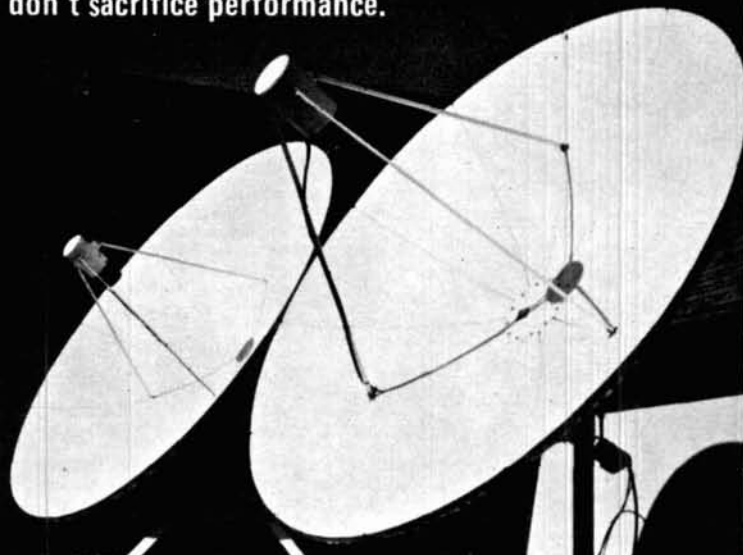
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part 3:

432 MHz with Knadle and Tilton

Computer model
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antenna designs

From the viewpoint of the antenna experimenter, the 432-MHz band is one of Amateur Radio's more intriguing frequency assignments. A Yagi with a boomlength of many wavelengths can be easily constructed, and stacking distances allow almost any operator to build arrays with formidable levels of performance. But with these advantages come several possible pitfalls: feedline losses can be a considerable factor in how well an array performs, and even the best of coaxial cables are noticeably lossy at 432 MHz. The matching system is very critical, and great care must be taken to avoid power losses between the driven element and the feedline.

While greater precision is required in cutting the parasitic elements for a 432 MHz Yagi than for a 144 MHz Yagi, precise element lengths are not as critical as is commonly believed. As is obvious from even a cursory examination of the tables of antenna iterations presented in this article, considerable latitude in the precise lengths of a series of parasitic elements is possible before the operator at either end of the signal path would notice any difference in signal strength.

Finally, even at today's inflated prices, a single pound of welding rod would yield the elements for many long Yagis at 432 MHz.

432 MHz computer iterations

Two different Yagi design approaches — based on the Knadle and Tilton/Greenblum design data — are discussed in this article. Both are familiar to VHF/UHF Amateurs; both enjoy good reputations for excellent performance and reproducibility; and both resulted from long hours of effort on the parts of well known, experienced Amateurs. The design frequency is 432.0 MHz. Previous articles used 144.5 MHz and 220.5 MHz for those respective VHF bands.^{1,2} This was a function of the stated design frequencies used in the development of the Yagis being iterated, or of the specific usage patterns of a particular band's frequency assignments. As is true of these two bands, the majority of weak-signal activity on 432 MHz is very close to 432.0 MHz. In addition, even long Yagis are comparatively broadbanded in frequency response on 432 MHz, making the use of 432.1 or 432.5 MHz as a design frequency of little practical purpose. An 8 MHz bandwidth, 428-436 MHz, is used to provide frequency response parameters. Because 0.0625 inch is probably the smallest measurement to which most Amateurs can accurately cut, it is used as the iteration increment.

the K2RIW Yagi antenna

Richard Knadle, K2RIW, is one of the most prolific contributors to Amateur VHF/UHF practice; his anten-

By Stanley Jaffin, WB3BGU, 800 Stonington Road, Silver Spring, Maryland 20902

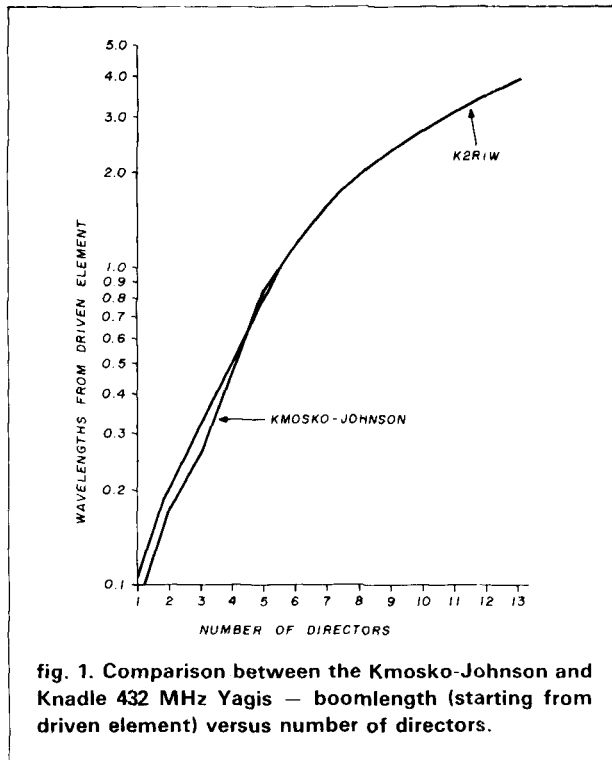


fig. 1. Comparison between the Kmosko-Johnson and Knadle 432 MHz Yagis — boomlength (starting from driven element) versus number of directors.

na and EME work is in addition to the transmitters, amplifiers, and receiver pre-amplifiers whose designs he has published in Amateur Radio journals. His original Yagi antenna design has been modified for introduction as a commercial product.³ Yet another modification of his original design is the subject of this article's computer iterations.

For a while it seemed that locating a copy of the Knadle Yagi antenna design was akin to trying to locate a schematic of the fabled Black Widow VHF/UHF transceiver. However, a full set of specifications was finally found in a rather obvious place,⁴ and the optimization process was begun.

The possible origin of the K2RIW Yagi may be apparent from table 1 and fig. 1. While its similarity to the Kmosko-Johnson design is apparent, the basic Knadle antenna has slightly more forward gain than the basic Kmosko-Johnson antenna (15.657 dBi versus 15.601 dBi). These basic antennas have thirteen elements and a zero director taper. What is perhaps the most interesting result of baselining the original K2RIW Yagi was finding the peak performance to be calculated to occur at the exact parasitic element lengths Knadle specified. Such close agreement between the empirical findings of a prominent practitioner and the iterations of a mathematical model is always a source of joy to the model's developers and users.

Before presenting the results of the computer iterations, it is worth noting that Knadle's exact matching method should be used on K2RIW Yagis. Other

table 1. A comparison of the interelement spacings of the Knadle and Kmosko-Johnson thirteen-element Yagis.

element number	name	spacing in wavelengths from previous element	
		Knadle	Kmosko-Johnson
1	reflector	0.0000	0.0000
2	driven	0.2289	0.2449
3	director 1	0.1098	0.0857
4	director 2	0.0984	0.0918
5	director 3	0.1235	0.0918
6	director 4	0.2013	0.1959
7	director 5	0.2745	0.3918
8	director 6	0.4323	0.3918
9	director 7	0.3889	0.3918
10	director 8	0.3889	0.3918
11	director 9	0.3889	0.3918
12	director 10	0.3889	0.3918
13	director 11	0.3889	0.3918

table 2. Baselined K2RIW Yagi at 432.0 MHz with fixed parasitic element spacings and parasitic element lengths supplied during each iteration.

element number	name	length (inches)	element spacing (λ)	cumulative length (λ)
1	reflector	—	0.000000	0.000000
2	driven	12.991445	0.228755	0.228755
3	director 1	—	0.109802	0.338557
4	director 2	—	0.098364	0.436922
5	director 3	—	0.123527	0.560450
6	director 4	—	0.201304	0.761755
7	director 5	—	0.274506	1.036261
8	director 6	—	0.432347	1.468609
9	director 7	—	0.388884	1.857493
10	director 8	—	0.388884	2.246378
11	director 9	—	0.388884	2.635262
12	director 10	—	0.388884	3.024146
13	director 11	—	0.388884	3.413030
14	director 12	—	0.388884	3.801914
15	director 13	—	0.388884	4.191789
16	director 14	—	0.388884	4.579683

methods are probably equally efficient,⁵ but by following the designer's instruction for at least the first antenna, the builder is able to establish a baseline for later comparisons.

iterating the K2RIW antenna

The original thirteen-element K2RIW Yagi was just over 3.4 wavelengths long, and was probably designed for use in multi-Yagi arrays; this would explain the relatively short boomlength. Extending this design to sixteen elements results in a Yagi still readily stacked, but with even more impressive results for the single antenna. Baselined in table 2, this antenna is just over 4.5 wavelengths long and fits easily on a 10-foot boom. All elements are 0.125 inch in diameter, and the design frequency is 432.0 MHz. As is necessary for successful

table 3. A comparison of optimized 432 MHz K2RIW Yagis for each of six different director tapering approaches.

taper	optimized performance parameter	parasitic element lengths (inches)		gain (dBi)	F/B (dB)
		reflector	director 1		
0.000000	gain	13.3125	11.5000	16.741	17.253
	F/B	13.4375	11.2500	16.372	32.666
0.015625	gain	13.3125	11.6250	16.737	17.535
	F/B	13.5000	11.3750	16.380	27.966
0.031250	gain	13.3125	11.7500	16.713	17.447
	F/B	13.5000	11.5000	16.400	25.026
0.046875	gain	13.3125	11.8750	16.696	16.971
	F/B	13.5000	11.6250	16.406	22.900
0.062500	gain	13.2500	11.9375	16.638	18.085
	F/B	13.6250	11.6875	16.211	21.372
0.078125	gain	13.1875	12.0625	16.595	17.428
	F/B	13.6250	11.8125	16.202	20.153

computer iterations, the driven element is specified at its $R + j0$ physical length.

Table 3 summarizes the results of six different pairs of K2RIW Yagi design iterations. As even the slightest element taper (increments of 0.015625 inch) results in degraded performance, full details are provided for only the zero taper antenna. Interestingly enough, Knadle specified a zero taper in the original design. Parasitic element lengths for optimizing a sixteen-element antenna differ from those that optimize a thirteen-element antenna. (More information on this phenomenon is contained in a later article in this series that addresses other Yagi optimization techniques.)

Table 4 presents the gain optimizing iteration that produced 16.741 dBi, and table 5 presents the F/B optimizing iteration that produced 32.666 dB. Tables

6 and 7 present these antennas' respective performance over the 8-MHz bandwidth. The gain optimized Yagi effectively illustrates the relatively broadband response of even long Yagis at 432 MHz. The F/B optimized antenna provides an excellent F/B across this same bandwidth. This optimized F/B is not a single frequency F/B resulting from sharp vectorial cancellation, but is the high level of F/B that comes naturally with long Yagis that are well designed. Figures 2 and 3 present these antennas' respective E-plane plots. The gain optimized antenna has the sharper main lobe, but the F/B optimized antenna has a deeper first null. Knadle seems to have preferred a gain optimized antenna, but depending on the chosen antenna's designated use, either of these optimized K2RIW designs result in first-rate antennas. His original thir-

table 4. Optimized gain iteration for the zero taper K2RIW antenna with a reflector length of 13.3125 inches.

director 1 (inches)	gain (dBi)	F/B (dB)
11.0000	15.754	20.051
11.0625	15.918	21.305
11.1250	16.081	23.071
11.1875	16.241	25.658
11.2500	16.394	29.312
11.3125	16.533	30.406
11.3750	16.648	25.467
11.4375	16.724	20.842
11.5000	16.741	17.253
11.5625	16.676	14.346
11.6250	16.504	11.908
11.6875	16.214	9.836
11.7500	16.004	8.469
11.8125	15.336	6.733
11.8750	14.848	5.873
11.9375	14.075	8.464
12.0000	13.632	8.218

table 5. Optimized F/B iteration for the zero taper K2RIW antenna with a reflector length of 13.4375 inches.

director 1 (inches)	gain (dBi)	F/B (dB)
11.0000	15.727	21.757
11.0625	15.811	22.437
11.1250	16.058	25.663
11.1875	16.219	29.167
11.2500	16.372	32.666
11.3125	16.510	28.755
11.3750	16.621	23.484
11.4375	16.690	19.491
11.5000	16.696	16.335
11.5625	16.614	13.713
11.6250	16.424	11.474
11.6875	16.116	9.549
11.7500	15.704	7.929
11.8125	15.232	6.664
11.8750	14.766	5.902
11.9375	14.339	6.060
12.0000	13.616	8.739

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teen-element Yagi provided a single frequency type of F/B when optimized for F/B.

the Tilton/Greenblum Yagi

The evolution of the Greenblum and Tilton/Greenblum designs was discussed in a previous article.² Tilton's 432 MHz Yagi was originally published as an eleven-element design.⁶ For purposes of computer iteration and comparison with the Knadle design, a sixteen-element Yagi is presented. The additional five directors are spaced equally apart in accordance with

table 6. Frequency response parameters for the gain optimized zero taper K2RIW antenna.

frequency (MHz)	gain (dBi)	F/B (dB)
428.0	16.630	25.127
429.0	16.683	23.056
430.0	16.721	20.926
431.0	16.736	18.982
432.0	16.741	17.253
433.0	16.717	15.716
434.0	16.667	14.340
435.0	16.589	13.097
436.0	16.480	11.969

table 7. Frequency response parameters for the F/B optimized zero taper K2RIW antenna.

frequency (MHz)	gain (dBi)	F/B (dB)
428.0	16.122	23.635
429.0	16.191	25.519
430.0	16.256	27.874
431.0	16.316	30.675
432.0	16.372	32.666
433.0	16.422	31.198
434.0	16.466	27.976
435.0	16.501	25.028
436.0	16.526	22.584

table 8. Baselined Tilton/Greenblum Yagi at 432.0 MHz with fixed parasitic element spacings and parasitic element lengths supplied during each iteration.

element number	element name	length (inches)	spacing (λ)	element cumulative length (λ)
1	reflector	—	0.000000	0.000000
2	driven element	13.032811	0.137253	0.137253
3	director 1	—	0.137253	0.274506
4	director 2	—	0.173854	0.448361
5	director 3	—	0.237906	0.686266
6	director 4	—	0.265356	0.951622
7	director 5	—	0.274506	1.226129
8	director 6	—	0.347708	1.573837
9	director 7	—	0.347708	1.921545
10	director 8	—	0.347708	2.269254
11	director 9	—	0.347708	2.616962
12	director 10	—	0.347708	2.964670
13	director 11	—	0.347708	3.312378
14	director 12	—	0.347708	3.660086
15	director 13	—	0.347708	4.007795
16	director 14	—	0.347708	4.355503

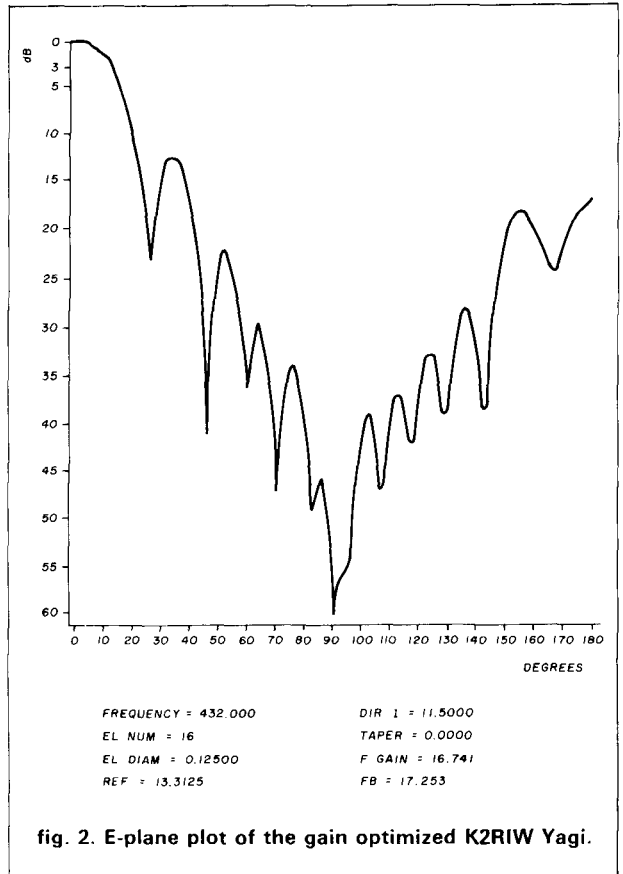


fig. 2. E-plane plot of the gain optimized K2RIW Yagi.

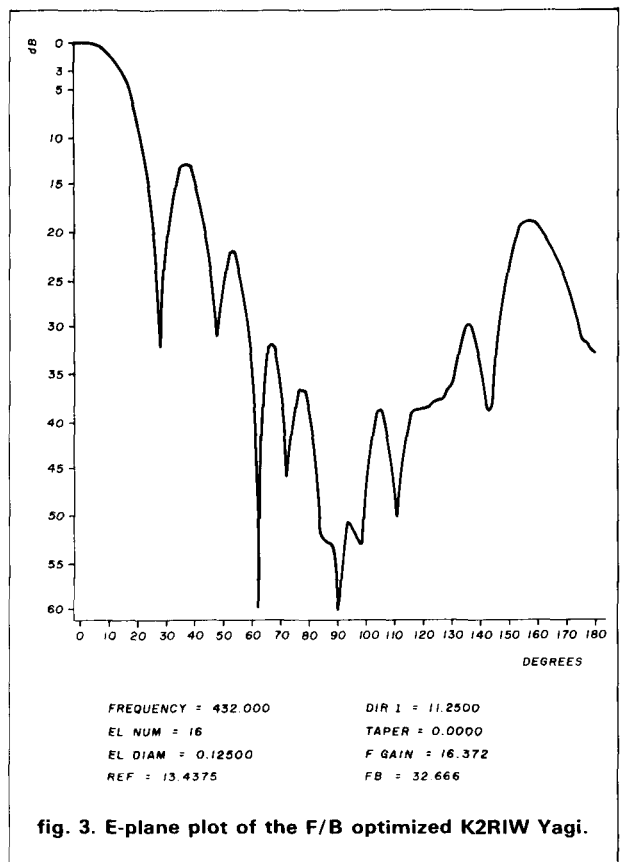


fig. 3. E-plane plot of the F/B optimized K2RIW Yagi.

table 9. A comparison of the optimized Tilton/Greenblum 432 MHz Yagis for each of thirteen director tapering approaches.

taper	optimized performance parameter	parasitic element lengths (inches)		gain (dBi)	F/B (dB)
		reflector	director 1		
0.000000	gain	13.5000	11.6875	15.942	12.794
	F/B	13.1875	12.0625	14.303	38.225
0.015625	gain	13.5625	11.8750	16.103	14.277
	F/B	13.1875	12.1875	14.473	37.976
0.031250	gain	13.6250	12.0000	16.259	15.754
	F/B	13.2500	12.3125	14.753	35.519
0.046875	gain	13.6250	12.1250	16.390	17.088
	F/B	13.2500	12.3750	15.299	30.234
0.062500	gain	13.6250	12.1875	16.498	18.106
	F/B	13.2500	12.5000	15.187	42.848
0.078125	gain	13.6250	12.3125	16.574	20.076
	F/B	13.3125	12.5625	15.619	39.416
0.093750	gain	13.6875	12.3125	16.657	22.212
	F/B	13.3750	12.6250	15.907	37.921
0.109375	gain	13.6875	12.4375	16.634	24.416
	F/B	13.4375	12.6875	16.067	39.146
0.125000	gain	13.5625	12.5000	16.651	24.325
	F/B	13.4375	12.7500	16.099	42.827
0.140625	gain	13.5625	12.5625	16.583	25.312
	F/B	13.5625	12.7500	16.319	48.957
0.156250	gain	13.6250	12.6250	16.529	29.287
	F/B	13.7500	12.6875	16.457	46.691
0.171875	gain	13.6250	12.6875	16.448	30.353
	F/B	13.7500	12.6875	16.421	35.637
0.187500	gain	13.6250	12.6875	16.364	28.608
	F/B	13.8125	12.6875	16.319	31.650

table 10. Optimized gain iteration for a taper of 0.0625 with a reflector length of 26.375 inches.

director 1 (inches)	gain (dBi)	F/B (dB)
11.7500	15.903	17.498
11.8125	16.028	17.296
11.8750	16.143	17.153
11.9375	16.247	17.087
12.0000	16.337	17.122
12.0625	16.413	17.285
12.1250	16.469	17.605
12.1875	16.498	18.106
12.2500	16.485	18.778
12.3125	16.408	19.504
12.3750	16.235	19.941
12.4375	15.931	19.609
12.5000	15.484	18.497
12.5625	14.930	17.179
12.6250	14.359	15.962
12.6875	13.839	14.147
12.7500	13.355	11.391

table 11. Optimized F/B iteration for a taper of 0.0625 with a reflector length of 13.25 inches.

director 1 (inches)	gain (dBi)	F/B (dB)
11.7500	15.821	13.870
11.8125	15.936	13.701
11.8750	16.036	13.568
11.9375	16.119	13.495
12.0000	16.180	13.513
12.0625	16.215	13.660
12.1250	16.220	13.992
12.1875	13.665	22.300
12.2500	16.113	15.587
12.3125	15.986	17.210
12.3750	15.796	19.961
12.4375	15.535	25.365
12.5000	15.187	42.848
12.5625	14.753	24.093
12.6250	14.231	17.825
12.6875	13.664	13.723
12.7500	13.251	10.706

the Greenblum design data and Tilton's adaptation. This Yagi is constructed on a non-conductive boom and is baselined in table 8. Parasitic element diameter is 0.09375 inch, and the design frequency is 432.0 MHz. Tilton did not specify his own exact design frequency, but a careful reading of his article gives the

impression that a slightly higher frequency was used. This would follow from the general band usage patterns of that era. As the matching of the transmission line and driven element is very critical on 432 MHz, Tilton's driven element assembly should be duplicated exactly. Any desired changes should be made in a sec-

table 12. Frequency response parameters for the gain optimized antenna with a 0.0625 taper.

frequency (MHz)	gain (dBi)	F/B (dB)
428.0	16.419	16.157
429.0	16.446	16.589
430.0	16.469	17.061
431.0	16.487	17.570
432.0	16.498	18.106
433.0	16.492	18.641
434.0	16.487	19.127
435.0	16.460	19.485
436.0	16.411	19.622

table 13. Frequency response parameters for the F/B optimized antenna with a 0.0625 taper.

frequency (MHz)	gain (dBi)	F/B (dB)
428.0	15.201	18.096
429.0	15.244	20.376
430.0	15.263	23.657
431.0	15.173	27.940
432.0	15.187	42.848
433.0	15.073	30.226
434.0	14.908	24.244
435.0	14.700	20.882
436.0	14.469	18.625

ond Yagi so as to allow comparisons with an established standard.

Table 9 summarizes the results of iterating thirteen pairs of Tilton/Greenblum 432 MHz Yagis. Performance trends are easily noted and there is no real need for additional iterations. As it is highly unlikely that many VHF/UHF operators could reliably measure or build to tolerances of 0.015625 inch, the Yagis of real interest are those at intervals of 0.0625 inch. These four Yagis also represent peaks or near-peaks in either gain or F/B. This same interval is also used for parasitic element lengths. Furthermore, the zero taper Yagis can be readily seen to be the poorest performers of these four pairs of antennas. As such they are excluded from the detailed examinations that follow for the tapering approaches of 0.0625, 0.125, and 0.1875 inch. The tables that follow refer to these Yagis.

taper = 0.0625

This is the only Tilton/Greenblum 432 MHz Yagi that was actually presented by Tilton. The two Yagis that follow (0.125 and 0.1875 taper) are the products of computer iteration. **Table 10** presents the gain optimizing iteration that resulted in 16.498 dBi of gain, and **table 11** presents the F/B optimizing iteration and its calculated result of 42.848 dB. Nearly 1.3 dB of gain and over 24 dB of F/B separate these two 0.0625 taper Yagis. **Tables 12** and **13** present these antennas' respective calculated performance over the specified

bandwidth. Both antennas show peaks in their calculated performance parameters at 432.0 MHz. The F/B optimized value is clearly the result of single frequency vectorial cancellation. When coupled with a weak signal bandwidth that is relatively narrow in terms of the design frequency's wavelength, this F/B value will not deteriorate as rapidly as it would at a lower frequency. Extensive QSYs will probably result in noticeable decreases in rearward attenuation. **Figures 4** and **5** present E-plane plots of these antennas. The gain optimized antenna has a significantly sharper and deeper main lobe as well as a measurably higher degree of unwanted signal attenuation between 100 and 160 degrees. The F/B optimized antenna provides the expected outstanding level of unwanted signal attenuation from 160 to 180 degrees.

table 14. Optimized gain iteration for a taper of 0.125 with a reflector length of 13.5625 inches.

director 1 (inches)	gain (dBi)	F/B (dB)
12.0000	15.826	20.040
12.0625	15.968	20.006
12.1250	16.103	20.023
12.1875	16.229	20.117
12.2500	16.345	20.324
12.3125	16.433	20.524
12.3750	16.532	21.296
12.4375	16.592	22.247
12.5000	16.651	24.325
12.5625	16.601	26.163
12.6250	16.519	30.366
12.6875	16.359	35.590
12.7500	16.119	29.599
12.8125	15.825	24.253
12.8750	15.543	20.913
12.9375	15.355	18.600
13.0000	15.271	16.726

table 15. Optimized F/B iteration for a taper of 0.125 with a reflector length of 13.4375 inches.

director 1 (inches)	gain (dBi)	F/B (dB)
12.0000	15.826	18.494
12.0625	15.962	18.442
12.1250	16.090	18.422
12.1875	16.210	18.456
12.2500	16.318	18.573
12.3125	16.411	18.812
12.3750	16.486	19.229
12.4375	16.538	19.905
12.5000	16.558	20.971
12.5625	16.537	22.664
12.6250	16.460	25.498
12.6875	16.315	31.062
12.7500	16.099	42.827
12.8125	15.832	28.671
12.8750	15.567	22.795
12.9375	15.373	19.036
13.0000	15.262	16.159

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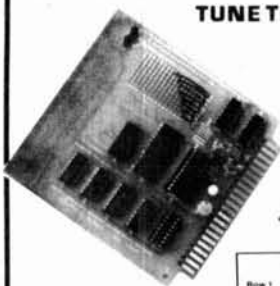
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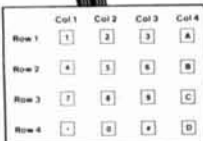
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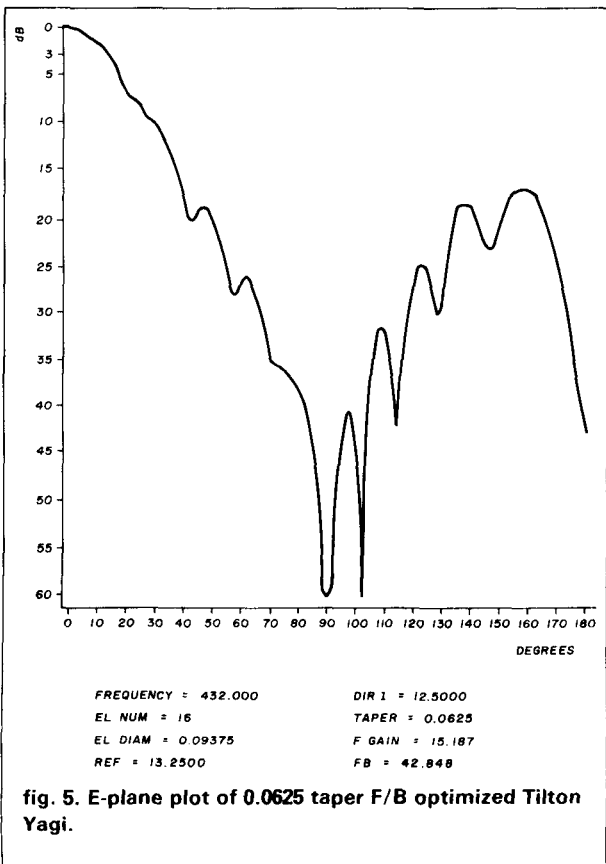
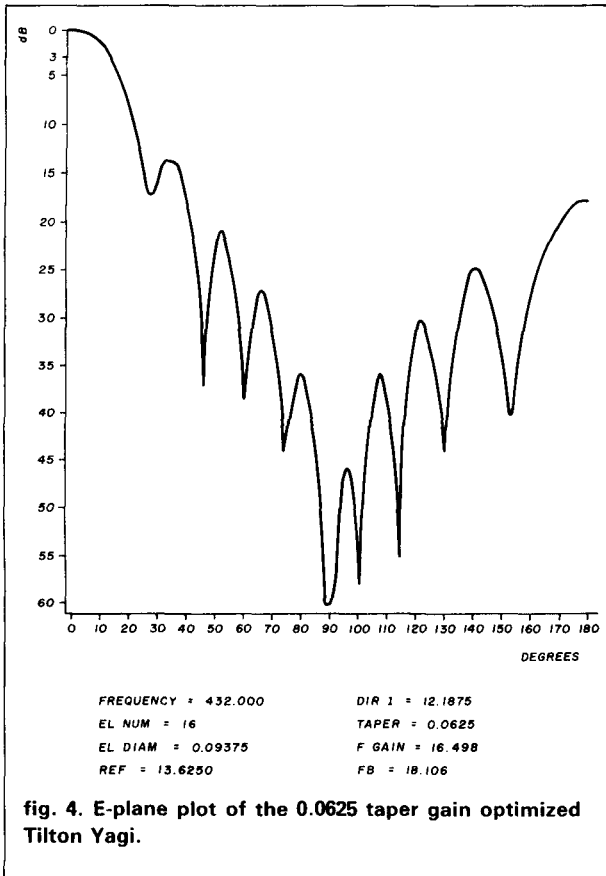
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taper = 0.125

This antenna exists solely as a product of computer iterations. In comparison with the 0.0625 tapered antenna design presented by Tilton and optimized through computer iteration, the optimized antennas with a 0.0125 taper require shorter reflectors and longer directors. **Table 14** presents the gain optimizing iteration that resulted in 16.651 dBi of gain, and **table 15** presents the F/B optimizing run with a calculated F/B of 42.825 dB. Over 0.5 dB of gain and 18 dB of F/B

table 16. Frequency response parameters for the gain optimized antenna with a 0.125 taper.

frequency (MHz)	gain (dBi)	F/B (dB)
428.0	16.498	19.253
429.0	16.542	20.106
430.0	16.578	21.101
431.0	16.604	22.290
432.0	16.651	24.325
433.0	16.622	25.548
434.0	16.608	27.807
435.0	16.575	30.379
436.0	16.520	31.856

table 17. Frequency response parameters for the F/B optimized antenna with a 0.125 taper.

frequency (MHz)	gain (dBi)	F/B (dB)
428.0	16.249	21.400
429.0	16.253	23.727
430.0	16.231	27.083
431.0	16.180	32.775
432.0	16.099	42.827
433.0	15.990	32.371
434.0	15.861	26.835
435.0	15.722	23.582
436.0	15.587	21.398

table 18. Optimized gain iteration for a taper of 0.1875 with a reflector length of 13.625 inches.

director 1 (inches)	gain (dBi)	F/B (dB)
12.2500	15.690	23.557
12.3125	15.830	23.848
12.3750	15.962	24.218
12.4375	16.083	24.698
12.5000	16.190	25.333
12.5625	16.277	26.172
12.6250	16.337	27.266
12.6875	16.364	28.608
12.7500	16.348	29.937
12.8125	16.281	30.455
12.8750	16.167	29.535
12.9375	16.023	27.980
13.0000	15.897	26.706
13.0625	15.845	25.256
13.1250	15.855	21.841
13.1875	15.733	17.729

separate these two antennas. **Tables 16 and 17** present these antennas' respective calculated performance over the relevant bandwidth. Both antennas' optimized parameters show peak values at 432.0 MHz. The F/B optimized antenna's F/B value is clearly a single frequency peak. However, as is true of the 0.0625 tapered F/B optimized antenna, the relative broad frequency responses of Yagis at 432 MHz is coupled with a relatively small bandwidth for the weak signal area. Consequently it is very likely that high F/B values, though not the calculated peak values, will be recognized in practice. **Figures 6 and 7** present these antennas' respective E-plane plots. The gain optimized antenna has the more sharply defined main lobe and generally deeper nulls throughout the pattern. Signal attenuation between 150 and 170 degrees is also greater than for the F/B optimized antenna. It is in the last 10 degrees that the F/B antenna provides a noticeable difference in performance. To some degree this F/B antenna typifies some of the exceptions to the use of F/B as an antenna performance parameter that were detailed by Lawson.⁷

taper = 0.1875

As is the case for the 0.125 tapered antennas, this pair of Yagis exists solely as the result of computer iterations. Compared to the 0.125 tapered antennas, longer reflectors and longer directors are used. **Table 18** presents the gain optimizing iteration that resulted in 16.364 dBi of gain, and **table 19** presents the F/B optimizing iteration with a calculated F/B of 31.650 dB. Less than 0.5 dB of gain and just over 3 dB of F/B separate these antennas. **Tables 20 and 21** present these antennas' respective calculated performance over the relevant bandwidth. Both antennas show peaks at 432 MHz for their respectively optimized parameters. The F/B values shown in **table 21** are not the single frequency F/B ratios of the two prior F/B optimized antennas. This F/B comes naturally from the antenna's design and is available over a 3 MHz bandwidth. **Figures 8 and 9** present these antennas' nearly identical E-plane plots, respectively. There are no distinguishing differences of any major consequence.

comparative results of computer iteration

These iterated comparisons between the single Knadle and multiple Tilton designs indicate there are no really significant differences in calculated forward gain. Any choice between these two design approaches, or from within the Tilton design approach would have to be based on a given antenna's calculated radiation pattern.

With the exception of the 0.1875 tapered Yagi, the F/B optimized antenna in each Tilton pair has the less clearly defined main lobe. The opposite was true of

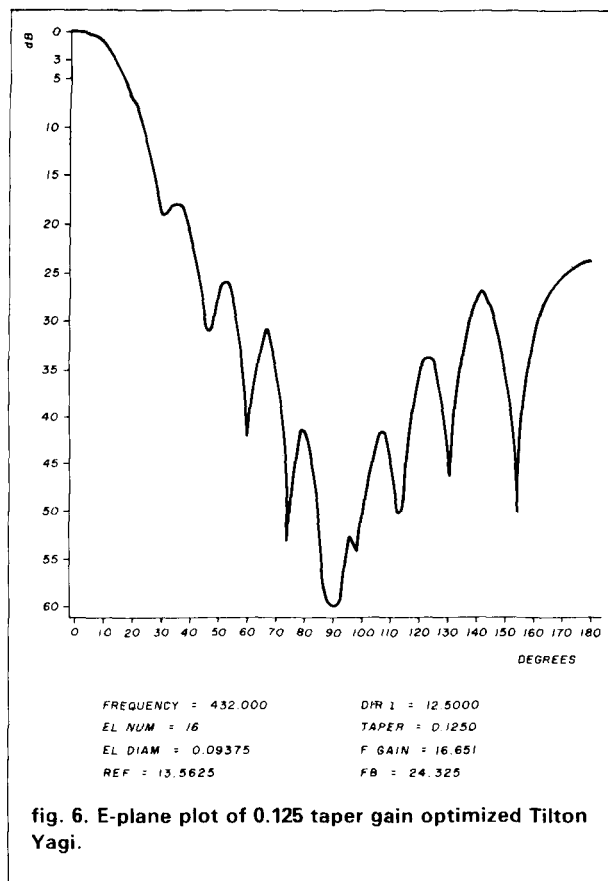


fig. 6. E-plane plot of 0.125 taper gain optimized Tilton Yagi.

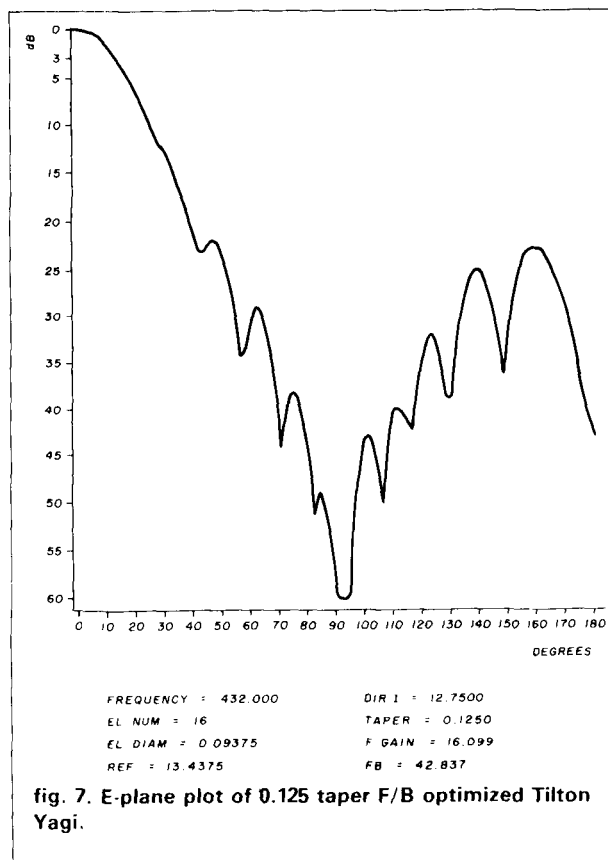
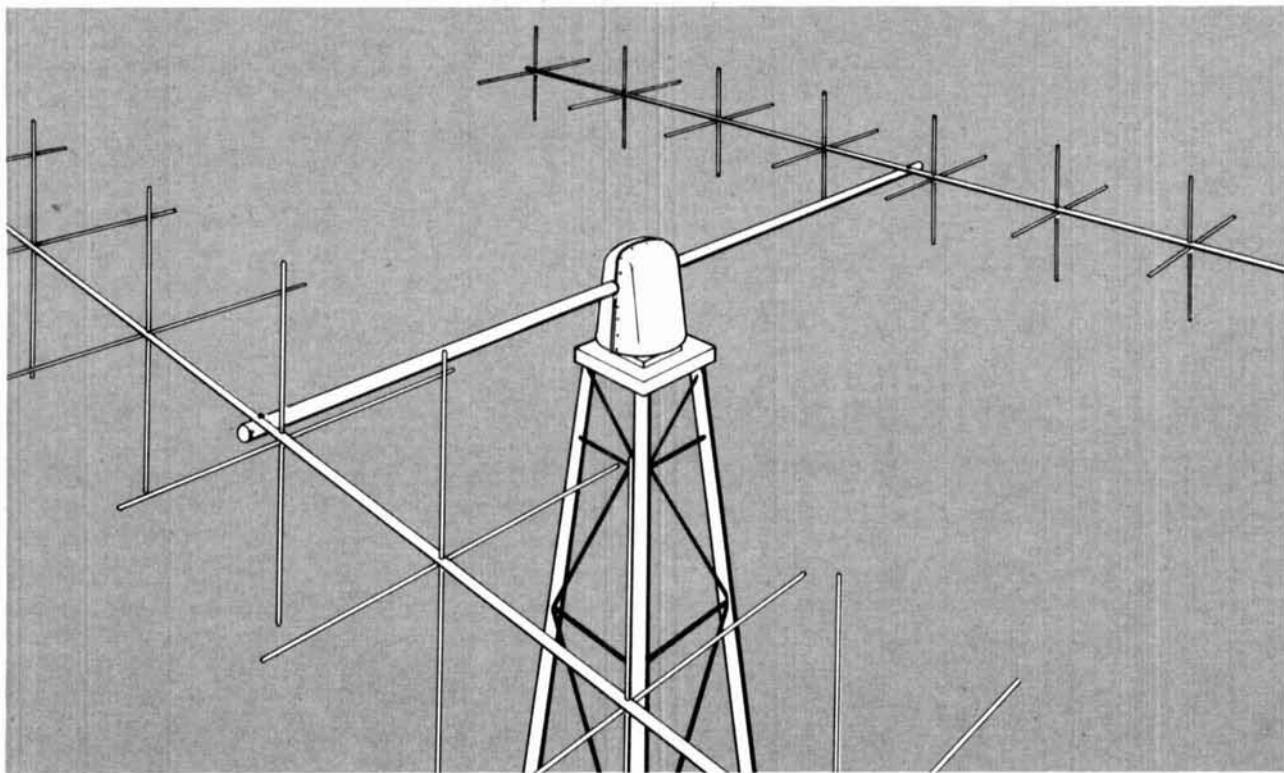


fig. 7. E-plane plot of 0.125 taper F/B optimized Tilton Yagi.

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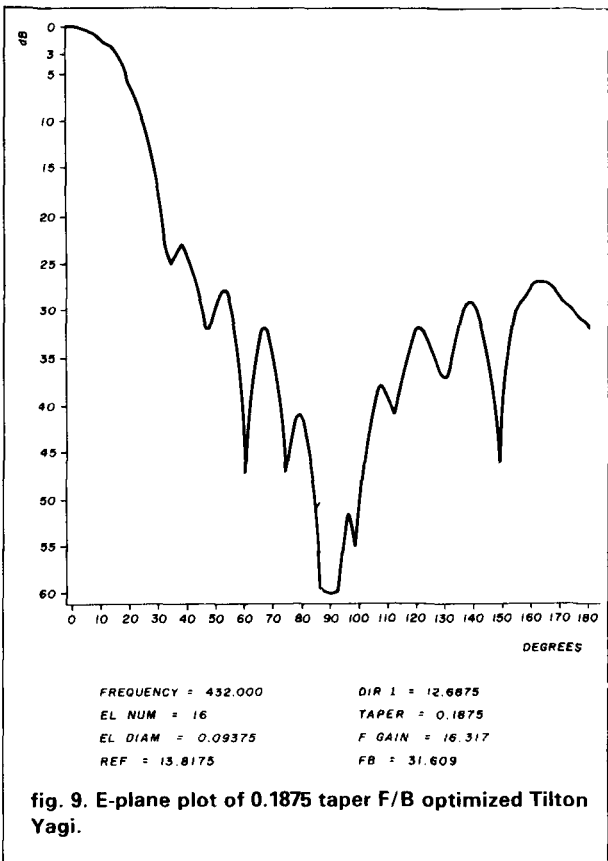
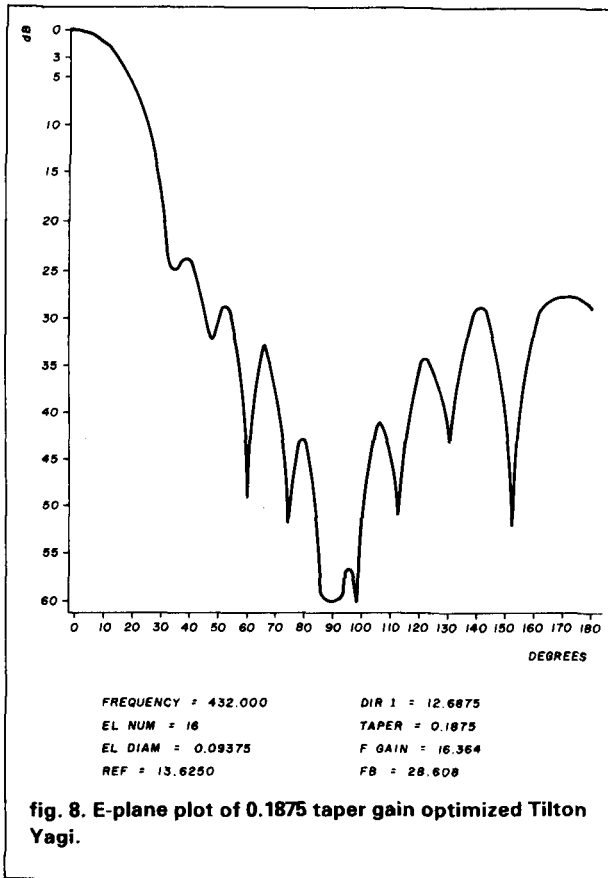


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the single Knadle Yagi. However, the first minor lobe on the Knadle Yagis tended to be of greater amplitude than the same lobe on comparable Tilton Yagis.

The need for an exceptionally high F/B on 432 MHz is open to question. F/B is a moot point for EME, and for terrestrial paths there simply is not the level of QRM comparable to 40 meters. Given that the pattern-wide attenuation of unwanted signals calculated for the Tilton 0.0625 and 0.125 gain optimized Yagis exceeds that of the F/B optimized Yagi in these pairs, these

table 19. Optimized F/B iteration for a taper of 0.1875 with a reflector length of 13.8125 inches.

director 1 (inches)	gain (dBi)	F/B (dB)
12.2500	15.627	25.171
12.3125	15.774	25.658
12.3750	15.912	26.283
12.4375	16.040	27.094
12.5000	16.151	28.143
12.5625	16.239	29.453
12.6250	16.299	30.867
12.6875	16.319	31.650
12.7500	16.291	30.726
12.8125	16.211	28.534
12.8750	16.083	26.331
12.9375	15.936	24.760
13.0005	15.823	24.066
13.0625	15.796	23.808
13.1250	15.782	21.524
13.1875	15.506	17.627
13.2500	14.849	15.885

table 20. Frequency response parameters for the gain optimized antenna with a 0.1875 taper.

frequency (MHz)	gain (dBi)	F/B (dB)
428.0	16.248	23.482
429.0	16.311	24.298
430.0	16.340	25.563
431.0	16.358	27.004
432.0	16.364	28.608
433.0	16.357	30.223
434.0	16.335	31.363
435.0	16.299	31.314
436.0	16.406	25.784

table 21. Frequency response parameters for the F/B optimized antenna with a 0.1875 taper.

frequency (MHz)	gain (dBi)	F/B (dB)
428.0	16.290	27.628
429.0	16.312	28.969
430.0	16.326	30.323
431.0	16.328	31.389
432.0	16.319	31.650
433.0	16.297	30.838
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gain optimized Yagis seem to be preferable. To a much lesser degree this is also true for the 0.1875 Tilton Yagi pair. In effect the real choice of antennas is narrowed to any of the gain optimized Tilton Yagis and either of the Knadle Yagis.

The minor lobe structure of the 0.125 and 0.1875 gain optimized Tilton Yagis is measurably sharper than either of the Knadle antennas. If a final choice of antennas were to be made, either of these Tilton designs would be appropriate, with the 0.125 design preferable. The selection of one antenna design from these many fine designs depends more on the station operator than any of the calculated differences in the stated selection criteria. Excellent results can be expected from either of the two preferable Tilton designs or from either of the Knadle Yagis. The differences in forward gain are more a function of the Knadle Yagi's longer boomlength than any verifiable design superiority. In fact, the additional 0.22 wavelength advantage should have given the Knadle Yagi a larger margin by at least another 0.1 dB.

Comparisons among these Tilton and Knadle Yagis and the NBS 4.2 wavelength Yagi are also interesting. Though the former Yagis are only marginally longer, they provide higher calculated forward gains. The NBS Yagi has a calculated forward gain of 15.71 dBi. The 0.0625, 0.125, and 0.1875 Tilton gain optimized Yagis were calculated to have 16.498, 16.651, and 16.364 dBi of gain, respectively. The gain and F/B optimized Knadle Yagis had calculated gain figures of 16.741 and 16.372 dBi, respectively. The additional gain calculated for any of these five Yagis is in excess of what the comparative differences in boomlength would explain. An additional director and the use of varying parasitic element spacing are the main reasons for these differences. The NBS antenna's first minor lobe is of greater amplitude than these 0.0625 and 0.125 Tilton Yagis. The NBS antenna also has slightly less F/B than these 0.125 and 0.1875 Tilton Yagis.

Next month's article will present a single pair of 50 MHz Yagis with highly desirable performance parameters. They represent an interesting exception to a very popular design approach.

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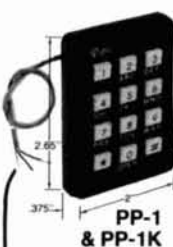
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During weekdays, until about 5 PM local time, 160 phone was a cross-section of juvenile America. High school lads, with plenty of enthusiasm

and little money, were on the air with 20 or 30-watt phone rigs. In the evening hours, they were obliterated by older, more affluent Amateurs who boasted powerful rigs of 50 to 150 watts. All in all, it was a lot of fun.

There was plenty of DX excitement for the young operators. Many a tired teen-ager stumbled into class in the morning after an all-night DX session. On the east coast, the mark of a true DXer was that he had been able to hear W6JYH in Los Angeles on phone. (*Working him was out of the question!*) On the west coast, the test was to hear W1DJL in Massachusetts. And every-

body envied the booming 160 phone signal of W4CPG in New Port Richey, Florida.

With the advent of World War II and the invasion of LORAN, the old 160-meter band remained practically deserted except for a few die-hards — until recently. Now, with the band appearing on the bandswitch of most new excitors, and LORAN banished to the low frequencies, interest in "top band" has exploded.

I listened in during the spring CW contest. The band was jumping with CW signals from all over the United States and Canada, crowding the

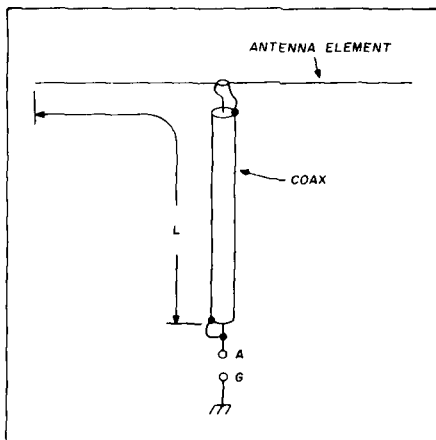


fig. 1. The active element of an HF antenna plus the feedline can be used as a T-Marcconi antenna on 160 meters. One-half the element length plus the feedline length (L) is the length of the 160-meter antenna. Note that the coax conductors are jumpered at the feedpoint (A-G).

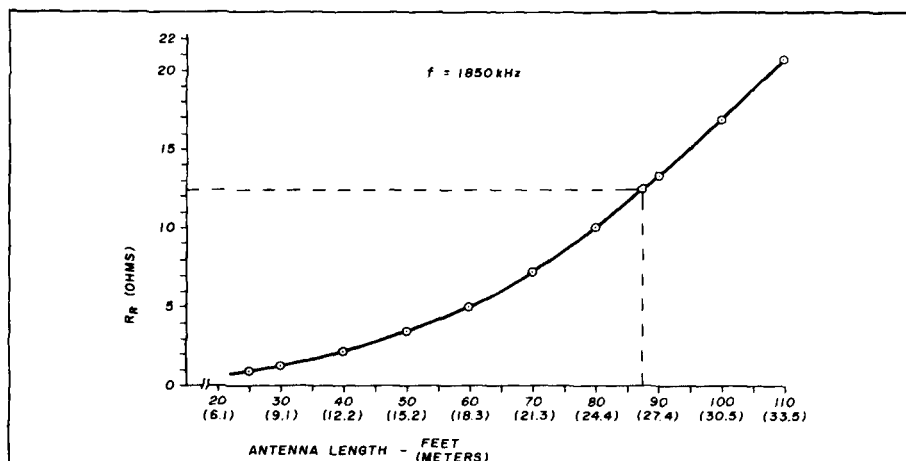


fig. 2. Approximation of feedpoint resistance (R_R) for a short 160-meter Marconi antenna.*

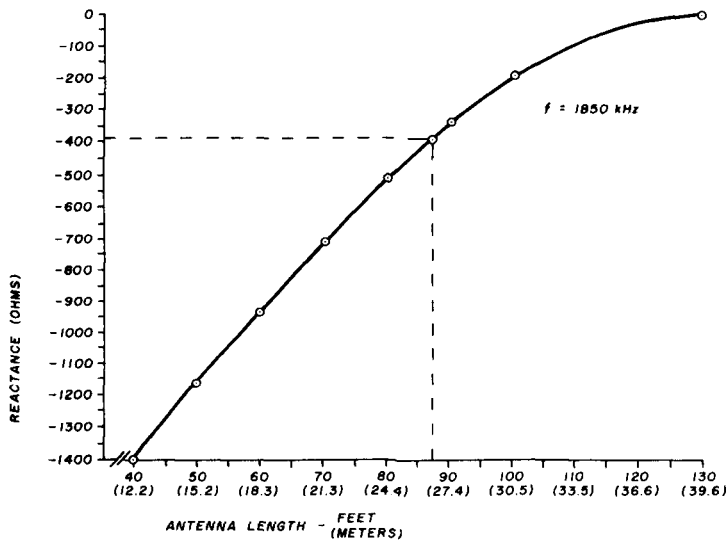


fig. 3. Approximation of the feedpoint reactance for a short 160-meter Marconi antenna.*

band from 1800 to about 1850 kHz. And there was plenty of SSB activity from 1850 to 1950 kHz, with some contented AM operation at the top end of the band.

Yes, 160 had come back to life and I had to get on. All I needed was an antenna.

let's get on 160 meters

One possible choice is to use the high frequency antenna (dipole, Yagi, Quad, or groundplane) as a T-type Marconi antenna, working the antenna-plus-feedline against ground (fig. 1).

This can be accomplished by shorting the inner and outer conductors on the coaxial line at the station and using a good earth ground connection as the return. If half of your driven element plus the feedline length approaches a quarter wave (about 126 feet) on the top band, you're in good shape; a simple antenna tuner will get you on 160 meters quickly. Just make sure your coaxial line is clear of the ground and not bundled up with rotator cables and such as it functions on 160 meters as part of the radiating system.

If your regular antenna tuner covers

*Derived from data presented in reference 1.

160 meters, it may work with overall antenna lengths between 115 and 150 feet. But what do you do if your antenna-plus-feedline length is shorter than this? A different approach to the problem is required.

very short antennas for 160 meters

I measured my feedline length, plus half the driven element length of my tribander and the total length came out to be only 87 feet 6 inches. Could I work this shortened antenna system on 160 meters?

First, I had to determine if the physical length (L) was the same, or close to, the electrical length. I connected the T-antenna to my ground connection via a small 4-turn coil and used a dip oscillator to determine the natural quarter-wave resonance of the system. It was 2.73 MHz. That agreed closely with the theoretical resonance value, which is:

$$f(\text{MHz}) = \frac{234}{\text{length (feet)}} = \frac{234}{87.5} = 2.67 \text{ MHz}$$

Now that I knew the electrical and physical length of my proposed 160-meter antenna were very close, I could determine the radiation (feedpoint) resistance of the antenna, assuming I had a perfect ground.

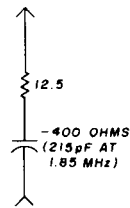


fig. 4. Equivalent circuit of my 160-meter Marconi antenna.

Figure 2 shows that value to be close to 12.5 ohms. (See note, fig. 2)¹

For my ground I ran a short, heavy conductor to the copper plumbing system of the house and grounded the pipes via two eight-foot long ground rods driven into the soil at each end of the house. (Unfortunately, the lawn sprinkling system buried in the front yard was constructed of PVC plastic pipe, otherwise it would have been added to the ground system too.)

I decided to use a simple L-matching network between my transceiver and the 160 meter T-antenna and concluded it would be best to design this for the lowest estimated feedpoint resistance of my antenna because it's much easier for the network to match a load higher in resistance than the design value than lower in value. Accordingly the worst-case feedpoint resistance was chosen to be 10 ohms. Because I didn't know the ground resistance, and didn't have the time or inclination to measure it, I ignored it for the time being.

antenna reactance

I wasn't out of the woods yet. An antenna shorter than an electrical quarter wavelength exhibits negative (capacitive) reactance at the feedpoint, with the exact value depending upon the antenna length and the length/diameter ratio of the conductor. For a thin wire, the chart in fig. 3 provides an approximation. (See fig. 3 footnote.)¹

My particular antenna would have a negative reactance of about -400 ohms. A schematic representation of what the antenna is, as far as the transceiver and matching network is shown

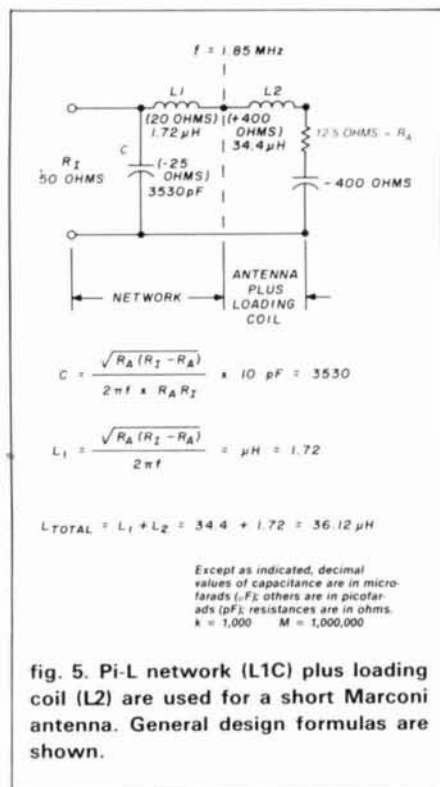


fig. 5. Pi-L network (L1C) plus loading coil (L2) are used for a short Marconi antenna. General design formulas are shown.

in fig. 4. Expressed as a complex number, the load to be matched is about $12.5-j400$. The resistive portion of the load can be estimated more accurately than the reactive portion, which varies widely with antenna capacitance to ground and nearby objects.

In any event, the requirement is a 4:1 impedance transformation to 50 ohms plus cancellation of the -400 ohms of capacitive reactance. The cancellation can be accomplished by adding $+400$ ohms of inductive reactance between the antenna and the matching device. The required reactance is termed a *loading coil*.

the matching network

The equivalent antenna circuit shown in fig. 4 has to be accurately matched to 50 ohms in order for modern transceivers to work properly on the top band. Because of limited adjustment range, most transceivers are not very "forgiving" with regard to a mismatched antenna load, particularly on the 160 meter range.

A matching network to transform approximately 12 ohms to 50 ohms and cancel out the negative reactance

exhibited by the antenna is shown in fig. 5. The circuit is an L-network, with extra series inductance added to cancel the capacitive effect of the short antenna. In practical terms it boils down to lots of shunt capacitance (C) plus a modest amount of series inductance (L1) in the network, plus the large extra loading inductance (L2) required as a loading coil. The two coils can be combined into one, as shown in the assembly of fig. 6.

Surplus mica capacitors are used, plus a large variable capacitor. A multi-gang "broadcast" capacitor with the sections tied in parallel can be substituted for the single section capacitor used in this unit.

it works — almost

In real life, the required inductance turned out to be less than the calculated amount, indicating that the antenna had less capacitive reactance than determined by the design chart. The antenna was measured to actually be 11.8 ohms in series with -211 ohms (407 pF).

After all was tuned up and the SWR reading between the tuner and the transceiver was unity, the last step was to decouple the house wiring from the antenna system. As soon as I got on the air, the lights in the family room blinked on and off in step with my keying.

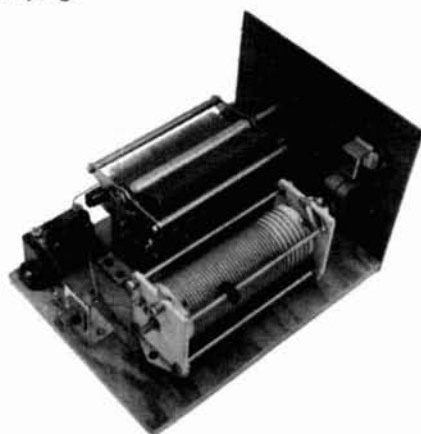


fig. 6. The 160-meter antenna tuner is built up on a plywood base and Masonite panel. The variable capacitor is a surplus Cardwell 2000 pF unit — probably unobtainable! Connected in parallel with the variable capacitor is a $0.002 \mu\text{F}$ transmitting-type mica capacitor and across it, a 250 pF mica unit.

It seemed as if a goodly proportion of my radiated power was being absorbed by the nearby house wiring. Since I couldn't move the antenna, or the house, the only thing left to do was to decouple the wiring from the RF field as much as possible. This was accomplished by taking a few AC plugs and mounting $0.01 \mu\text{F}$, 1.6 kV ceramic capacitors across the pins.* The plugs were then inserted into wall outlets around the house at random until no lights came on when I was on the air and turning lights off and on did not affect the SWR reading. No kidding, when the house wiring was "hot," switching lights on and off *did* change the 160-meter antenna tuning and the SWR on the transmission line! (Live and learn.)

This all came about because the exposed house wiring was in close proximity to the antenna. It can happen on other bands, too. The best situation is to live in a home where the wiring is fed through metal conduit.

the results

After all of this horsing around (which took only about a day of spare time) I settled down to see what I could work with this puny antenna. While I was not the biggest kid on the block, I could do well within 500 miles and could get reasonable reports out to the Midwest. I capped my DX activities one weekend by working two stations in New England! Granted, I got only a 339 report from each of them, but the contacts were genuine.

a 160-meter harmonic filter

Part 97.73 of the FCC rules specifies that spurious signals generated by the transmitter must be attenuated 40 dB below the output power level at frequencies between 1 and 5 MHz. Most Amateur excitors can meet this require-

*The "garden variety" $0.01 \mu\text{F}$, 600-volt disc ceramic capacitor is not rated for operation at 115 VAC. Various manufacturers market special capacitors for this purpose that are rated for continuous operation at 125 VAC and 1400 VDC. (The high DC rating is required because of high-voltage transients that often appear on the power line.) Three well-known brands of capacitors are Aerovox type AC-7, Centralab type CI-103, and Sprague type 125L-S10.

ment with room to spare, but this doesn't help the nearby Amateur working DX on 80 meters when he or she picks up your weak second harmonic atop the weaker, more desirable signal. A few extra dB of harmonic attenuation will solve this problem.

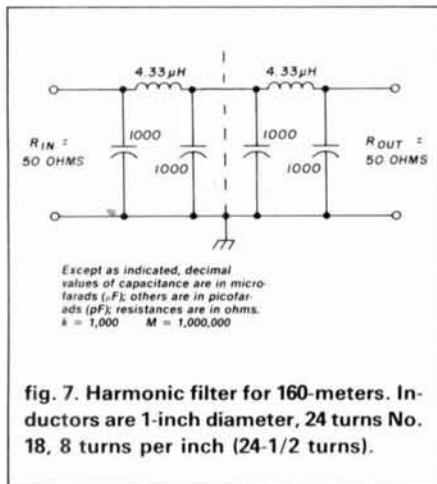


fig. 7. Harmonic filter for 160-meters. Inductors are 1-inch diameter, 24 turns No. 18, 8 turns per inch (24-1/2 turns).

Shown in fig. 7 is a simple 5-element Chebyshev lowpass filter that will attenuate the second and higher harmonics of a 160-meter signal about 24 dB, provided the SWR on the transmission line is near unity. The filter is placed immediately after the transceiver and the SWR meter and before the tuner.

Construction of the filter is simple. A two-compartment box is soldered up out of circuit board and a filter section is placed in each compartment. The size of the box depends upon the size of the components. For powers below 150 watts, postage-stamp size mica capacitors can be used, together with miniature air-wound coils. Matching coaxial receptacles are placed on the ends of the box.

The cutoff frequency of this filter is just above the top edge of the 160-meter band, so be sure to remove it from your antenna circuit when you operate on the higher bands, or you'll have fireworks.

in summary, then . . .

In order to use your HF beam, dipole, or whatever, with your feedline as a Marconi antenna, you'll have to determine the electrical length of the

installation for 160-meter operation. This measurement is from one tip of the antenna element to the station. You can readily see that the coaxial line comprises the greater portion of the antenna. If the line runs close to the ground, performance on the top band won't be very good, because your makeshift antenna will be low. If the line runs 10 to 20 feet above the ground, you are in luck. Don't worry about twists or turns in the line; the antenna tuner will take care of that.

Watch out for coupling between your antenna and the house wiring or other nearby antennas. Some time ago, during an earlier attempt to get on 160 meters, I loaded up a random, 100-foot wire I'd used for general reception with my vintage National HRO receiver. During the tuning process I noticed smoke coming out from underneath by beloved receiver. I turned everything off quickly and soon discovered that the 15-foot long lead-in to the HRO antenna post was draped near the wire serving as part of the 160-meter antenna. Enough RF pickup existed to fry the receiver antenna coil to a crisp, even though no physical connection existed between the transceiver and the receiver.

The point is that a large portion of the 160-meter antenna was *in* the house, or near to it, and a strong RF field existed where one had never existed before, because the usual high-frequency antenna is not in close proximity to the house. Any unbalanced Marconi-type antenna working against ground is capable of pumping large portions of RF into the house wiring, if you don't take precautions to prevent it!

So there you have it. 160-meter operation is possible even with a small antenna *if* you have a reasonably good ground connection and the right antenna tuner. Keep clear of your house wiring, get on the band, and I'll see you on the low end!

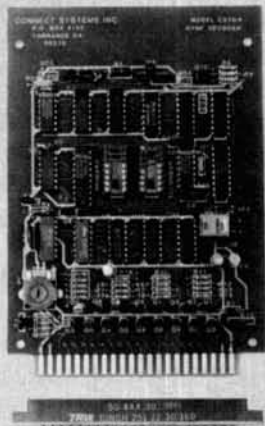
reference

1. Henry Jasik, *Antenna Engineering Handbook*, McGraw-Hill Book Company, New York.

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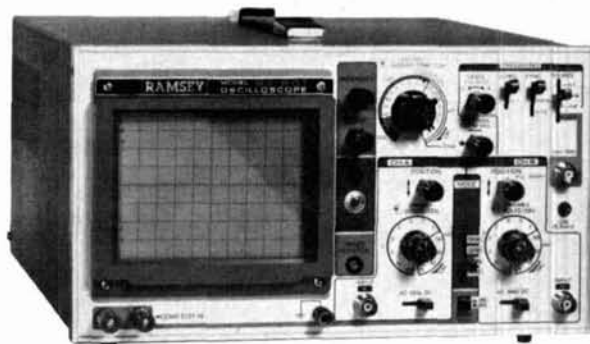
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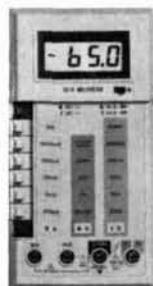


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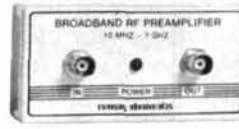
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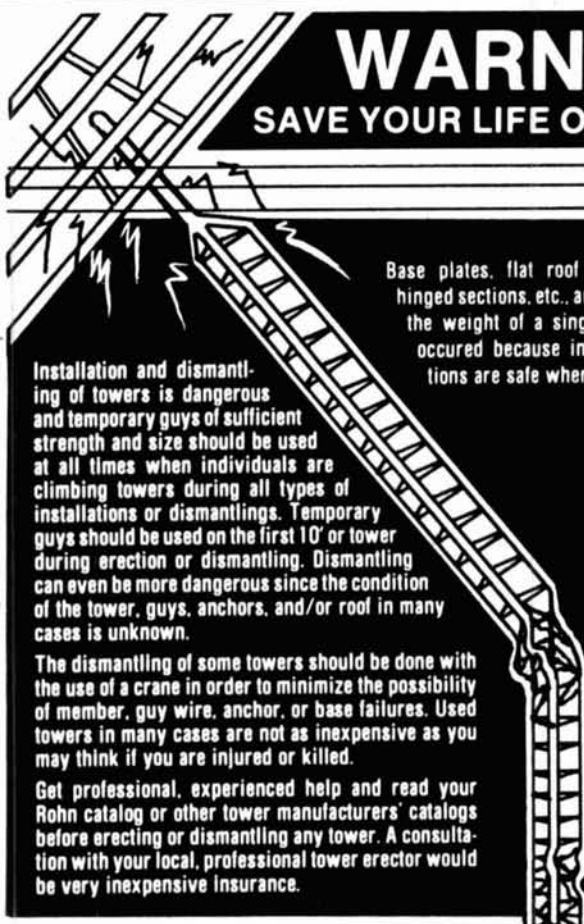
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ground rod resistance

Exploring ground, ground rod, and antenna relationships

An approximate equation has been derived for determining the resistance of a ground rod under a quarter wave vertical antenna. The physical factors involved are the antenna height and ground rod length and diameter, combined with the resistive and dielectric properties of the ground under the antenna. The derivation is based on choosing earth current paths which are both realistic and expressible with simple equations. With the equation it can then be demonstrated that in the regions where the current path is less certain, the power loss and hence the resistance contributions are minor.

The electrical characteristics of the ground are that of a "quasi-conductor" because of its dielectric property.¹ At 160 meters, it behaves more nearly as a resistive body, but at 10 meters, the dielectric currents become predominant. The effect is to markedly reduce the "ground resistance" at the higher frequencies.

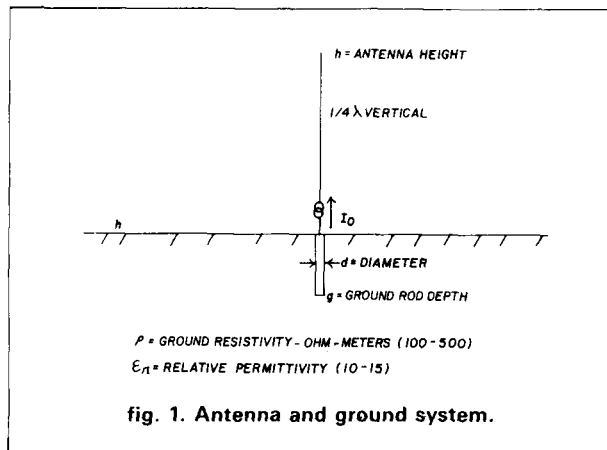
The "constriction resistance" to the radial current as it leaves the ground rod can be calculated. As an example, at 80 meters, over one-third of the ground rod resistance is located within 6 inches (12.7 cm) of a 1-inch (2.54 cm) diameter ground rod. It confirms that the injection of salt brine into this very small region is of great benefit in reducing the effective ground resistance.²

The equation will answer such questions as what would be the effect of changes to the ground system. Such changes might be the use of longer or greater diameter ground rods, or the addition of more, well separated ground rods.

A ground rod can be considered as an inverted antenna in a lossy dielectric. At 10, 15, and even 20 meters, adverse resonances can occur, adding to the ground resistance. The approximate equation derived in this article does not include this effect, although the conditions for its presence are discussed in an appendix.

approximate equivalent circuit for ground currents

When a vertical quarter wave antenna is used with a ground rod, the current which enters the ground rod leaves it along its length, just as the antenna current leaves along its length. Figure 1 shows the antenna system considered here, sketching the vertical plane through the antenna. Dimensions h , g , and d indicate antenna height, ground rod length, and ground rod diameter, respectively, and will appear in the ground rod resistance equation. The assumed current paths are discussed later.



Evaluation of the ground currents which flow from the ground rod requires a knowledge of the electrical characteristics of the ground. Ground has both resistive and dielectric properties.^{1,3} Resistivity is the reciprocal of conductivity, the latter being the characteristic usually tabulated. In this article, resistivity will be used in the ground rod equation. However, conductance may be used in the discussion, when appropriate.

The normal ranges for resistivity and relative permittivity are given in fig. 1. The resistivity shows such great variability that at a particular site it probably should be measured. This can be done simply and accurately with a four-point probe.⁴

Fortunately the relative dielectric constant seems to be less subject to variation. A major contributor is the

By Mason A. Logan, K4MT, 1607 Monmouth Drive, Sun City Center, Florida 33570

moisture content. A choice of 12 to 14 could suffice, and is adequate for the present article.

These two fundamental constants will now be related to approximate discrete equivalent circuit elements. A cubic meter of ground is shown in **fig. 2**. Two one-meter square conducting plates are placed on opposite sides. Such a meter cube has the property that when using MKS (meter-kilogram-second system of units — metric) units, the resistance between the two plates is numerically equal to the resistivity. Thus from a measurement or by estimation the parallel resistance can be determined for the approximate equivalent circuit shown below the cube in **fig. 2**.

A representative relative dielectric constant, $\epsilon_r = 13$, will usually be used for discussion, and preparation of figures in this article. The capacitance for this value is 115 pF.

The formula for the capacitance between two parallel plates is from reference 5. Because the cube obviously conducts DC, the approximate equivalent network capacitance must appear in parallel.

When RF current flows through the ground, both equivalent parallel elements conduct. At very low frequencies, almost all goes through the resistor. As the frequency increases, an increasing part passes through the lossless dielectric. Only current through the resistor causes power loss. As shown in **fig. 2**, the magnitude of the resistive part of the current is:

$$I_R = \frac{I}{\sqrt{1 + Q^2}}$$

where Q from **fig. 2** introduces the current division effect. The sum of all the power losses, P , determines the ground rod resistance through the relation:

$$R_g = \frac{P}{I^2} \quad (1)$$

The ground behaves as an inductive impedance, rather than simply as a resistance.⁶ (This is discussed in **appendix B**.) The inductive effect is caused by the lower velocity of wave transmission through the dielectric, compared to that through the resistance, acting like current lagging a voltage. *This inductive effect contributes to a vertical antenna being shorter than the length called for by the formula; the negative phase angle of the antenna is used to neutralize the positive phase angle of the ground.*

ground resistance equation

The approximate equation for the ground rod resistance is:

$$R_g = \frac{\rho}{(1 + Q^2)} \cdot \frac{1}{2\pi g} \left[\left(\log_e \frac{2h}{d} \right) - 1 \right] \text{ ohms} \quad (2)$$

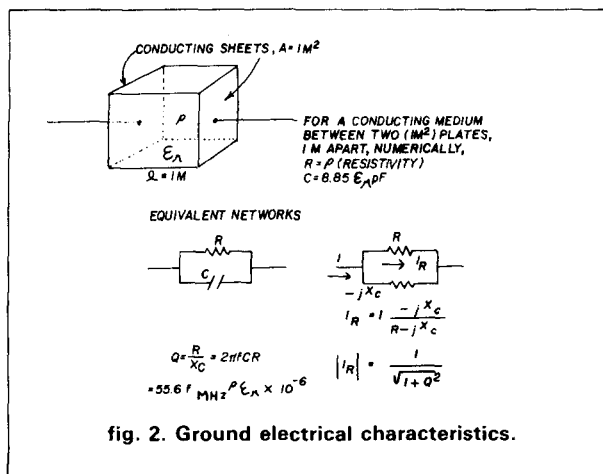


fig. 2. Ground electrical characteristics.

- where h = antenna height, meters
- g = ground rod length, meters
- d = ground rod diameter, meters
- ρ = ground resistivity, ohm-meters
- $Q = 55.6 f_{\text{MHz}} \rho \epsilon_r \times 10^{-6}$, from **fig. 2**.

The derivation of this equation is given in **appendix A**.

As an example, take a 20-meter high, quarter wave vertical for 80 meters, with an 8-foot ground rod 1 inch in diameter, and a ground resistivity of 200 ohm-meters. Using the equations in **fig. 2**, $Q = 0.5$. Then:

$$R_g = \frac{200}{(1 + 0.5^2)} \cdot \frac{1}{2\pi \cdot 2.44} \left[\left(\log_e \frac{2 \times 20}{0.025} \right) - 1 \right]$$

$$= 66.5 \text{ ohms}$$

(equal to about that for eight radials.⁹)

If the ground rod diameter were increased to 12 inches, the ground resistance would be 40.5 ohms, about 40 percent reduction. Thus, as mentioned earlier, over one-third of the ground loss occurs within 6 inches of a 1-inch rod. One half is inside the 1-foot radius.

It is convenient to consider this equation as the product of two factors, which have been plotted as curves in **figs. 3** and **4**. **Figure 3** represents how the ground resistivity, with its relative dielectric constant and the frequency, enter into the equation. **Figure 4** represents how the one-quarter wavelength vertical antenna height and the relatively shorter ground rod dimensions enter. The product of the two factors determined by these curves is the ground rod resistance in ohms.

equivalent series resistivity

The curves of **fig. 3**, one for each frequency band, are directly proportional to the antenna's ground resistance. The ground resistivity usually is reported as being in the range from 100 to 500 ohm-meters.³

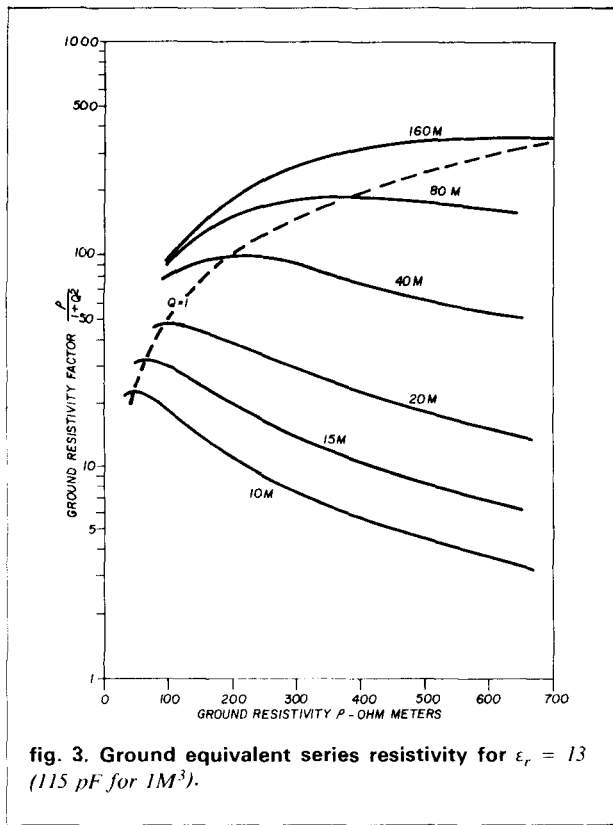


fig. 3. Ground equivalent series resistivity for $\epsilon_r = 13$ (115 pF for 1M³).

These curves can be considered as plots of the equivalent series resistance determined by a fixed capacitor shunted by a range of resistances. For each curve, the plot is for a shunting resistor increasing from less than the reactance of the capacitor, up to 700 ohms. Such a network has the property that the maximum equivalent series resistance occurs when the parallel resistance is numerically equal to the reactance, and for that condition, that is $Q = 1$, the series resistance maximum is exactly equal to half the parallel resistance.

The curves for 40 and 80 meters surprisingly show that because the maximum is centrally located, the series resistance changes less than 2 to 1 over the normal ground conductivity range.

The reactance of the parallel capacitor decreases inversely with increasing frequency. Thus the corresponding equivalent series resistivity peak decreases, with each curve becoming much lower overall. Two advantageous effects appear here. Not only is the peak less, but because it moves outside the parallel resistivity range normally encountered, the working equivalent series resistivity range is much lower than the peak. For example, at 10 meters, the effective resistivity is decreasing to below 10 ohm-meters, less than 1/20th of that for 80 meters. This is because an increasing portion of the ground current has become lossless dielectric current.

antenna system dimensions

The curves of fig. 4 are drawn using the ratio of the one-quarter wavelength high antenna to the ground rod diameter as the x-axis. The height of the antenna is taken as representing the radius on the ground beyond which practically no ground currents flow. The curves are for different ground rod lengths. A possible adverse resonant effect not included in the approximate equation and which may be important at 10 and 15 meters, is considered in appendix B.

The chart is entered through the x-axis. The ground rod length is found next. From there across to the y-axis determines the dimension factor.

Repeating the 80-meter example calculated earlier, from fig. 3, the ground resistivity factor is 150. From fig. 4, for $g = 2.4$ meters, the dimension factor is about 0.42. The product is 63 ohms, duplicating the earlier result.

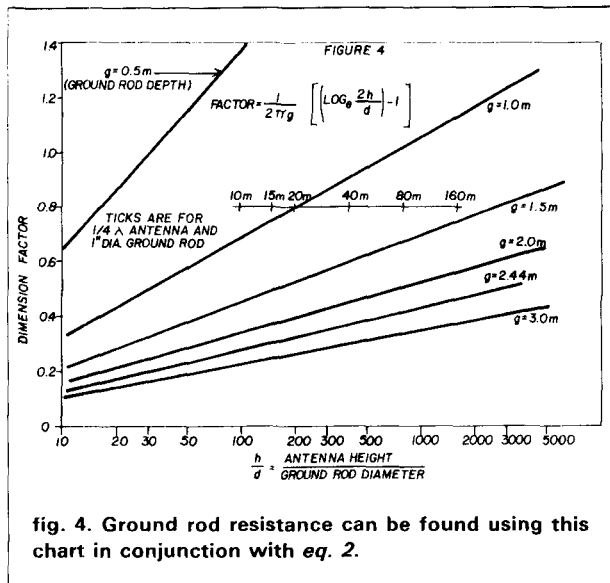


fig. 4. Ground rod resistance can be found using this chart in conjunction with eq. 2.


For convenience, a bar is drawn with ticks shown for each Amateur HF band, locating the h/d for 1-inch diameter ground rods and quarter-wave verticals. For other diameters, start with a tick for 1 inch, then move right or left inversely as the ratio of the 1-inch diameter to the diameter wanted. For instance, for a 1/2-inch diameter ground rod, move right to twice the 1-inch h/d value. Thus at 20 meters, move from a scale of 200 to 400. Then locate g to find the dimension factor.

The curves clearly show that there is a large decrease in effective ground resistance as the frequency increases. The dimension factor from fig. 4 is also lower for the higher frequencies. Approximate ground resistance measurements at 10, 15, and 20 meters to support the results of these calculations will be given later.

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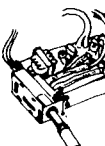
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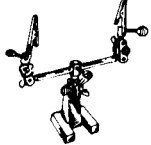
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
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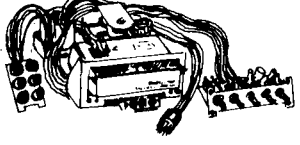
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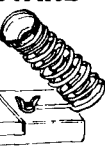
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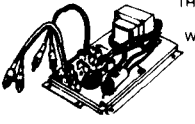
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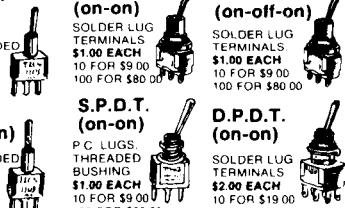
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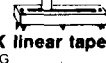
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parallel ground rods

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The image repels any current flow across a perpendicular plane which bisects the line joining the two rods. The bisector thus acts as a virtual insulator. Visualization of the current flow paths from the two rods is helped by field maps shown in many texts.⁸ They usually are drawn for static charges, but the field lines are like current flow lines in sheets.

Near each rod and inside a radius of about half the distance to the bisector, the effect of the other rod, while increasing, is small. Inside this region then, almost the full advantage of separate rods is realized. A resistance factor of 1/2 will be used.

For the next region, to a radius of the distance to the bisector, all currents including those which started out toward the bisector have completed most of their change in direction. The advantage of separate ground rods thus decreases in this region. A resistance factor of three quarters will be used.

Beyond this second region there is very little gain. To apply the above discussion an estimation involves first calculating the external resistance for circles centered around a single ground rod. This is done for diameters of 2 feet, 3 feet, and so on, using the formula. Such calculations for 80 meters are shown in **fig. 5**. Two cases have been chosen as examples, applying to 4-foot and 6-foot spacings.

For **Case 1**, the estimate of the resistance using two ground rods spaced 4-feet apart is shown as 48 ohms or a reduction compared to a single rod of 27 percent. For comparison, about 14 radials have a resistance of 48 ohms.⁹ The calculation for the first foot assumed a 0.5 factor as complete independence, as discussed

earlier. The second foot used a 0.75 factor for an intermediate effect, while outside that, negligible reduction compared to a single ground rod was used.

A very large number of rods in the circle could only approach 26 ohms. Thus two rods accomplish almost half of the possible reduction.

Case 2 is for rods spaced 6 feet apart. Calculating in the same manner there is a reduction to about 45 ohms, or a 31 percent decrease. The increased spacing from 4 to 6 feet thus gained another 2.3 ohms.

20 meter measurements

The striking information of **fig. 3** and **4** is the exhibition of the beneficial effect of the ground's dielectric property in reducing the effective ground resistance. With increasing frequency, the increasing Q rapidly reduces the resistance.

Elementary but restricted resistance measurements were made with a double-pointer SWR bridge. The restriction with this method is that the resistance can be determined only at a frequency where the SWR is a minimum.

Starting with a vertical wire having a 16 foot 9 inch formula length, the wire was shortened until the minimum was within the band (final length was 15 feet, 10 inches). Using two rods four feet long and four feet apart, measurements and calculations were as follows:

rods	SWR	R_g ohms	R_g (calc.)
1" D	1.43*	34.5	27
3/4" D	1.33	28.0	30
parallel	1.18*	19.0	20 (est.)

The addition of a shunt resistor* has reduced the SWR in the measurements printed in bold type, establishing that the load was greater than 50 ohms. The formula for such a minimum SWR, is:

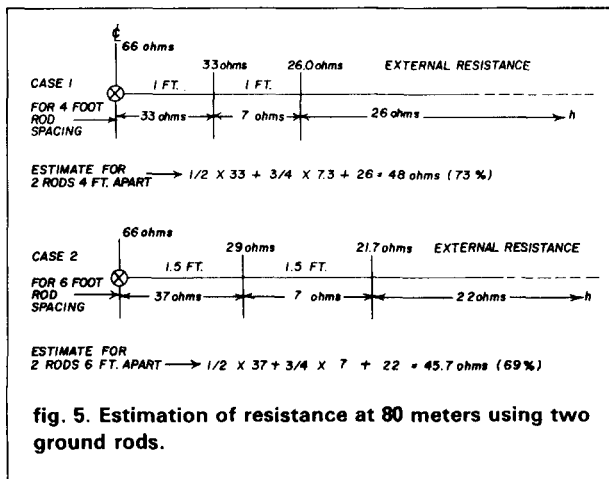
$$R_g = [(50 \times SWR) - 37.5] \text{ ohms} \quad (3)$$

These results agree to within a few ohms of the resistances calculated using the formula. The measurement formula for R_g may be optimistic in that the radiation resistance of the antenna probably decreases from 37.5 ohms as the wire is shortened for system resonance.

10 and 15 meter measurements

There was further confirmation at 10 and 15 meters when measuring with a shorter 2 foot, 3/4-inch diameter round rod:

band (meters)	formula height	tuned height	min. SWR	R_g ohms	calc. R_g ohms
15	11' 0"	9' 9"	1.49	37	33
10	8' 4"	7' 7"	1.14	19	17



Even with a 2 foot ground rod, at 10 meters (10 meter band) the resistance was about half that at 20 meters with a 4 foot ground rod.

However, a problem was found when trying to measure using the 4-foot ground rod. As the antenna height was reduced, the SWR curve kept the same slope across the band, reached a lowest curve, and then increased again. There was no minimum in the band. Thus the SWR bridge method could not be used. The lowest SWR, at the band edge for both bands, was higher than the minimum found for 20 meters.

The lower end of the SWR curve was on the high frequency edge for 15 meters and on the low frequency edge for 10 meters. It may be that a resonance in the 4-foot ground rod, acting as an inverted antenna in a lossy dielectric prevents the lowest SWR curves having a minimum in the band. (Further discussion is in **appendix B**.) At 10 and 15 meters, for the local conductivity condition, one-quarter wavelengths are 2-1/2 and 3 feet respectively. Thus the 4-foot ground rods were above their series resonance. It may be that an odd number of underground quarter wave lengths is best.

conclusion

An approximate equation for the resistance of a ground rod has been derived when using a quarter wave vertical antenna. It relates the elements which affect the ground rod resistance and provides a means for estimating the result of changes in the ground system. Measurements confirm the importance of the relative dielectric constant of ground in reducing the effective ground resistance as the frequency increases.

How well the formula applies to trap verticals has not been established. Knowing the trap antenna resistance for the subtraction is another problem.

With the use of ground rods only there always is some power loss penalty. However, sometimes pavements, sidewalks, buildings, or someone else's property precludes other approaches. Even with such a restriction, it appears that a system equivalent in power loss to quite a few radials can be realized — but it is unlikely that the radiation angle will be as low.

appendix A

derivation of the approximate ground resistance equation

This equation applies to the antenna and ground rod system shown earlier in **fig. 1**. That figure, and **fig. 2**, defined the physical characteristics included in the ground resistance formula.

Figure 6 shows in more detail the underground geometry and the current flow paths assumed. The ground current I_0 entering the ground rod is assumed to leave the rod uniformly along its length. This is represented by the equation:

$$I = I_0 \left[1 - \frac{z}{g} \right]$$

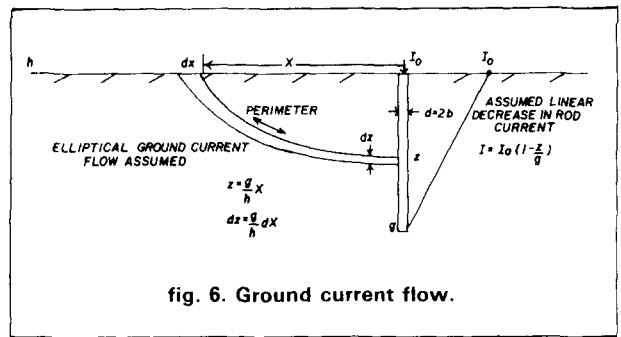


fig. 6. Ground current flow.

where z is the variable depth from the ground surface and g is the length of the ground rod.

An elliptical path is shown leaving the ground rod. An ellipse terminates at right angles to both the ground and ground rod. The path shown leaves the ground rod at z , and ends at x on the ground surface. This sheet, which starts with thickness dz , and is flattened out in **fig. 7**, carries the current dI . All such circuits are in parallel and account for the total current. For any sheet like the one shown, the current entering is:

$$dI = -\frac{I_0}{g} dz$$

As discussed earlier, the resistive current portion is:

$$dI_R = \frac{-I_0}{g\sqrt{1+Q^2}} dz$$

The resistance to radial current flow through the parallel resistive part of the differential ring shown in **fig. 7**, is:

$$dR = \rho \cdot \frac{\text{length}}{\text{area}} = \frac{\rho dr}{2\pi r dz}$$

At this point, two simplifying assumptions will be made: first, the outer radius is just x rather than $1.1x$, applicable to the elliptical perimeter, and second, that the thickness of the sheet remains a constant dz instead of increasing. These are reasonable because they introduce opposite resistance changes having a cancelling effect, and because their effect is in the far region where only a small part of the total resistance is involved. By integration, the sheet resistance to a radial current leaving the ground is:

$$dR = \frac{\rho}{dz} \int_b^x \frac{dr}{2\pi r} = \frac{\rho}{2\pi dz} \log_e \frac{x}{b}$$

There is an equal differential current in each sheet. Squaring the current which flows through the resistance and multiplying by the sheet resistance just arrived at, determines the sheet power:

$$dP = \left(\frac{I_0}{g\sqrt{1+Q^2}} dz \right)^2 \frac{\rho}{2\pi dz} \log_e \frac{x}{b}$$

Substituting

$$dz = \frac{g}{h} dx$$

$$P = \frac{I_0^2}{gh} \frac{\rho}{2\pi(1+Q^2)} \int_b^h \log_e \frac{x}{b} dx$$

where the quarter wave antenna height is used as a measure of the end of the outer region.

Finally, dropping the very small lower limit factor for simplicity, the approximate ground rod resistance formula is:

$$\frac{P}{I_0^2} = R_g = \frac{\rho}{(1+Q^2)} \frac{1}{2\pi g} \left[\left(\log_e \frac{2h}{d} \right) - 1 \right]$$

- where ρ = ground resistivity
- h = quarter wave antenna height
- d = ground rod diameter
- g = ground rod depth
- $Q = 55.6 f_{MHz} \rho \epsilon_r \times 10^{-6}$

appendix B ground electromagnetic wavelength

For the Amateur HF bands, the ground is described as a quasi-conductor because of its relative dielectric constant, greater than unity.¹ In such a medium, the velocity of an electromagnetic wave is reduced, compared to the velocity of an electromagnetic wave in a vacuum. The physical characteristics which apply to a conducting medium are:

- ϵ_r = relative permittivity (12 to 14 estimated locally)
- ϵ_0 = vacuum permittivity = 8.85×10^{-12} farads/meter
- $\epsilon = \epsilon_0 \epsilon_r$ = actual permittivity
- μ_0 = vacuum permeability = $4\pi \times 10^{-7}$ henrys/meter
- σ = conductivity - siemens/meter
(7×10^{-3} measured locally)
- $\rho = 1/\sigma$ = resistivity ohm-meters
- $\omega = 2\pi \times \text{frequency} - \text{radians/second}$

The equation¹⁰ for a wave travelling in a positive x direction is:

$$E_y = E_0 e^{-\gamma x}$$

where γ is the propagation constant and x is the distance. The constant is:

$$\gamma^2 = j\omega\mu\sigma - \omega^2\mu\epsilon$$

It is convenient in the last term to substitute:

$$a = \epsilon\omega/\sigma$$

Then $\gamma^2 = \omega\mu\sigma (j - a)$

$$\text{But } \sqrt{j-a} = \sqrt[4]{1+a^2} (\cos \theta + j \sin \theta)$$

where $\theta = (90^\circ + \tan^{-1}a)/2$

$$\text{Finally: } \gamma = \sqrt{\omega\mu\sigma} \sqrt[4]{1+a^2} (\cos \theta + j \sin \theta)$$

Thus γ has a real and imaginary part. The real part is associated with attenuation and the imaginary part with phase. Equating the phase part to 2π , determines the x which is equal to one wavelength. Thus the equation for one wavelength is:

$$\lambda = \frac{2\pi}{\sqrt{\omega\mu\sigma}} \cdot \frac{1}{\sqrt[4]{1+a^2} \cdot \sin[(90^\circ + \tan^{-1}a)/2]}$$

This equation has been plotted in **fig. 8**. The reciprocal of "a" is the x -axis. The label for each curve uses the variable part from the left of the fraction above. The left vertical axis is the result and gives the wavelength inside the conducting ground. It always is less than the wavelength in free space.

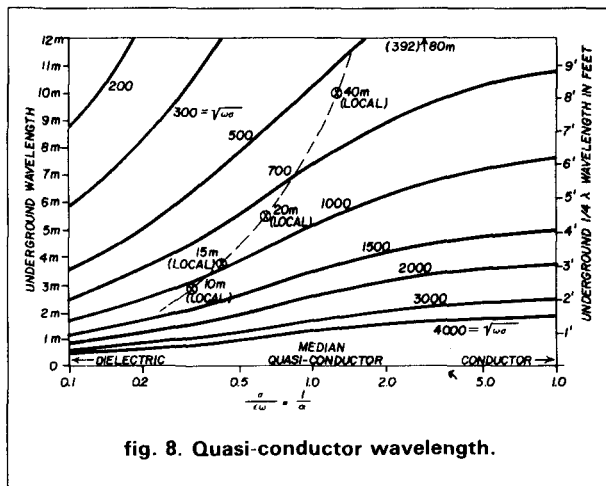
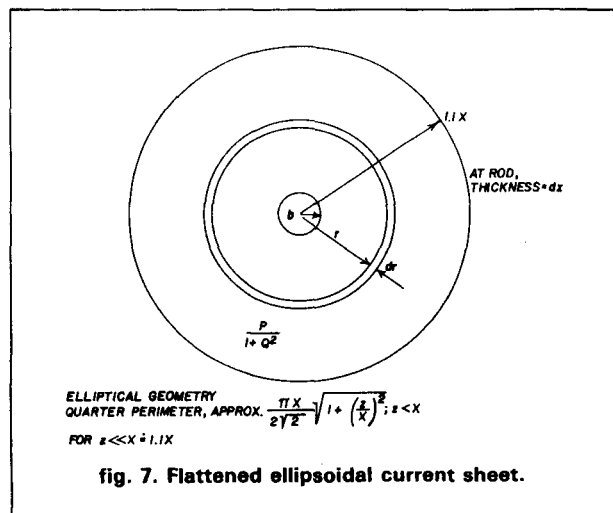


fig. 8. Quasi-conductor wavelength.

The right vertical shows the quarter wavelength in feet, which is significant for a ground rod.

On the chart in **fig. 8**, the circled crosses marked 10, 15, and so on represent the local conditions. Four-foot ground rods were used, and are very close to a quarter wavelength at 20 meters. At 10 and 15 meters they are much longer. For these, a 2-foot rod was also used.

A ground rod can be considered to be an inverted antenna in its own medium, and as an antenna, could have resonant effects. These were not included in the elementary derivation of the approximate ground resistance equation which has been presented.

Aside from any resonant effect, there is another viewpoint. The impedance of the ground rod acts as if it were inductive. The wave through the earth may be considered as made up of two parts, one through the resistive medium and the other through the dielectric medium. The latter travels at a lower velocity than the velocity through the former. The total wave is the vector sum of the two, a complex quantity which thus lags in time phase. This is analogous to the situation in a circuit having resistance and inductance in series, where the current lags the applied voltage. Therefore, the conducting medium behaves like an inductive impedance.

The existence of such an inductive impedance is supported by the frequent comment that a quarter wave antenna is much shorter than called for by the formula. A shorter antenna develops a negative reactance which neutralizes the positive ground rod reactance.

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3. *Reference Data for Radio Engineers*, Fifth Edition, 1974, ITT/Howard W. Sams, Inc., Indianapolis, Indiana, page 26-3.
4. Jerry Sevicik, "4-Point Probe Measurements," *QST*, March, 1981, page 38. (Caution: use an isolating transformer in the extension cord to prevent any current to the lightning ground rod near the power meter.)
5. John D. Kraus, *Electro-Magnetics*, McGraw-Hill, 1953, Chapter 2, page 61.
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7. Forrest Gehrke, K2BT, "Vertical Phased Arrays, Part 2," *ham radio*, June, 1983, page 26.
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10. John D. Kraus, *Electro-Magnetics*, McGraw-Hill, 1953, Chapter 10, equation 10-14.

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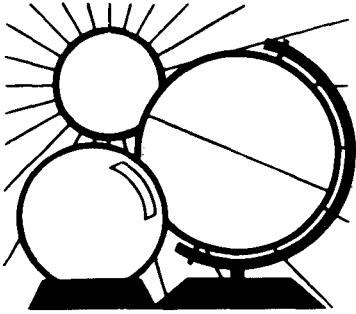
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DX FORECASTER

Garth Stonehocker, KØRYW

summer DX

Every season of the year offers advantages and disadvantages for DX operation. The winter and summer solstices (days of shortest and longest daylight) and the equinoxes (days of equal light and darkness) produce distinct propagation characteristics that require specialized operating procedures.

Summertime DX offers longer high frequency (10-30 meter) operating time. Higher MUFs occur earlier in the day and end later than they did in previous seasons. In the higher latitudes (i.e., in the northern hemisphere), MUFs for east-west and transpolar paths are highest at this time of year.

But summer is not without its operating disadvantages: signal strengths are generally lower, as are midday MUFs; hop lengths are shorter; and there's little one-long-hop transequatorial propagation. Amateurs in the northern hemisphere can expect increased noise QRN as well.

Some of these negative characteristics of summertime operation can be turned into advantages. Others can be overcome. In this column and the next, I'll discuss these characteristics and offer some suggestions for improving your summertime DX operating.

last-minute forecast

The higher frequency bands (6-30

meters) are expected to be best during the first ten days of July. During this time, both long and short skip openings should be plentiful except on 6 meters, where only short skip openings by sporadic E are possible. During the latter two weeks of the month sporadic-E short skip will provide the best openings. The lower bands (30-160 meters) are expected to be of limited use during the month because of summer thunderstorm QRN; the first of the month may have the better nighttime openings, and the last two weeks the better daytime openings if the solar radio flux is 80 or less, as expected.

A full moon will occur on the 13th; perigee (closest approach) is on the 2nd and 30th. The Aquarid meteor shower starts on July 18, peaks on the 28th, and lasts until August 7 (all dates approximate, but close). The radio-echo rate at maximum is about 34 per hour.

band-by-band summary

Six meter paths will exist during several days around local noon by means of sporadic-E short skip propagation.

Ten and fifteen meters will provide long-skip conditions in the afternoon during the peak times of the 27-day solar maximum. Otherwise, look to sporadic-E short-skip and multihop

openings around local noon for DX on these bands. Transequatorial evening openings do not usually occur in the summertime.

Twenty and thirty meters will be open all day and much of the night. If twenty does not stay open through the night, thirty probably will. Sporadic-E short-skip is also often effective on these bands throughout the day. Propagation paths to most areas of the world are possible in a sequence that follows the sun's journey across the sky: east in the morning, south during midday, and west during the evening.

Thirty and forty meters will be the main nighttime DX bands this time of year, although long-skip distances will be shorter. Sporadic-E openings are possible during most of the day into pre-sunrise and after sunset. With thunderstorm-induced static levels high in the evening, look to pre-dawn periods for best results.

Eighty and one-sixty meters are difficult DX bands during this time of year. Short nights and high noise levels hamper DX operation, although eighty offers slightly lower noise levels. Most useful openings may occur during the pre-dawn hours. Sporadic-E propagation signal strengths may exceed the static level near sunrise and sunset.

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WESTERN USA

GMT	PDT								
		N	NE	E	SE	S	SW	W	NW
0000	5:00	20	20	15	10	20	10	10	20
0100	6:00	20	20	20*	10	20	10	10	20*
0200	7:00	20	20	20	10	20	10	10	15
0300	8:00	20	20	20	10	20	10	10	15
0400	9:00	20	20	20	10	20	15	10	15
0500	10:00	20	20	20	10	20	15	15	15
0600	11:00	20	30*	20	15	30	15	15	15
0700	12:00	20*	30*	20	15	30	15	15	15
0800	1:00	20*	30*	20	15	30	20	15	20
0900	2:00	20*	30*	20	20	30	20	20*	20
1000	3:00	20	30*	20	20	30	20	20	20
1100	4:00	20	20	20	20	30	20	20	20
1200	5:00	20	20	15	20	30	20	20	20
1300	6:00	20	20	15	20	30	20	20	20
1400	7:00	20	20	15	20	30	20	20	20
1500	8:00	20	20	15	20	30	20	20	20
1600	9:00	20	20	15	20	20	15	20	20
1700	10:00	20	20	10	20	20	15	20	20
1800	11:00	20	20	10	20	20	15	20*	20
1900	12:00	20	20	10	15	20	15	15	20
2000	1:00	20	20	10	15	20	15*	15	20
2100	2:00	20	20	10	15	20	10	15	20
2200	3:00	20	20	15	15	20	10	15	20
2300	4:00	20	20	15	15	20	10	15	20

JULY

MID USA

MDT								
	N	NE	E	SE	S	SW	W	NW
6:00	20	20	15	15	20	10	10	20
7:00	20	20	20*	20	20	10	10	20
8:00	20	20	20	20	20	10	10	20
9:00	20	20	20	20	20	10	10	20*
10:00	20	20	20	20	30	15	15	20*
11:00	20	20	20	20	30	15	15	20
12:00	20	30*	20	20	30	20	15	20
1:00	20	30*	20	20	30	20	15	20
2:00	20	30*	20	20	30	20	20*	20
3:00	20	30*	20	20	30	20	20	20
4:00	20	30*	20	20	30	20	20	20
5:00	20	20	15	15	30	20	20	20
6:00	20	20	15	15	30	20	20	20
7:00	20	20	15	15	30	20	20	20
8:00	20	20	15	15	30	20	20	20
9:00	20	20	15	15	30	20	20	20
10:00	20	20	10	10	20	15	20	20
11:00	20	20	10	10	20	15	20	20
12:00	20	20	10	10	20	15	20	20
1:00	20	20	10	10	20	15	20	20
2:00	20	20	10	10	20	15	20	20
3:00	20	20	10	10	20	15	20	20
4:00	20	20	15	15	20	15	20	20
5:00	20	20	15	15	20	15	20	20

EASTERN USA

EDT								
	N	NE	E	SE	S	SW	W	NW
8:00	20	20	15	15	20	10	10	20
9:00	20	20	20*	20	20	10	10	20
10:00	20	20	20	20	20	10	10	20
11:00	20	20	20	20	20	10	10	20*
12:00	20	20	20	20	30	15	15	20*
1:00	20	20	20	20	30	15	15	20*
2:00	20	20	20	20	30	15	15	20
3:00	20	30*	20	20	30	20*	15	20
4:00	20	30*	20	20	30	20	20*	20
5:00	20	30*	20	20	30	20	20	20
6:00	20	30*	20	20	30	20	20	20
7:00	20	30*	15	15	30	20	20	20
8:00	20	20	15	15	30	20	20	20
9:00	20	20	15	15	30	20	20	20
10:00	20	20	15	15	30	20	20	20
11:00	20	20	15	15	30	20	20	20
12:00	20	20	10	10	20	15	20	20
1:00	20	20	10	10	20	15	20	20
2:00	20	20	10	10	20	15	20	20
3:00	20	20	10	10	20	15	20	20
4:00	20	20	10	10	20	15*	15	20
5:00	20	20	10	10	20	10	15	20
6:00	20	20	15	15	20	10	15	20
7:00	20	20	15	15	20	10	15	20

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides the MUF during "normal" hours.
 *Look at next higher band for possible openings.

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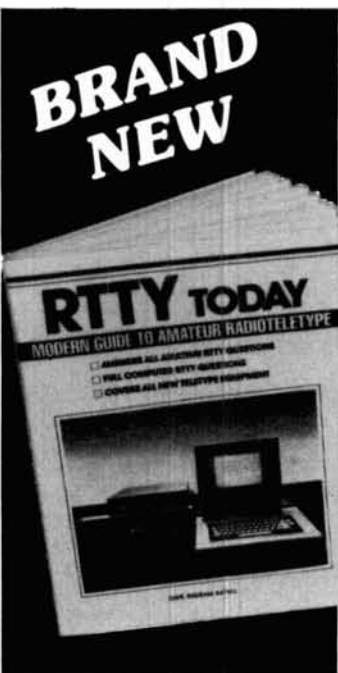
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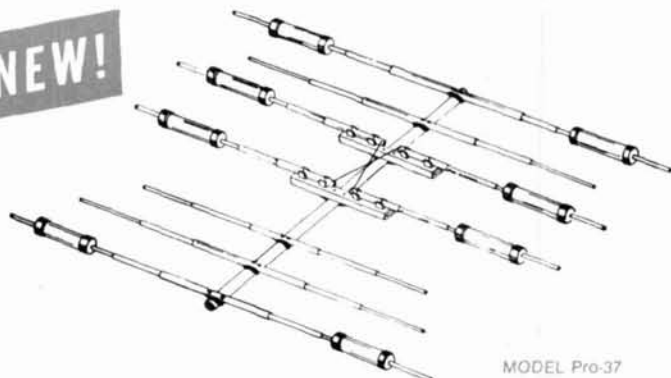
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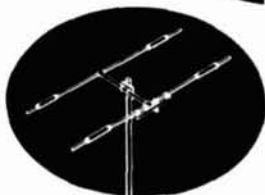
NEW!



MODEL Pro-37



TA-33 Jr.
Three element
rotary beam
aerial.
10-15-20M.
Rated to 300W.



Two element
rotary beam
aerial.
10-15-20M.
Rated to 300W.
MODEL TA-32 Jr.

The Pro-37 follows in the Mosley tradition of high performance, dependability, and quality construction. The Pro-37 is pre-drilled for easy assembly. No adjustments or measuring. Average assembly is about 1½ to 2 hours. As with all the Mosley antennas we use stainless steel hardware throughout. Rugged construction makes our antenna the cleanest, strongest of its class, no cluttered elements or boom to cause electrical and mechanical problems down the road. Put it up and leave it up. In performance it has no peers...It is as broadbanded or broaderbanded than any antenna made. Its gain and front to back is as good or better than other antennas in its class, even those with longer booms. Mechanically we feel it's the best built.

The Pro-37 has 7 elements on a 24 foot boom which needs no boom support. It has 3 wide spaced elements on 20 and 15 not counting the extra driven element. 10 meters has 4 wide spaced elements not counting the extra driven element. The Pro-37 uses a unique direct feed system which enables the driven elements to contribute gain to the antenna, while giving it the broadest possible frequency spectrum. Clean design makes the antenna easy to assemble and erect and solves maintenance problems. No clutter on the elements or boom. The Pro-37 uses the proven Mosley traps which on the Pro-37 will handle 2.5 KWDC out on C.W. and 5 KWPEP on SSB. We're quite excited about the Pro-37 and we know you will be too!

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Then Try...



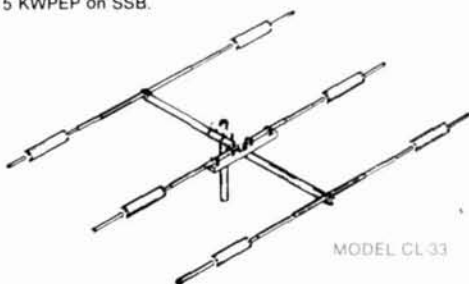
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BROADBAND SINGLE ELEMENT
Can be made into 2 element or 3 element later.



S-402

**FULL SIZE PERFORMANCE WITH 44' ELEMENT
AND A 20' BOOM**
Excellent Gain and Front to Back.
Strongest Built 2 Element on 40 Meters
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MODEL CL-33

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BUT SMALLER?
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- * Rated at 1KW CW and 2KW on SSB



new!

Vertical Aerial, 10 thru 40 no band-switching is necessary. Very portable and no pipe mount needed
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V-4-6

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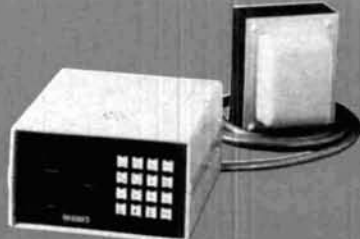
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Your Choice Of Center, North Or South



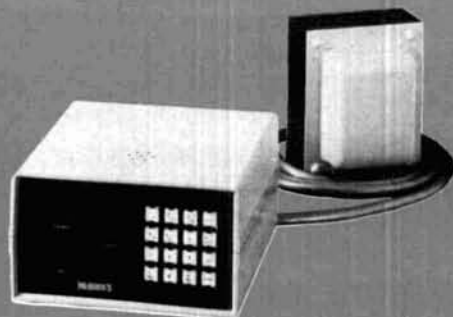
GOOD
PSE-1A, 3A

The "CONTESTER" provides the least expensive DIGITAL CONTROL UNIT WITH COMPLETE COMPUTERIZED CONTROL, BUT WITH LESS FEATURES, than the "DX'ER" and "DELUX". This unit gives you the current position of your antenna digitally in 5° steps. It has 2 memories and the command mode, plus single button operation. The PSE-1A, "CONTESTER" comes with a 10 amp continuous duty motor supply. PSE-3A has a 12 amp power pack. It is not capable of being modified to talk or accept the computer interface or remote interface. It is completely shielded and made of the same quality components as the other models. The warranty on our unit is one year on materials and labor, and ninety days on parts. This unit is a very inexpensive way to have the best of both worlds. A real time saver during contests. Hands off operation will save many hours of hanging on the rotor. Just a few dollars more than the manual control box, but worlds apart in state-of-the-art and operation. Price \$229.95*



BETTER
PSE-1, PSE-3

The "DX'ER" is the top of the line of the non-voice synthesized units, and is for the ham who is in need of more features on their controller. It has "2" digital readouts, one to show the antenna's current position, plus a storage readout which holds a heading or digitally displays your last position. This is valuable for switching between long path or short path, or checking front to back, or working between two different stations, a real time saver and a nice convenience. The "DX'ER" also has "5" scan functions: 0-90, 90-180, 180-270, 270-360, and 0-360. This is a real aid in looking for that doppleg opening or peaking a weak signal. The "DX'ER" has 2 memories for storing headings, it can be expanded to talk, and does have the hardware necessary to use with the computer interface. It can be remotely keyed, where verbal confirmation isn't required. Price \$362.95*



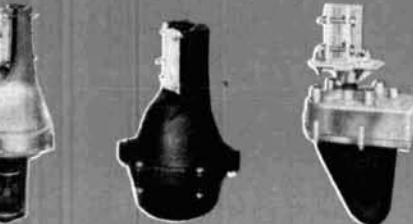
BEST
PSE-2, PSE-4

This is the ultimate in rotor controls. Nothing tops this one. It has all the features of the other models, plus it talks...Yes, it talks. The "DELUX" has a voice synthesizer which confirms your entries, plus tells you your heading as you enter it and when your antenna arrives. All commands are spoken, plus as your antenna turns you hear a 400HZ tone going in one direction and a 80HZ tone in the other. This gives you positive verification of movement. This unit, as the others, will combine with the HAM IV, T2X, and HDR-300, giving you the best antenna rotor combination you could ever want at any price. Price \$469.00*

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Package #2 PSE-1/PSE-3

The "DX'ER" Package...Couple this unit with a rotor and you have the best non talking control we make. Expandable, plus has 5 scan functions, 2 DIGITAL displays and REC/LAST to check long path or short path. Has all internal hardware to plug into our computer interface. Can be remotely controlled from accessory jack. Try this with any of the TELEX/HY-GAIN* Rotors! This will give you the broadest of functions with a mid-range price.

Package Special

- PSE-1 + HAM IV \$502.95
- PSE-1 + T2X 548.95
- PSE-3 + HDR-300 677.95

Package #3 PSE-2/PSE-4

The "Delux" is the most sophisticated antenna control unit ever made. With the "Delux" you have all the functions of our other units, plus it talks...Yes it talks. Not only do you have your headings digitally displayed, but is also said as your antenna stops...All commands are spoken, plus as your antenna turns you hear a 400Hz tone in one direction and an 80Hz in the other, giving you positive verification of movement. This unit, when combined with the HAM IV, T2X or HDR-300 gives you the best buy anywhere at any price...

Package Special

- PSE-2 + HAM IV \$608.95
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Controllers also available for other rotors. Prices and specifications subject to change without notice or obligation. U.S. and Foreign Patents

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★ SANYO UHF VARACTOR TUNER ★

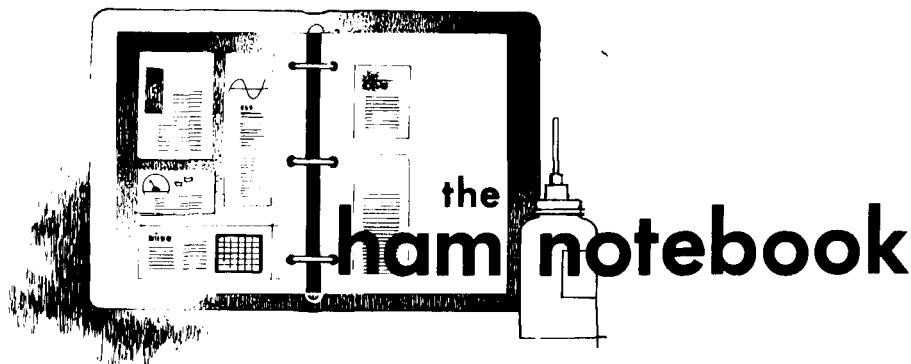
For channels 14-83 • Tuning voltage: 0-1 to 28VDC • Input impedance: 250 Ω • IF band width: 7.0MHz • Size: 20 x 11 x 10 mm • Supply voltage: 5VDC
PN 151B-401A for 40.0MHz
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RIT for the KWM2

Tired of playing leapfrog when working stations on CW that have rigs like yours, but lack any clarifier provision in the receive mode? And are you tired of working in nets where 20 percent of the operators aren't exactly on frequency, and you have to keep leaving the NCS (Net Control Station) frequency in order to read them clearly? Well, I was — so I decided to add a clarifier module to my KWM2A (fig. 1).

Most of the necessary parts, with the exception of a varactor diode, are probably already in your junk box; the diodes are quite plentiful and reasonably priced.

design approach

No kinks were found in this unit; it works like a charm, providing about 2 kHz or better frequency swing on receive.

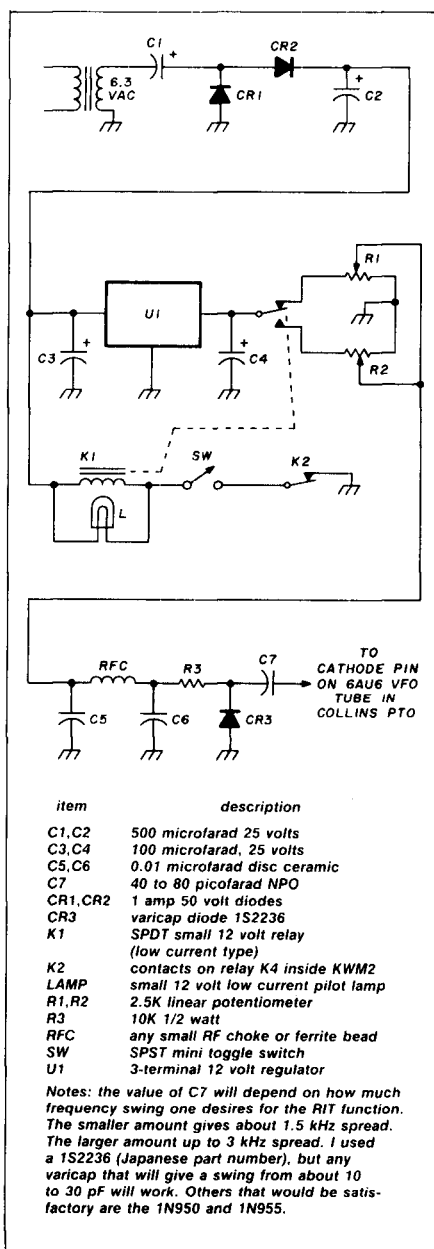
You can make the swing as much as you desire by using different types of varactor diodes or by varying the size of C7 (see fig. 1), which is effectively in series with the varactor diode. The diode I used has a capacitance variation of 4.5 to 22 pF when the bias is varied from 0 to 10 volts. Many varactor sizes are available from 5 to 10 pF up to hundreds of pF in value. Choose whatever you need; any of those in the parts list should suffice.

For the Collins modification I decided the best place for the power supply section was in the external power supply speaker unit. I had never used the built-in speaker, so I just removed it and used the space to house a board with the voltage doubler circuit shown, using the 6.3 VAC filament supply as a source.

I found one lead in the power cable

from the AC power supply to the KWM2 that terminated in an unused pin (power supply end). This is pin 6, which actually has switched 110 VAC coming from the transceiver end. I

disconnected the 110 VAC from this lead and used it to carry the 15 VDC from the AC power supply into the transceiver. I also disconnected this lead from the T/R relay, K4, in the KWM2, in which it formerly appeared on relay contact No. 13, and ran it via shielded wire up through a hole in the chassis near the VFO unit. This becomes the 15 VDC supply to power the RIT board and regulator circuit. This leaves a relay arm and two contacts (No. 12 and 11) unused in T/R relay K4. I put the arm (No. 12) to use as a disable circuit so that during transmit the clarifier is automatically out of the circuit, regardless of whether it is left switched on from the front panel switch or not. When receiving, this relay arm furnishes a ground and in turn activates the RIT control relay. When transmitting, however, this arm closes to contact No. 13; this prevents the confusion that would result from transmitting with the clarifier inadvertently left on and thereby operating on an undesired frequency. I made the entire regulator and RIT circuitry on one small perforated hole board and mounted it on the two screws on the back of the Collins PTO. This puts it as close to the VFO tube (6AU6) as possible and permits running a short lead from the varactor diode blocking capacitor, C7, to the cathode lead of the 6AU6 VFO tube. It isn't necessary to enter the PTO box at all. Just wrap a small solid wire a turn or two around the cathode pin of the 6AU6 tube and solder it. Be careful; too much heat for too long a time will cause the glass on the tube to crack. Be sure the potentiometers used are the linear taper type in order to obtain a smooth frequency swing from stop to stop; one is used for adjusting the transmit frequency and should be set somewhere near mid-range. The other potentiometer is switched in only when the RIT switch is on. This potentiometer has a shaft brought out to the front panel right over the top of the PTO chassis. This is your receiving RIT control. If you're squeamish about drilling holes in the front panel, knocking out the "Collins" name decal will leave a hole in the



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MRF412	80W	18.00	40.00
MRF412A	80W	18.00	40.00
MRF421	100W	25.00	54.00
MRF421C	110W	27.00	58.00
MRF422*	150W	38.00	82.00
MRF426*	25W	17.00	40.00
MRF426A*	25W	17.00	40.00
MRF433	13W	14.50	32.00
MRF435*	150W	42.00	90.00
MRF449	30W	12.00	27.00
MRF449A	30W	11.00	25.00
MRF450	50W	12.00	27.00
MRF450A	50W	12.00	27.00
MRF453	60W	15.00	33.00
MRF453A	60W	15.00	33.00
MRF454	80W	16.00	35.00
MRF454A	80W	16.00	35.00
MRF455	60W	12.00	27.00
MRF455A	60W	12.00	27.00
MRF458	80W	18.00	40.00
MRF460	60W	16.50	36.00
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MRF485*	15W	6.00	15.00
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MRF224	40W	13.50	\$32.00
MRF231	3.5W	10.00	—
MRF234	25W	15.00	39.00
MRF237	1W	2.50	—
MRF238	30W	12.00	—
MRF239	30W	15.00	—
MRF240	40W	16.00	—
MRF245	80W	25.00	59.00
MRF247	80W	25.00	59.00
MRF260	5W	6.00	—
MRF264	30W	13.00	—
MRF492	70W	18.00	39.00
MRF607	1.8W	2.60	—
MRF627	0.5W	9.00	—
MRF641	15W	18.00	—
MRF644	25W	23.00	—
MRF646	40W	24.00	59.00
MRF648	60W	29.50	69.00
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SD1477	125W	37.00	—
2N4427	1W	1.25	—
2N5945	4W	10.00	—
2N5946	10W	12.00	—
2N6080	4W	6.00	—
2N6081	15W	7.00	—
2N6082	25W	9.00	—
2N6083	30W	9.50	—
2N6084	40W	12.00	29.00
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MRF138	30W	35.00	—
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panel through which the control shaft may be passed.

I put the on/off switch and an optional warning light (to let me know when the clarifier is operating while in receive mode) below the PTO dial area near the bottom of the front panel near the center. You can use the new mini-toggles or a push-on/push-off mini-switch and one of the smaller types of pilot lights. Make sure the relay, K1, and the pilot lamp are both low-current consumption devices. If these two items pull too much current from the unregulated 15 VDC source, degradation of the voltage regulator's operation could result.

My relay is very small and has the required SPST configuration. The relay and the pilot lamp pull only about 50 mA of current. I would say that up to 100 mA could be handled without any loading down of the 15 VDC supply. The operation of the clarifier is straightforward, and has no adverse effect on the stability of the VFO; whatever stability existed before will remain even with the clarifier in use.

I happened to use a 12-volt three-terminal regulator because that was what I found in my junk box, but you could use a 9-volt unit as well, except for its slightly narrower frequency range on the RIT. Also, when reconfiguring the power lead pins, I found that C108 and R101, which were formerly across the K4 relay contacts, were no longer needed, so I clipped them out. (Tracing these two components in the KWM2 is easy as they are right behind the K4 contacts in question. Note also that the K4 contact numbering is different in the older KWM2 than in the later KWM2A series. On the former, the contacts were numbered 9, 10, and 11, instead of 11, 12, and 13.)

not limited to Collins transceivers

This modification can be used in most transceivers that do not have RIT, such as the Drake TR4, Heath SB104, etc., by connecting a lead from the varactor blocking capacitor C7 to the proper point in your VFO tuned cir-

cuit. This additional capacitance helps tune the VFO. This in turn will require you to estimate the amount of capacitance your varactor diode will need in order to cause your VFO frequency to swing the desired number of kHz.

After adding this modification to the KWM2, your VFO (Collins PTO) will read a little off frequency one way or the other. Just take a turn or two on the coil slug, which is on top of the PTO box and just to the right of the 6AU6 VFO tube. This adjustment corrects the readout for all bands. The amount you have to adjust this slug is small and will depend somewhat on the particular varactor diode you select.

Joe Fenn, KH6JF

QRP wattmeter

Prowling around radio swap meets or surplus stores, one sometimes finds a Weston Thermo Galvanometer. Because no one seems to know how they can be used, they just stay in the junk pile.

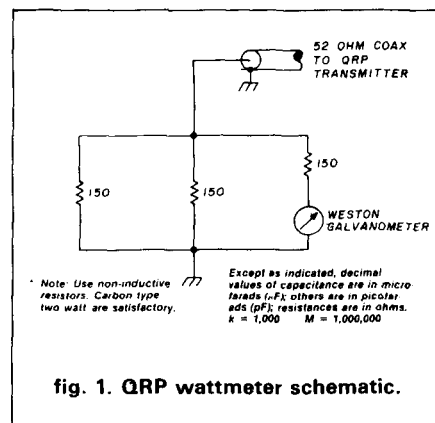


fig. 1. QRP wattmeter schematic.

A 0-100 mA RF current indicated galvanometer makes an excellent direct-reading 0-5 watt power meter that can be used with QRP rigs. The internal resistance is 5.2 ohms for 100 mA full scale reading.

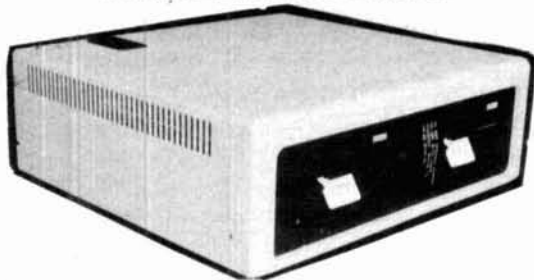
Using three 150-ohm 2-watt resistors in parallel, and putting the galvanometer in the leg of one of them makes an excellent wattmeter (fig. 1) with an accuracy of 2 percent up to 65 MHz.

Ed Marriner, W6XM

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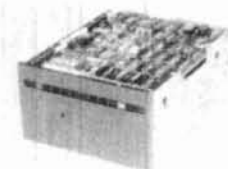
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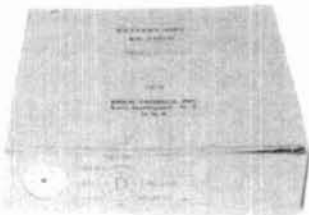
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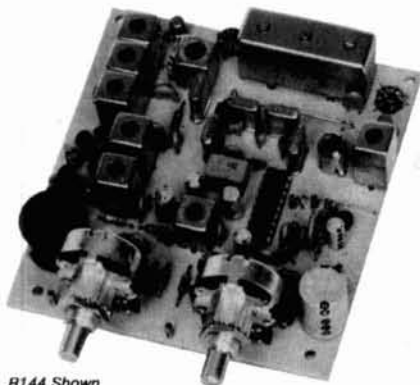
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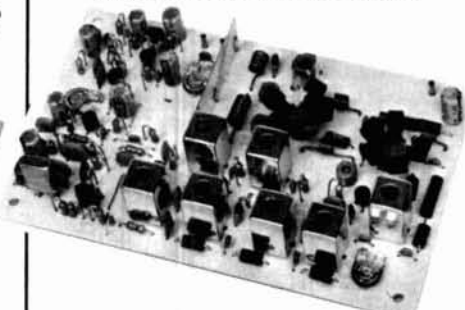
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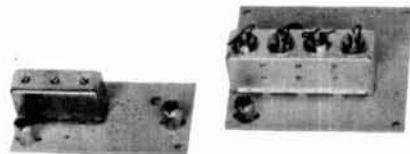


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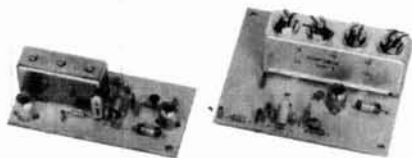
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	144-146	28-30
	145-147	28-30
	144-144.4	27-27.4
	146-148	28-30
	144-148	50-54
	220-222	28-30
	220-224	144-148
	222-226	144-148
	220-224	50-54
	222-224	28-30

UHF MODELS	Antenna Input Range	Receiver Output
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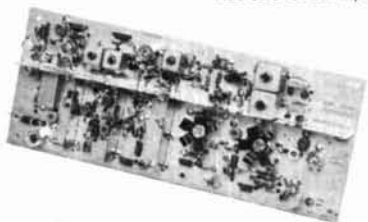
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	28-29	145-146
	28-30	50-52
	27-27.4	144-144.4
	28-30	220-222*
Wired \$149 (Specify band)	50-54	220-224
	144-146	50-52
	50-54	144-148
	144-146	28-30
	144-148	28-30

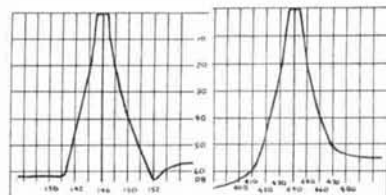
	Exciter Input Range	Antenna Output
For UHF, Model XV4 Kit \$99	28-30	432-434
	28-30	435-437
	50-54	432-436
	61.25	439.25
Wired \$169	144-148	432-436*

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book and product

REVIEWS

Palomar Engineers P-308 preamplifier

Not everyone needs a preamplifier these days because most of the newest generation of receivers and transceivers have more than sufficient sensitivity. Some, like the ICOM 751, Yaesu FT102 and TenTec Corsair, to name a few, have switchable RF amplifiers already installed. However, for older solid-state units and for tube-type radios, preamplifiers can make the difference between being able to hear the weak station or missing it altogether.



Another situation that will often require the use of preamplifiers is when you're using specially designed receiving antennas such as beverages and loops. These antennas aren't "gain" devices and are, in fact, 10-20 dB down from full-sized dipoles or other types of antennas. They're used because they're less susceptible to noise and because they exhibit directivity.

In my installation, the beverages are several hundred feet away from the station, so in addition to the low signal input, I also have several hundred feet of coax to get a signal through. As you VHF/UHFers know, this is a major problem. On 160 meters, coax loss isn't nearly as bad as at VHF/UHF, but a dB here, a dB there, all add up.

I looked through my 160-meter file to see what I had in the way of information on preamps and found several interesting circuits and specs for commercially manufactured gear. I realized I wouldn't have enough time to collect all the parts I needed to complete the project before the upcoming 160 meter CQ CW test. So I decided that this would be a good opportunity to try out a commercially manufactured preamp, and I gave Palomar Engineers a call.

Within a few days I had a P-308 preamplifier in hand to try out.

the unit

The P-308 is one of four dual-gate FET amplifiers available from Palomar. The P-308 is designed to be used with receivers and runs off

110 VAC (the P-305 is the same unit, but it runs off a 9-volt battery). The P-310X and P-312X are designed to be used with transceivers and have a built-in carrier operated relay (COR) that automatically switch the preamp circuit in and out.

All Palomar preamps use a tuned RF circuit and cover 1.8-54 MHz in four continuous bands: 1.8-4 MHz, 4-10 MHz, 10-23 MHz, and 23-54 MHz. The preamp uses a dual-gate FET and has a variable gain of up to 20 dB controlled by a front-panel control. The unit also has a 20-dB pad included for situations in which you might have too much gain in crowded band conditions, where cross mod or overloading the receiver could be a problem.

One tricky feature about the unit is making absolutely sure that it is properly tuned when in use. Failure to properly tune the preamp can result in images or spurs being amplified at the same time as the weak signal. The RF tuner stage uses a tapped coil that is switch-selectable by band and a 150-pF variable capacitor. Careful adjustment of the capacitor will eliminate this potential problem.

use

I've used this unit during the last two 160-meter contests and found it to be quite helpful in bringing those very weak DX signals up to an audible level. (That doesn't mean I actually *worked* them — but at least I could hear them!) During the contests, careful adjustment of the capacitor and gain reduction reduced or eliminated cross mod and overloading, due to the extremely crowded band conditions. (Last night I tried to get through the "wall of 4s" to work YV0AA. The YV0 was uncopiable without the preamp being on.)

I haven't spent much time with the P-308 on 15 or 10 meters. I would expect that it would be useful at that end of the ham spectrum, because that's the region where many ham receivers and transceivers need extra "oomph."

conclusion

If you're looking to pep up an old tube-type receiver, one of the Palomar preamplifiers may be just right for you. The attractive silver-gray front panel and black chassis will fit quite nicely into any ham shack. The unit weighs approximately 3 pounds and measures 8 x 5 x 3 inches.

For the name of your local dealer, contact Palomar Engineers, Box 455, Escondido, California 92025.

Circle 1315 on Reader Service Card.

N1ACH

"The Complete DX'er" by Bob Locher, W9KNI

Over the years there have been some pretty good DX books, and a few that have been sim-

ply terrible. What there hasn't been is a really great DX book — until now, that is. Drawing on the skill and knowledge that earned him one of the first CW DXCCs in 1975 and has kept him at the top of that mode's DXCC Honor Roll ever since, W9KNI has created a first-class treatise on the art of DXing that's every bit as entertaining as it is educational.

Of course this should be no surprise to readers of *ham radio* or *Ham Radio Horizons*. Bob's very popular articles on DXing and DX adventures in the two magazines were avidly read by all kinds of people, even non-hams, because they were well written and entertaining. Hams read them eagerly because each one of those articles included priceless "tricks of the trade" known but to consummate DXers. No one, whether newly-licensed Novice or grizzled DXCC Honor Roll member will fail to find something useful in Bob's latest dissertation on DXing. (Even though Bob's credentials are for CW, what he has to say applies equally well to other modes as well. That's why this is a unique DX book.)

The book is divided into two sections, the first primarily directed to the beginning DXer and the second for the advanced (200+ countries) DX chaser. The experienced DXer might be tempted to skim or even skip the first. *Don't*. It's not only very entertaining reading, but every page is laced with those little morsels of DX wisdom that always spice Bob's writing. Oh yes, there are chapters on the basics of listening, operating, and equipment, but even in those mundane subjects Bob has sewn some pearls that almost any DXer, regardless of experience, will find profitable.

The fun continues in the second half. After a very practical discussion of the art of QSL-chasing, Bob launches into "Graduate Hunting" and later on "Hunting — Again." Here the reader learns that a first class station and operating skills are not always sufficient in themselves. The top DXer must also bring to the chase the deductive ability of a Sherlock Holmes, the results of which Bob demonstrates with some fascinating anecdotes. Finally, after a much-needed chapter on the ethics of DXing and discussions on various special tools for the DXer, Bob sends the reader back to the shack to resume the search for that ever-elusive new one. He'll find him, too, now that he's been helped along by one of the true masters of the art.

Those who buy this book looking for beam heading charts, prefix lists and postal rates are going to be disappointed — there are no charts or tables. What it does contain is the wit and wisdom of DX chasing, written by an acknowledged expert. This book could be the best investment a DXer could make; I can think of no higher recommendation!

The Complete DX'er is available from Ham Radio's Bookstore, Greenville, NH 03048, for \$10.95 plus \$2.50 shipping and handling.

W9JUV



ICOM mobile transceiver

ICOM has announced the release of the new IC-37A 220 MHz ultra-compact mobile transceiver. The IC-37A features: 25 watts/5 watts low; and measures only 5-1/2" wide x 1-1/2" high x 7" deep, offering the same compact design as the IC-27A. 32 PL frequencies are stan-



dard and built-in; nine memories with offset and PL storage are included. Dial steps are in increments of 10 kHz/5 kHz. Scanning features include memory scan, band scan, and priority scan. Dual VFOs and HM-23 Touchtone® and scanning mic are standard. A speech synthesizer option is available.

For additional information, contact ICOM America, Inc., 2112 116th Avenue, N.E., Bellevue, Washington 98004.

Circle #317 on Reader Service Card.

H/T amplifiers

Mirage Communications has added two new low-profile H/T amplifiers to its expanding line of American made communications equipment.



The B23A (144-148 MHz) and C22A (220-225 MHz) incorporate features that are typically available only on larger, more expensive amplifiers. Both feature a built-in receive preamp that delivers a 1.5-2.0 dB noise figure, all-mode operation (CW, FM, or SSB), and automatic antenna changeover.

Their RF power input range is from 100 mW to 5 watts; high RF power output (B23A, 2W in, 20W out/C22A, 2W in, 30W out) makes them ideal for use with virtually all low-power transmitters.

They're each backed by a five-year factory warranty (1 year on RF power transistors) and a worldwide sales network, and priced at \$89.95.

For more information, contact Mirage Communications, P.O. Box 1000, Morgan Hill, California 95037.

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Fox Tango stocks superior CW, SSB, and AM filters for practically all Yaesu, Kenwood, and Heath models. Also for Drake R-4C, 7-line; Collins 75S3-B/C, and some ICOM's. More than 80% of our filters sell for \$60. Most are designed for easy *drop-in* installation. For the others, complete instructions and all needed parts are included in the price.

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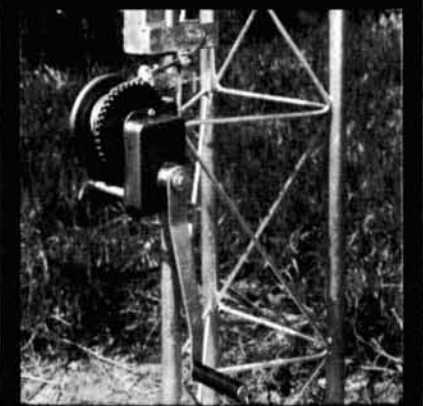
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NEW products

robot color SSTV converter

Robot Research has introduced a new black and white-compatible single-frame slow scan TV color converter. Designated Model No. 450C, it incorporates the latest in microcircuit technology and represents a significant breakthrough in the application of microprocessor-based systems to Amateur SSTV.

Model 450C features touch-sensitive front panel switches for full station control and several automatic functions for easy use. Fine tuning, speed switching and color or black and white detection are automatically accomplished without operator intervention.

Three selectable 4-bit memory planes combine to form 4,096 color combinations in a 128 pixel by 120 line full screen display. Eight different black and white and color transmission formats are available with automatic selection on receive. The unit accepts color or black and white composite video from standard TV cameras and has RGB, composite or RF modulated video output.



A unique feature of the 450C is the 8-bit parallel I/O ports for computer interface and hard copy picture printing. This analog provides total access to each individual pixel by a host computer for image processing, transformation, storage and recall, and graphics. In addition, the unit has provisions to connect to the new robot model 800C super terminal for color graphics, SSTV graphics composition, graphics overlays, and special test patterns.

For further information, contact Robot Research, Inc. 7591 Convoy Court, San Diego, California 92111.

Circle #312 on Reader Service Card.

Model 230 decoder

SYT Corporation has announced the Model 230 DTMF mobile decoder for autopatch and selective call systems.

The 230 DTMF decoder is housed in a compact metal housing for RFI protection. It features a high-speed precision decoder with wrong-digit lockout to prevent falsing. It is field programmable for DTMF code lengths from 1 to 8 digits. Call alert outputs are provided for horn, external speaker control, and internal call lamp. An optional internal alert buzzer is available.

For more information, contact Larry Francis at SYT Corporation, 1220 Barranca, El Paso, Texas 79935.

Circle #311 on Reader Service Card.

pen-type DMM

North American Soar Corporation has released the new Model 3100 Pen Type DMM, offering 25 percent greater range capability and a 3 1/2 digit LCD readout with annunciators that are said to be 50 percent larger than similar units presently available.



Model 3100 is fully autoranging and can measure DC volts from 0.1 mV through 500 volts on five ranges, AC volts from 1 mV through 500 volts on four ranges and resistance from 0.1 ohm through 20 Megohms on six auto-ranges. This dynamic range capability is made possible by use of Soar's custom 80-pin flat pack chip. Use of this state-of-the-art circuit allows fast, stable readings to be obtained. The Model 3100 has an audible continuity check feature that indicates a circuit is continuously conductive by beeping; the beeper reaction time is 0.4 seconds or less. A "Data Hold" switch is provided for freezing a reading even though the test probe is removed from the test point.

The unit is supplied with two interchangeable test points, one uninsulated 1/2 inch and one 2 3/4 inch insulated extension tip, safety type ground probe with slip-on insulated alligator clip, and two batteries. The Model 3100 is priced at \$49.99.

For further information, contact North American Soar Corporation, 1126 Cornell Avenue, Cherry Hill, New Jersey 08002.

Circle #310 on Reader Service Card.

Transi-Trap™

The new Alpha Delta Model ACTT AC Transi-Trap™ is a direct plug-in-the-wall AC surge protector providing two 120 VAC sockets, status light, circuit breaker, and a three-stage automatic surge protection circuit. The Model ACTT provides both transverse and common mode protection with a hot-to-neutral, neutral-to-ground and hot-to-ground 6000 volt, 2000 ampere surge discharge self-restoring high speed circuit. The configuration of the Model ACTT also protects equipment plugged into any other common branch AC wall outlet down line from the ACTT. The unit is UL listed and is priced at \$29.95.

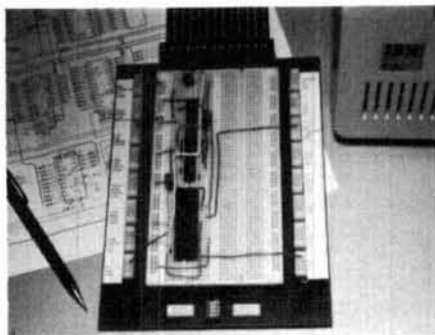


For further information, contact Alpha Delta Communications, P.O. Box 571, Centerville, Ohio 45459.

Circle #307 on Reader Service Card.

computer prototyping board

The "eZ BOARD" is a solderless system for building experimental add-ons to interface with personal computers. Its features include a glass epoxy printed-circuit board mounted with a set of solderless breadboarding units. Four separate distribution buses with fifty tie-points each can be used for power, ground, clock lines, reset commands, and other purposes. A four-position DIP switch is mounted on the board. Each switch position connects to a set of the tie-point block sockets on either side. A flat ribbon cable connects the board to the computer's bus expansion slot.



The breadboarding area consists of 1460 tie-points with a capacity of sixteen 14-pin DIPs. Components with lead diameters up to 0.032 can be plugged in with ordinary solid hook-up wire.

Models IPC, APC, and CPC are available for IBM-PC, APPLE and Commodore, respectively, and all other hardware-compatible computers of similar types. Models for other computers will be introduced during 1984. The retail price for the entire system, including cable and connectors, is \$174.95 plus \$5.00 shipping.

For further information, contact Sabadia Export Corporation, P.O. Box 1132, Yorba Linda, California 92686.

Circle #308 on Reader Service Card.

VHF/UHF diplexer

If you operate VHF and UHF, you know that long coaxial cable runs will reduce your power to the antenna significantly. You also know that low-loss coaxial cable is quite expensive. So what do you do if you want to operate both VHF and UHF without using a lot of expensive coax to feed your antennas? Microwave Filter has come up with an answer: the Model 4525 diplexer.

But what's a diplexer? A diplexer either combines or splits RF signals; for example, you could use one diplexer in the shack to combine RF from your 144 MHz and your 420 MHz radios. These

combined signals would then be fed through just one coaxial cable to the top of the tower, where a second diplexer would be located. This diplexer would again split the signals and route one to the 144 MHz antenna and the other to the 420 MHz antenna.

The Model 4525 diplexer, priced at \$104.50, is designed for the 144 and 420 MHz bands. With insertion loss less than 0.4 dB, it's designed to handle up to 200 watts of RF.

For more information, contact Microwave Filter Company, 6743 Kinne Street, East Syracuse, New York 13057.

Circle #309 on Reader Service Card.

Design Kit™ Series

Communications Consulting Corp. has announced the availability of its General Purpose Design Kit™ series. The series currently consists of an RF design kit, communications design kit, and a PLL design kit.

Most software packages available for desktop computers are concentrated in the area of computer aided analysis. The important area of circuit *synthesis* is frequently overlooked. In introducing the Design Kit™ Series, Communications Consulting Corp. has made these very powerful tools available for the HP series 9845B/C, the HP 9000, series 200 and series 500 (Model 9020). They all consist of a universal mathematical function plot and a frequency selection for minimum IMD products in mixers and relevant programs.

The RF Design Kit™ includes software for a universal mathematical function plot; frequency selection for minimum IMD products in mixers; optimization of noise figure or intercept point of cascaded amplifiers, mixers, and filters; determination of noise figure from S/N ratio; compensated wideband transformer; equalizers; quarter and half wavelength UHF oscillators; and design of microwave striplines.

The Communications Design Kit™ contains software for a universal mathematical function plot; frequency selection for minimum IMD products in mixers; dual loop AGC with group delay correction; digital filter design program; complex impedance of electrical short antennas; antenna array pattern with all driven elements; and quarter and half wavelength UHF oscillators.

The PLL Design Kit™ includes software for a universal mathematical function plot; frequency selection for minimum IMD products in mixers; optimization of type 2, second order loops; optimization of type 2, third order loops; optimization of type 2, fifth order loops (these programs include BODE plot, lock-up calculations, and component selection); general analysis of PLL circuits; and quarter and half wavelength UHF oscillators.

For further information, contact Communications Consulting Corp., 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458.

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Design Kit™ is a registered trademark of Communications Consulting Corp.

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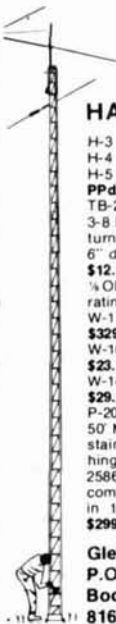
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7-21-50 radio

The new 7-21-50 from NCG is an all solid-state radio that covers the complete 40 and 15-meter bands and from 50 to 50.5 MHz on the 6-meter band. All bands operate in either the SSB or CW mode; PLL circuitry in the VFO ensures drift-free operation. The transmitter runs 26 watts PEP and utilizes balanced modulation for clear, crisp SSB audio.

Designed with extensive TVI suppression to minimize TVI problems while operating on a well matched 6-meter antenna, the 7-21-50 is small enough to be used mobile or portable, and offers additional features for use as a base station radio,



too. No external power supply is required. Technician class hams will find the 7-21-50 to be well suited to 6 meter SSB and 40 and 15 meter CW.

The 7-21-50 comes complete with an internal AC/DC power supply.

For additional information, contact NCG, 1275 N. Grove Steet, Anaheim, California 92806.

Circle #316 on Reader Service Card.

computer-controlled scanner

Electra Company has announced that the Bearcat® CP-2100, said to be the first scanner radio designed as a peripheral for today's popular personal computers, is now available in versions compatible with the IBM Personal Computer, Atari 800, Apple II and IIe, Osborne and Commodore 64 personal computers.

The CP-2100 can monitor live police and fire calls, emergency and Amateur Radio transmissions, Coast Guard rescues, and aircraft communications.

Each of its 200 channels can be programmed to display the source and location of a transmission, 10-codes, phone numbers and more. Whenever a broadcast is monitored, the information programmed into the channel will automatically appear on the screen. For scanner enthusiasts, the Bearcat CP-2100 can eliminate pages of cumbersome frequency lists. In the newsroom, it can help news crews be dispatched to the scene of a story with less confusion.

Its 200-channel capacity is three times that of the most sophisticated programmable scanners.



The Bearcat CP-2100 is also the first scanner to feature multiple priority levels. Users can select up to three different priority frequencies so most important calls will be heard first. During a priority transmission, the video monitor will flash to alert the listener. "Search/Store/Count" lets users search frequency ranges of their choice for active channels. The scanner will automatically find all active frequencies and store them in separate memory without the need for the operator to be present. The count register shows how many transmissions were noted on each active frequency. In addition, every channel includes four auxiliary settings which can be programmed to activate tape recorders, alarms and other optional equipment whenever a call is received on the programmed channel.

Other features include patented "selective scan delay," "automatic lockout," "automatic and manual search," and patented "track tuning." Frequency coverage includes 10, 6, and 2-meters, and 70-centimeter Amateur; VHF Low and High; VHF Aircraft; UHF and UHF-"T"; and Military Land Mobile bands.

The Bearcat CP-2100's basic package includes the radio, AC adapter, plus a special telescoping whip antenna with 20 foot coaxial cable and mating BNC connectors. A custom 5-1/4 inch program diskette, custom interface cable, and manual are packaged separately for compatibility with different models of computers. The software can be user-modified to suit individual needs.

The suggested retail price of the Bearcat CP-2100, including both hardware and software packages, is \$499.95. For additional information, write Electra Company, 300 East County Line Road, Cumberland, Indiana 46229.

Circle #304 on Reader Service Card.

VIC-20 programs

Three new HAMWARE programs developed by John Vesty Company are said to extend the utility of VIC-20 computers to logging and QSO operations.

Ham List serves as a memory jogger during a QSO, quickly searching for a call and displaying data on file. The program provides for the convenient addition, revision, or deletion of entries, and a screen-review of the list.

1984 THE RADIO AMATEUR'S HANDBOOK



STATE OF THE ART

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The three programs are available on tapes, and are designed for use with both unexpanded and expanded VIC-20 computers. The capacity of the logging programs ranges from 100 to 700 entries maximum, depending on the memory expansion used and the length of individual entries.

For further information, contact John Vestly Company, 415 Elm Street, Fayetteville, New York 13066.

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For further information, contact Sabre Communications Corp., 117 Main Street, Sioux City, Iowa 51102.

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Chances are you have spent a couple thousand dollars on setting up a computer system that gets a lot of your work done. But sometimes it gets to be work to work at it.

I know that when I have to move two program manuals and a pencil holder to boot up the disk drive, it is work. When there is an unlabeled floppy (that I am going to identify some day) on top of the monitor and the business check-book is on top of the printer . . . and I will remember (I hope) before the next "report" comes through . . . that is work.

I found the annoyance of my own "computer clutter" was even worse than the extra work the disorder created. And that is when I started looking for some practical furniture for my computer set up. Since I had already spent a lot of money on the system itself, I was really dismayed when I found out how much it would cost to get a decent-looking desk or even a data table for my equipment. \$400 . . . \$500 . . . even more for a sleazy unit that looked like junk! In fact, it was junk! And it took a long time for me to find something that was really worth the money . . . and more.

A lot of my working day is spent with my computer, and I will bet a lot of your time is too. So I figure a "home" for my system—a housing that is good looking as well as efficient to work at—will pay off two ways:

1. Less work: an efficient and orderly layout will save me time and energy.
2. Personal satisfaction: good quality furnishings look better; they just plain feel better to work at too.

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NEW products

Ten-Tec Century 22

Ten-Tec has just released its newest radio, the Century 22. The Century 22, an update of the popular Century 21, features the latest in solid-state RF technology. The design concept is a low power, gimmick-free, CW only radio. Ideal for beginners on a budget — as well as for established hams as either a second set or mobile radio — this new unit offers full QSK, 50 watts of RF input power, a six-pole audio filter, linear crystal mixed VFO and covers the standard five bands 80-10 meters plus the WARC 30-meter band.



The Century 22 also features receiver sensitivity of 0.5 μ V, offset receiver tuning, automatic gain and level control, adjustable side tone, CW and SSB or receive, and SWR and forward power metering. The unit weighs just 6 pounds (2.7 kg) and measures 4 x 10 x 10.5 inches (10.2 x 25.4 x 26.67 cm). It has a rigid metal chassis with molded front panel and aluminum back, top and bottom. It includes 28 transistors, 24 diodes, and 7 ICs. Frequency tolerance is ± 5 KC of dial reading, (± 2 KC when using the optional calibrator). The Century 22 is priced to fit the beginner's budget at \$389. The optional 110 VAC to 12 VDC, 5-amp power supply is \$89 additional.

For more information, contact Ten-Tec, Inc. Sevierville, Tennessee 37862.

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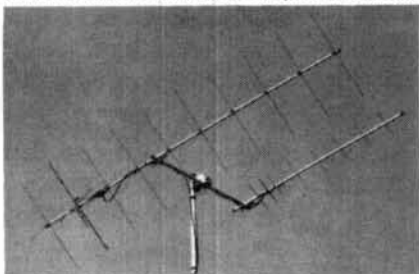
The improved NMO series of antenna hardware from Larsen Electronics features an extra lip around the bottom of the coil, providing a place for an "O" ring. The ring surrounds the threads that tighten to the vehicle surface, eliminating the chance that water may be drawn through the threads, decreasing performance and corroding mounting hardware. This improvement is said to make a difference in areas where antennas are constantly exposed to heavy rain, and to offer additional protection under less severe conditions as well. All NMO-series VHF and UHF products now incorporate this change; LM and NLA series are also equipped with a neoprene gasket around mounting hardware for a weather-tight seal.

For details, contact Larsen Electronics, P.O. Box 1799, Vancouver, Washington 98668.

Circle #314 on Reader Service Card.

satellite antenna

Cushcraft has introduced a new Amateur satellite antenna system featuring two high gain circularly polarized Yagi antennas. The 70 cm, 16-element uplink and 2-meter, 20-element downlink antennas are fixed to a common mounting boom. The entire array is lightweight with reasonable dimensions for quick installation.



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

Circle #301 on Reader Service Card.

HF antenna design program

HF Antenna Design is the latest offering in Cynwyn's line of software for Amateur Radio operators. The program makes the necessary calculations for building three popular types of antennas — dipole, Yagi, and quad — for frequencies of 1.8 - 30 MHz and displays them in an easy-to-read tabular format. The dimensions for the Yagi and quad are optimized for maximum gain.

HF Antenna Design required a TRS-80C Color Computer™ with 16K RAM and Extended Color Basic or MC-10 with 4K RAM. The program is available from Cynwyn — 4791 Broadway, Suite 2F, New York, New York 10034 — on cassette for \$10 plus \$2 shipping and handling.

Circle #305 on Reader Service Card.

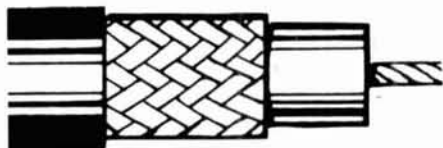
repeater amplifier

Falcon Communications has announced its new Model 4114 2-meter repeater amplifier, a basic amplifier that supplies a full 100-watt output when driven with 2 watts. Features include carrier operated relay or external keying; operation on 13.8 volts DC, from either a battery or power supply; regulated bias supply (adjustable for limited power output adjustment); and a thermostat designed to prevent any damage in the event of overheating. No damage results from high VSWR.



Other units in this series supply maximum power outputs of from 50 to 100 watts and accept drive levels up to 25 watts. A 220 MHz unit is also available.

For further information, contact Falcon Communications, P.O. Box 620625, Woodside, California 94062.



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SD1004	15.00	SD1127	3.50	SD1283	10.00	SD1477	48.00
SD1009	15.00	SD1133	14.00	SD1289-1	15.00	SD1478	21.00
SD1009-2	15.00	SD1133-1	14.00	SD1290-4	15.00	SD1480	60.00
SD1012	9.90	SD1134-1	3.00	SD1290-7	15.00	SD1484	1.50
SD1012-3	9.90	SD1135	8.00	SD1300	3.00	SD1484-5	1.50
SD1012-5	9.90	SD1136	15.00	SD1301-7	3.60	SD1484-6	1.50
SD1013-3	13.50	SD1136-2	15.00	SD1305	3.00	SD1484-7	1.50
SD1013-7	13.50	SD1143-1	12.00	SD1307	3.00	SD1488	39.00
SD1014	11.00	SD1143-3	17.00	SD1308	3.00	SD1488-1	28.00
SD1014-6	11.00	SD1144-1	3.00	SD1311	1.00	SD1488-7	27.00
SD1016	15.00	SD1146	15.00	SD1317	10.00	SD1488-8	28.00
SD1016-5	13.00	SD1147	15.00	SD1335	3.00	SD1499-1	39.00
SD1018-4	15.00	SD1188	10.00	SD1345-6	5.00	SD1520-2	18.00
SD1018-6	15.00	SD1189	24.00	SD1365-1	2.50	SD1522-4	33.00
SD1018-7	15.00	SD1200	1.50	SD1365-5	2.50	SD1528-1	24.00
SD1018-15	15.00	SD1201-2	10.00	SD1375	7.50	SD1528-3	34.00
SD1020-5	19.00	SD1202	10.00	SD1375-6	7.50	SD1530-2	38.00
SD1028	15.00	SD1212-11	4.00	SD1379	15.00	SD1536-1	41.00
SD1030-2	12.00	SD1212-12	4.00	SD1380-1	1.00	SD1545	34.00
SD1043	12.00	SD1212-16	4.00	SD1380-3	1.00	SD1561	79.00
SD1043-1	10.00	SD1214-7	5.00	SD1380-7	1.00	SF4557 Mot.	25.00
SD1045	3.75	SD1214-11	5.00	SD1405	40.00	SK3048 RCA	5.00
SD1049-1	2.00	SD1216	12.00	SD1409	18.00	SK3177 RCA	15.00
SD1053	4.00	SD1219-4	15.00	SD1410	22.00	SMS7714 Mot.	2.50
SD1065	4.75	SD1219-5	15.00	SD1410-3	21.00	SFR750 Mot.	36.00
SD1068	15.00	SD1219-8	15.00	SD1413-1	18.00	SFR1018 Mot.	5.00
SD1074-2	18.00	SD1220	8.00	SD1416	50.00	SFR2147 Mot.	22.00
SD1074-4	28.00	SD1220-9	8.00	SD1422-2	24.00	SFR2356 Mot.	38.00
SD1074-5	28.00	SD1222-8	16.00	SD1428	33.00	SFR2378 Mot.	16.00
SD1076	20.00	SD1222-11	7.50	SD1429-2	15.00	SFR2584 Mot.	40.00
SD1077-4	4.00	SD1224-10	18.00	SD1429-3	15.00	SFR2821 Mot.	25.00
SD1077-6	4.00	SD1225	18.00	SD1429-5	15.00	SFR2857 Mot.	20.00
SD1078-6	24.00	SD1228-8	POR	SD1430	12.00	TA8894 RCA	15.00
SD1080-8	6.00	SD1229-7	13.00	SD1430-2	18.00	TA1889/MRF966	3.55
SD1080-9	3.00	SD1229-16	13.00	SD1434-5	30.00	TP312	2.50
SD1084	8.00	SD1232	4.00	SD1434-9	30.00	TP1014 TRW	5.00
SD1087	15.00	SD1240-8	15.00	SD1438	26.00	TP1028 TRW	15.00
SD1089-5	15.00	SD1244-1	14.00	SD1441	91.00	01-80703T04/	
SD1095	15.00	SD1262	12.00	SD1442	15.00	458-949 Mot. Comm.	65.00
SD1100	5.00	SD1263	15.00	SD1444	6.00	TXVF2201 H.P.	450.00
SD1109	18.00	SD1263-1	15.00	SD1444-8	6.00	62803 RCA	100.00
SD1115-2	8.00	SD1272	13.00	SD1450-1	28.00	TA7205/2N5921	80.00
SD1115-3	8.00	SD1272-2	15.00	SD1451	18.00	TA7487/2N5920	75.00
SD1115-7	2.50	SD1278	20.00	SD1451-2	18.00	TA7995/2N6267	150.00
SD1116	5.00	SD1278-1	18.00	SD1452	20.00	SFR2092 Mot.	18.00
SD1118	22.00			SD1452-2	20.00	MRF479	8.05

We Can Cross Reference Most RF Transistors, Diodes, Hybrid Modules And Any Other Type Of Semiconductor.

* DIODES (HOT CARRIER, MICROWAVE, PIN, SCHOTTKY, TUNNEL, VAJACTOR, GUNN) *

1N21	\$ 3.40	1N21B	\$ 3.40	1N21BR	\$ 3.40	1N21C	\$ 3.40
1N21D	4.00	1N21DR	4.00	1N21FR	6.00	1N21RF	5.00
1N21WE	5.80	1N21WG	5.80	1N22	5.00	1N23A	10.00
1N23B	3.40	1N23C	3.40	1N23CR	3.40	1N23D	4.95
1N23DR	4.00	1N23WE	5.00	1N25	7.50	1N25AR	18.00
1N28WE	10.00	1N29	10.00	1N32	20.00	1N53A	55.50
1N76	26.00	1N76R	28.00	1N78	26.00	1N78A	20.00
1N78B	26.00	1N78D	28.00	1N78DR	28.00	1N78R	28.00
1N149	6.00	1N150MR	18.00	1N415	4.00	1N415C	4.00
1N415G	15.00	1N416D	5.00	1N416E	6.00	1N446	10.00
1N831	10.00	1N833	10.00	1N950	4.00	1N1084	2.00
1N2930	15.00	1N2932	15.00	1N3540	15.00	1N3712	11.00
1N3713	18.00	1N3714	11.00	1N3715	16.00	1N3716	10.00
1N3717	14.00	1N3718	10.00	1N3721	14.00	1N3733	10.00
1N3747	21.00	1N4386	20.00	1N4396	15.00	1N4785	11.00
1N4812B	9.00	1N5139A/B	4.25	1N5140A/B	4.25	1N5141A/B	4.25
1N5142A/B	4.25	1N5143A/B	4.25	1N5144A/B	4.25	1N5145A/B	4.25
1N5146A/B	4.25	1N5147A/B	4.25	1N5148A/B	4.25	1N5167	5.50
1N5453	3.75	1N5465	7.65	1N5711	1.00	1N5711 JAN	2.00
1N5713	5.00	1N5767	2.00	1N6263	1.00	1S2199	15.00
1S2200	15.00	1S2208/9	1.00	8B1087/48R869558	65.00	8D3020	65.00
AZK116M Aertech	50.00	BB105B	1.00	BB105G	1.00	BD4/4JFEM G.E.	15.00
BL161 Bornec	5.00	CM0514AB C.M.	POR	D4060 Alpha	POR	D4159 Alpha	POR
D4233B Alpha	POR	D4900 Alpha	POR	D4959 Alpha	POR	D4987M Alpha	POR
D5047C Alpha	POR	D5147D Alpha	POR	D5503 Alpha	POR	D5506 Alpha	POR
DGB6158-98 Alpha	POR	DMD6022 Alpha	POR	DMD6460A Alpha	POR	DP20054 Crown	POR
GC1691-89 GHZ	31.35	GC1602-89 GHZ	31.35	GC1607-40 GHZ	31.35	GC2531-88 GHZ	37.40
GC2542-46 GHZ	37.40	GC3208-40 GHZ	37.40	GC17044 GHZ	50.00	HP33644A-H01	125.00
HP5082-0112	14.20	HP5082-0241	75.60	HP5082-0253	105.00	HP5082-0320	58.00
HP5082-0375	POR	HP5082-0386	POR	HP5082-0401	POR	HP5082-0438	POR
HP5082-1028	POR	HP5082-1332	POR	HP5082-2254	POR	HP5082-2302	10.70
HP5082-2303	5.20	HP5082-2696	POR	HP5082-2711	23.15	HP5082-2727	POR
HP5082-2800	1.00	HP5082-2805	4.45	HP5082-2835	1.00	HP5082-2884	POR
HP5082-3039	6.70	HP5082-3040	36.00	HP5082-3080	2.00	HP5082-3188	1.00
HP5082-3379	1.50	HP5082-6459	POR	HP5082-6462	POR	HP5082-6888	POR
HP5082-8016	POR	HP5082-8323	POR	K3A Kemitron	7.00	MA450A	POR
MA475	POR	MA40008	POR	MA41487	POR	MA41765	POR
MA41766	POR	MA43004	46.00	MA43589	POR	MA43622	POR
MA43636	POR	MA45104	27.00	MA47044	POR	MA47051	25.50
MA47100	3.05	MA47202	30.80	MA47771	POR	MA47838*	POR
MA47852	POR	MA49106	37.95	MA49558	POR	MA96731	125.00

* OUR STOCK CHANGES DAILY SO CALL IF THE PART YOU NEED IS NOT LISTED *

For information call: (602) 242-3037

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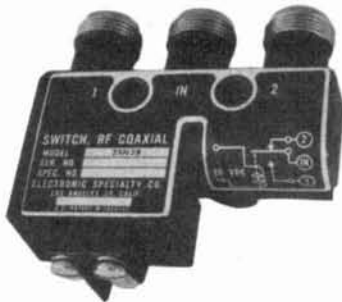
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MHz electronics

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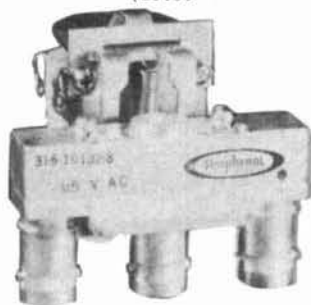
COAXIAL RELAY SWITCHES SPDT

Electronic Specialty Co./Raven Electronics FSN 5985-556-9683 \$49.00
 Part # 25N28 Part # SU-01
 26Vdc Type N Connector, DC to 1 GHz.



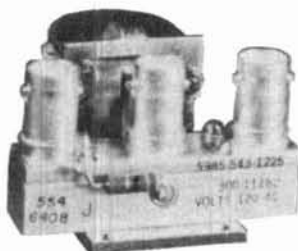
Amphenol
 Part # 316-10102-8
 115Vac Type BNC DC to 3 GHz.

\$29.99



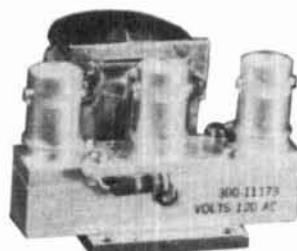
FXR
 Part # 300-11182
 120Vac Type BNC DC to 4 GHz.
 FSN 5985-543-1225

\$39.99



FXR
 Part # 300-11173
 120Vac Type BNC Same
 FSN 5985-543-1850

\$39.99



BNC To Banana Plug Coax Cable RG-58 36 inch or BNC to N Coax Cable RG-58 36 inch.

\$7.99 or 2 For \$13.99 or 10 For \$50.00

\$8.99 or 2 For \$15.99 or 10 For \$60.00



SOLID STATE RELAYS

P&B Model ECT1DB72 5vdc turn on
 PRICE EACH \$5.00

Disisig, Inc. Model ECS-215 5vdc turn on
 PRICE EACH \$7.50

Grigsby/Barton Model GB7400 5vdc turn on
 PRICE EACH \$7.50

120vac contact at 7amps or 20amps on a 10"x 10"x .124 aluminum. Heatsink with silicon grease.

240vac contact 14amps or 40amps on a 10"x 10"x .124 aluminum. Heatsink with silicon grease.

240vac contact at 15amps or 40amps on a 10"x 10"x .124 aluminum. Heatsink with silicon grease.

NOTE: *** Items may be substituted with other brands or equivalent model numbers. ***

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TUBES

TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
2C39/7289	\$ 34.00	1182/4600A	\$500.00	ML7815AL	\$ 60.00
2E26	7.95	4600A	500.00	7843	107.00
2K28	200.00	4624	310.00	7854	130.00
3-500Z	102.00	4657	84.00	ML7855KAL	125.00
3-1000Z/8164	400.00	4662	100.00	7984	14.95
3B28/866A	9.50	4665	500.00	8072	84.00
3CX400U7/8961	255.00	4687	P.O.R.	8106	5.00
3CX1000A7/8283	526.00	5675	42.00	8117A	225.00
3CX3000F1/8239	567.00	5721	250.00	8121	110.00
3CW30000H7	1700.00	5768	125.00	8122	110.00
3X2500A3	473.00	5819	119.00	8134	470.00
3X3000F1	567.00	5836	232.50	8156	12.00
4-65A/8165	69.00	5837	232.50	8233	60.00
4-125A/4D21	79.00	5861	140.00	8236	35.00
4-250A/5D22	98.00	5867A	185.00	8295/PL172	500.00
4-400A/8438	98.00	5868/AX9902	270.00	8458	35.00
4-400B/7527	110.00	5876/A	42.00	8462	130.00
4-400C/6775	110.00	5881/6L6	8.00	8505A	95.00
4-1000A/8166	444.00	5893	60.00	8533W	136.00
4CX250B/7203	54.00	5894/A	54.00	8560/A	75.00
4CX250FG/8621	75.00	5894B/8737	54.00	8560AS	100.00
4CX250K/8245	125.00	5946	395.00	8608	38.00
4CX250R/7580W	90.00	6083/AZ9909	95.00	8624	100.00
4CX300A/8167	170.00	6146/6146A	8.50	8637	70.00
4CX350A/8321	110.00	6146B/8298	10.50	8643	83.00
4CX350F/8322	115.00	6146W/7212	17.95	8647	168.00
4CX350FJ/8904	140.00	6156	110.00	8683	95.00
4CX600J/8809	835.00	6159	13.85	8877	465.00
4CX1000A/8168	242.50*	6159B	23.50	8908	13.00
4CX1000A/8168	485.00	6161	325.00	8950	13.00
4CX1500B/8660	555.00	6280	42.50	8930	137.00
4CX5000A/8170	1100.00	6291	180.00	6L6 Meta1	25.00
4CX10000D/8171	1255.00	6293	24.00	6L6GC	5.03
4CX15000A/8281	1500.00	6326	P.O.R.	6CA7/EL34	5.38
4CW800F	710.00	6360/A	5.75	6CL6	3.50
4D32	240.00	6399	540.00	6DJ8	2.50
4E27A/5-125B	240.00	6550A	10.00	6DQ5	6.58
4PR60A	200.00	6883B/8032A/8552	10.00	6GF5	5.85
4PR60B	345.00	6897	160.00	6GJ5A	6.20
4PR65A/8187	175.00	6907	79.00	6GK6	6.00
4PR1000A/8189	590.00	6922/6DJ8	5.00	6HB5	6.00
4X150A/7034	60.00	6939	22.00	6HF5	8.73
4X150D/7609	95.00	7094	250.00	6JG6A	6.28
4X250B	45.00	7117	38.50	6JM6	6.00
4X250F	45.00	7203	P.O.R.	6JN6	6.00
4X500A	412.00	7211	100.00	6JS6C	7.25
5CX1500A	660.00	7213	300.00*	6KN6	5.05
KT88	27.50	7214	300.00*	6KD6	8.25
416B	45.00	7271	135.00	6LF6	7.00
416C	62.50	7289/2C39	34.00	6LQ6 G.E.	7.00
572B/T160L	49.95	7325	P.O.R.	6LQ6/6MJ6 Sylvania	9.00
592/3-200A3	211.00	7360	13.50	6ME6	8.90
807	8.50	7377	85.00	12AT7	3.50
811A	15.00	7408	2.50	12AX7	3.00
812A	29.00	7609	95.00	12BY7	5.00
813	50.00	7735	36.00	12JB6A	6.50

NOTE * = USED TUBE

NOTE P.O.R. = PRICE ON REQUEST

"ALL PARTS MAY BE NEW, USED, OR SURPLUS. PARTS MAY BE SUBSTITUTED WITH COMPARABLE PARTS IF WE ARE OUT OF STOCK OF AN ITEM.

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MHz electronics

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HEWLETT PACKARD SIGNAL GENERATORS

606A	50KHz to 65MHz in 6 bands $\pm 1\%$ Output level adjustable 0.1uV to 3V into 50 ohms. Built-in crystal calibrator. 400 - 1000Hz modulation.	\$ 650.00	616B	Same as above but later model.	\$ 600.00
606B	Same as above but has frequency control feature to allow operation with HP 8708A Synchronizer.	\$1100.00	618B	3.8 to 7.6GHz range, with calibrated output and selection of pulse-FM or square wave modulation.	\$ 600.00
608C	10MHz to 480MHz, 0.1uV-1V into 50 ohms, AM, CW, or pulse modulation, calibrated attenuator.	\$ 500.00	618C	Same as above but later model.	\$2200.00
608D/TS510	10MHz to 420MHz, 0.1uV-0.5V into 50 ohms, $\pm 0.5\%$ accuracy, built-in crystal calibrator, AM-CW or pulse output.	\$ 375.00	620A	7 to 11GHz range, with calibrated output and selection of pulse-FM or square wave modulation.	\$ 750.00
608E	Improved version of popular 608C. Up to 1V output. Improved stability, low residual FM.	\$1450.00	620B	Same as above but later model.	\$2200.00
608F	10MHz to 455MHz in 5 bands $\pm 1\%$ frequency accuracy with built-in crystal calibrator. Can be used with HP 8708A Synchronizer. Output continuously adjustable from .1uV to .5V into 50 ohms.	\$1100.00	626A	10 to 15GHz, 10mW output power with calibrated output and pulse-square wave or FM modulation.	\$4200.00
612A	450-1230MHz, 0.1uV-0.5V into 50 ohms, calibrated output.	\$ 750.00	8708A	Synchronizer used with 606B, 608F. The synchronizer is a phase-lock frequency stabilizer which provides crystal oscillator frequency stability to 430MHz in the 608F signal generator. Phase locking eliminates microphonics and drift resulting in excellent frequency stability. The 8708A includes a vernier which can tune the reference oscillator over a range of $\pm 0.25\%$ permitting frequency settable to 2 parts in 10 to the seventh. Provides a very stable signal that satisfies many critical applications.	(With HP 606B or 608F) \$ 350.00 (Without) \$ 450.00
614A	900-2100MHz with many features including calibrated output and all modulation characteristics.	\$ 500.00	EMC-10	ELECTROMETRICS EMC-10 RFI/EMI RECEIVER Low frequency analyzer covering 20Hz to 50KHz frequency range. Extendable to 500 KHz in wideband mode.	\$2500.00
616A/TS403	Direct reading and direct control from 1.8 to 4.2GHz. The H.P. 616A features ± 1.5 dB calibrated output accuracy from -31.27dBm to -dBm. The output is directly calibrated in microvolts and dBm with continuous monitoring. Simple operation frequency dial accuracy is $\pm 1\%$ and stability exceeds 0.005% / C change in ambient temperature. Calibrated attenuator is within ± 1.5 dB over entire output band. 50 ohm impedance unit has internal pulse modulation with rep rate variable from 40 Hz to 4KHz, variable pulsewidth (1 to 10usec) and variable pulse delay (3 to 300usec). External modulating inputs increase versatility.	\$ 375.00	NF-105F	Empire Devices Field Intensity Meter. Has NF-105/TA, NF-105/TX, NF-105/T1, NF-105/T2, NF-105/T3. Covers 14KHz to 1000MHz.	\$2100.00

ALL EQUIPMENT CARRY A 30 DAY GUARANTEE.

EQUIPMENT IS NOT CALIBRATED.

TERMS: DOMESTIC: Prepaid, C.O.D. or Credit Card
FOREIGN: Prepaid only, U.S. Funds, Money Order, or Cashier's Check Only.

C.O.D.: Acceptable by telephone or mail. Payment from customer will be by Cash, Money Order, or Cashier's Check. We are sorry but we cannot accept personal checks for C.O.D.'s. C.O.D.'s are shipped by air only and thru United Parcel Service.

CONFIRMING ORDERS: We would prefer that confirming orders not be sent after a telephone order has been placed. If company policy necessitates a confirming order, please mark "CONFIRMING" boldly on the order. If problems or duplicate shipments occur due to an order which is not properly marked, the customer will be held responsible for any charges incurred, plus a 15% restock charge on the returned parts.

CREDIT CARDS: We are now accepting MASTERCARD, VISA, AND AMERICAN EXPRESS

DATA SHEETS: When we have data sheets in stock on devices we will supply them with the order.

DEFECTIVE MATERIALS: All claims for defective materials must be made within 30 DAYS after receipt of the parcel. All claims must include the defective material for testing purposes, a copy of our invoice, and a return authorization number which must be obtained prior to shipping the merchandise back to us. This can be obtained by calling (602) 242-8916 or sending us a postcard. Due to Manufacturer warranties we are unable to replace or issue credit on items which have been soldered to or have been altered in any way. All return items must be packed properly or it will void all warranties. We do not assume responsibility for shipping and handling charges incurred.

DELIVERY: Orders are usually shipped the same day they are placed or the next business day, unless we are out of stock on an item. The customer will be notified by post card if we are going to backorder the item. Our normal shipping method is UPS or U.S. Mail depending on size or the weight of the package. Test Equipment is shipped only by air and is freight collect, unless prior arrangements have been made and approved.

FOREIGN ORDERS: All foreign orders must be prepaid with a Cashier's Check, or Money Order made out in U.S. FUNDS ONLY. We are sorry but C.O.D. is not available to foreign countries and letters of credit are unacceptable as a form of payment. Further information is available on request.

HOURS: Monday thru Friday 8:30 a.m. to 5:00 p.m. Saturdays 8:30 a.m. to 4:00 p.m.

INSURANCE: Please include 25¢ for each additional \$100.00 over \$100.00. UPS ONLY. All insured packages are shipped thru UPS only. If you wish to have it shipped through the post office there is a \$5.00 fee which is additional to the shipping, handling and insurance.

OPEN ACCOUNTS: We regret that we do not issue open accounts.

ORDER FORMS: New order forms are included with each order for your convenience. Additional order forms are available on request.

PARTS: We reserve the right to substitute or replace any item with a part of equal or comparable specification.

POSTAGE: Minimum shipping and handling in the U.S., Canada, and Mexico is \$3.00 for ground shipments, all other countries is \$5.50. Air rates are available at the time of your order. All foreign orders please include 25% of the ordered amount for shipping and handling. C.O.D.'s are shipped AIR ONLY.

PREPAID ORDERS: Orders must be accompanied by a check.

PRICES: Prices are subject to change without notice.

PURCHASE ORDERS: We accept purchase orders only when they are accompanied by a check.

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ILLINOIS: The Quad-Co. ARC will sponsor the 27th annual "Breakfast Club" Hamfest, July 21 and 22, Terry Park, Palmyra. All other groups are invited. Please give prior notice to Hamfest Committee. Dancing and movies Saturday night. Bring a basket lunch. Sandwiches and soft drinks available on grounds. Games, contests, golfing and fishing. Bring your swap gear. Camping facilities open from Friday afternoon to Monday morning. Talk in on 3973 kHz. Write: Hamfest, c/o Quad-Co. ARC, 602-D East Walnut, Chatham, IL 62629.

SOUTH CAROLINA: The Charleston Amateur Radio Society will host the annual Charleston Hamfest, July 14 and 15, Omar Shrine Temple. Commercial tables \$40.00 (over 2, \$20.00 each additional). Flea market tables \$5.00 each. Talk in on 146.19/79. For information/table reservations: Hamfest Committee, P.O. Box 70341, Charleston Heights, SC 29405.

TEXAS: The Austin ARC and the Austin Repeater Org. will sponsor Summerfest '84, August 10, 11 and 12, Austin Marriott Hotel, I-35 at Hwy. 290. Admission \$5 advance (deadline July 31). \$7.00 at the door. Indoor swapfest, dealers' showcase, transmitter hunt. Featured speakers: KG5U, president of the NASA/Johnson Space Center ARC, KQ5I of AMSAT, K5FOG and WA5MWD on packet radio. Ladies' programs. Reserved swapfest tables \$1.00 each, limit two. Talk in on 146.34/94. For more information: Austin Summerfest '84, P.O. Box 13473, Austin, TX 78711.

WEST VIRGINIA: The 6th annual TSRAC Hamfest, Sunday, July 22 at Wheeling Park. 9 AM to 4 PM. Admission \$3.00 by reservation. Dealers, exhibits all under roof. Refreshments, family park activities, flea market, auctions, free parking. All spaces free both dealers and flea market. For brochure, information and map contact: TSRAC, Box 240, RD 1, Adena, OH 43901. (614) 546-3930.

TENNESSEE: The Radio Amateur Transmitting Society is pleased to announce the 6th annual Nashville Ham and Computer Fest, July 29, at the Nashville Municipal Auditorium. No admission charge. Tables available for \$5.00. For further information: SASE to Willie Porter, KB4BLL, 4907 Idaho Avenue, Nashville, TN 37209.

NEW YORK: The Allied Armored Force Amateur Radio National Emergency Team, (AFAR NET) will hold an eyeball bivouac, July 28, Sheraton Inn in Canandaigua starting at 1 PM. All Amateur Radio operators who have been assigned or attached to an armored unit are invited to attend the get-together. For additional information: Harry B. Thomsen, W2PJH, 348 Jefferson Avenue, Apt. 15, Canandaigua, NY 14424 Please SASE.

NEW JERSEY: Sussex County ARC will sponsor "SCARC '84", Saturday, July 14, at the Sussex County Fairgrounds, Plains Rd., Augusta. Doors open at 8 AM. Admission \$2. Indoor tables \$5 advance, \$6 at door. Tailgate space \$4 advance, \$5 at gate. Food and refreshments. Free parking. Talk in on 90/30 and 52 simplex. For further information: Donald R. Stickle, K2OX, Weldon Rd., RD #4, Lake Hopatcong, NJ 07849. (201) 663-0677.

WISCONSIN: The Eau Claire Amateur Radio Club's annual Hamfest, Saturday, July 14, 4-H Buildings in Eau Claire. 8 AM to 4 PM. Tickets \$2.00 in advance, \$3.00 at door. Free tables and coffee. Talk in on 31/91 and 52 simplex. For information, tickets SASE to Gene Lieberg, KA9DWH, 2840 Saturn Avenue, Eau Claire, WI 54703.

FLORIDA: The 11th annual Greater Jacksonville Hamfest, August 4 and 5, Orange Park Kennel Club, US 17 south near I-295. 8 AM to 5 PM Saturday and 9 AM to 3 PM Sunday. Registration \$4.00. Swap tables \$9/one day, \$15/weekend. Exhibitors, large swap table area, forums and programs. Special discounts and promotions available to exhibitors contracting for space prior to July 15. Plenty of free parking. For information, swap tables, registration: Mike Parnin, N4EPD, 6716 Diane Rd., Jacksonville, FL 32211.

MICHIGAN: The Copper Country Radio Amateur Association is hosting the 1984 Upper Peninsula Hamfest, July 28, Memorial Union Cafeteria, Michigan Technological University campus, Houghton. For further information contact: Howard Junkin, N8FHF, Co-chairman UP Hamfest, 106 West South St., Houghton, MI 49931. (906) 482-4630.

MONTANA: The Great Falls Area ARC's 50th annual Glacier-Waierton International Hamfest, July 20, 21 and 22 at Three Forks Campground on the southern edge of Glacier National Park. QCWA meeting and contests, 2m transmitter hunts. Pre-registration is \$8.50 and includes Saturday night dinner (bring

your own meat and utensils) and Sunday morning breakfast. Talk in on 52 and 34/94. For more information SASE to Shirley Smith, KC7OA, 1822 - 14th Avenue South, Great Falls, MT 59405.

MARYLAND: The Baltimore Radio Amateur Television Society again presents the BRATS Hamfest and Computerfest, Sunday, July 29, Howard County Fairgrounds, Route 144 at Route 32, West Friendship. Indoor tables with A/C \$20.00 each. Indoor tables no A/C \$10.00 each. Outdoor tailgating. RV hook-ups available. For table reservations and information: BRATS, P.O. Box 5915, Baltimore, MD 21208 or call Mayer Zimmerman, W3GXK (301) 655-7812. Talk in on 146.76 (-600), 147.03 (+600) or 52 simplex.

WEST VIRGINIA: Wheeling Hamfest, Sunday, July 22, Wheeling Park. Flea market, auction, dealers welcome. Under roof tables available. Admission \$3.00. For information/reservations: TSRAC, Box 240, RD 1, Adena, OH 43901. (614) 546-3930.

INDIANA: The combined LaPorte-Michigan City Amateur Radio Clubs will sponsor their Summer Hamfest, Sunday, July 15, LaPorte County Fairgrounds, State Road 2, LaPorte. 8 AM to 2 PM. Donation \$3.00. Indoor tables by reservation, 40¢/ft. P.O. Box 30, LaPorte, IN 46350.

KENTUCKY: The Central Kentucky ARRL Hamfest, sponsored by the Bluegrass Amateur Radio Society, Sunday, August 12, 8 AM to 5 PM, Scott County High School, Longlick Road and US 25, Georgetown. Tech forums, awards, exhibits. AC facilities. Free outside flea market space. Tickets \$3.50 advance and \$4.00 at gate. For information or tickets: Edward B. Bono, WA4ONE, P.O. Box 4411, Lexington, KY 40504.

NORTH CAROLINA: The WCARS annual Hamfest, July 28 and 29, Firemen's Training Center, Asheville. Admission \$4.00. Preregistration \$3.50 before July 15. Talk in 31/91, 16/76 and 52 simplex. For information: Nelda Williams, KA4WPM, P.O. Box 1488, Asheville, NC 28802.

PENNSYLVANIA: The Mid-Atlantic ARC announces its annual Hamfest, Sunday, August 12, 9 AM to 4 PM, rain or shine, Route 309 Drive-In Theater, Montgomeryville. Admission \$3.00 plus \$2.00 additional for each tailgate space. Bring your own table. Plenty of parking and refreshments. Talk in on WB3JQER, 144.66/06 or 146.52. For information: MARC, P.O. Box 352, Villanova, PA 19085 or call Bob Josuweit, WA3PZO (215) 449-9727

OKLAHOMA: The Central Oklahoma Radio Amateurs will host "Ham Holiday" and State ARRL Convention, July 21 and 22, Lincoln Plaza Inn & Conference Center, 4445 Lincoln Blvd., Oklahoma City, DX, Packet Radio, satellites, computers with RTTY and a host of special interest events. Unlimited free parking for cars and self-contained RV's. Dealers Saturday and Sunday. Flea Market Saturday only. Pre-registration by July 6, \$8.00; \$10.00 at the door. Saturday evening banquet \$14.00. Sunday QCWA breakfast \$7.20. Reserved flea market table \$5.00; \$8.00 at door (if available). Mail reservations to CORA, P.O. Box 44091, Oklahoma City, OK 73144.

MICHIGAN: ARRL State Convention, sponsored by the Livonia ARC with the help of nine other Radio Clubs. Friday, June 29 and Saturday, June 30, Schoolcraft College campus, 18600 Haggerty Road, Livonia. Friday evening "Eye-Ball Social", 7:30 PM at the Plymouth Hilton with a Wouff Hong initiation at Midnight. Convention opens Saturday, 8 AM to 5 PM. Exhibits, forums, seminars, YL activities, operating demos, state nets and more. Convention banquet Saturday evening, 7:30 PM at the Plymouth Hilton. Admission \$3.00 at the door; \$2.50 advance. Swap tables \$1.00/ft. and trunk sales \$5.00 space. Talk in on LARC Repeater 145.35 (-600) or the 146.52 simplex. For tables, trunk sales, tickets or information: Neil Coffin, W8GWL, Livonia ARC, P.O. Box 2111, Livonia, MI 48151.

NEW HAMPSHIRE: Fly-in to the 2nd largest Amateur Radio/electronic flea market in the state, Saturday, July 14, Manchester Municipal Airport. Sponsored by the New Hampshire FM Association. Starting time 9 AM. General admission \$1.00. Sellers \$5.00 with own table. Refreshments available. For information: Dick DesRosiers, W1KGZ (603) 668-8880 or Doug Aiken, K1WPM, 30 Meadowglen Dr., Manchester, NH 03103 (603) 622-0831.

OHIO: The Northern Ohio Amateur Radio Society's 7th annual ARRL approved NOARSFEST, July 21, Lorain County Fairgrounds, Wellington. 8 AM to 4 PM. Huge black-topped flea market area \$1.00 per car space. Setup 6 to 8 AM. Free overnight camping Friday night, no hookups. Dealers indoor 8' tables \$8.00 each. Donation \$3.00 advance, \$3.50 gate. Children under 12 free. Talk in on 144.55 - 145.15. Mobile checkin 146.52. For advance registration mail check to John Paul Jones, WA8CAE, 4612 Timberview Drive, Lorain, OH 44052 (216) 282-4256.

NORTH CAROLINA: The Cary ARC's 12th annual Mid-Summer Swapfest, Saturday, July 21, 9 AM to 3 PM, Lion's

Club Shelter, Cary (near Cary High School). Open auction starting at 1:00 PM. We sell anything! No commission. No admission. Talk in on 146.28/88; 147.75/15; 146.52/52. For information: Cary ARC, P.O. Box 53, Cary, NC 27511.

NEW JERSEY: The West Jersey Radio Amateurs' 6th annual Hamfest, July 15 (rain or shine) 9 AM to 3 PM, Super 130 Drive-in Theatre, Route 130, Edgewater Park. Registration \$3.00. Tailgating \$3.00 additional with own table. Vendors' only setup starting at 7 AM. For information or tickets SASE to: Mary Lou Shontz, N2CLX, 107 Spruce Lane, Route 16, Mount Holly, NJ 08060. (609) 267-3063.

MISSOURI: The 22nd annual Zero-Beaters ARC Hamfest, July 15, 9 AM to 3 PM, Washington, MO, Fairgrounds. Free admission. Free flea market area. Limited rental spaces under pavillion. Advance reservation advised. Cake walk, candy scramble, traders row, refreshments and food available. Talk in on 147.24-84, 146.52. For information: Zero-Beaters ARC, Box 24, Dutzow, MO 63342.

COLORADO: The Ski Country ARC's third annual Swapfest and CCARC meeting, July 28, 9 AM to 3:30 PM, CMC Building, 1402 Blake, Glenwood Springs. Tables \$5.00 each. Half table \$3.00. Speakers, demos. Talk in on 146.07/67. For information: Bob Ludtke, K9MWM, 1001 Grand Ave., Glenwood Springs, CO 81601. (303) 945-5966.

VERMONT: The annual ARRL International Hamfest, Saturday, August 11 and Sunday, August 12, Old Lantern Camp Grounds, Charlotte. Tickets \$4.00 for both days. Heterodynes under 12 free. Outdoor flea market space \$2.00; indoors \$5.00. Overnight camping available. Talk in on 34/94, 01/61, and 52 simplex. For information: Roger, WA10ZE, Burlington ARC President, P.O. Box 312, Burlington, VT 05402.

WASHINGTON: W7DK, the Radio Club of Tacoma, presents Hamfair '84, August 11 and 12, Olsen Auditorium, Pacific Lutheran University campus. Registration \$5.00. Trailer and dormitory space available on campus at reasonable rates. Saturday night banquet. Commercial space and flea market tables available by advance registration. Talk in on W7DK repeater, 147.88/28. For information or registration: Grace Teitzel, AD7S, 701 South 120th, Tacoma, WA 98444.

IOWA: The 18th annual Central States VHF Conference, July 27-29, Sheraton Inn, Cedar Rapids. Technical presentations, DXpedition reports and organizational meetings. Plan to attend and meet your friends. For more information: Barry Buelow, WA0RJT, 4110 Emerson Ave N.E., Cedar Rapids, IA 52402.

ILLINOIS: The DuPage Amateur Radio Club Hamfest/Computerfest will be held on Sunday, July 8, 1984, at the Downers Grove American Legion Post 80. Large outdoor flea market and swappers row. Indoor commercial exhibits available. General admission \$2.00, \$3.00 for swappers row sellers. Tickets available at the gate only. Plenty of free parking space. Food and drink available. Talk-in on 145.490 Rpt. or 223.74 Rpt. For more information, send SASE to W9DUP, P.O. Box 71, Clarendon Hills, IL 60514 or call 312-971-3298 between 8 A.M. and 9 P.M.

OPERATING EVENTS

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JULY 21: The Tank-Automotive Command ARC will operate W8JPW from 1300 to 2000Z to commemorate the 43rd year of the Detroit Arsenal. Frequencies: Phone 7.274, 21.400 and 146.49 MHz. CW 7.055 from 1500-1700Z. Send 9 x 12 SASE with QSO number and frequency for certificate to W8JPW, U.S. Army Communications Command, Att: CCNC-TAC-M, 28251 Van Dyke, Warren, MI 48090.

SEPTEMBER 9-15: The Southern Counties Amateur Radio Association (SCARA) is planning to have a special events station during the Miss America Pageant. Check September Ham Radio for details.

AUGUST 4-5: The Wild Bunch 160 SSB Contest: 0000 GMT Aug. 4 to 2359 Aug. 5. Single operators only. Exchange: RST/State, Country or Province. 10 pts. per QSO. Multipliers: total number of states, countries. VES Plaque to winner. Deadline for logs September 6, 1984, to: KA1SR, R.J. Koziomkowski, 5 Watson Dr., Portsmouth, R.I. 02871.

JULY 14-15: The Eastern Michigan ARC (K8EPV) will commemorate the annual Port Huron to Mackinac Island Yacht Race. 1400Z to 0200Z both days. Frequencies: 3.910, 7.235, or 14.235. Phone 3.710, 7.110 or 21.110 CW. For a certificate send QSL with legal SASE to K8EPV (C.B.A.) or 654 Georgia, Marysville, MI 48040.

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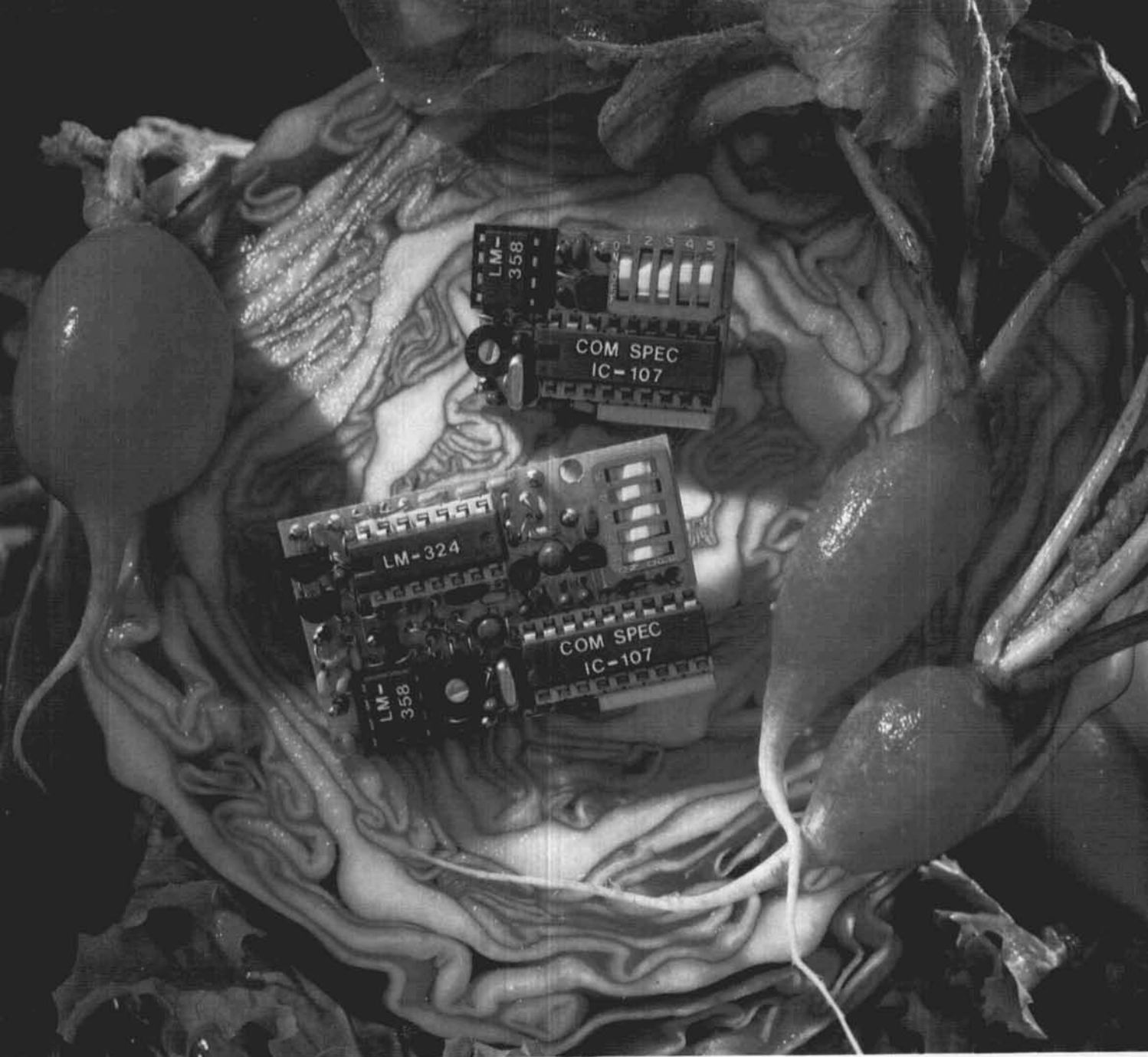
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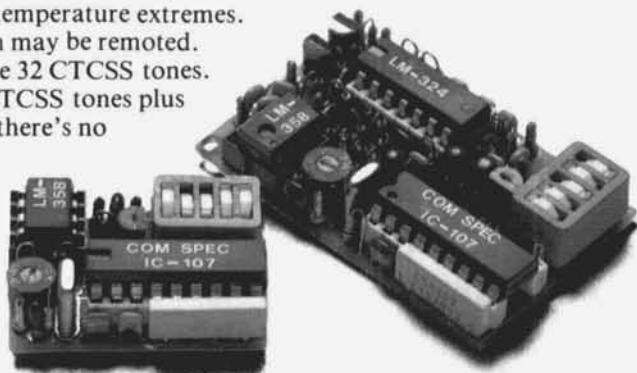
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More information on the TS-930S is available from authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.



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