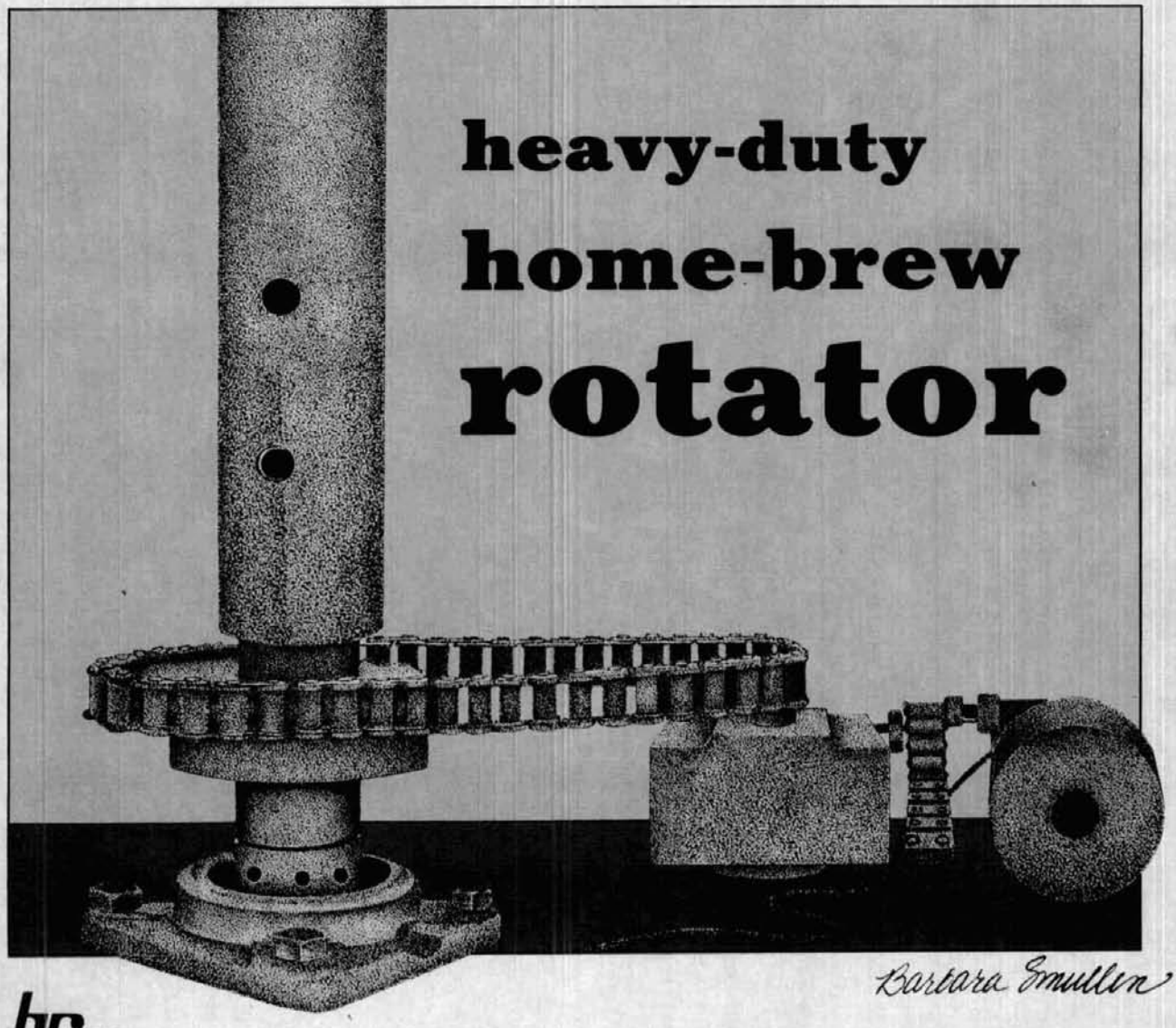
JUNE 1986 / $2.50

ham radio magazine



heavy-duty home-brew rotator

Barbara Smullen

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communications
technology

ICOM IC-751A

CAN YOU HANDLE THIS MUCH TRANSCEIVER?

- **All HF Band Transceiver/ General Coverage Receiver**
- **New Design**
- **100% Duty Cycle Transmitter**
- **105dB Dynamic Range**
- **All Modes Built-In USB, LSB, AM, FM, CW, RTTY**
- **12 Volt Operation**

The new IC-751A top-of-the-line HF base station transceiver is designed for the ham operator who demands high performance. Whether contesting or QSO'ing for pleasure, the 100 watt IC-751A incorporates the best features of the IC-751, plus brings you to the forefront with the following most-asked for additions.

More CW Control. For the CW enthusiast, the new IC-751A includes an electronic keyer unit, QSK rated at up to 40WPM, standard FL-32A 9MHz/ 500Hz CW filter and CW sidetone to monitor your code in RX or TX modes... great for practice!

All Amateur Band Coverage. Plus general coverage reception from 100kHz to 30MHz. May be easily modified for MARS operation.

Improved Smooth Tuning. The IC-751A features a newly designed tuning knob for velvet smooth tuning.

Added LED Annunciator. For easily identifying if you're using the tuning speed, dial, or band switching functions.

32 Memories. Mode and frequency may be stored in any of 32 memories...all the memory capability that you'll ever need.

More Stable. Even in the receive mode, the IC-751A has a sophisticated thermal sensor to monitor the internal temperature. The sensor automatically activates the cooling fan which gives maximum stability ...critical for contesting.

Newly Designed Features. The IC-751A boasts a number of newly designed features for better performance ...new 9MHz notch filter to drastically reduce QRM, new AGC system, new compressor for better audio and a new AF gain control system to improve control of the CW sidetone volume.

Options Available. Options for the IC-751A include the IC-PS30 external AC system power supply, IC-PS35 internal AC power supply, IC-AT500 antenna tuner, IC-EX309 microprocesso interface connector, SM-8 or SM-10 desk mics, IC-2KL linear amplifier, RC-10 remote controller, SP-7 or IC-SP3 external speakers, IC-EX310 voic synthesizer, CR-64 high stability 30.72MHz crystal and GC-5 world clock

Optional Filters. FL-52A CW 455kHz at 500Hz, FL-53A CW-N 455kHz at 250Hz, FL-63A CW-N 9.0106MHz at 250Hz, and FL-33 AM 9.010MHz at 6000Hz filter.

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First in Communications

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Work VHF or HF Packet On Any Computer With Kantronics Complete Packet Communicator

KPC-2

From IBM to C-64, or any computer with an asynchronous serial port, you can now work packet on VHF or HF with one TNC, the KPC-2! Extra cost options are unnecessary. KCP-2 is packed full of features and backed by our full-time customer support departments. KPC-2 has totally new hardware and software, Kantronics designed. For more information contact Kantronics or a Kantronics dealer.

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Features

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- Supports multiple connects, up to 26
- RS232 or TTL compatible (C-64 too!)
- HF modem included! (both U.S. and European tones)
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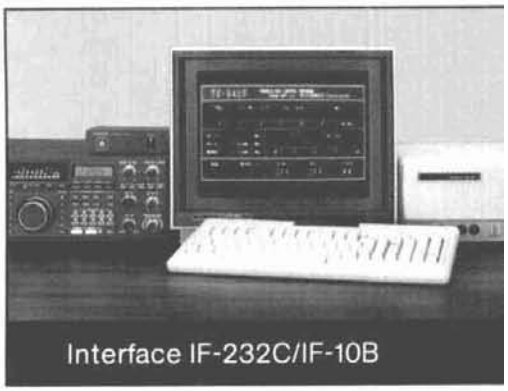
"DX-cellence!"

TS-940S

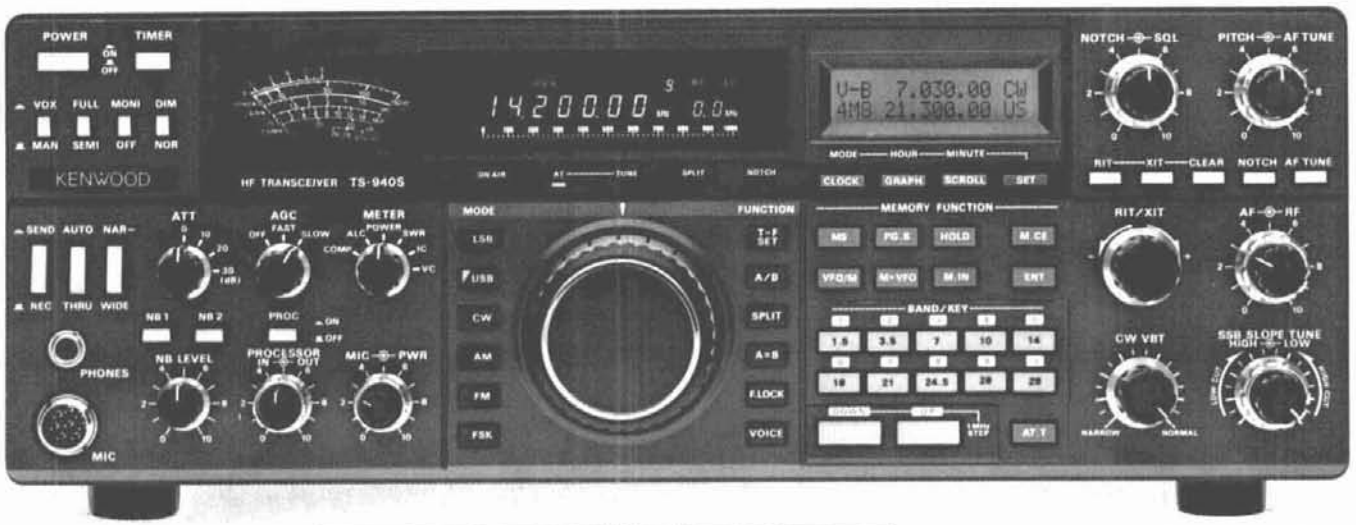
The new TS-940S is a serious radio for the serious operator. Superb interference reduction circuits and high dynamic range receiver combine with superior transmitter design to give you no-nonsense, no compromise performance that gets your signals through! The exclusive multi-function LCD sub display graphically illustrates VBT, SSB slope, and other features.

- 100% duty cycle transmitter. Super efficient cooling system using special air ducting works with the internal heavy-duty power supply to allow continuous transmission at full power output for periods exceeding one hour.
- High stability, dual digital VFOs. An optical encoder and the flywheel VFO knob give the TS-940S a positive tuning "feel."
- Graphic display of operating features. Exclusive multi-function LCD sub-display panel shows CW VBT, SSB slope tuning, as well as frequency, time, and AT-940 antenna tuner status.
- Low distortion transmitter. Kenwood's unique transmitter design delivers top "quality Kenwood" sound.
- Keyboard entry frequency selection. Operating frequencies may be directly entered into the TS-940S without using the VFO knob.
- QRM-fighting features. Remove "rotten QRM" with the SSB slope tuning, CW VBT, notch filter, AF tune, and CW pitch controls.
- Built-in FM, plus SSB, CW, AM, FSK.
- Semi or full break-in (QSK) CW.
- 40 memory channels. Mode and frequency may be stored in 4 groups of 10 channels each.
- Programmable scanning.
- General coverage receiver. Tunes from 150 kHz to 30 MHz.
- 1 yr. limited warranty. Another Kenwood First!

Optional accessories:
• AT-940 full range (160-10m) automatic antenna tuner • SP-940 external speaker with audio filtering • YG-455C-1 (500 Hz), YG-455CN-1 (250 Hz), YK-88C-1 (500 Hz) CW filters; YK-88A-1 (6 kHz) AM filter • VS-1 voice synthesizer • SO-1 temperature compensated crystal oscillator • MC-42S UP/DOWN hand mic. • MC-60A, MC-80, MC-85 deluxe base station mics. • PC-1A phone patch • TL-922A linear amplifier • SM-220 station monitor • BS-8 pan display • SW-200A and SW-2000 SWR and power meters.



Interface IF-232C/IF-10B



More TS-940S information is available from authorized Kenwood dealers.

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25th Anniversary

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JUNE 1986

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contents

REFLECTIONS

Who is Dorothy Rosa?

For the past three years anyone who's telephoned or corresponded with the *ham radio* editorial department has probably had the pleasure of hearing the pleasant, patient voice of or receiving a well-wrought response from Dorothy Rosa, our Assistant Editor. Magazines, of course, represent team effort, a necessity in the consistent publication of issue after issue of timely, accurate information. Dorothy, KA1LBO, is an important team member who's involved in every aspect of production from initial edit to final proof just prior to press run.

Dorothy came to us at an important time in our development, replacing Marty Hanft, KA1ZM, and stepped into a position that requires an extremely fast learning curve. Deadlines and schedules in general do not conveniently wait for someone to come aboard and get up to speed. They're planned, they arrive, and must be met. Then they rapidly become a thing of the past, only to be replaced by new ones.

Dorothy, in a sense, is not a newcomer to radio. Though recently licensed, she shared, at an early age, in the excitement of radio. Her father, an avid experimenter and SWL'er, had the normal collection of vacuum tubes, countless bins and small wooden drawers of parts, as well as innumerable carcasses of radios and various sorts of instrumentation. She remembers playing in the tube-lit glow of his repair shop, the smell of solder ever-present. It was, she says, the stuff of magic because even with his eighth-grade education, he could put all the pieces together and make a radio — and receive signals from thousands of miles away.

At the time, the unfortunate and mistaken notion that radio was for boys and reading was for girls was prevalent, so Dorothy became a voracious and compulsive reader, and as she likes to say, "a passable speller and moderately able writer." Though her major and degree were in English, she studied "a little bit of everything" in high school and college because "it was all so interesting." After college, she worked for a medical magazine in New York City, then moved on to a weekly newspaper and finally to dailies.

She spent several years as an advertising copywriter and photographer, trying to live what she calls "the simple life — which was anything but simple" in a log cabin in Vermont. She taught high school English while still finding time to tend the gardens. She traded all that in for the present position at *ham radio* and we are much the better for it.

Presently, while raising two sons and juggling multiple issues of the magazine at the same time, she's working on upgrading her license. She says she feels that, in some very small way, she's working off a debt here at HR . . . to her father for giving her the world through radio and to the hams who sent word of her first child's birth to Vietnam in 1969.

Rich Rosen, K2RR
Editor-in-Chief

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The Smallest HT!

TH-21AT/31AT/41AT

Kenwood's advanced technology brings you a new standard in pocket/handheld transceivers!

- High or low power. Choose 1 watt high – enough to "hit" most local repeaters; or a battery-saving 150 mW low.
- Pocket portability! Kenwood's TH-series HTs pack convenient, reliable performance in a package so small, it slips into your shirt pocket! It measures only 57 (2.24) W x 120 (4.72) H x 28 (1.1) D mm (inch) and weighs 260 g (.57 lb) **with PB-21.**
- Expanded frequency coverage (TH-21AT/A). Covers 141.000-150.995 MHz in 5 kHz steps, includes certain MARS and CAP frequencies.
  TH-31AT/A: 220.000-224.995 MHz in 5 kHz steps.
  TH-41AT/A: 440.000-449.995 MHz in 5 kHz steps.

- Easy-to-operate, functional design. Three digit thumbwheel frequency selection and handy top-mounted controls increase operating ease.

- Repeater offset switch.
  TH-21AT/A: ±600 kHz, simplex.
  TH-31AT/A: – 1.6 MHz, reverse, simplex.
  TH-41AT/A: ±5 MHz, simplex.
- Standard accessories: Rubber flex antenna, earphone, wall charger, 180 mAH NiCd battery pack, wrist strap.

NOW! Extended-life battery pack

- Quick change, locking battery case. The rechargeable battery case snaps securely into place. Optional battery cases and adapters are available.
- Rugged, high impact molded case. The high impact case is scuff resistant, to retain its attractive styling, even with hard use.

See your authorized Kenwood dealer and take home a pocketful of performance today!

Optional accessories:

- **HMC-1** headset with VOX
- **SMC-30** speaker microphone
- **PB-21** NiCd 180 mAH battery
- **PB-21H** NiCd 500 mAH battery
- **DC-21** DC-DC converter for mobile use
- **BT-2** manganese/alkaline battery case
- **EB-2** external C manganese/alkaline battery case
- **SC-8/8T** soft cases
- **TU-6** programmable sub-tone unit
- **AJ-3** thread-loc to BNC female adapter
- **BC-6** 2-pack quick charger
- **BC-2** wall charger for PB-21H
- **RA-8A/9A/10A** StubbyDuk antenna
- **BH-3** belt hook

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TH-series transceivers shown with optional StubbyDuk antenna. TH-21AT shown with EB-2H.
Specifications and prices are subject to change without notice or obligation.
Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.

presstop de W9JUV

ARRL'S "NOVICE ENHANCEMENT" PROPOSAL IS NOW AN FCC NPRM, released by the Commission just in time for the Dayton Hamvention. As released, the Notice of Proposed Rule Making follows the League's original proposal very closely (see Presstop, July and August, 1985).

In Brief, The 10-Meter Novice Band Would Become 28.1-28.5 MHz with CW, RTTY, AMTOR and packet on the bottom 200 kHz plus SSB from 28.3-28.5 MHz; the 200 W power limit (Novices and Techs only) would remain. Full privileges on the entire 220 MHz band plus 1246-1260 MHz are also proposed, though with a 25 W power limit on 220 and 5 W on 23 cm.

Though 220 MHz is Included In The NPRM, There's A Serious Question as to whether it will remain as part of the final result. That band has been the subject of attack from other services in the past, and is presently part of an as yet unfinished FCC study. The latest threat is a Petition for Rule Making from the Association of Radio Reading Services, which proposes using frequencies in the 220-225 MHz band for a new service for the blind.

Though Originally Hailed As A Means Of Attracting New Novices, as written the proposal looks more effective as a means for retaining existing Novices. However, that in itself would be a worthwhile result as the Novice dropout rate has consistently been the highest.

Comment due date for the Novice Enhancement NPRM, PR Docket 86-161, is July 16. Reply Comments will be due at the Commission on August 20.

THE FCC HAS REVERTED TO ITS ORIGINAL DEFINITION OF "EMERGENCY COMMUNICATIONS" as defined in Part 97.3(w). In an April 14 news release, the Commission said it reinstated the old definition in response to petitions for reconsideration filed by the ARRL and David Popkin, W2CC. The League's petition maintained that the new definition, which had been part of BC Docket 79-47, was too specific. The issue really came to a head during the Mexican earthquake emergency last year, when a number of non-Amateur organizations were heard using the Amateur bands for support and coordination activities. However, the issue of emergency communications is still far from resolved and will be addressed again soon.

ANY TWO REPEATERS WITH AN INTERFERENCE PROBLEM ARE "EQUALLY AND FULLY RESPONSIBLE" FOR RESOLVING IT, the FCC decided in its Report and Order on PR Docket 85-22. If only one of them is coordinated, however, the uncoordinated repeater has "primary responsibility" for resolving the problem. In the same action the Commission also dropped its restrictions on repeater power and antenna height. Effective date for the Report and Order is July 12.

RFI PROBLEMS HAVE BROUGHT THE SHUTDOWN AND FINING OF A CANADIAN AMATEUR, VE3SR. Ruling on a nuisance complaint brought by neighbors, the judge found that the neighbors' rights had been "unreasonably invaded by conduct which forms a basis for liability" and issued a permanent injunction against VE3SR operating a transmitter! In addition, he fined VE3SR $2500 for creating "inconvenience and interference with the enjoyment of various pieces of electronic equipment," $58.50 in Special Damages, plus costs and interest.

Canadian Amateurs Are Appalled At The Adverse Decision, as VE3SR had been supported by the Canadian Department of Communications as well as the CRRL, CARF, and a number of both Canadian and U.S. Amateur clubs. VE3SR had made a strong effort to resolve the problem, which involved a number of the neighbors' home entertainment devices, but met with little cooperation from them. At presstime he had not decided whether to appeal the decision, in light of the considerable investment he's already made in defending himself.

PRB-1's First "Victory," Lakeside Park, (Kentucky), Is Still Not Resolved. WM4T still has to appear before a Federal District Court judge to determine what constitutes a "reasonable" antenna, and now the city has adopted a new antenna ordinance that it calls "fair and reasonable" but area Amateurs feel is little better than the old one.

Even A 2-Meter Vertical Can Get An Amateur In Trouble with the law. KA7TVC put a 2-meter vertical on the roof of his Kirkland, Washington, apartment building with the owner's permission, then found himself in trouble with the city over a law requiring engineering drawings, a public hearing, and a $350 hearing examiner review fee before installation of any transmitting antenna! The law applies only to transmitting antennas, so the same antenna installed by a scanner user would not have been covered! KA7TVC is appealing his citation, and hopes with ARRL and PRB-1 help to be able to have the ordinance rescinded on the grounds that it is vague and unenforceable.

ROY NEAL, K6DUE, HAS BEEN NAMED "RADIO AMATEUR OF THE YEAR" by the Dayton Hamvention. The NBC newsman received the award for his many years of personal and public dedication to the Amateur Radio Service, and specifically for his key role in initiating Space Shuttle Amateur Radio activity. He's also been directly involved in many film and video promotions on behalf of Amateur Radio. U.S. Senator and former astronaut John Glenn paid a surprise visit to the Hamvention banquet to help honor Roy, who was also the banquet's keynote speaker.

The 1986 "Special Achievement Award" Went To Fr. Michael Mullen, C.M., WA2BQW, President of the International Mission Radio Association. He was cited for his dedication to IMRA and his accomplishments in supplying Amateur equipment to missionaries worldwide.

Doug DeMaw, W1FB, Received the 1986 "Technical Achievement Award" for his numerous contributions to Amateur Radio communications technology. Congratulations to all three!

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Good for Satellite Digital QSOs

Matching Pair

Look for JAS-1 and PHASE III-C

TS-711A/811A VHF/UHF all-mode base stations

The TS-711A 2 meter and the TS-811A 70 centimeter all mode transceivers are the perfect rigs for your VHF and UHF operations. Both rigs feature Kenwood's new Digital Code Squelch (DCS) signaling system. Together, they form the perfect "matching pair" for satellite operation.

- **Highly stable dual digital VFOs**
  The 10 Hz step, dual digital VFOs offer excellent stability through the use of a TCXO (Temperature Compensated Crystal Oscillator).
- **Large fluorescent multi-function display**
  Shows frequency, RIT shift, VFO A/B, SPLIT, ALERT, repeater offset, digital code, and memory channel.
- **40 multi-function memories**
  Stores frequency, mode, repeater offset, and CTCSS tone. Memories are backed up with a built-in lithium battery.

- **Versatile scanning functions**
  Programmable band and memory scan (with channel lock-out). "Center-stop" tuning on FM. An "alert" function lets you listen for activity on your priority channel while listening on another frequency. **A Kenwood exclusive!**
- **RF power output control**
  Continuously adjustable from 2 to 25 watts.
- **Automatic mode selection**
  You may select the mode manually using the front panel mode keys. Manual mode selection is verified in International Morse Code.
- **All-mode squelch**
- **High performance noise blanker**
- **Speech processor**
  For maximum efficiency on SSB and FM.
- **IF shift**
- **"Quick-Step" tuning**
  Vary the tuning characteristics from "conventional VFO feel" to a stepping action.
- **Built-in AC power supply**
  Operation on 12 volts DC is also possible.
- **Semi break-in CW, with side tone**
- **VS-1 voice synthesizer (optional)**

More TS-711A/811A information is available from authorized Kenwood dealers.

Optional accessories

- IF-10A computer interface
- IF-232C level translator
- CD-10 call sign display
- SP-430 external speaker
- VS-1 voice synthesizer
- TU-5 CTCSS tone unit
- MB-430 mobile mount
- MC-60A, MC-80, MC-85 deluxe desk top microphones
- MC-48 16-key DTMF, MC-42S UP/DOWN mobile hand microphones
- SW-200A/B SWR/power meters:
  SW-200A 1.8-150 MHz
  SW-200B 140-450 MHz
- SWT-1 2-m antenna tuner
- SWT-2 70-cm antenna tuner
- PG-2J DC power cable

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An identical TAPR TNC 2 clone with a new cabinet and added features ... for an incredible $129.95!

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Join the exciting packet radio revolution and enjoy error-free communications ... for an incredible $129.95!

MFJ brings together efficient manufacturing and TAPR's (Tucson Amateur Packet Radio) leading edge technology to bring you affordable packet radio. You get a nearly identical clone of the widely acclaimed TAPR TNC 2 with identical software and hardware. It's in a new cabinet and includes a TTL serial port for extra versatility.

All you need is your rig, home computer with a RS-232 serial port and a terminal program. If you have a Commodore 64, 128 or VIC-20 you can use MFJ's optional Starter Pack to get on the air immediately. You get interfacing cable, terminal software on tape or disk and complete instructions ... everything you need to get on packet radio. Order MFJ-1282 (disk) or MFJ-1283 (tape), $19.95 each.

Unlike machine specific TNCs, you never have to worry about your MFJ-1270 being obsolete because you change computers or because packet radio standards change. You can use any computer with an RS-232 serial port and an appropriate terminal program. If packet radio standards change, software updates will be made available as TAPR releases them. Also speeds in excess of 56K bauds are possible with a suitable external modem! Try that with a machine specific TNC or one without hardware HDLC as higher speeds come into widespread use. You can also use the MFJ-1270 as an inexpensive digipeater.

It features the latest AX.25 Version 2.0 software, hardware HDLC for full duplex, true Data Carrier Detect for HF, 16K RAM, simple operation plus more.

Join the packet radio revolution now and help make history. Order the MFJ-1270 today.

Here are MFJ's latest and hottest products for improving your station's performance.

SUPER KEYBOARD

MFJ-496
$169.95

Price slashed 50% to $169.95! Get a full feature Super Keyboard that sends CW/RTTY/ASCII for the price of a good memory keyer.

You get the convenience of a dedicated keyboard —no program to load—no interface to connect—just turn it on and it's ready to use.

This 5 mode Super Keyboard lets you send CW, Baudot, ASCII, use it as a memory keyer and for Morse Code practice. You get text buffer, programmable and automatic message memories, error deletion, buffer preload, buffer hold.

TRIPLE OUTPUT LAB POWER SUPPLY MFJ-4002 $149.95

Lab quality power supply gives you plenty of voltage and current for all your analog and digital circuits. **3 completely isolated outputs**: 2 variable 1.5-20 VDC at 0.5 amp and a fixed 5 VDC at 1 amp. Connect in series or parallel for higher voltage and current. It's short circuit protected, has excellent line (typ.0.01%/V) and load regulation (typ.0.1%). **Lighted meters** monitor volt./cur. 12x3x6 in. 110 VAC.

CROSS-NEEDLE SWR/WATT METER MFJ-815 $59.95

MFJ's cross-needle SWR/Wattmeter gives you SWR, forward and reflected power —all at a single glance! SWR is automatically computed —no controls to adjust. Easy-to-use push buttons select three power ranges that give you QRP to full legal limit power readings. Reads 20/200/2000 W forward, 5/50/500 W reflected and 1:1 to 1:5 SWR on easy-to-read two color scale. Lighted meter. Needs 12 V. ±10% full scale accuracy. 6½ x 3¼ x 4½ inches.

2 KW COAX SWITCHES

MFJ-1702 $19.95

$29.95 MFJ-1701

Instantly select any antenna or rig by turning a knob. Organizes coax cables and eliminates plugging and unplugging. Unused terminals are grounded to protect your equipment for stray RF, static and lightning. 2 KW PEP, 1 KW CW. For 50 to 75 ohm. Negligible loss, SWR, and crosstalk gives high performance. SO-239s. Convenient desk or wall mounting.

MFJ-1702, $19.95. 2 positions. Cast aluminum cavity construction gives excellent performance up to 500 MHz with better than 60 dB isolation at 450 MHz. Heavy duty, low loss switch has less than 20 milliohm contact resistance, less than 0.2 dB loss and SWR below 1:1.2. 2 x 2½ x 1 inches.

MFJ-1701, $29.95. 6 positions. White markable surface for recording ant. positions. 8½ x 1½ x 3 in.

ANTENNA CURRENT PROBE MFJ-206 $79.95

This new breakthru MFJ Antenna Current Probe lets you monitor RF antenna currents—no connections needed! Determine current distribution, RF radiation pattern and polarization of antennas, transmission lines, ground leads, building wiring, guy wires and enclosures.

- **Indicate transmission line radiation** due to high SWR, poor shielding or antenna unbalance.
- **Detect re-radiation** from rain gutters and guy wires that can distort antenna field patterns.
- **Detect RF radiation** from ground leads, power cords or building wiring that can cause RFI.
- **Determine if ground** system is effective.
- **Pinpoint RF leakage** in shielded enclosures.
- **Locate the best place** for your mobile antenna.
- **Use** as tuned field strenght meter.

Monitors RF current by sensing magnetic field. Uses an electrostatically shielded ferrite core, FET RF amplifier, op-amp meter circuit for excellent sensitivity, selectivity. 1.8-30 MHz. Has sensitivity, bandswitch, tune controls, telescoping antenna for field strenght meter. 4 x 2 x 2 inches.

MFJ's Best VERSA TUNER

MFJ-949C $149.95

MFJ's best 300 watt tuner is now even better! The MFJ-949C all-in-one Deluxe Versa Tuner II gives you a tuner, cross-needle SWR/Wattmeter, dummy load, antenna switch and balun in a new compact cabinet. You get quality conveniences and a clutter-free shack at a super price.

A new cross-needle SWR/Wattmeter gives you SWR, forward and reflected power—all at a single glance. SWR is automatically computed with no controls to set. Has 30 and 300 watt scale.

Run up to 300 watts RF output—and match coax, balanced lines or random wires from 1.8 thru 30 MHz. Tune out SWR on dipoles, vees, long wires, verticals, whips, beams/quads. 10x3x7 in.

DIGITAL SWR/WATTMETER

MFJ-818
$89.95

Fully automatic Digital SWR/Wattmeter reads SWR 1:1 to 1:9.9 directly and instantaneously—no SWR knob to set. Huge 0.6 inch bright orange digits make across-the-room reading easy. 12 segment LED bar graph wattmeter gives instantaneous PEP readings up to 200 watt RF output.

Good, bad, mismatch tri-color LEDs indicate SWR conditions. Small size (5½ x 4¼ x 1 in.) and easy-to-read digital display makes it ideal for mobile use. For 50 ohm systems. 1.8-30 MHz. 12 VDC or 110 VAC with MFJ-1312, $9.95.

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MFJ-910 $19.95

Lower your SWR and Get more power into your mobile whip for solid signals and more QSOs. Your solid state rig puts out more power and generates less heat. For 10-80 meter whips. Easy plug-in installation. Complete instructions. Fits anywhere, 2½x2½in

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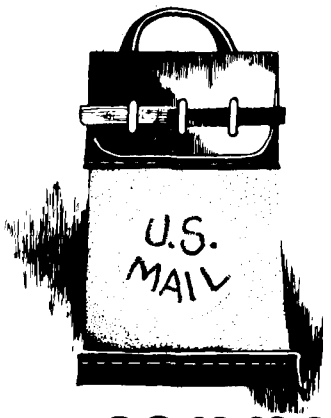


comments

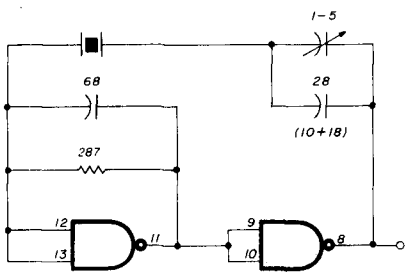
improving "a frequency and level standard"

Dear HR:

While I always find several articles of interest in each issue of *ham radio*, the January, 1986 issue — with PA0CX's article, "A Frequency and Level Standard" (page 10) — was especially timely. I have needed a frequency standard usable up to the 70-cm ham band for some time. To get one with calibrated amplitude was too much to miss, so out came my breadboard.

I've since made several improvements to the circuits that appeared in the article.

The first change was to use a different oscillator circuit. I couldn't get the author's circuit shown in **fig. 3** (page 12) to oscillate with any 1-MHz crystal that I owned. The circuit shown below has worked with all 1-MHz crystals



that I've tried. One advantage of this circuit is that it uses the 74LS00, which draws less current than the 7400. This aids frequency stability because the IC doesn't heat up as much. I measured approximately 15 Hz of drift at 200 MHz for a 7400, while the 74LS00 had less than 5 Hz from turn-on.

The second change is to substitute another 74LS00 for U3; this lowers current consumption and thus increases battery life.

I first built the circuit on a protoboard. The output amplitude was within 1 dB through 150 MHz, as the author, Hans Evers, had stated. This was without the use of any of the bypass capacitors shown in the schematic.

I then wired a final version on vector board for enclosure in a shielded box. This version did not have the flat amplitude response that protoboard had. In fact, there were a number of peaks in the response. Adding the 2.2 μF capacitors (especially the ones on U2 and U3) improved the response at the higher frequencies, but the problems at 100 kHz and 1 MHz mentioned by the author still remained. This was cured by placing a 2.2 μF capacitor from the 78L05 input to case ground (*not* circuit ground). I'm not sure if the regulator was oscillating or if there was a ground loop problem. I wired the IC grounds together with one long piece of No. 26 wire, although the protoboard has a good, wide low-impedance ground bus. The author's version appears to be wired in a similar fashion.

With the above changes the output amplitude was -73.0 ± 0.5 dBm from 100 kHz to 150 MHz and ± 1 dB to 220 MHz, as measured with an HP-71100A Spectrum Analyzer. For such a simple circuit, I couldn't ask for more.

The schematic (**fig. 3**) omits one important detail: pins 2, 3, 6, and 7 of U4 and U5 need to be grounded. This is correctly shown in **fig. 4** (page 14), but is easily overlooked when wiring up the circuit from the schematic diagram.

Thanks for the excellent article. I'll be waiting for the next issue of *ham radio*.

Steve Lund, WA8LLY
Santa Rosa, California 95401

on novice proposals

Dear HR:

I've been reading some negative comments about the proposals before the FCC to enhance Novice privileges. Both the ARRL's RM-5038 and my own RM-5025 request small band segments, restricted power, and the inclusion of digital modes. We never intended to "give the store away," nor do we expect the FCC to grant all the privileges we requested. Our common interest is the growth of our hobby in a responsible way.

I fail to see what those who oppose these proposals fear. There will be no loss of "higher class" privileges. Who protested the access we gained to 30 meters, or 12 meters, or 902 MHz? The Novice operators have gained nothing. The Technicians gained a band, but it is not really an incentive to Novices to upgrade. The big incentive to Novices seems to be 2-meter FM, and that is why my proposal did not include that band.

The ARRL's proposal includes more kHz than mine and is less practical with its inclusion of the 1246 MHz band. I have seen my proposal mentioned in only one publication (*Worldradio*, September, 1985) and have received no comments. My aim is to offer non-hams a Novice license that will attract intelligent adults and young people. We need computer enthusiasts, story tellers, teachers, students, accountants, laborers, etc., etc. Our record shows that we cannot lure them in any numbers with our CW-only Novice license.

Teach a Novice or an upgrade course like I do and you will see the work that goes into each new ham. You old-timers may forget that ham radio and electronics are a new language to the non-ham. We can help squash the myth that equipment is too expensive if we offer new hams phone and digital modes as well as CW. The equipment will be of more use and will [therefore] seem a better value. Besides, Novices really do *earn* a license.

If, after reading this, you still think enhanced Novice privileges are a bad idea, go read the actual proposals and then comment to the FCC.

Larry W. Garens, WD5H
Brady, Texas

turning that big array

Homebrew this inexpensive, quiet rotator

I recently bought, and was faced with the problem of rotating, some large five-element monobanders made by a manufacturer whose promotional materials emphasize their products' ruggedness and resistance to wind damage. Until that time, my largest antenna had been a loaded 2-element beam for 40 meters that could be handled by a HAM IV rotor. But my new antennas were much more massive — for example, my booms measured 3 inches (7.6 cm) in diameter, thus presenting a wind load that was not only large, but unbalanced as well because the boom length each side on the mounting mast differs slightly. This imbalance increases the stress on any rotator in high winds. Wise heads, then, agreed that disaster would be certain unless I obtained a heavier rotator.

Unfortunately, such rotators are expensive. In the past, Amateurs used World War II surplus prop-pitch motors designed for bomber aircraft; these, however, are no longer plentiful and also come with their own set of problems. I concluded that it should be entirely possible, in a city as diverse as Toronto, to find enough surplus mechanical components to homebrew a rotator at reasonable cost. What follows is not a detailed, step-by-step construction article, but instead a description of a general approach that can be adapted to suit the materials at hand.

mechanical design

A trip to the local surplus store uncovered a 20-to-1 worm gear reduction drive and a powerful single-phase, capacitor-start induction motor with integral gear reduction. The shaft speed of the motor is 56 rpm at 50 in.-lb (5.6 N.m) torque. It draws 2.1 amperes at 115 VAC. These two parts form the heart of the rotator and should be purchased first because the rest of the design will depend on how these have to be mounted and coupled together. The type of worm drive shown in **fig. 1** is ideal, in that the input drive shaft is horizontal, and the output drive shaft is vertical; this facilitates running a chain drive to the mast. Furthermore, it mounts with four bolts at the bottom, making it easy to mount on a horizontal plate. Because a worm drive cannot be back-driven, no brake is required.

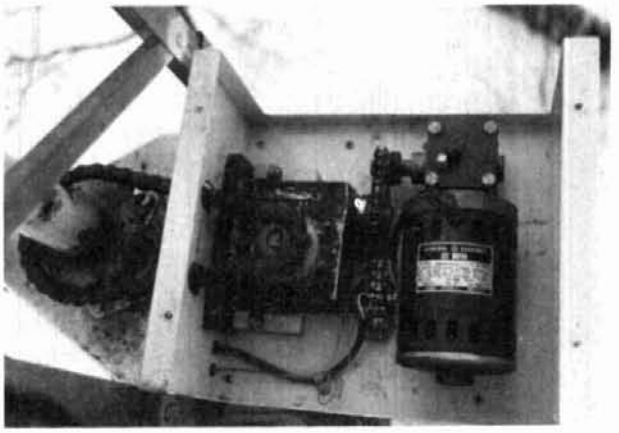


fig. 1. Worm gear reduction drive; input drive shaft is horizontal, output drive shaft is vertical.

The type of motor used, common on the surplus market, is available with various speed and torque ratings. The exact rating isn't too critical, as long as the product of speed and torque is at least 1500 and the

By Victor Mozarowski, VE3AIA, 1 Belgrove Drive, Islington, Ontario M9B 1S2, Canada

speed is low enough so that the rest of the drive train can reduce it to the desired antenna rotation speed.

drive motor and gearbox

A tremendous amount of torque is not required; the ruggedness of the gearbox is far more important. After all, if static friction is overcome, the antenna will eventually come up to speed, at which point its inertia will help keep it moving. Since most installations now use a high-quality ball-type mast bearing, starting would be a problem only if this bearing were iced up solid. Be that as it may, with the sprocket and gear ratios I used, and disregarding losses, the torque at the antenna mast works out to approximately 4500 in.-lb (508 N.m). (I suspect it might be possible to have a too-powerful motor that might damage the gearbox if the antenna mast were frozen.) There are formulas in machinery handbooks for calculating the size of components in the worm drive, but because these are based on a continuous running load and a certain working life, they're of little use if you want to know the ultimate yield strength under catastrophic load conditions. With carefully selected components, this type of failure would seem unlikely — and, in any case, as I'll show later, this type of failure isn't really catastrophic after all.

other components

As for the various other drive parts, suppliers sell a standard range of mechanical components, such as bearings, drives, gears, sprockets, and chains, at reasonable prices. The particulars of these components can be found in specialized catalogs (such as from Boston Gear Company, 14, Hayward Street, Boston, Massachusetts 01271), in the same way that we select standard values of electronic components from manufacturers' and distributors' catalogs. If a part isn't in stock, the supplier can almost always get it quickly through a distribution network. All the components used here except the motor and gearbox, which were bought at surplus, and the mast coupling, which was custom-machined, are standard components.

When I disassembled the gearbox, I found that its gears were also standard Boston Gear parts, so that in the unlikely event of a failure, it could also be repaired. This is one advantage of building your own rotator; because the parts are standard, reasonably priced, and readily available.

The mechanical parts required include the following:

- **Flanged cartridge.** A high-quality, sealed, ball-bearing unit set in a horizontal mounting flange (**fig. 2**), it can support both thrust and radial loads. The one I used could take about 2000 pounds (907 kg), although it's only a small unit and takes a 1-1/8 inch shaft (2.85 cm). Mounted at the bottom of the mast, it takes the full weight of the antenna array through the machined adapter shown in **figs. 2** and **3**. My unit's mounting holes were very close to the standard rotator mounting bolt pattern, so only a bit of

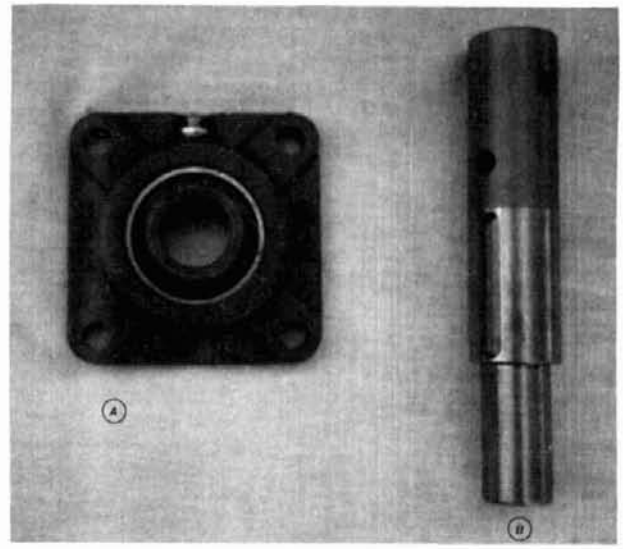


fig. 2. (A) Flanged cartridge is a high-quality ball-bearing unit set in a horizontal mounting flange. (B) Hollow steel pin secures mast adapter to the mast.

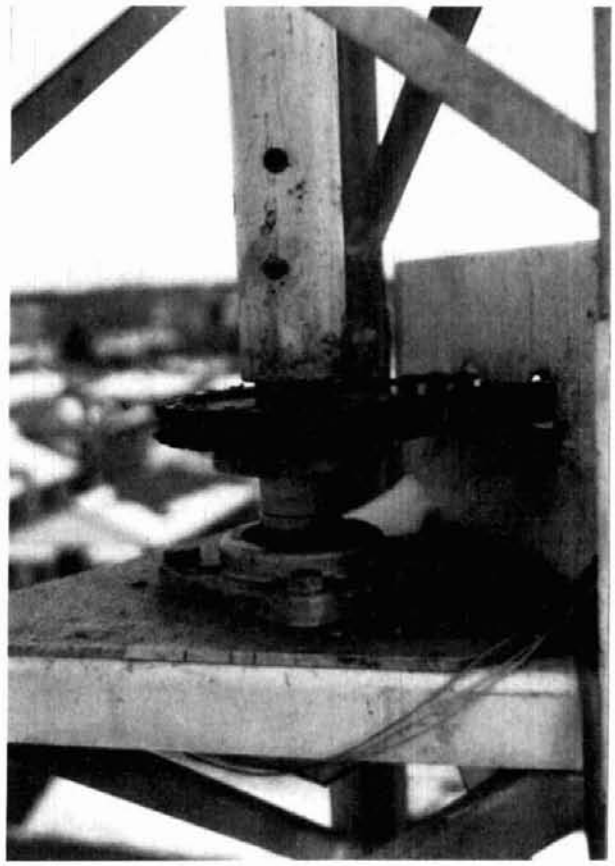


fig. 3. Completed mast assembly consists of chain drive steel pin and flanged cartridge.

filing was necessary on the tower's existing mounting holes.

- **Sprockets.** These are quite similar to bicycle sprockets. The type I used is available for various shaft sizes and is keyed for convenience in mounting and to prevent any slippage between shaft and sprocket. When the sprockets are pinned with a piece of key-stock, slippage is impossible; no clamping method can ensure this.
- **Rolled pin (or split dowel).** This is a hollow steel pin with a slot running the length of it. It holds the mast adapter (**fig. 2**) in the mast, and is driven with a sledge hammer into a hole drilled through mast and adapter. The slot allows it to compress as it's driven in, for a tight fit. There are two good reasons to use a rolled pin or split dowel rather than a bolt: one, there's absolutely no free play — and any free play in a large system is dangerous, because the antennas can slam back and forth, loosening or even shearing hardware — and two, there's no protrusion as long as the correct length is used. I used two 2-inch (5 cm) rolled pins, each measuring 3/8 inch (9.5 mm) in diameter, at right angles. One is visible in the lower hole in **fig. 3**; the hole above allows ventilation to protect the mast against condensation. The pins are available in various sizes and lengths (check the Yellow Pages under *Fasteners — Industrial*), but are probably not available at your local hardware store.
- **Gears for the direction potentiometer.** Small aluminum gears in various ratios that gear down the mast rotation to drive the direction-indicator potentiometer are available from hobby shops. Make sure both gears have the same tooth size (pitch). This is readily visible; inspect carefully.
- **Chain.** Chain is available in various sizes from the same sources as the sprockets (see above). For the final drive to the mast, I used a No. 50 chain, which also happens to be a common motorcycle chain. Note that it's much cheaper to buy this from a motorcycle parts counter than from a machinery supplier. It may also be possible to scrounge the short length actually needed from a motorcycle or bicycle repair shop.
- **Keystock.** This steel rod, square in cross section, is available in 1-foot (30.48 cm) lengths. You cut the length you need with a hacksaw. The keystock fits into a keyslot machined in the sprocket and the shaft to prevent slippage.
- **Mast adapter.** This is a straightforward piece of custom-machined steel (**fig. 2**). The end with the two transverse holes slides into the bottom of your mast and is secured with two rolled pins through mast and adapter. The length of this portion isn't too critical, though it probably shouldn't be shorter than 3 inches (7.6 cm), which is what I used, to minimize play. To determine the diameter for close fit, your machinist should measure the inside diameter of your mast, since it can vary significantly from nominal. Mine was 0.01 inch (0.5 mm) undersize, which means that if the adapter had been machined to nominal, it could not have been inserted! The sprocket fits into the middle part of the adapter, which should be long enough so you can line up this sprocket with the one on the gearbox. A keyslot should be machined to correspond to the keyslot in your sprocket. Be aware that sprockets for different shaft diameters will also use different key sizes. This portion was turned down to 1.5 inches (3.8 cm), which was the maximum shaft diameter for a keyed No. 50 sprocket with 24 teeth.

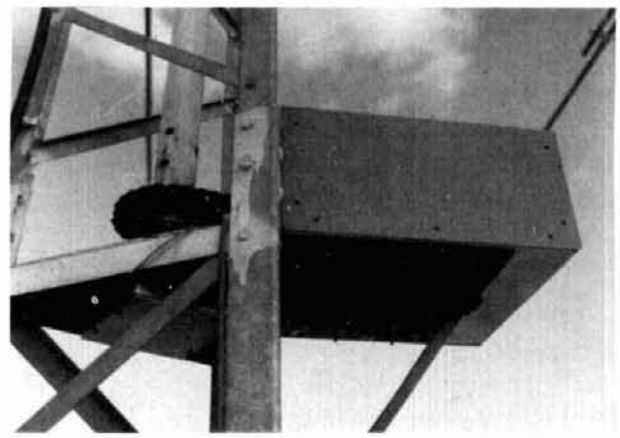


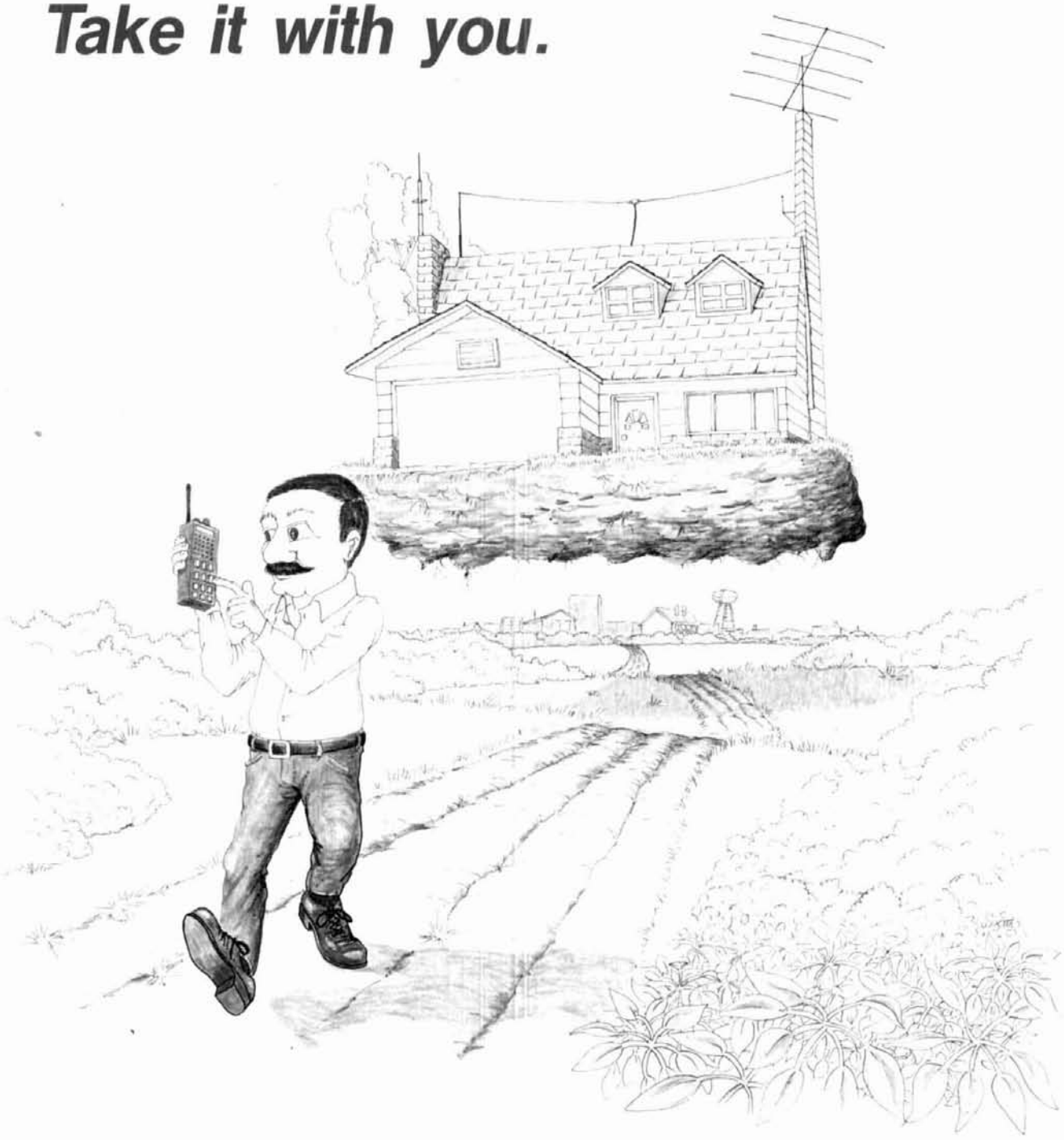
fig. 4. Bracing mounting plate to cross member prevents excessive flexing.

If you're using a large-diameter mast, I recommend machining a shoulder between the portion that slides into the mast and the portion that takes the sprocket. In this way, the shoulder takes the weight instead of the rolled pins or through-bolts.

The bottom part of the adapter, of smaller diameter, fits into the bearing in the flanged cartridge, resting on the shoulder formed by the middle part, which is of larger diameter. It should be long enough to protrude far enough below the rotor plate to mount a small gear for transmitting the motion to the direction pot. The end face was drilled and tapped in the center to take an insert onto which the gear could be mounted. Although the end could be machined down to the required 1/8 inch (3.1 mm) diameter, you would be unhappy if this little bit ever broke off. The insert is easy to machine.

The method described above for transmitting motion to the mast is superior to any mast clamping arrangement because the forces concentrated on this area are tremendous. The clamp on a popular commercial rotator has been known to loosen even in

Take it with you.



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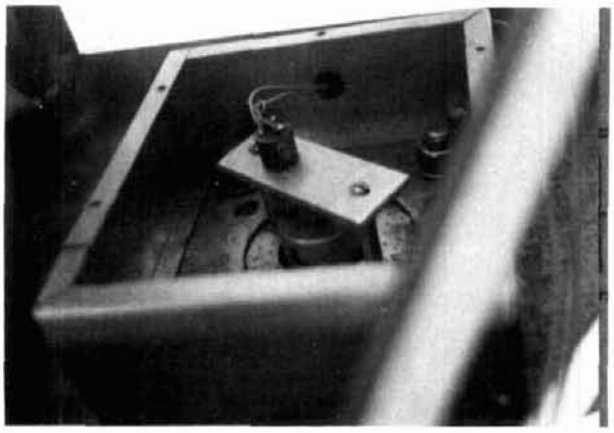


fig. 5. Rotation switch reverses output leads for reversing direction.

moderate winds, and the bolts have been known to shear altogether. A rotator manufacturer must accommodate a range of mast sizes, but you can make something that's perfect for the mast you're actually using.

As for having the machining done, any medium-size industrial town will have a number of shops that do general machining. I found one by driving through an industrial area and stopping at the first machine shop I saw; you may want to check the Yellow Pages or ask friends for their recommendations.

final assembly

When the adapter has been machined, take your mast to the shop and have the machinist drill the holes through both pieces together. This also allows you to check the fit.

My objective was a rotation speed of approximately 0.7 rpm , as a compromise between speed of rotation and starting-torque stresses on the tower. In the case of giant arrays, 0.5 rpm or less may be preferable.

The sprockets were selected this way: I wanted to use the heaviest chain to the mast for which sprockets were available that would fit both the 5/8 inch (1.58 cm) gearbox output shaft and the 1.5-inch (3.8 cm) mast adapter. The Boston Gear catalog showed that sprockets for No. 50 chain were the biggest that would allow this.

To minimize the stress on the gearbox, I wanted the maximum possible reduction between gearbox and mast. With standard keyed sprockets, this was 9 teeth to 24 teeth. A much lighter chain (No. 35) could be used between motor and gearbox. To achieve the desired rotation speed with the motor and gearbox I had, a ratio of 9 teeth to 15 teeth was used between motor and gearbox. Luckily, the 15-tooth sprocket was also the largest sprocket that could fit on the gearbox input shaft without scraping the mounting plate.

The rotor is assembled on a piece of 3/16 inch (4.76 mm) hardened aluminum plate bought from a junkyard (*also a good source of gearboxes*). If normal aluminum is used, I would recommend at least 1/4 inch (0.635 cm) thickness. Steel is preferable because of greater stiffness, but is much harder to work with, especially when filing or cutting, since it can't be cut on a shear. The mounting holes for the motor and gear drive must be slotted to allow the chains to be tensioned. Since the main drive chain is too heavy to tension directly by hand, a mechanical method had to be incorporated. **Fig. 1** shows the steel bar across the front face of the gearbox. Screws passing through it and the L-shaped blocks on either side of the gearbox are tightened to pull the gearbox in the direction away from the mast, thus tightening the chain. The gearbox mounting nuts and bolts are then tightened. The sprockets can be aligned by sliding them along the shafts, then securing them with the set screws. **Fig. 3** shows the mounting plate braced to a cross member across the tower face to prevent excessive flexing.

If you live in the North, make sure the grease in the gearbox doesn't solidify at low temperatures. Also, build or buy an enclosure to protect the rotator against rain. (I built another small box below the rotor plate to house the direction pot.) The mounting holes for the potentiometer bracket should be slotted to allow alignment of the gears, as shown in **fig. 4**.

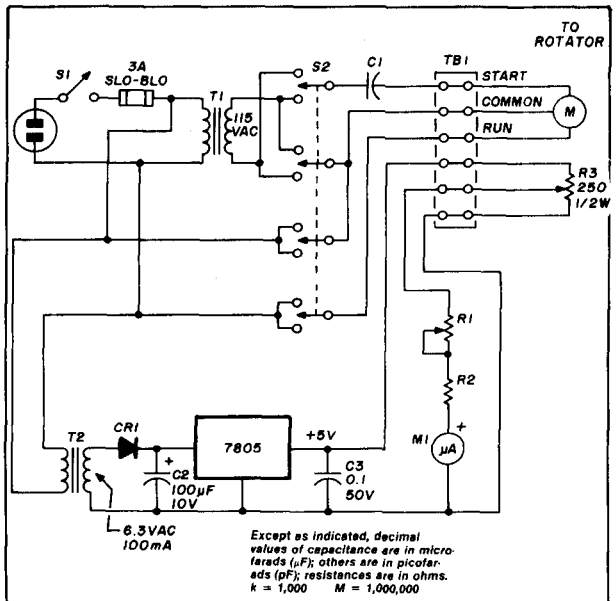
electrical design

For obvious reasons, the motor must be reversible. A capacitor-start motor can be reversed by reversing the current in the starting winding. To do this, I used a 1:1 isolation transformer in the starting winding; the rotation switch reverses the output leads for the reverse direction (**fig. 5**). The starting winding is the one with the higher resistance; the other is the running winding. Since the entire motor is rated at 2.1 amperes, I would think that a 100-watt transformer would be more than adequate. Usually only three wires are brought out from the motor, since a common return is used for both windings. If you're lucky and find a motor with the windings brought out separately, no transformer will be needed for reversing.

rotation switch and indicator pot

I didn't incorporate overtravel limit switches for a number of reasons. It was very awkward to mount microswitches and actuate them; also, many more heavy conductors would have been needed in the control cable. To minimize risk of overtravel, a spring-loaded rotation switch is used, with a center off position. Also, a meter was used for direction indication. Unlike a selsyn, this has no 0/360-degree ambiguity. If you want to use selsyns, install limit switches.

Since a pot turns only about 270 degrees, I used



C1	Motor starting capacitor. Depends on the motor. I used 10µF 330 VAC.
C2	100 µF 10-volt electrolytic.
C3	0.1 µF 50-volt ceramic disc.
CR1	1N4000
M1	Panel meter; I used a 250 µA movement.
R1, R2	Value depends on meter movement. I used 5K 10-turn trimpot and 16.2 k, 1/8-watt, 1 percent metal film resistor.
R3	250-ohm, 1/2 watt potentiometer 1/8 inch (3 mm) shaft.
S1	SPST switch, 2-ampere contacts
S2	4PDT switch spring-loaded with center off position, 2-ampere contacts.
T1	Isolation transformer; need not be more than 100 VA rating.
T2	Step-down transformer; 6.3 VAC 100mA rating.
TB1	Terminal block.

fig. 6. Control box schematic.

gears to couple to the mast. The exact gear ratio isn't critical, since full-scale deflection can be adjusted by the resistors in series with the meter (**fig. 6**). I recommended at least a ratio of 1:1.5, which provides for some travel past 0 and 360 degrees. (270 degrees × 1.5 = 405 degrees). Use a small pot with a 1/8 inch (0.318 cm) shaft, so standard Japanese gears can be used.

antenna direction

Antenna direction is displayed on a large panel meter. I painted over the original calibration, retaining only the scale, and used dry transfer lettering to re-label it in degrees. I wouldn't recommend using the original zero on the meter scale as your 0-degree azimuth point, but rather the next major scale marking. This is because a pot wiper seldom goes to 0 ohms, and you would risk damaging the pot or losing your calibration by having the pot rotate on its mounting if you accidentally went a bit past 0 degrees. I used a meter with a 250 microampere movement, but other movements (up to 1 milliampere) would be appropriate if the resistors in the control box were changed.

calibration

The direction indication can be calibrated as follows; it's best done on a sunny day. Take the control box outside for convenience. After deciding which scale markings on the meter will be your 0 and 360-degree points, turn the antenna for 0 degrees indicated. At this time the antenna heading isn't important because we're first calibrating the meter only for full-scale deflection. Place a long stick on the ground, in line with the antenna boom, or in line with the shadow of the boom. Rotate the antenna 360 degrees so the boom once again lines up with the stick. The antenna should have turned in a clockwise direction. Adjust trimpot R1 for 360 degrees indication on the meter. Double check the 0-degree point and repeat the above if necessary. Now you're ready to calibrate the true heading of the antenna.

Using one of the usual methods, rotate the antenna until it points to true North. The meter should show between 0 and 360 degrees. Loosen the mounting nut on the pot and turn the body until the meter reads 0 degrees. Your control box is now calibrated.

One of the nice features of this rotator is quiet operation. The tower doesn't resonate with the clang of a wedge brake disengaging and engaging, since no brake is provided or needed. Rotation is totally inaudible from the ground. Maintenance consists of keeping the chain greased and tight (though not *too* tight) and greasing the bearing once in a while.

I hope you have as much pleasure homebrewing and using your own rotator as I did.

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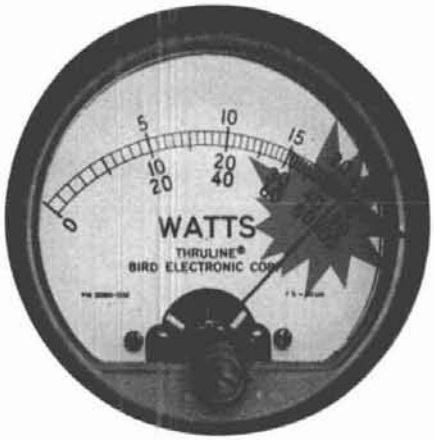

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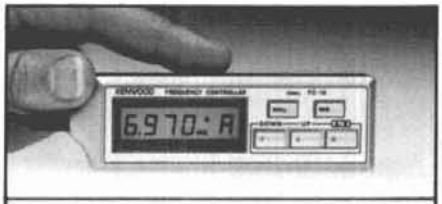
- PG-2K extra DC cable
- PG-3A DC line noise filter
- MB-201 extra mobile bracket



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secrets of successful low-band operation: part 2

Careful planning, quality components give DXing's "big guns" the competitive edge

This concluding section examines site requirements, lightning precautions, construction, maintenance, performance, and propagation. In addition, some of the most competitive stations reveal their plans for further improvements.

siting

Though most stations surveyed opt for the highest, quietest location possible, several work within the same constraints that the majority of us (the "little pistols") must deal with. Those surveyed were asked to describe their sites in terms of near and far field topography, obstructions, and noise.

Near field topography is a description of the contours of land in the immediate vicinity (i.e., within approximately one wavelength) of the antenna system. Of those who responded to this question, 83 percent described their near field topography as being flat or having a negative slope; the remaining 17 percent indicated a positive slope. It's important to remember that especially on the lower bands, optimum launch angles often exceed 30 degrees, so perhaps that mountain range in your backyard doesn't have as deleterious an effect as it might on the higher HF bands.

Far field topography in which the land rises at some distance should have an even less pronounced effect on the reception and transmission of low-band signals. However, the actual slope is important (in both the near and far field) and can be determined through the use of United States Geological Survey 7.5-minute (1:24,000) or 15-minute (1:62,500) maps.* Those surveyed described their far field conditions in basically the same terms as near field: flat or negative horizon. For example, they used the words "flat to ocean," "flat many miles," "mountains 26 miles away," "top of hill," "top of ridge," "flat and drops off," "flat to within 1/2 mile in all directions," and "80 meters above local terrain." So you see what most of the big guns have in common: a good site — topographically speaking, at least.

Obstructions. In terms of obstructions on those sites, the worst offender appears to be trees. Yet many of the low-band installations depend on these trees for supporting wire antennas. To date I haven't seen any definitive studies indicating whether the presence or absence of trees greatly affects patterns or performance of low-band antennas. (Any reader who has information on this subject, please contact me.)

Many of those surveyed indicated "none" when asked about obstructions; it's no accident that the FCC at its various monitoring facilities has extremely stringent requirements with regard to the height and location of any obstructions (even in what's defined as the far field). Apparently development of many of the high-performance stations involved site examination and evaluation as a first necessary step. An example of a good near and far field site is seen from the boom's perspective of W6NLZ's 80-meter Yagi (**fig. 1**).

Noise. The oft-spoken adage, "If you can't hear them, you can't work them," certainly applies to low-band operation. (There are some who have a particular knack for working stations that just aren't there, but that's another story). The limiting factor in the reception of signals is noise, be it man-made or atmospheric.

*Maps for areas east of the Mississippi are available in the United States from the United States Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202. Maps for areas west of the Mississippi may be ordered from the United States Geological Survey, Box 25286, Federal Center, Denver, Colorado 80225. USGS maps are also sold by more than 1650 commercial dealers listed in the pamphlet, "Index to Topographic Maps," available without charge from either USGS distribution center listed above.

By Rich Rosen, K2RR, Editor-in-Chief, *ham radio*

After reviewing all the responses and assigning a range of 10 (no manmade noise whatsoever) to 1 (terrible), the average value appears to be around 8. Although most of the high-performance stations have a quiet noise environment, one of the top stations surveyed — with over 300 countries worked on 80 meters and well over 100 on 160 — described his location as "high noise," with a 115-kv high-voltage line within 0.5 mile. Don't give up hope for successful low-band operation if you have a high noise level. If it's the result of faulty electrical equipment, power companies can be helpful in tracking down the source of the noise and correcting the problem.

Other sources of interference can sometimes be located using portable equipment (for example, a pocket AM radio with a ferrite loop or circuit designed especially for that purpose). Noise cancellation techniques have been used for many years with some degree of success.[1,2,3] Many who use directional arrays (phased verticals, for example) probably notice that switching the antennas around produces a noticeable increase or reduction in noise level. Sometimes it's better to point the antenna's null at the interference, trading off a dB or two of gain from the preferred signal direction. A suggestion from some of the veteran 160-meter operators is for newcomers to be aware of noise from TV horizontal oscillators, either your own or your neighbors'.

lightning

The expression, "Into each life a little rain must fall" could be particularly applicable to big guns, whose large antenna systems are more exposed to the elements than others. Lightning poses a real threat to some of these stations, with their high towers and negative horizons. Precautions can be taken, however, and the danger lessened.

Two locations worthy of attention are in the shack and out at the antenna. Precautions taken at the shack include the simple expediency of disconnecting all transmission lines, grounding the equipment and/or antennas or a combination of both. Outdoor precautions include using antennas that are permanently DC grounded by design; for example, the base of a shunt-excited vertical is at DC ground. One method of DC grounding a horizontal wire antenna would be to attach a quarter-wave shorted stub (or odd multiple of a quarter wave) across the dipole's feedpoint and ground it at the shorting bar at the opposite end. This technique, primarily used to drain off static charge, works well only if the antenna is used over a narrow band of frequencies. Otherwise the short reflects back to the feedpoint as other than an open circuit and must be accounted for (in matching). Some of those surveyed were quite satisfied that the grounding system designed as part of their antenna installation would prevent any lightning damage.

fig. 1. Sighting along boom of a KLM 4 element Yagi reveals unobstructed near field topography.

Even if a lightning discharge should occur at your antenna, shack damage is not inevitable. One "big gun" responding to the survey said he felt that by locating the antenna a considerable distance from the shack, the danger of damage occurring at the station end was greatly lessened.

Those who have taken direct strikes reported losses ranging from only a fuse box on one hand to almost total destruction of their home, with walls and windows blown out and ceilings collapsed. Anyone who's ever experienced even a very close lightning strike knows that this is a subject to be taken seriously, with every reasonable precaution applied.

construction

It's one thing to design, on paper, a three-element 80- meter Yagi. It's quite another matter to build, install, and keep it up. Wire antennas, though easier to install, still require an investment in quality materials, labor, and time.

Several of those surveyed built their own rotary Yagis. Noel, VE2HQ, described his efforts to construct his three-element, 515-pound, 43 square foot (windswept area) Yagi, the result of three years of planning, determination, and hard work, marked by several setbacks.

Working all winter in his basement, he built the linearly loaded elements, starting with 3-inch O.D. tubing and down to 0.5 inch in increments of 0.25 inch (11 different diameters). The linear loading was added 125 inches from the butt of each element by cutting the 2-inch diameter section, inserting a fiberglass tube and winding the coil with copper-clad wire. Additional element support was provided by double element guying on each side with Phillystran.**

The boom consisted of two 35-foot long flag poles

****Phyllystran** is a registered trademark of Philadelphia Resins Corp.

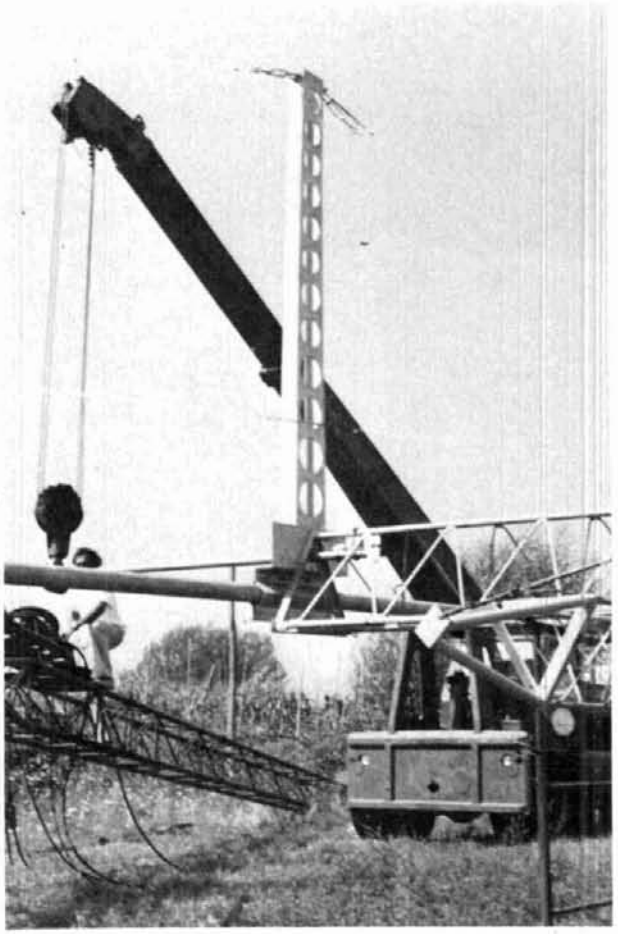

fig. 2. Vertical member and stays prevent element droop.

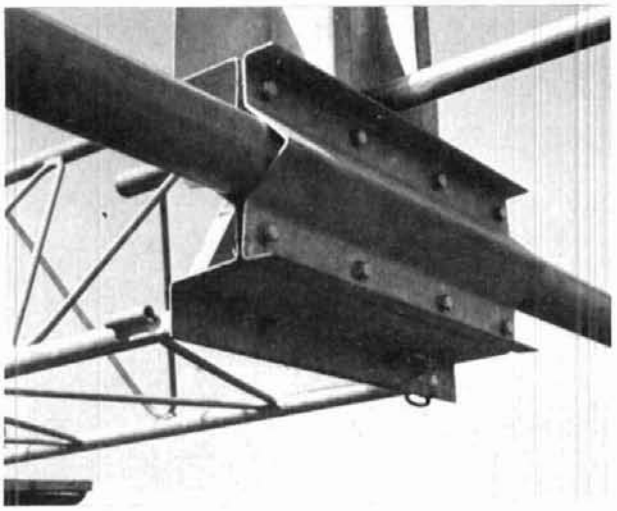

fig. 3. Method of attaching full length elements to boom involves use of 8 bolted through plate for mechanical rigidity.

(4.5 inch O.D., 0.25-inch wall) resulting in an overall length of 65 feet. At this point Noel had to consider what type of tower could support this heavy antenna. He purchased a commercial 60-foot tower designed for supporting large microwave antennas and fabricated a 50-foot triangular extension measuring 33 inches on a side to be mounted on top of that.

The first time Noel installed his antenna at 110 feet, it resonated too high in frequency and had to be taken down. It was made to resonate at 3625 kHz at 15 feet above ground so that it would resonate at 3785 kHz at its final height.

Chris, I5NPH, erected an even larger three-element Yagi using full-size elements. A careful examination of **fig. 2** provides an appreciation of the size of the components used in this antenna. The structure at the right that looks like a tower is the end of the boom; the large tubing at the left, which looks like a large boom, is one of the parasitic elements. Notice the size of the vertical strut used to support the long elements. **Figure 3** shows the method used to attach the parasitic elements to the boom. When one considers the difficulty of installing a completed antenna, eight bolts in the element-to-boom clamp don't represent "overkill."

While W6RJ put his three-element KLM Yagi together on the tower, K3ZO completed his Yagi's construction on the ground and raised it with a 164-foot crane. WA1EKV used ropes strung from his tower in a vee to slide and pull his Yagi to the top.

Because wire antennas tend to break at the worst times, a quick means of lowering and raising them is necessary. Ropes, pulleys, and continuous halyards are successfully used by some to provide this capability. In addition, if you want your antenna to stay up, use the best quality material. One of those surveyed has had success with white/blue marine rope. Polypropylene rope, though less expensive, disintegrates after exposure to sunlight. It might take several years, but it *will* deteriorate; be sure to wear gloves when working with old polypropylene.

installation and maintenance

Two more practical questions were asked of those questioned in this survey: "What precautions did you take in installing your system to make sure it would stay up?" and "What periodic maintenance procedures do you follow?"

In general the consensus of opinion can be summed up in a single word: *quality*. Though topnotch material costs more initially, it delivers years of consistent good performance and pays for itself.

The "big guns" offered specific advice on the subject of non-wire antennas (rotaries and towers). Here's what they recommend:

- Tighten all guy wires and clips to specification.
- Choose all materials carefully — anything that isn't aluminum or stainless steel will rust.
- Paint all towers and masts.
- Lubricate all moving parts properly.

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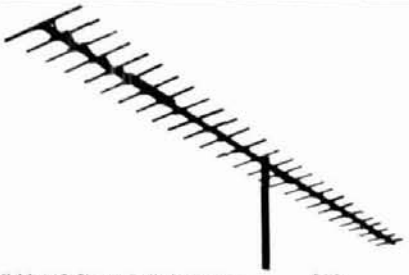

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Alinco ELH-730G 20 watt amp $109
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With regard to wire antennas, they advise the following:

- Use quality halyards — for example, white/blue marine rope.
- Use steel line for the halyard section that goes over tree branches.
- Avoid the use of galvanized steel wire for radials.
- Protect all critical connections with a good weather-resistant sealant such as Coax-seal.®

Periodic maintenance procedures include:

- Tightening of guy wires, clips and hardware.
- Lowering wire antennas with pulleys to check the condition of the halyards, wire, and insulators.
- Cleaning insulators with a rag and water.
- Clearing foliage away from verticals.
- Repairing thin wire ground radial systems.
- Protecting systems with the same paint used on the undersides of boats.

Many of the big guns found that they experimented so frequently with new antennas that the short life cycle of their old antennas precluded the need for periodic maintenance.

performance

The next question posed was, "How does your present antenna system perform in comparison to others — either your own or the competition's?" In general most felt that the latest was the best. Specifically:

K3ZO found that his three-element KLM rotary at 140 feet was 25 dB better than a half-wave sloper and up to 8 dB better than his previously used three-element, 80-foot boom delta loop beam.

OH1RY found his full-size three-element Yagi outperformed a dipole by 20 to 30 dB on the long path shot to the United States.

4X4NJ uses four tilted verticals on 160 meters, fed in various phase combinations with passive reflectors to create an electronically rotatable vertical beam system. He feels "it's almost as good as having a full rosette of Beverages, with the added advantage of having a good low-angle rotatable transmitting antenna."

W2JB, another 160-meter operator, stressed the importance of being able to *hear*. "Most of the DX runs low power and signals are usually at the noise level. That's where you need your Beverage antennas," he wrote.

SP3GEM, who trades off between a vertical and a delta loop, doesn't see much difference between the two in the favored delta loop direction. However, he prefers the vertical in other directions — that is, where the delta loop exhibits a null.

KG7D, like many others, believes slopers provide good performance by launching a low angle signal, showing nulls off the sides, and having reasonable feedpoint impedances and consequently high efficiency.

One of the truly big signals from Japan on 80 meters, **JF1IST**, uses the Create Manufacturing CY-703 three-element Yagi and is very pleased with its electrical and mechanical performance. The specification sheet lists its forward gain, F/B ratio and 2:1 VSWR bandwidth as approximately 8.5 dBi, 20 dB and 100 kHz, respectively. JF1IST has his centered on 3.80 MHz, right in the middle of the Japanese SSB window.

W1NH, formerly W1SWX, can often be heard pulling out the rarest of stations on 80 meters, thanks to his three slopers and inverted vee from a 100-foot skyhook and six 1000-foot long Beverages. To illustrate its performance, he enclosed copies of QSL cards from VS5MC, HS5ABD (both short and long path) and JT0DAQ — all very difficult shots from the East Coast on 80.

K5UR attributes his success on the low bands to a superior receiving capability (Beverages once again). Considering that he holds the *CQ* Worldwide DX Contest U.S. record on 160 meters, his transmitted signal must also be outstanding to be heard above some of his competition on the East Coast. He does mention that his new 130-foot vertical appears to work noticeably better than his old 70-footer.

YU7PFR's three-element wire Yagi at 56 feet outperforms his previous single vertical or dipole while providing a 2:1 VSWR bandwidth of 250 kHz. With one of the strongest signals from Yugoslavia, he's consistently heard in the United States.

SM4CAN has noticed as much as a 6 dB improvement in signal level using his Bobtail curtain as compared to his gamma fed tower with 120 radials. However, on long path to the United States his delta loop performs better than the Bobtail *during the month of November.*

According to **SM6EHY**, it's possible to have too low an angle radiator. He says that his four-element phased vertical array just doesn't have that extra punch when high angle signals are propagated, and goes on to say that "the greatest advantage in using phased antennas is that you can reduce noise and QRM pickup from unwanted directions to such a degree that you can hear everything on the band."

VE2HQ compared his home-brewed three-element Yagi with a sloper at 155 feet and found the Yagi to be superior in terms of signal strength. He also estimated the front-to-back ratio to be 22 dB.

With over 300 countries worked on 80 meters, **W4DR**, in comparing his four-element phased vertical array with other antennas, says he believes that the really high horizontal beams still have the edge. **N4AR** uses a pair of phased Bobtail curtains on 80

meters and finds that the F/B ratio on low-angle signals is often in the 15-20 dB range and the front-to-side is "astronomical." He prefers this antenna over Beverages for receiving as well. He also says that having an antenna with noticeable gain and a very definite controllable pattern has provided him with insights on propagation on 80 meters. He's probably one of the few to have worked Laos (XW8BP) on 80 from the East Coast . . . .

Attributing his success to a two-element delta loop array, **DJ0IA** says he's experimented with other antennas but keeps on coming back to it.

W1FV, showing true ham ingenuity, fit a well-designed and constructed phased vertical array into very narrow confines without any compromise in performance. He rates its overall performance on 80/75 meters as excellent. Winner of the single-band category in the 1984 *CQ* WW CW contest, he observed: "The vertical array is the best antenna I have ever used for the difficult paths (central Asia, Japan, deep Pacific, and Indian Ocean)." He has tried many slopers, high dipoles, and delta loops but finds the present configuration to be the best.

EA8ADP proves that sometimes a simple antenna can be a top performer if other conditions are met. His inverted vee has accounted for 225 countries worked on 80 meters in less than three years. He can normally be heard in the States when the rest of Europe is barely being copied. His inverted vee is supported at the 33-foot level on a tower atop a 148-foot high building situated on top of a hill.

propagation

As far as I'm concerned, this has to be one of the most interesting areas considered in the survey. The perspective gained by being able to review responses from different countries, continents — and in general, both ends of a communications path — starts to explain observations made over the years but not understood. I feel fortunate to be the compiler of this information and I'll try to convey some propagational correlations and leave the rest to you. A special vote of thanks is due to **SM6EHY**, who provided an extremely detailed account of his observations made during 20,000 hours of listening on the low bands.

160-meter propagation

For those not familiar with 80 and 160 meters, there is a tendency to lump them both together as "those noisy, short-range bands." That static exists on the lower frequencies is undeniable; that the communications range is limited is true sometimes, but not always. How else could one explain stations working over 300 countries on 80 and 200 countries on 160 meters, given the right conditions and activity? Furthermore, 160-meter enthusiasts are quick to point out that there's sometimes a world of difference between propagation modes on 160 meters and on 80 meters, and that one band should not be judged by the performance of the other. **K1MEM** best expressed this when he said "The basic creed is, don't go by 80-meter conditions to judge 160. 160 can be great to Europe or Africa when 80 is poor and vice-versa. QRN on one band is no indicator of the other. Also the beacons from Europe seem to have no relation to Amateur signals."

K5UR finds propagation to be best towards Africa and the Indian Ocean in the early evenings. At this time of day he's occasionally observed long path signals from Asia (YB, 9M, . . .) coming from the direction of South America. The same stations are also heard on a skewed path at a bearing of 235 degrees in the morning. Signals from Russia appear on a bent path with a heading of 75 degrees.

From the northwest, **KG7D** believes that chordal propagation is the mode on 160 when Europe is being heard at his QTH, yet not being copied at other locations in the United States. He believes this occurs when the F1 and F2 layers fail to merge. "It would be nice to know the optimum takeoff angle for chordal propagation. For me it appears medium angle north/south, low to the east, and again medium angle to the west. Frequent openings do definitely occur along the terminator lines, with signals coming from over the poles. Frequently we see enhanced propagation effects from the auroral zone."

VE7BS found a good opening occurring to VK almost every day throughout the summer of 1985. It started well before his sunrise and ended well afterwards. The observation of this path, he believes, is largely a function of the operating habits of Australians, pointing out that in June and July, VE7 sunrise occurs at a reasonable time in the VK evening. At other times of the year — for example, when VE7's sunrise occurs at 1430Z — the VKs have already gone to bed . . . thus no communications. But the path may still exist. This is somewhat analogous to a tree's falling in the forest; is a sound made even though no one's there to hear it? The answer is an emphatic *yes*.

SM6EHY echoed this same point in discussing the polar path between Sweden and stations on the East Coast of the United States and in the Midwest. Stations can be worked from 0800 to 1200Z on 80. Bjorn believes that the same conditions should hold true for 160 and attributes the lack of contacts to the low level of activity in the northern United States at this time. Bjorn also wishes United States Amateurs would improve their receiving capability; for example, on the 10th of June he failed to attract the attention of W9s after 15 attempts. He also feels that 160 can open up on occasions to a degree that has never been observed on 80 meters. For example, ZL3GQ was 599

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+10 dB at 1652Z on December 24 for about 1 minute. The best he's been able to observe on 80 was 589 over both the short and long path.

80-meter propagation

Consisting of two DX segments separated by approximately 300 kHz, 80 meters sometimes also acts as if it were two different bands. Conditions can be excellent on the short path to Europe on SSB and poor on the CW portion and vice-versa.

More responses were received for this band than for 160 meters. Consequently the subject is divided into several sections: short path, bent path, long path and other influences.

• **Short path.** For the most part, those surveyed concentrated on the unusual paths either long path, bent, or skewed. Perhaps it's because the normal great circle path is in reality not all that common or at least certainly not as exciting. If one assumes that several "short paths" exist between two locations at the same time and one path is more severely attenuated than the other, then it's reasonable that the latter path (non great-circle) will be observed as the only path and classified as a bent path. For example, suppose a station in New Hampshire is in contact with a station in the U.K., and that they're both using single verticals. If at the time of the QSO the geomagnetic field is disturbed and the normal great circle path, at a bearing of 54 degrees, is severely attenuated, then signals coming from the second path, off the coast of North Africa, will provide the only viable means of communications. This situation, which has often been observed over the past several years from K2RR to the U.K., normally coincides with a fairly high K index. However, even the latter path disappears at still higher values of K approximately 24 to 36 hours after a major solar event. It's at these times that only signals from the South can be copied and usually only unilaterally. A case in point was during the recent Revilla Gigedo dxpedition, **XF4MDX**. It was as if a traveling blanket of absorption was moving from north to south. A few minutes after the fortunate contact, the signal from XF4 simply vanished. One could observe this effect by listening to which stations were able to get through W1 to W2 to W3, etc.

From his location in Louisiana, Mike, **NW5K**, is able to work into Africa between 0330 and 0630 and into Europe between 0600 and 0700Z via the short path.

Roy, **ZL4BO**, finds that the normal short path into Europe can vary as much as 30 degrees during his (southern) winter.

bent path

The term "bent path" can probably best be explained by saying what it's not: it is *not* a short or long great circle path. Can we then consider the vast number of other possibilities as bent paths? Were it only that simple! Perhaps it's more accurate to say that any path that's strictly not great circle, short or long, contains some element of bending. Remember, the distances covered in some cases are to locations more than halfway around the globe, where the time-varying ionospheric layers are in a different state of flux. Perhaps the signal starts out on a great circle path, only to be diverted by conditions along the way. Maybe this also explains why some of the paths appear to be unilateral or one-way; wouldn't conditions between the stations have to be the mirror-image of each other to be reciprocal? One way to analyze this effect scientifically might be through the use of simultaneous encoded transmission beacons, each with its own directional antenna at both ends of each path, with each transmitter keyed to an atomic clock. Precise time measurements would then determine the path interval and at least its length. But this, some might say, would take the fun out of Amateur Radio. Isn't it the unpredictability of the arrival of signals from exotic locations that makes DXing so exciting?

But I'm straying from the subject. Let's get back to which bent paths, under what conditions, have actually been observed.

Using a three-element Yagi, **W6RJ** observes that most northern European openings are bent somewhat to the south. Furthermore, he states that two stations with coinciding sunrise and sunset times can communicate 90 percent of the time, in the absence of high QRN levels.

ZL4BO attributes his success in bent path propagation to his extreme southern latitude, utilizing the path over both the North and South Poles when the normal (short path) and long path conditions aren't good.

SM4CAN notices that the best direction for working United States stations "short path" is at a bearing of 270 degrees as opposed to the indicated 330-degree great circle azimuth. During auroral conditions, he has worked W6NLZ with signals appearing to come from South America; this correlates with Peter's (W6NLZ) observation from his end of the path.

N4AR has observed signals from Japan, Hong Kong, and Indonesia from the Southwest. In fact, he always hears VS6DO and YB5ASO more strongly on this bent path than from the great circle direction. "This bent path is clearly in the direction of the terminator line [Gray-line — Ed.] and somehow these far eastern Asiatic and Pacific signals scatter into the terminator line path," he says.

Using his full-size three-element Yagi, **OH1RY** observes signals from Hawaii at a bearing of 90 degrees (east), whereas great circle calculations would indicate a northerly direct path.

W1FV, as well as many others on the east coast of

the United States, has observed the same bent path towards Japan and Southeast Asia in the morning by beaming to the southwest. Not only have other stations observed this path, but they've also seen it change abruptly (within a matter of minutes) from the southwest to the northwest when hearing Japanese stations. Using a rapidly switched phased vertical array, John finds that it often exhibits ill-defined directional characteristics for long-haul paths around sunset and sunrise, although the antenna is otherwise quite directional. "Perhaps this is explained by multipath propagation or some unusual radiation-angle and/or polarization effects?" he wonders, adding that "this ill-defined directionality is also noted on most signals during periods of a disturbed geomagnetic field."

long path

It's not uncommon to hear stations calling CQ long path around sunset from the east coast. What are they hoping to accomplish? And what's this phenomenon called "long path?" It's reasonable to assume that the practice first gathered momentum with stations on the higher HF bands — for example, on 20, 15, and 10 meters years ago. They observed that it was possible to contact stations by pointing their highly directional antennas in the opposite direction of the great circle short path. At the time very few stations on 80 meters had directional antennas and it was even less likely that *both* stations at opposite ends of the path would have directional arrays. That long path contacts occurred on 80 meters in those years was, however, certain; they just weren't called "long path." (I would like to hear from anyone who operated 80-meter long path years ago.)

N4RJ, W4DR, K2FV and **W1FV** have been able to work into western Australia, Indonesia, and Japan at their sunset by beaming southeast, utilizing primarily the "long path."

From the other side of the path, **VK6LK** finds that his long path opening to the East Coast of the United States normally starts about 15 to 20 minutes after his sunrise and lasts 20 to 30 minutes when the conditions are good. "My first long path opening was with W1FC on 13 September this year, and I would expect the path to close sometime next May. One problem here is short skip from YB. They can drown the weaker long path signals from the United States." From Japan, **JA1FRE** has also noticed the existence of a US-JA long path through his (reception) observations of east coast United States stations at 2130Z.

Other, long path shots not well known by US stations of course still occur. **JA1FRE** works into the UK and Scandinavian countries at 0800Z, taking advantage of this mode. **SP3GEM** and other European stations are able to work into the Pacific areas using the long path. **K5UR** has a morning long path into Europe that isn't too common, but when it does occur, produces high signal levels.

Using his phased Bobtail curtain, **N4AR** has shown how reliable the early morning long path into central Asia can be. He has maintained a schedule over the years with **UL7GW**, talking to him approximately *100 times per season* using this mode. "During that period, many other Asiatic Russians were easily worked on a daily basis," he wrote. Besides these USSR stations, he also worked **XW8BP** and other southeast Asians at this time of day.

What's even more interesting is that he found that the path essentially disappeared during the sunspot *minimum* of 1974-1975. This is contrary to the widely accepted belief that sunspot *minimum* years provide the best low-frequency DX. N4AR commented, "While stronger signals (during this period) were evident from Europe in the evening and an occasional UA9 or UL7 QSO was possible in the evening, for all practical purposes the morning long path disappeared."

As stated earlier, this path returned during the most recent solar maximum. Fortunately at that time, **HS1ABD** and **UL7GW** were again active, serving as markers for band openings.

N4AR remarked that with the phased Bobtails, "There's no question deciding if signals are indeed coming from the direction of the long path. This tends to be along the terminator line during the 1130 to 1230Z window. Looking at the MUF limited F2 hops doesn't seem to explain the loss of signal (during sunspot minimum) adequately. In any event, it's certainly a real phenomenon, at least from this part of the world."

SM6EHY disagrees with the contention that a true long path condition exists with signals *originating* and *terminating* in the same hemisphere. "Long path — with the meaning of true long path direction — does not occur on 80 meters," he wrote. Signals arriving at SM6EHY's QTH from KL7, KH6, VE7, W7 and W6 have the same azimuth angle: 110 degrees. "They arrive at a very high angle (50 to 60 degrees), with some noticeable echo. This holds true only for the same hemisphere. Signals coming from the southern hemisphere have all true azimuth angles for both short and long paths." He also believes that at W0, W6, and W7 sunrise, stations should not be beaming long path but using the Arctic path instead.

other influences

Through his 20,000 hours of low-band observations, **SM6EHY** credits the significant influence of the aurora on propagation. "The conditions this far north are very heavily affected by aurora with regards to paths to stations in the northern hemisphere such as JAs and Ws. The maximum particle radiation from the sun (which causes the aurora) is predicted to occur ap-

proximately two years after the sunspot maximum. In this last cycle the aurora has consistently occurred from December, 1981, until now (March, 1986) leaving the polar path open only on special occasions." When this polar path is open SM6EHY can work the east coast and midwestern United States from 0800 till 1200Z. Japanese stations can be worked 24 hours a day. This occurs from mid-November until mid-February, when the path is open.

where is this auroral activity?

SM6EHY continued, "The aurora expands between Spitzbergen (JX) and northern Norway (LA) and under most conditions the maximum activity is experienced close to 64 degrees N (latitude). From 144 MHz observations, the reflection belt travels from the far east through the north to the west and then disappears. Occasionally, it's the other way around.

Bjorn went on to mention that the aurora can change very rapidly — within a period of seconds — virtually closing down a good path. When the auroral activity is *south* of his location the "arctic is like an open field where signals experience very little attenuation."

what other paths does it affect?

"A bent path has been observed during auroral activity," Bjorn wrote. "The signals coming from W1 [stations] just cannot travel through the arctic region [the auroral can be considered to be a 0 to 30 dB pad, depending on the level of activity and signal path — Ed.] and must be reflected in an area close to the equator and other places at the same time. This causes the signal to be heard with some echo and QSB."

benefits of a low-angle radiator

With his phased vertical array and large ground system, Bjorn feels he's able to launch an extremely low-angle signal that can go *under* the aurora's attenuation belt. "The lower you go in frequency, the more important is the takeoff angle; the angle fluctuations are more pronounced at lower, rather than higher, frequencies," he said.

Bjorn believes it's important to transmit at angles between 0 degrees and 10 degrees on 80 meters. "A low takeoff angle antenna can be used very effectively during auroral activity to contact some stations at least *part of the way* through the auroral region. A case in point is when he's not able to hear the W1s, but can still work OX or VE8 stations with good signal strengths."

ducting

Another propagation mode noticed by **SM6EHY** and others involves signals entering at one location, traveling and being trapped between ionospheric layers, and finally exiting at a second location, whereby stations in-between cannot copy either end point. Specifically, on north-south paths signals from stations as far south as 15 degrees follow normal paths. Further south, ducting appears to occur. There are times when Swedish stations north of SM6EHY are able to communicate with South Africa but not be heard by him.

Ducting also possibly occurs on the North Atlantic path between the east coast of the United States and Europe. This might explain the high signal strengths received across the Atlantic by stations using low dipoles that launch high-angle signals. If it were simply a case of multihop propagation between the ionosphere and earth, signal levels would be lower. However, reflections *between* layers, on the other hand, would account for less loss. The entrance and exit requirements for ducting might be high-angle.

when are low-band conditions best?

SM6EHY echoes the sentiment expressed by N4AR that low-band conditions are probably best during the period of maximum solar activity (sunspot maximum). He explains that it's probably not noticed, since proportionately fewer stations operate on the low bands when the MUF is high and 10 through 20 meters are more heavily utilized at that time. It's possible to test this hypothesis during the next sunspot maximum, because there'll be more stations on than ever before using high-performance directional 80-meter antennas.

disturbed geomagnetic field affects path

N4AR kept close track of WWV's A and K indices for many years and believes that neither the bent path nor the great circle long path appear to be beneficially influenced by geomagnetic disturbances. However, with the onset of a geomagnetic field disturbance, spectacular increases in signal strength are occasionally evident over the short path. Also observed by others, the latter situation is normally a precursor of the arrival of the lower energy electrons from the sun 24 to 36 hours later and its associated high level of D layer absorption.

plans for the future

Because improvements are always possible in any station — big guns not excluded — the final question asked in the survey was "What improvements are you considering making to your station?" The responses to this question included ideas for improving receiving capability, installing higher performance transmitting arrays, increasing tower height, using a bigger radial system, installing lower loss transmission line and even acquiring a better site.

• **Receiving capability improvement. K3ZO** wants to improve his 160-meter reception in general. **N1ACH**

wants to lengthen his 160-meter Beverages from 1.5 to 2.0 wavelengths. **4X4NJ** looks forward to an improved R4C for 160 meters. **SM4CAN** wants to use better Beverages. **N4RJ** feels that his Beverages could be better tuned and that adding a preamp at the antenna would help. **K1MEM** will terminate his Beverages and run additional ones SE and SW.

• **Transmitting array improvement. VE3BMV** wants to put a two- or three-element quad on his tower. **OH1RY** wants to install a two-element shortened 160-meter rotary. **OE6MBG** would like a two-element driven IV beam; **K2FV**, an additional half square. Phased verticals or phased delta loops would please **SP3GEM**. **KG7D** plans a three-element 160-meter parasitic vertical array using shortened elements. **JF1IST** would prefer a four- or five-element 80-meter rotatable Yagi. **DL0WU** wants a three-wavelength on a leg 80-meter rhombic; **K5UR**, a two-element phased 160-meter vertical aray. **YU7PFR** would like to construct four- or five-element wire Yagi, and **SM6EHY** a four-element 160-meter phased vertical array. A three-element full-size 80-meter Yagi at 160 feet would interest **VE2HQ**; **JA1FRE** would enjoy a two-element full-size Yagi. **W4DR** wants an 80-meter horizontal beam at 150 feet. **W6RJ** plans to raise his existing 80-meter three-element Yagi on his tower.

Other items on the big-gun wish list include increasing tower height (**PA3DFU**), adding more radials (**W3BGN** and **W1FV**), and using lower loss cable; **W1NH** wants to switch to hardline coax to reduce losses on his 500-foot run to the antenna. **WB2ITR** expresses a commonly felt need for a new site, one that has more land and better topography.

conclusion

Well, now we have it: the secrets of successful low-band operation. Well, not quite. One necessary ingredient that's hard to quantify is, of course, the desire to succeed — in this case, to have the very best signal on the band. Besides the other three factors mentioned before (hard work, time, and expense) there's also the dream, the enthusiasm that keeps you climbing to greater heights, laying out just ten more radials and extending that Beverage even further, hoping that one night as you're scanning, that BY4 will come pounding through on 3.505 with a never-before-heard clarity and strength.

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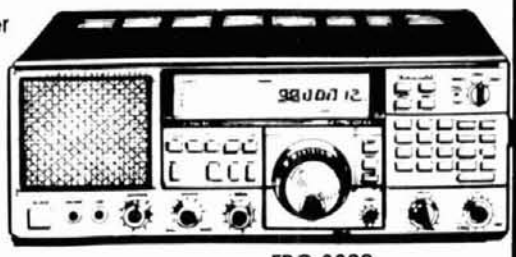

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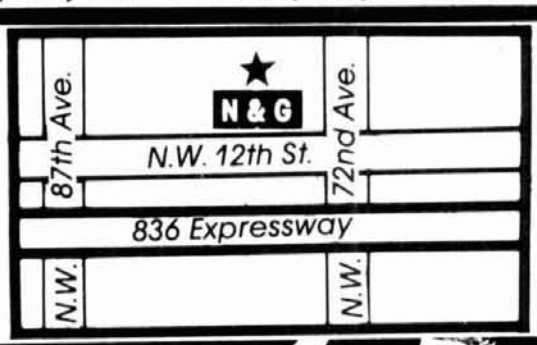

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ham radio TECHNIQUES

Bill Orr W6SAI

a wrangle over Wrangell

Want to work a "new country?" Maybe you can. Unknown to most radio Amateurs, the United States has claims to Wrangell Island (UA0) and other island territories north of the Soviet Union. The situation isn't clear, and maritime-boundary discussions about this region — spurred on by the discovery of oil — are underway .

In a recent editorial *The Wall Street Journal* called attention to deliberate Soviet harassment of U.S. drilling rigs in the Navarin Basin. This harassment, which includes dangerous overflights by Soviet aircraft, is one of several subjects of discussion between the two powers. Although the issue bears watching, only limited information about it has appeared in the daily press.

Little-known Wrangell Island seems to be assuming an importance greater than its size. I doubt if there will be much radio Amateur activity from that part of the world until the boundary issue is settled.

the five-band coffee pot

Mobile antennas for the HF bands have always been a problem because of low operating efficiency and restricted bandwidth. A mobile enthusiast, Varouj Kalinian, (N6DBH, ex-OD5CS and F0HN) has solved this problem to his satisfaction. His solution is to use a short mobile antenna, but to increase the diameter of the element below the loading coil (**fig. 1**). For the base section, he used an old coffee pot about 8 inches (20 cm) in diameter and 14 inches (35 cm) tall. His loaded whip sections were mounted to the top of the pot (**fig. 2**).

Varouj removed the electrical components of the pot, drilled a hole in the middle of the plastic cover, screwed the cover to the pot, screwed a 40-meter Hustler resonator and whip to the top and then adjusted the antenna to resonance. He found that

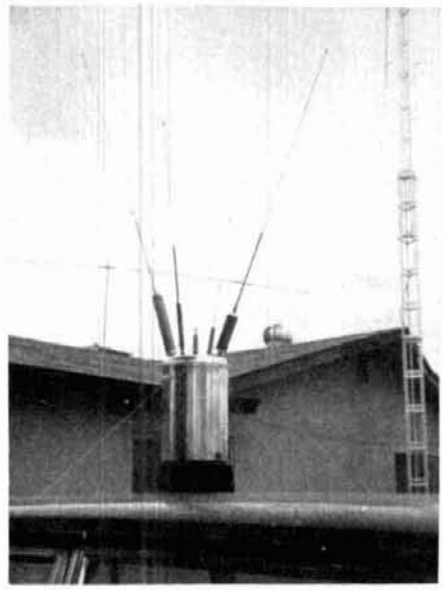

fig. 1. The "coffee-pot" mobile antenna of N6DBH mounted atop his station wagon. Separate resonators are used for various hf bands.

he had a bandwidth of 150 kHz between the 1.75-to-1 SWR points on the feedline on 40 meters.

Encouraged by the results, Varouj added other resonators and antenna tops for the other HF bands. The results were a bandwidth of 60 kHz on 80 meters, 200 kHz on 20 meters, 300 kHz on 15 meters, and 800 kHz on 10 meters. In a short time he had a "five-band coffee pot antenna."

Varouj admits the antenna looks a trifle bizzare and that he gets curious stares from other drivers. He reports that one driver pulled alongside, handed Varouj a coffee cup, and yelled, "Fill me up!"

a mini-antenna for 160 meters

It's unfortunate that a halfwave antenna for 160 meters has to be so big. Walt Bollinger, AF3V, must have thought about this as he tried to put out a reasonable signal on that band from a small lot. His solution to this problem is shown in **fig. 3**. This configuration is a loaded Marconi antenna whose overall length is about 50 feet (15 meters). It is mounted about 20 feet (6 meters) above the ground. A 6-foot (1.8 meters) ground rod is used in conjunction with a 65 foot (19 meters) long counterpoise wire running beneath the antenna, just below the surface of the soil. As illustrated, the antenna operates over the range of 1.8 to 1.825 kHz with an SWR figure of 1.5-to-1 or less. If a variable capacitor is connected in series at the feedpoint (X), the antenna will operate over the rest of the band with low SWR. The approximate capacity necessary to achieve this without exceeding the 1.5-to-1 SWR is as follows: 1.85 to 1.92 MHz, 700 pF; 1.92 to 1.97 MHz, 450 pF; 1.97 to 2.00 MHz, 350 pF.

Walt uses a three-gang variable capacitor long ago removed from an old tuned-RF broadcast receiver (QRP only). It has three 365 pF capacitors on a common shaft. "For its size," Walt

says, "I think this antenna will surprise most everyone. It seems reasonably omnidirectional and provides me with a lot of fun on the 'top band'."

a rectangular loop antenna for 80-10 meters

Walt, AF3V, checks in with a second interesting multiband antenna **fig. 4**. A rectangular loop in the vertical plane, its overall length is about 58 feet (17.6 meters) with the bottom wire about 7 feet (2.13 meters) above ground. Its unique feature is the knife switch (SW) placed across the insulator in the center of the bottom wire. Easily reached, the switch permits the operator to change from an open loop to a closed one quickly. The feedline is a home-made, open wire line about 42 feet (12.8 meters) long. It drops down vertically to within 8 feet (2.4 meters) of the ground and then extends horizontally to the station, perpendicular to the plane of the antenna. The antenna is adjusted to resonance by means of an old Johnson "Matchbox" tuner. The antenna switch is closed for operation on 7, 10, and 21 MHz and is open on the other bands. With a different length feedline, different switch settings may be necessary.

Walt supports the center of the top section to offset the weight of the feedline. He says that the antenna outperforms the center-fed horizontal wire that he had previously and reports that the pattern appears reasonably omnidirectional on all bands.

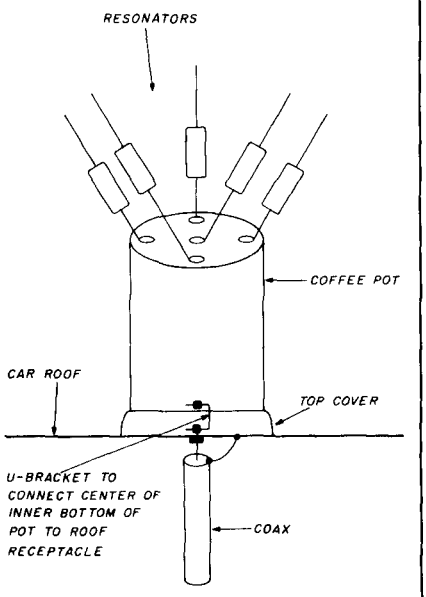

fig. 2. Coffee-pot is screwed to cover which acts as a base insulator. U-bracket fixes bottom inner section of pot to existing VHF antenna base in middle of station wagon roof.

a simple antenna for 40 and 30 meters

Many Amateurs say they enjoy the 30-meter (10 MHz) band because there are no disconcerting contests on it and because it's possible to rag-chew with a DX station without having a horde of eager beavers making rude noises on the frequency, unhappy that they're thwarted in their search for a "new one."

Harvey Hunter, W8TYX, enjoys 40- and 30-meter operation with the simple antenna shown in **fig. 5**. Basically, it consists of a 30-meter ground plane antenna, roof-mounted, with a ground screen of 60 radials. The radials also serve with the 40-meter antenna, which is mounted a few feet away from the 30 meter whip. About 5 feet (1.5 meters) of the 40-meter antenna is vertical; the remainder is more or less horizontal, about 25 feet (7.62 meters) above the ground.

Slightly longer than a quarter-wavelength, the 40-meter wire antenna has a feedpoint impedance of close to 50 + j50 ohms. A good match to the 50-ohm transmission line is achieved by using a series capacitive reactance of −j50 (450 pF) between the feedline and the base of the antenna.

The 30-meter antenna has a feedpoint resistance of about 35 ohms, so a simple L-network is used to match it to the transmission line. The antenna adjustments are slightly interactive, but tune-up using an SWR meter quickly compensates for that.

the "hy-tower" antenna operates 160-10 meters

The many Amateurs who have the "Hy-Tower" vertical antenna may find the automatic tuning arangement for multiband operation used by Paul Scholz, W6PYK, of interest. The scheme should work well for any vertical antenna over 35 feet (10.7 meters) high.

The basic network, shown in **fig. 6**, consists of a series-connected LC circuit (L1, C1) in parallel with a second inductor (L2). The series network is adjusted for minimum SWR on 75 meters with the parallel inductor set to maximum value. The last step is to adjust the parallel coil for resonance on the 160-meter band. The two adjustments don't interact if the 75-meter adjustment is done first. Operation of the antenna is normal on the higher frequency bands.

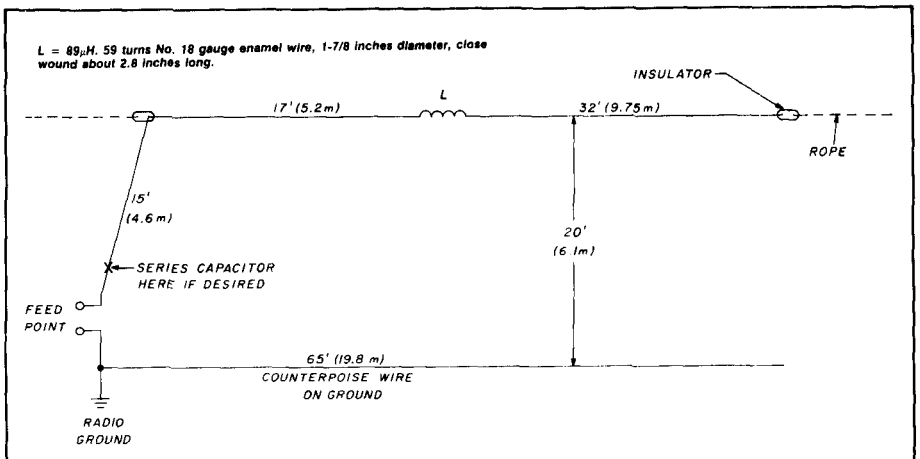

fig. 3. The compact 160 meter antenna at AF3V.

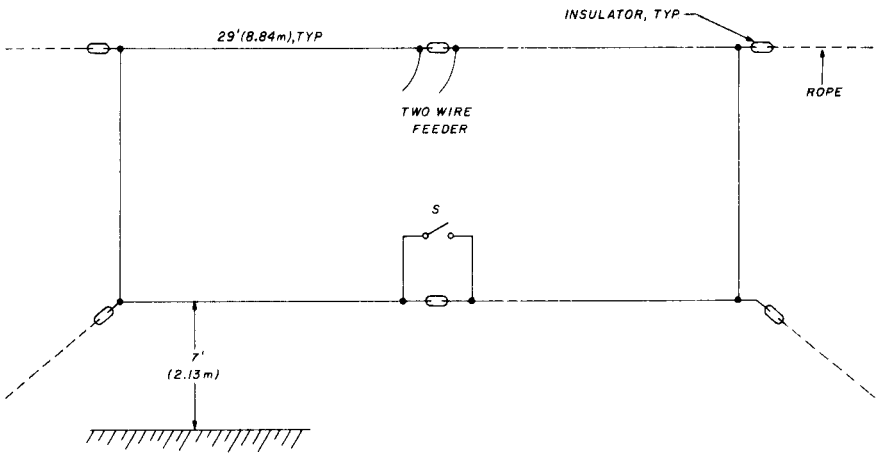

fig. 4. The multiband loop at AF3V. Switch permits operator to change from open loop to closed loop. Loop operates on all bands between 3.5 and 29.7 MHz.

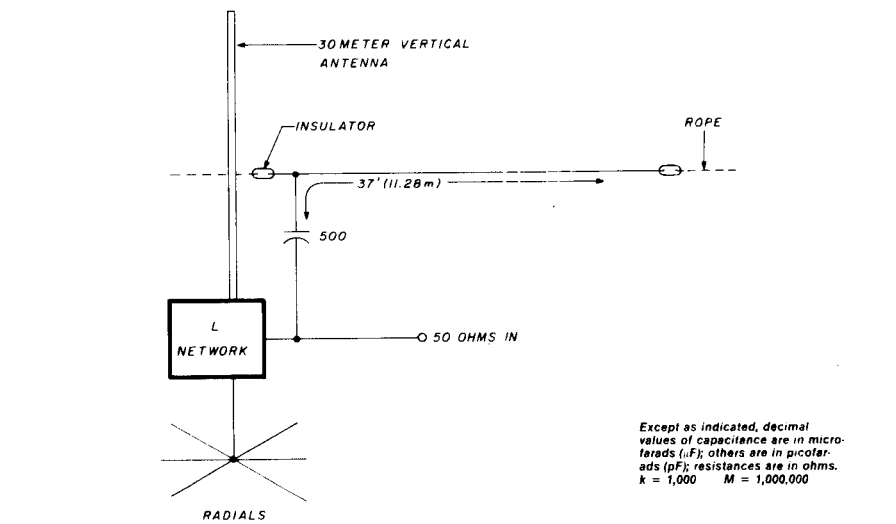

fig. 5. Two-band antenna for 40 and 30 meters used by W8TYX.

For 75-meter operation, a range of 200 kHz is obtained between the 2-to-1 SWR points. On 160 meters, operational bandwidth is about 50 kHz.

Although Paul recommends the component values shown in **fig. 6**, he has a computer program that provides component values for different LC ratios in the network. For low-power operation, 5 kV transmitting-type mica capacitors can be used; for high power, he recommends a variable air capacitor with 0.125 inch (3.2 mm) spacing.

a rugged, long-life quad

Many exasperated Amateurs have wondered how it's possible to keep the Quad antenna alive and well year after year. The common weak point of many Quads is the junction between the wire and the Quad arm; the wire tends to either break at this point or "saw" its way through the Quad arm.

In my February, 1986, column I suggested one way of easing this vexing problem. I recently received a communication from Paul Atkins, K2OZ, suggesting a different (and simpler) technique that has permitted his Quad to stay aloft for over 13 years. On the advice of a friend in the wire business, Paul rebuilt his Quad with silverplated teflon-coated wire. The teflon coating sheds water easily and retards ice buildup. The manner in which he attached the wire to the Quad arm is shown in **fig. 7**. The teflon covering is removed from the Quad wire about 10 inches (25 cm) out from each arm. The slug of teflon removed is about 2 inches (5 cm) long. A thermal stripper is recommended. Next, two pieces of No. 14 tinned copper wire long enough to be twisted in opposite directions are tightly wrapped around the wire element. Using a large iron, the ends of the twisted wires are soldered to the stripped portions of the antenna element. Run solder over the connections to stiffen them. This brings the moment arm away from the spreader arm and minimizes flexing at the point the element is secured to the spreader. Finally, the flux is wiped off the connections, which are then wrapped with

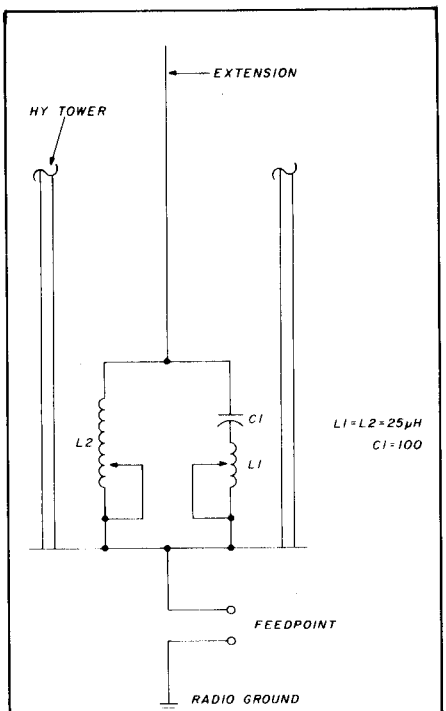

fig. 6. The two-band network used by W6PYK for automatic 160 meter operation of his "Hy-tower" antenna. Network operates as an electrical switch.

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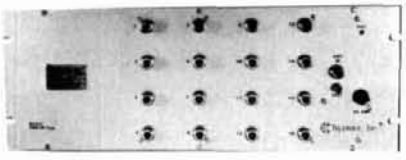

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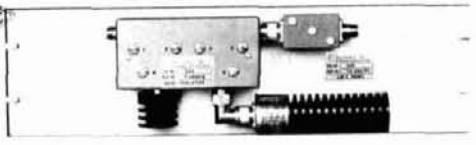

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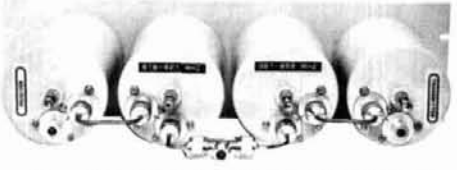

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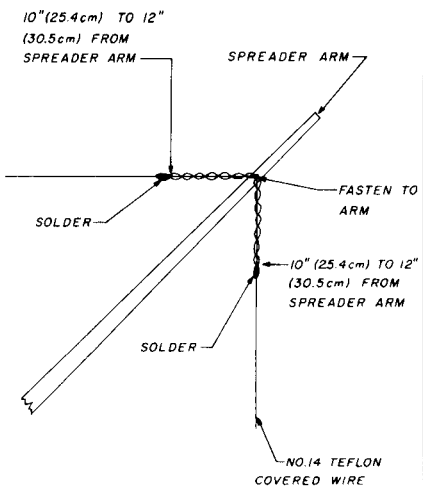

fig. 7. Quad wire is strengthened by twisted No. 14 wires wrapped around it and soldered about 10 inches to 12 inches from spreader arm. Installation at K2OZ has been up for over 13 years.

tape to protect the exposed soldered joint from the weather.

The final addition to Paul's Quad was to tie the driven element to the reflector element with polyethylene cord. The tie is made near the tips of the spreaders to keep the arms from distorting too badly in high winds or under heavy ice loading. The black polyethylene cord — about 1/8 inch (0.32 cm) in diameter — is still in service.

the 40-meter DX beam at K6NQ/7

Forty-meter DX operators have heard the strong signal of Jim Villasana, K6NQ/7. This is a tough band for serious DX competition because some of the "big guns" use multielement Yagi and Quad beams. Great antennas, if you have the time, money and space to put 'em up!

Jim's solution to the 40-meter DX problem is to use two sloper dipoles hung from a 140-foot (42 meters) fir tree and fed 270 degrees out-of-phase (**fig. 8**). The slopers are at a 45 degree angle with respect to ground. The centers of the dipoles are at the same height. This places the top ends of the dipoles at 100 feet (30.48 meters).

The dipoles are fed with equal lengths of RG-8X coax (230 feet/70.1 meters) and the phasing of the reflector element is accomplished by adding an extra 3/4 wavelength of line (approximately 86 feet, or 26 meters) coiled up inside the operating room.

While Jim has tried various other antenna arrangements, he finds that this simple antenna works best for DX. Dismayed to find that the array exhibited little gain on short-haul contacts, he was amazed at how well it worked on long-haul DX. He found, to his gratification, that his 7-MHz signal was as strong in Europe as those of other west coast DXers running high two- and three-element Yagi beams. On very good openings, the simple

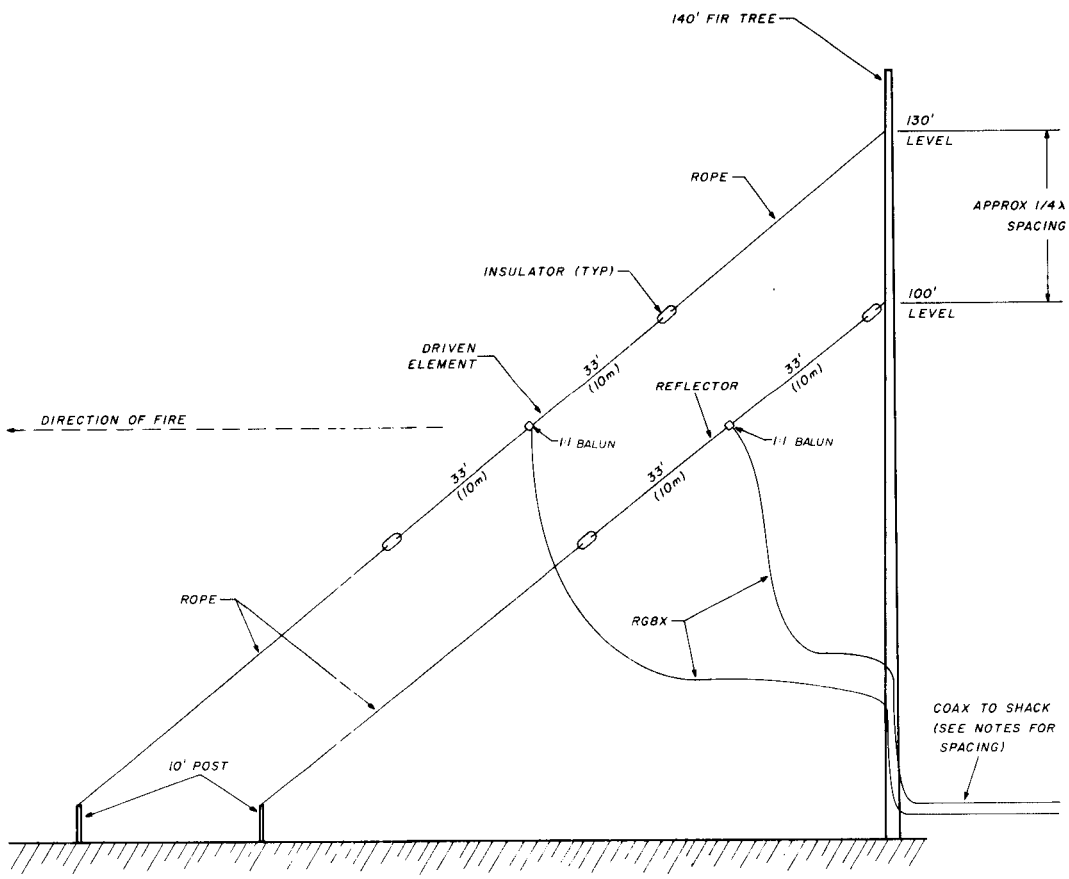

fig. 8. 140 foot high fir tree in yard of K6NQ/7 provides support for "hot" 40 meter beam!

sloper antenna was better than 1 S-unit over competitive Yagi antennas located at the 120-foot (36.6-meter) level.

Its beam pattern is broad enough to cover Europe and Northern Africa; Jim estimates about 90 degrees beamwidth to the −3 dB points. He tried several phasing schemes to get the required 90-degree phase difference and found out the hard way that the best results were obtained when the rear element used 3/4 wavelength phasing.

Jim wishes he had the room to string up two or three arrays of this type to get full coverage, but that will have to wait until he has more real estate. Meanwhile, he does a fine job with a very inexpensive antenna!

the British "zip code"

Some time ago I admitted that the British Postal Code was a mystery to me — and to most other Amateurs as well, I suspect. Jim Miller, G3RUH, very kindly sent me a Post Office brochure explaining the system in such a lucid manner that even I could understand it. (The Canadian code works on the same principle, I am told).

In brief, the code is a simplified address, with each part of it focusing on a progressively smaller area. The United Kingdom is divided into 120 areas, each being identified by the first two letters of the code. As an example, the code MK42 8LA is given. The MK indicates the Milton Keynes area of England; the 42 stands for a district within the Milton Keynes area; the digit 8 indicates a sector in district 42; and the LA designation identifies the street. The code is read by a machine which converts it to two rows of blue dots imprinted on the envelope. The dots, in turn, are read by a mechanized system which sorts it on its way. Thus, the code helps identify an individual person on a particular mail route! It's also often imprinted on bicycles, automobiles, and other vehicles to assist in the return of stolen property.

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Additional copies of "Design Considerations for Linear Amplifiers" are at hand, too. For a copy, send four first-class stamps or four IRCs to me at the above QTH. Ask for Bulletin AS-53.

Finally, copies of the 144-MHz EME Directory (AS-49-37), which lists worldwide EME operators, their QTHs, and station equipment, are available for five first-class stamps or IRCs.

ham radio

short circuits

narrowband filters

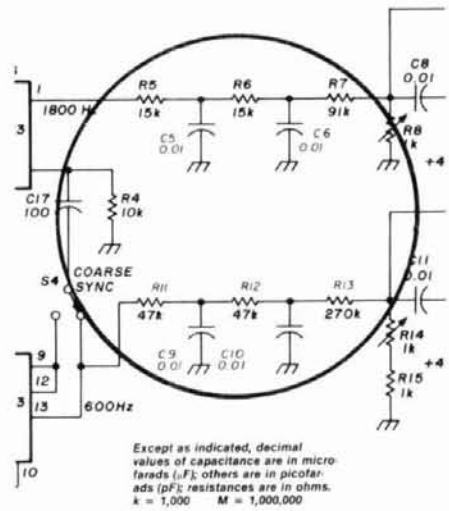
In WB4EHS's March article, "Build Narrowband RF Filters (page 10), the word "smaller" in the second sentence on page 14 should be changed to "larger."

In the program listing on page 15 (**fig. 7**), **line 145** should be corrected to read as follows:

```
145 INPUT O:IF O<1 OR O<5
    THEN GOTO 145
```

signal generator

Values for four capacitors and labels for three resistors were omitted from **fig. 8** of YB9ATA's article, "Two-tone Signal Generator" (February, 1986, page 26). The corrected portion of the schematic is shown below.



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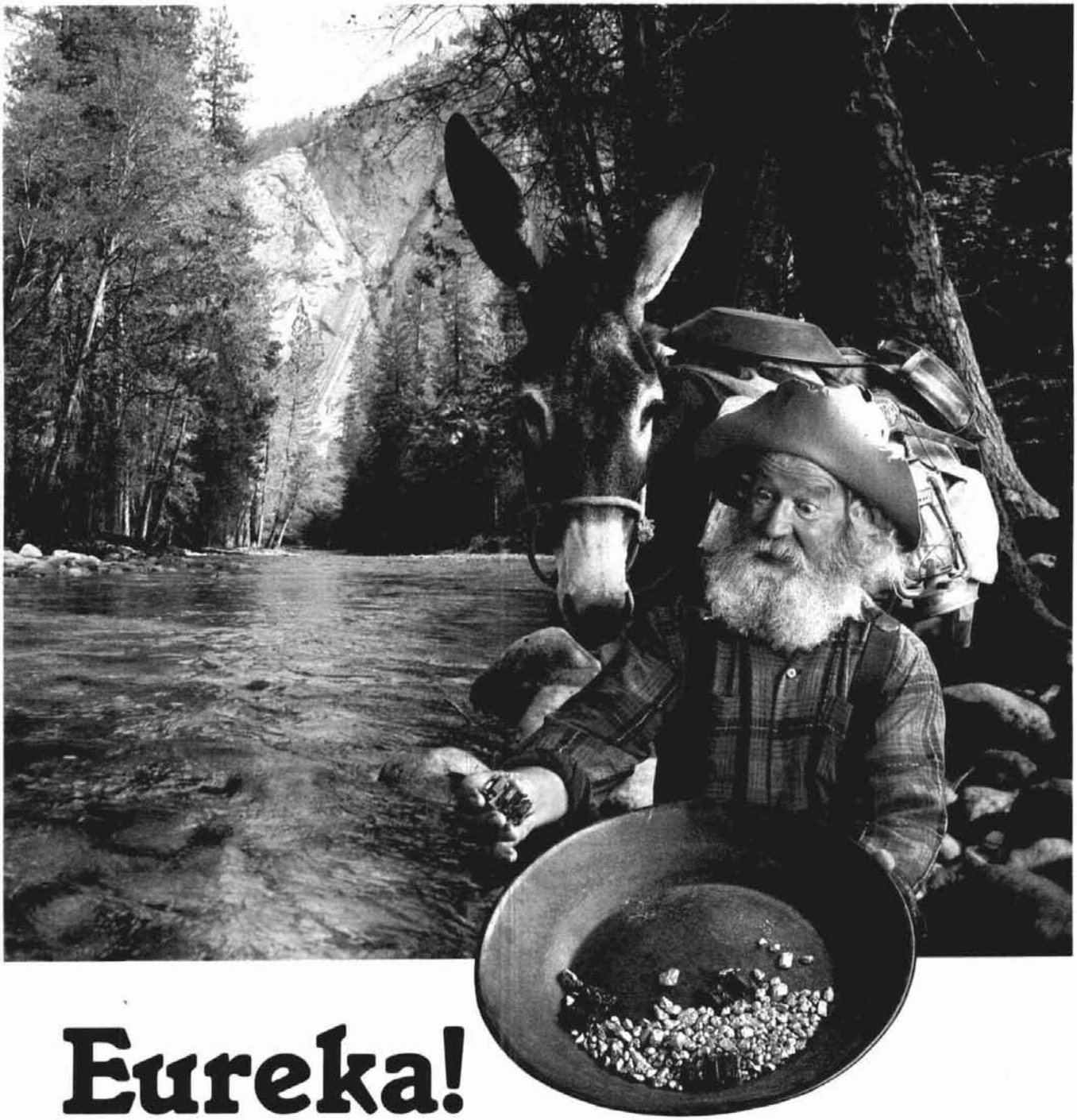

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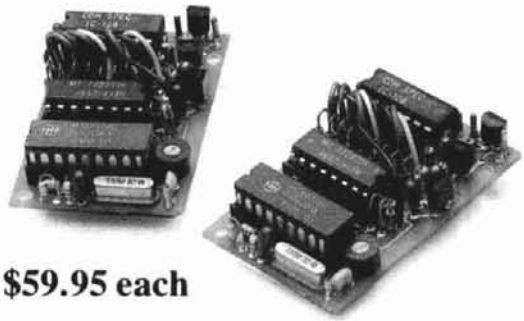

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make a homebrew sheet metal brake
for chassis construction projects

Save time, money — and build a better box

Radio Amateurs have been bending aluminum at home for years, making brackets, panels, and boxes for electronic construction projects. Light weight, workability, good corrosion resistance, and electrical conductivity make aluminum an ideal material for small hand-fabrication projects. But classical bending techniques that require a hammer, vise, and pliers can result in dents and scratches, and extra work straightening undesired bends.

This article describes how to make a sheet metal bending tool that makes quality bends in thin metal without damage. The tool is made with just a few dollars worth of steel angle stock and some common household hardware.

Because the correct choice of material is important, information is included to enable you to identify aluminum alloys for bendability, strength, and corrosion resistance. A construction project of a small box is included as an example.

bending theory

Figure 1 shows the physical arrangement required to bend sheet metal without causing deformation in areas other than the bend. The bar holds the workpiece to the table while the leaf forms the corner around the bar's "knife edge." The major objective illustrated in **fig. 1** is to maintain a precise hinge centerline between the moveable leaf and fixed table at the bend corner. **Figure 1B** shows the direction of maximum bending force at the completion of the bend. The leaf must be rigid and the bar must be held securely to maintain a consistent bend radius along the work.

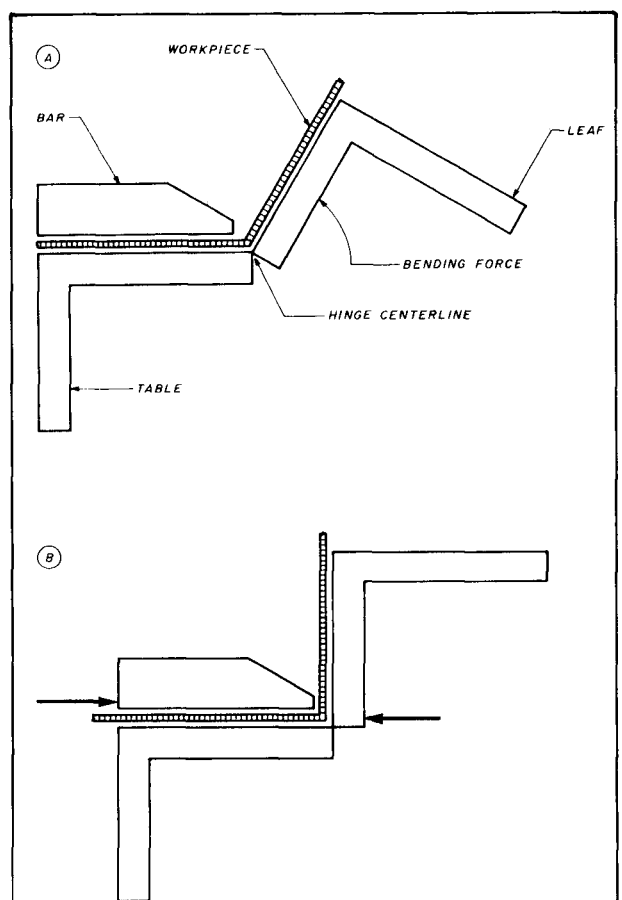


fig. 1A. Basic bending mechanics diagram. fig. 1B. Direction of maximum force.

By Cliff Klinert, WB6BIH, 1126 Division Street, National City, California 92050

table 1. List of aluminum alloys with zero bend radius (wrought sheet 0.062 inch (1.6 mm)-thick cold bent, 90 degrees)

Alloy	Yield Strength (psi)	Corrosion Resistance
1100-0	5000	A
1100-H12	15000	A
1100-H14	170000	A
2014-0	14000	D
2024-0	11000	D
3003-0	6000	A
3003-H12	18000	A
3003-H14	21000	A
5005-0	6000	A
5005-H12	19000	A
5005-H32	17000	A
5005-H14	22000	A
5005-H34	20000	A
3004-0	10000	A
3004-H32	25000	A
3004-H34	29000	A
5050-0	8000	A
5050-H32	21000	A
5052-0	13000	A
5652-0	13000	A
6061-0	8000	B

Note: Corrosion resistance is given in decreasing merit from A to D. Metal with an A or B rating can usually be used outdoors without protection. A D rating indicates that protection is required to prevent corrosion. Data was compiled from references 1 and 2.

We will later see that this can be a limiting factor in bending thicker or stronger material.

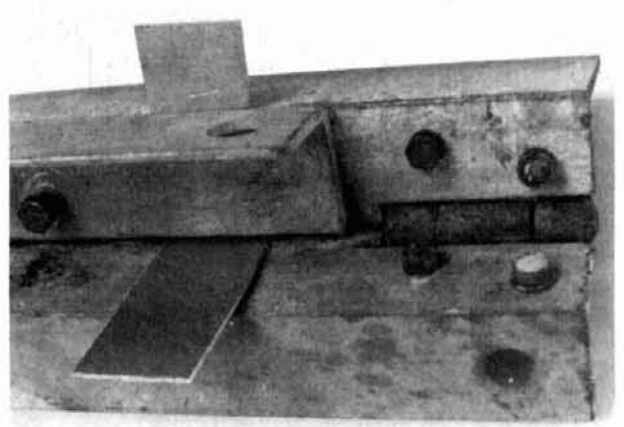
selection of alloys for bending

Availability of the correct material may limit the practicality of homebrew sheet metal projects. To determine which materials will be bendable, it helps to understanding the use of *alloy numbers*. The most common system of alloy numbers uses a four-digit alloy number followed by a combination of a letter and numbers that indicate the temper or hardness. The two major types of hardening are the "H" (strain hardened) and "T" (thermal hardened) processes. In the strain hardened system, the H is followed by two or more numbers, the second of which indicates the relative hardness of the material. The T in the temperature hardening system is followed by one or more numbers, the first of which indicates the relative hardness. If the four-digit alloy number is followed by an "0," the material has been annealed to make it as soft as possible and is readily bendable. The 0 material is soft for easy forming with the possibility of being hardened later. Incidentally, material marked "alclad" is covered with a thin layer of relatively pure aluminum for extra corrosion resistance.

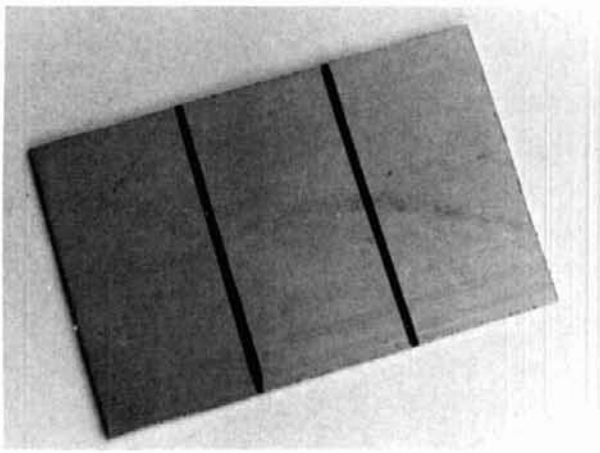
The most desirable alloy used for bending and forming is 3003-H14, which combines optimum strength and workability, making it the ideal material for box and chassis construction. The "3003" indicates that this series of alloys is strain hardened without any subsequent heat treatment. The first temper digit, "1," indicates strain hardening without any subsequent heat treatment. (Another digit in the first position, such as a "3," could be used to indicate a low-temperature thermal "soak" to improve ductility.) The "4" indicates the relative hardness. A higher number denotes a harder material.

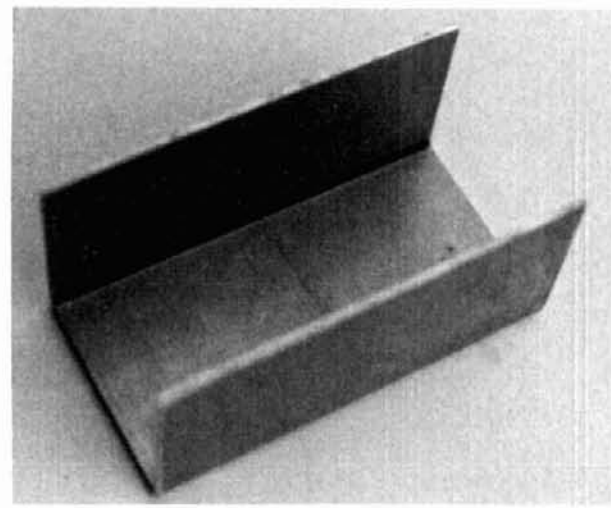
Table 1 is a shopping list of alloys appropriate for bending[1,2]. Since low cost is almost always a consideration, the best source of materials in small quantities will usually be a salvage or surplus store. Aluminum manufacturers typically require a $300 minimum purchase, and hardware store material is usually quite expensive in the small quantities required. For best results, take a pair of gloves, a tape measure, and a copy of **table 1** to all the metal salvage yards in your area. Prices should range from 75 cents to $1.50 per pound. Sheets are marked in alloy numbers (as shown in **table 1**) and thickness in thousandths of an inch. The optimum thickness is ".040" (1.02 mm). If a sheet is not marked, try to bend a corner with your fingers to determine bendability. You'll usually be expected to buy the entire piece, and cutting service may or may not be provided. Cutting may cost from 50 cents to a few dollars, so you may wish to take some sort of cutting tool with you if you want to buy a piece too large to carry home uncut.

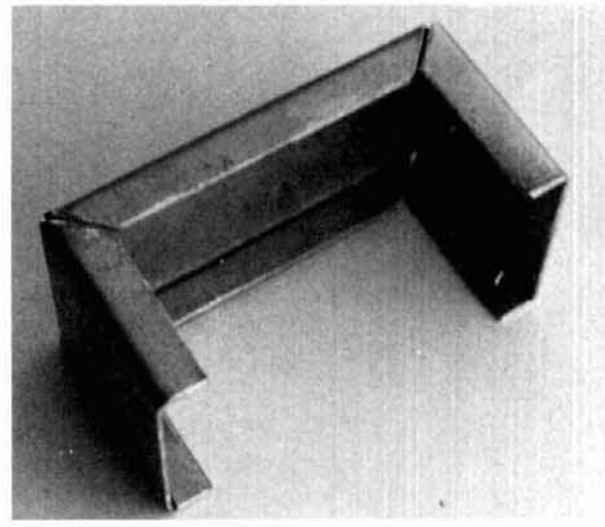
Salvage steel angle stock for making the bending tool should be available for ten to 25 cents per pound. The type of industries in your area will determine the type of salvage material available. Please note that "3003-H14-.040" is the optimum material for our projects. Thicker or harder material may produce bends with larger radii and make more crude-looking parts.

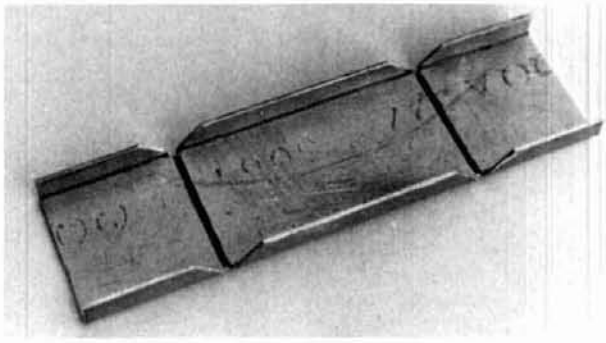


The construction of the bender, location of the hinges, attachment of the bar with bolts, and a small piece of sheet metal being bent.







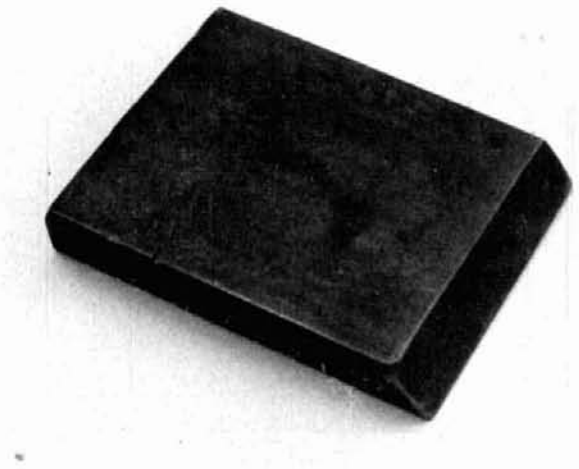


The bend sequence for making a small box. The material was 6061-00.062 thick, somewhat too thick for making precise bend corners. Note that a small hole was drilled at the intersection of the double bends to allow space for the material thickness.

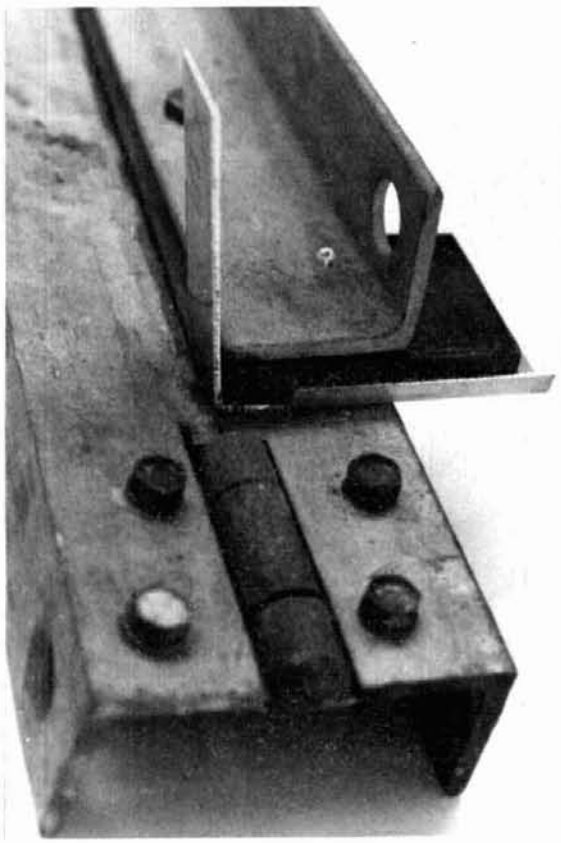
building the bender

The photographs show how the bender was assembled from angle steel and two door hinges. The overall width was about 3 feet (1 meter). You can select dimensions appropriate to the material available. The wider the bender, the more likely it is to warp in use. The photographs were taken to illustrate the geometry of the bender as shown in **fig. 1A**. Depending on the shape of the hinges used, the ends of the angle stock must be notched for clearance. In shimming the hinges with washers, locating the hinge centerline required some patience.

The corners were cut with a circular saw using a metal cutting blade (i.e., a carborundum disc). Grinding or filing the angle steel edges along the hinge centerline to produce a square corner is optional since even a fairly crude tool will produce good results with the right material. The "bar" is another piece of the angle steel bolted to the table. The bar could be secured with C-clamps, but the bending force shown



This piece was cut from a steel bar to allow making a double bend.



The die can be used to accomodate a part that has been bent in the opposite direction. The edge of the die is shown for clarity, but would normally be mounted between the two bolts holding the bar to the table.

in **fig. 1B** may cause the bar to slide away from the leaf when you bend stronger material. You may wish to reinforce the leaf by bolting another piece of steel behind it, if you have problems with warping later. Clamp the table in a vise, attach Vise-grip® pliers to the leaf for handles, and the bender is ready for use.

making a box

Obtain a sheet of bendable alloy and cut some pieces for practice bends. Mark bend lines on the aluminum as shown in the photographs. Some practice will be necessary to determine where to place the material relative to the bend line and to anticipate the amount of springback in the bend angle. You can use tin snips or a nibbler; most wood sawing methods (using power tools) can be applied to aluminum as well. A bandsaw is ideal for thin material, and a circular saw with a plywood cutting blade is excellent for thicker sheet. A router works well for trimming or shaping, and most of the bendable alloys can also be whittled with a pocket knife. Use paraffin to lubricate the blade, wear ear plugs, and observe the normal safety precautions.

The photographs illustrate the sequence of bends for making a small box. A die was made from a piece of steel bar with an angle cut for a knife edge. (The size of the die determines the size of the box to be bent.) The die was used as a "finger" in a pan brake to make a bend perpendicular to a previous bend. The bar in a pan brake is made of several removeable fingers in various widths to allow for making double bends like this.

It is common to etch the finished part in a lye and water bath to produce an attractive finish. If lye is not available, welding supply stores sell aluminum cleaning solutions that work faster, but are somewhat more expensive. A quart bottle of cleaning solution costs about $5, but it can be diluted in water for several uses. Be sure to follow the safety instructions of the bottle since these solutions may contain a very powerful acid. Alloys receiving an *A* or *B* corrosion rating in **table 1** require no further treatment to prevent destructive corrosion for several years of use. A coating of clear lacquer or acrylic spray may be used to protect the porous metal surface from stains and cosmetic corrosion.

conclusion

I don't expect anyone to start manufacturing chassis boxes at home; the process is far too time consuming. The main point in having a simple bending tool is to enable you to fabricate a special part in a size and shape not available commercially, with a professional, high-quality appearance.

references

1. *Product and Data Catalog*, Reynolds Aluminum Supply Company, free to Reynolds customers at Reynolds distributors.
2. *Metals Handbook*, 8th Edition, Volume 1 (of II volumes), American Sociey for Metals, Metals Park, Ohio, 1977.

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Rise & Fall Time	5 nsec
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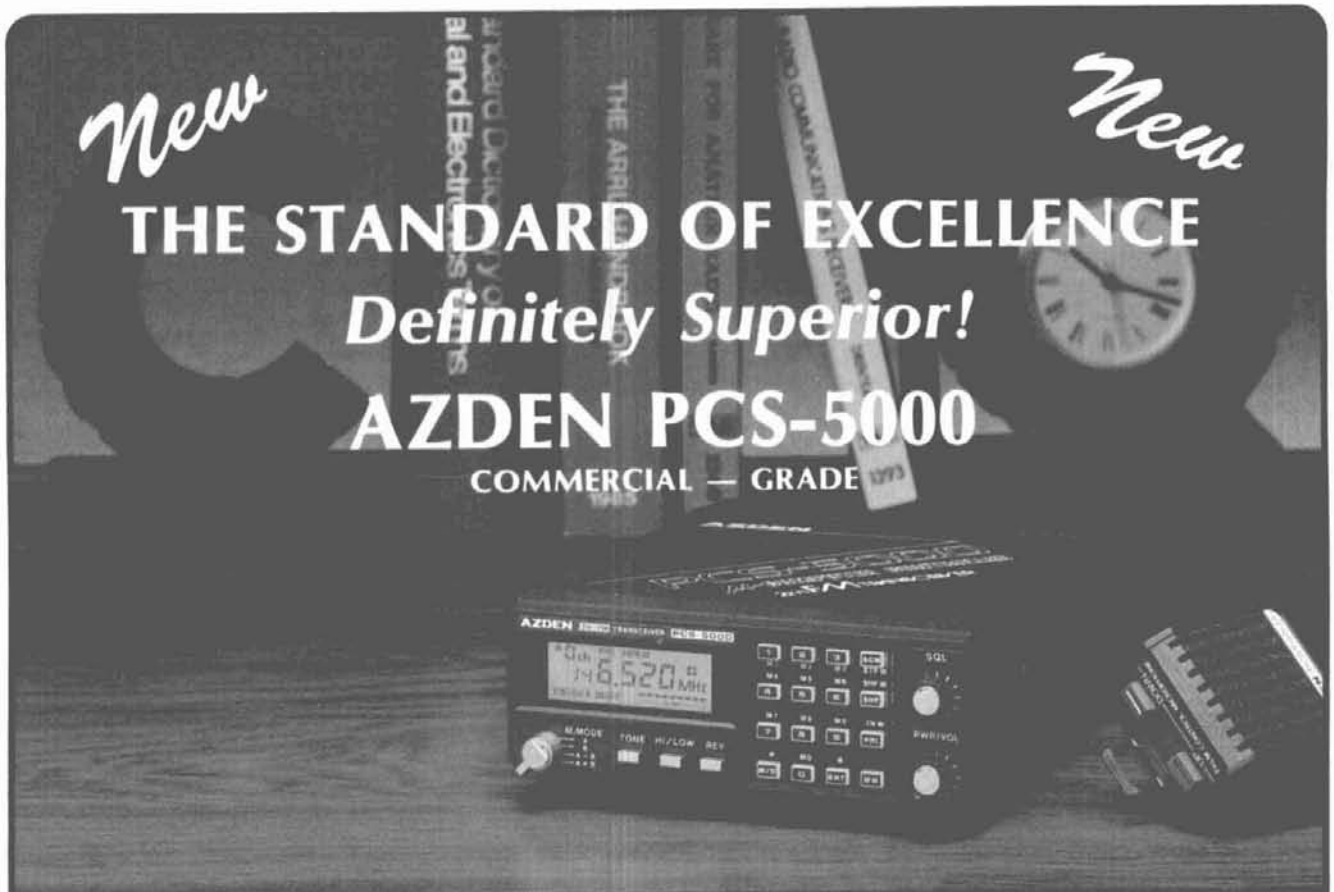

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a regulated screen grid power supply

An easy-to-build solid-state design using Motorola's new TMOS power-FET technology

For about the last 20 years, the most common type of amplifier used by hams has been the grounded-grid, class AB2 linear, sometimes erroneously referred to as "Class B." In Class B operation, no quiescent plate current is drawn; Class AB2, on the other hand, has quiescent plate current. Both classes run grid current when a signal is present. If there were no idling current in a grounded-grid amplifier, it wouldn't be linear. There is no such thing as a single-ended "grounded-grid Class B linear."

Every linear amplifier type has some advantages and some tradeoffs. One advantage of a grounded-grid amplifier is that it supposedly does not need to be neutralized. This is probably true for 813 tubes, which wouldn't take off and oscillate on a VHF parasitic frequency even if you wanted them to. An 813 doesn't even like to work at 29 MHz. Tubes such as the 3-500Z are designed to amplify well, or oscillate, at 100 MHz.

During the last ten years I have been involved in more than 30 cases of amplifier repair. More than 80% of these failures involved damage from parasitic oscillation in grounded grid amplifiers that supposedly do not need to be neutralized. A stable grounded grid amplifier design is not as easy as the popular literature on the subject indicates. This subject is covered in detail in the April 1986 issue of this magazine.

Another advantage of the grounded-grid configuration is that no screen or control grid bias supplies are needed. Control grid bias supplies are simple for Class AB-1 grid-driven amplifiers, since, typically, no current flows. Screen grid supplies are a different matter because they must also furnish current — sometimes over 100 mA. One disadvantage in grounded-grid operation is that separate tuned inputs must be constructed for each band in use.

The grid-driven linear offers certain advantages. A separate tuned input is not required for each band, and up to approximately 23 dB of amplification can be obtained instead of the typical 12 dB gain from grounded-grid. This means you can drive a legal-limit amplifier with a 10-watt QRP transceiver. To do this you'd have to neutralize the amplifier; this would complicate the grid input circuit because the easy, 50-ohm grid swamping resistor circuit would not work. One disadvantage, however, is that you'd have to build a high-voltage screen supply. For a 4-1000A, a screen voltage of 1000 volts is required for Class AB1 linear amplifier service. With 6000 volts on the plate, this tube will deliver 1500 watts output. Another good tetrode for ham service is the 4CX1500A, which requires up to 750 volts for the screen grid.

The choice between grounded-grid and grid-driven Class AB1 would have to go to grounded-grid up until the World Administrative Radio Conference of 1979; until that time, amplifiers were in use on only about five Amateur Radio bands below 30 MHz, and building five tuned inputs for the common grounded-grid Class AB1 amplifier posed no problem. The advantages of using grid-driven Class AB1 amplifiers were not yet apparent, especially in light of the grief of building a regulated high-voltage screen supply. Most people would rather build the separate tuned inputs for the simpler grounded-grid triode circuit than use the inherently broad-band Class AB1 input circuit.

Today amplifiers are used on eight Amateur bands below 30 MHz, and can be used with reduced output on the 30-meter band. In a while we'll have nine bands on which amplifiers can be used below 30 MHz. Building nine separate Pi-networks requires 27 components

By Richard Measures, AG6K, 6455 LaCumbre Road, Somis, California 93066

and a rare nine-position bandswitch; in comparison, the Class AB1 input circuit begins to look very simple. Perhaps building a screen supply isn't really that much of a problem after all. . . .

For the Amateur who is also a MARS member, the new general-coverage transceivers are a blessing. A general coverage amplifer would be a nice accessory for a general coverage transceiver.

to regulate or not

According to Eimac, "The power output from a tetrode or pentode is very sensitive to screen voltage. For this reason, any application requiring a high degree of linearity through the amplifier requires a well-regulated screen supply."[1]

For some small tetrodes, it's possible to use gas voltage regulator tubes. For larger tetrodes with higher than about 25 mA of screen current the VR tube isn't practical; a better choice is a conventional series pass regulator circuit, which offers the added benefit of adjustable screen voltage, to either control power output or to set the idling plate current to the desired value, a nice feature for those times when 100 watts isn't enough, but 1500 watts is too much. If a roller-coil is used for the plate tank inductor, a general coverage 1.8 to 30 MHz amplifier is yours. The only band-switching operation needed is that of adding loading capacitor padders for frequencies below about 5 MHz.

With the common grounded-grid amplifier, reducing power is not easy; in a Class AB1 amplifier, it's simple. Series pass transistor regulator circuits are used in 12- to 14-volt power supplies for Amateur transceivers and other low-voltage applications. Screen supplies for Class AB1 amplifiers typically must provide between 500 and 1500 volts. Until recently, a regulated supply for these voltages required tube circuits because transistors couldn't handle the required voltages and currents.

Bipolar transistors that would handle high voltages, at low current, for TV applications have been around for some time. The Motorola BU207 was one example. It could withstand either high voltage (up to 1300 volts) or high current — but not both at the same time, because of secondary breakdown effects: a 1500-volt, 8 ampere bipolar may be able to hadle only 0.2 amps at 200 volts. Your 100-watt transistor is now a 40-watt transistor. Three transistors are required for 100 watts dissipation. High voltage bipolar transistors have another trade-off: low current gain. So you need a driver transistor to provide high base current. It was possible to use bipolars in high-voltage regulated supplies, but it took a bank of them to form the series pass element. (The first high-voltage regulated supply I built used six BU207 bipolars to produce 1500 volts at 0.2 amps. It worked, but it wasn't as simple as I'd have liked it to be.)

There has been progress, however. Just as FET RF power transistors are taking over jobs from bipolars, the high-voltage FET is now available for use in high-voltage applications such as regulated supplies. Motorola is using this new technology in its TMOS power FET. The TMOS offers high gain and virtually no secondary breakdown problems that would reduce the dissipation rating.

A TMOS FET is similar to a triode electron tube; the more positive the control element, the more current flows in the load. Tubes have some nasty disadvantages: they lose linearity when the control grid goes positive and start to draw lots of grid current at the same time. TMOS devices don't exhibit this effect. The gain of a triode is rated in micromhos — or more recently, in microSiemens. A triode with a transconductance of 25,000 micromhos is considered a "hot" tube.

The TMOS device I used to construct the power supply for this article has a transconductance of about 500,000 microSiemens in its linear range. As you may have guessed, the device drives so easily it can be a problem to keep it from taking off unless you swamp the control gate with a resistor and a capacitor.

design considerations

In a typical 13.8-volt supply the filter capacitor is charged to about 22 volts. If a short circuit were placed across the output, 22 volts would appear across the pass transistor — until the fuse in the primary burned out. In a 1500-volt supply the filter capacitor can be charged to 1900 volts in the no-load condition. In this case a short would place 1900 volts on the pass transistor. Twenty-two volts isn't a problem for a typical 40-volt bipolar, so no protection is needed; 1900 volts, however, is a completely different matter. To protect the high-voltage power supply series pass element from short circuits, some kind of pass element crowbar is required. I used an SCR whose gate is fired by a string of zener diodes when the voltage gets into to danger region above 520 volts difference across the pass element. Since it takes about 2 microseconds to fire the SCR, an RC delay circuit is used (R3C1) to protect the pass element while the SCR is reaching threshold. R2 limits the current through the SCR to less than its rated 160 peak amps. R2 is 10 ohms for up to 1000 volts output and 20 ohms for up to 2000 volts output.

The voltage rating of the pass element needs to be slightly greater than the difference between no-load voltage across the filter capacitor and the desired regulated output voltage. Naturally, the power supply must provide enough voltage at full load or regulation is not going to occur. In addition, the product of current and voltage across the pass element must not exceed its dissipation rating.

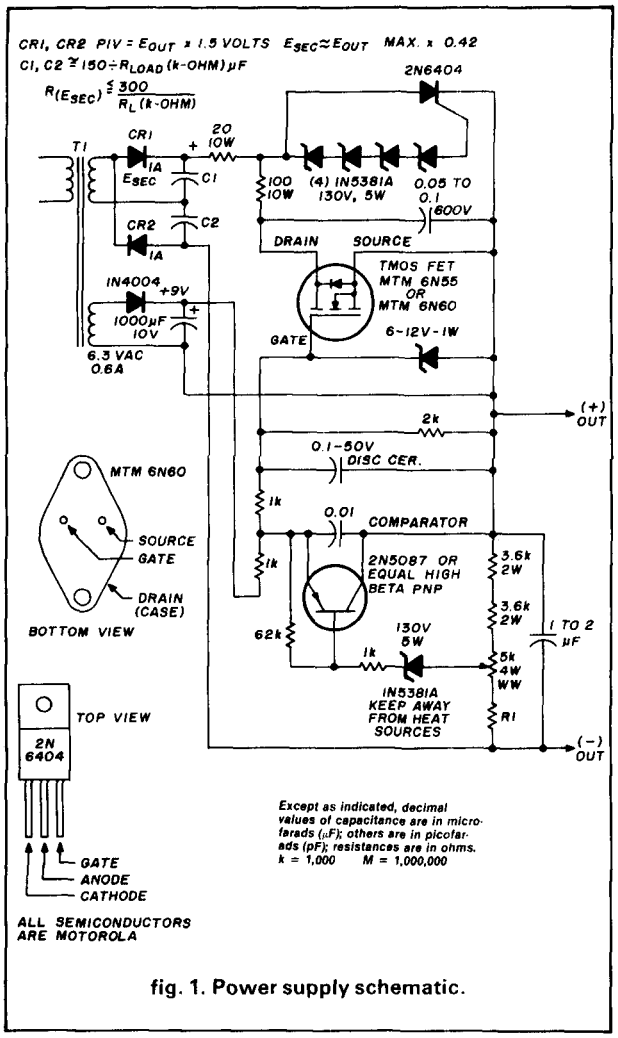

fig. 1. Power supply schematic.

Most capacitor filter power supplies see a voltage drop of about 15 per cent from no-load to full load. This means that the pass element needs to withstand only about 15 percent of the output voltage plus a small safety factor. A 600-volt pass element can easily regulate a 3000-volt supply. The highest rated voltage available in the Motorola TMOS series is 1000 volts, which means you could build a regulated 5000-volt supply with an output current of 2 amps if you needed one. To achieve the current requirement it would be necessary to parallel some TMOS devices and connect equalizing resistors of a few ohms in each source lead. The comparator circuit, Q1, is simplicity itself, since no driver transistor is required for the TMOS pass device.

circuit operation

The positive output terminal is the common reference point, or circuit common. When the output voltage rises to a high enough negative value V_z begins to conduct, causing Q1 to conduct. This increases the voltage drop across R4, causing the gate voltage of Q2 to be less positive, which causes Q2 to conduct less. If Q2 is conducting less, then the output voltage begins to fall because of the increased voltage drop across the pass element. As the output voltage falls, V_z conducts less, causing Q1 to conduct less. This causes Q2's gate to go more positive. Q2 conducts more heavily, causing the output voltage to rise again. The process repeats and regulation results.

The threshold voltage for turn-on/turn-off is determined by the voltage division ratio of the R1, R5, R6 voltage divider and the V_z zener voltage. R6 is adjusted to the desired output voltage as long as not much more than 500 volts is dropped across the pass device. Setting the output voltage too low fires the pass-protect crowbar, causing the output voltage to rise to the voltage on the power supply filter capacitor less about 1 volt. At this point you need to turn the power off and on, unlocking the crowbar, and then make a mark on the R6 scale to indicate how low you can go. Starting the power supply with a heavy load in place will also fire the crowbar. This isn't a problem in screen supplies because the amplifier won't be operated until the final amplifier tube's filament comes up to temperature. This is about 1 second for a 4CX1500A. If you want to be able to start with a heavy load connected, you'll need to add one or more zener diodes from the drain to the gate of Q2 to start conduction when the voltage drop is about 20 volts less than the crowbar trigger voltage.

performance

The load regulation is more than adequate for this application. With the output set for 900 volts on my prototype supply, the voltage drops to 896 volts with a 225 mA load. Reverse screen current up to about 20 mA is no problem. Beyond 20 mA reverse current, you'll need to add an appropriate bleeder resistor across the output terminals.

This screen supply can provide conventional positive output, or, negative output for grounded screen Class AB1 grid-driven amplifiers, in which the positive output terminal is grounded and the screen negative voltage is connected to the cathode or filament transformer center-tap. This configuration is used in many commercial short-wave transmitters because there's no need for a screen bypass capacitor and the unwanted added inductance associated with it.

choosing the right fuse

It's important to fuse this supply in order to protect the screen of your amplifier tube from excessive dissipation, which will never occur unless you tune up under light load conditions, as might occur, for example, if your antenna were not connected. Light loading allows the instantaneous plate voltage to fall to a level that fails to attract the electrons coming from

the cathode. These electrons will then find the relatively positive screen very attractive, causing an unhappily large flow of current in the screen grid. The screen grid will suffer a melt-down unless something is done quickly. An ordinary fuse will perform this duty faithfully if the right ampere rating is used.

With a capacitor filter supply, which normally has high peak currents in the primary of the power transformer, a fuse that is about 1.5 times larger than the screen dissipation rating would indicate is adequate. For example, with a 120-VAC primary, a 1-amp fuse would allow 120 watts to flow. This would be adequate for a screen grid rated at 80 watts maximum dissipation. The screen supply transformer should be connected to the same step-start source used for the plate transformer so that the regular fuse won't burn out at turn-on. A one-third duty cycle tuning pulser will save fuses if you make an error during tune-up.

choosing the transformer

When you're selecting a power transformer for a screen supply, "heavy duty" is *out*. You don't want a screen supply that can do double duty as an arc-welder. A screen supply transformer should have about the same CCS current rating as the typical screen current on the tube's spec sheet. The transformer selected should also have a filament winding to provide the voltage to operate the comparator circuit, as shown in **fig. 1**. The current drawn by this circuit is about 6 mA — so any 6.3-volt or 12.6-VCT winding will do the job. Other transistors can be used in the comparator as long as they are high Beta and PNP.

Motorola TMOS power FETs have many other interesting uses besides series pass regulators. The MTM 6N60 I used in this article will make a nice shunt regulator at up to 600 volts at 100 watts dissipation — if you keep it cool. If that's not enough, the MTM 6N60 has a big brother, the MTE 40N60, which is a 40 amp, 600-volt device.

I believe we're going to see a lot more TMOS devices in Amateur Radio equipment. Military transceivers already use TMOS output amplifiers. How about 300 watts output on 2 meters with 5 watts of drive? That's a pair of Motorola MRF 150s, which will do the same job on 160 meters. TMOS RF amplifiers produce less intermodulation distortion than conventional bipolar RF amplifiers. Their use could represent a pleasant improvement on the ham bands. With RF-negative feedback it is possible to make a solid-state TMOS SSB signal as clean as some of the cleanest tube-type equipment such as the TS830S.

references

Care and Feeding of Power Grid Tubes, EIMAC Division, Varian Inc., 301 Industrial Way, San Carlos, California 94070.

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direct currents reduce core permeability

BASIC program shows how to compensate for this effect

Applications involving coils that carry DC are common. Perhaps not so common, however, is the understanding that inductance determination requires a knowledge of the anticipated DC current. A DC bias reduces the inductance value and must be taken into consideration for accurate results.

Although this toroidal-inductor design program was written for Microsoft™ BASIC and tested on a Commodore Pet Computer with 32k of memory, no special machine-dependent functions were used; therefore, it can be used on virtually any home computer with little or no modification. Remark statements are liberally provided throughout the program listing to identify operations.

design procedure

The design sequence of calculations for each wire size is as follows:

- Calculation of the number of turns (N) assuming a winding factor of 0.525.
- Calculation of DC resistance (RDC).
- Calculation of copper weight.
- Calculation of maximum DC current.
- Calculation of inductance (mH).
- Calculation of wound outside, inside diameter, and height of wire and core.
- Calculation of temperature rise in No. 30 AWG wire considering copper losses only.

A complete enamel wire table is included in the program for wire sizes No. 12 AWG through No. 46 AWG. Coils are designed to have a winding factor of 52.5 percent maximum.

Selection of a core size and core material for a desired inductance can be determined by doing a set of iterative calculations using vendor curves (**fig. 1**) showing percent permeability reduction versus DC. The magnetizing force, H, (in oersteds) is:

$$H = 0.4\pi NI/P \qquad (1)$$

where N = number of turns
I = current in amperes
P = magnetic path length in centimeters

In **fig. 1**, a certain percent permeability reduction is initially assumed for material of the selected permeability. This establishes the maximum magnetizing force, H, in oersteds, which must not be exceeded if the application's determined requirements are to be met. AC flux density (BAC) is assumed to be small.

The design program uses this information and other core data from the selected vendor data sheet to compute a table of inductor designs.

Toroidal Molypermalloy Powder (MPP) cores are a useful alternative for gapped cores in applications where there is a direct current component which tends to saturate the core. MPP cores are well suited for low inductances, below 2 mH. Advantages of using MPP cores are largely in elimination of assembly and labor costs for handling two core halves, fitting gap spacers and mechanical parts.

One vendor has published a core and permeability selection procedure that simplifies the choice of a core. Because selection of the core to avoid saturation is a most significant choice in inductor design, a modified version of this procedure, courtesy of Magnetics, Inc.,* is used here as a part of the computer design program user instructions.

program user information

Only two parameters for each (design) application must be known: inductance required under DC bias conditions and the amount of DC current.

Calculate the product LI^2 where:
L = inductance required with DC bias (millihenries)
I = DC current (amperes).

Locate the LI^2 value on the DC bias core selector chart (**fig. 2**). Follow this coordinate to the intersec-

By Walter Kunde, K5BVM, Route 3, Box 346, Quinlan, Texas 75474

*Magnetics, Inc., P.O. Box 391, Butler, Pennsylvania 16003.

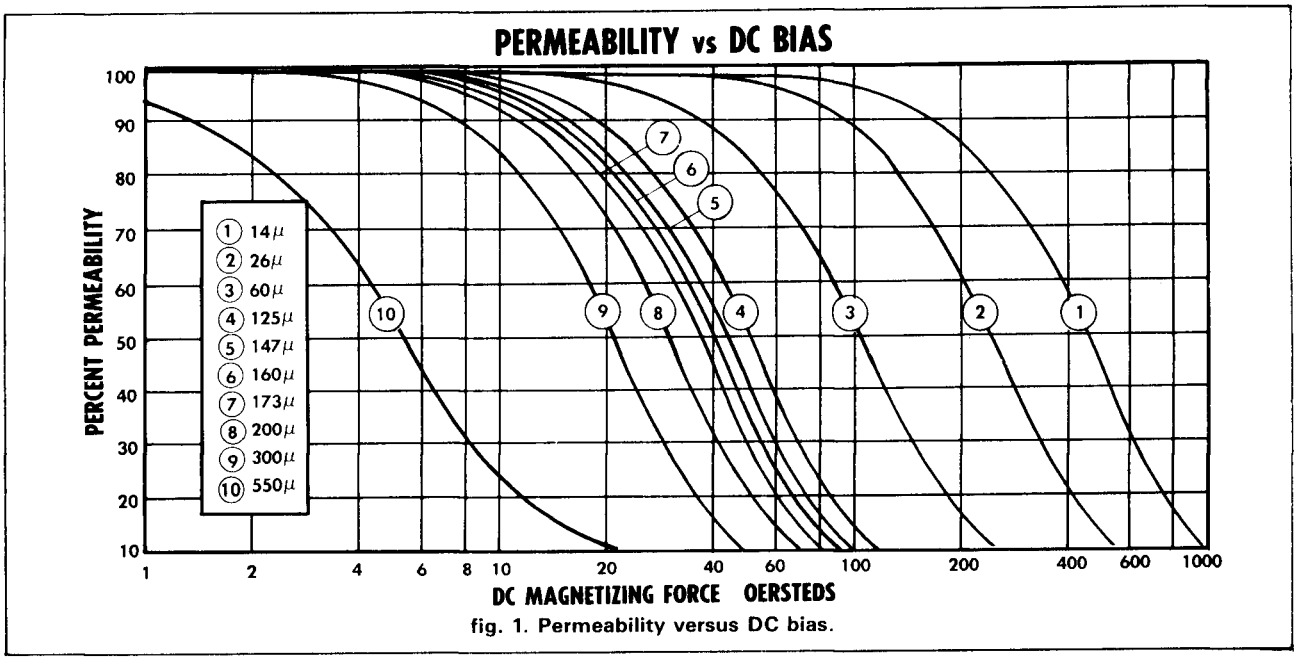


fig. 1. Permeability versus DC bias.

tion with the first core size that lies within the family of solid permeability lines. This core size is the smallest that can be used. (In **fig. 2**, small core sizes are at the bottom and large sizes at the top.)

Any solid permeability line that passes through the intersection point of the LI^2 and core size coordinates or crosses the LI^2 coordinate below this intersection point may be used.

The choice of permeability can be based on Q requirements at the operating frequency of the application. Use the Q curves in **fig. 3** for this selection. If Q is not a consideration, use the highest permeability indicated. This choice will yield the lowest winding factor.

The design application may call for a Q requirement at a higher frequency than the core/permeability combinations indicated in **steps 2** and **3**. By following the LI^2 coordinate to lower permeabilities and larger core sizes, an optimum choice for this type design may be made. For a given permeability, always use the core size just above the permeability line.

Inductance, core size and permeability are now known. The remaining core data is obtained from the selected core data sheet, see **fig. 4**. Use core dimensions which include the core finish.

Load the program and respond to input commands when requested.

Inputs include the following:

- core outside diameter (in inches)
- core inside diameter (in inches)
- core height (in inches)
- core permeability
- core mH/1000 turns
- magnetic path (in inches)
- window area (in circular mils) — CMIL* $\times 10^6$
- MLT (mean length of turn) — full winding (in inches)
- HDC (Peak) Maximum
- percent Nom. Perm @HDC (Peak) Maximum

Upon completion of the last input, "**CALCULATING**" will appear on the monitor screen as the program calculates all values. Results are displayed as printer outputs; see **figs. 5** and **6**.

core selection example

Choose a core meeting the following requirements:

- minimum inductance with DC bias, 25 μH
- DC current, 2 amps.
- operating frequency, 8 kHz.
- optimum Q is required.

The product of $LI^2 = 0.1$. Following this coordinate, the first core size encountered that falls within the solid line permeability family is the 55050 size.

The intersection point of the 0.1 coordinate and the 55050 core size coordinate falls between the 60μ curve and the 125μ curve. Only those permeability lines intersecting the LI^2 coordinate below the core intersection are usable; either 125μ or 160μ may be used.

A review of the Q curves (**fig. 3**) indicates that a 55050 core in 160μ peaks in the neighborhood of 8 kHz, whereas this size in 125μ peaks near 20 kHz. For optimum Q at 8 kHz, 160μ is chosen, core 55048. From **fig. 1**, determine magnetizing force H for the percent-

DC BIAS CORE SELECTOR CHART

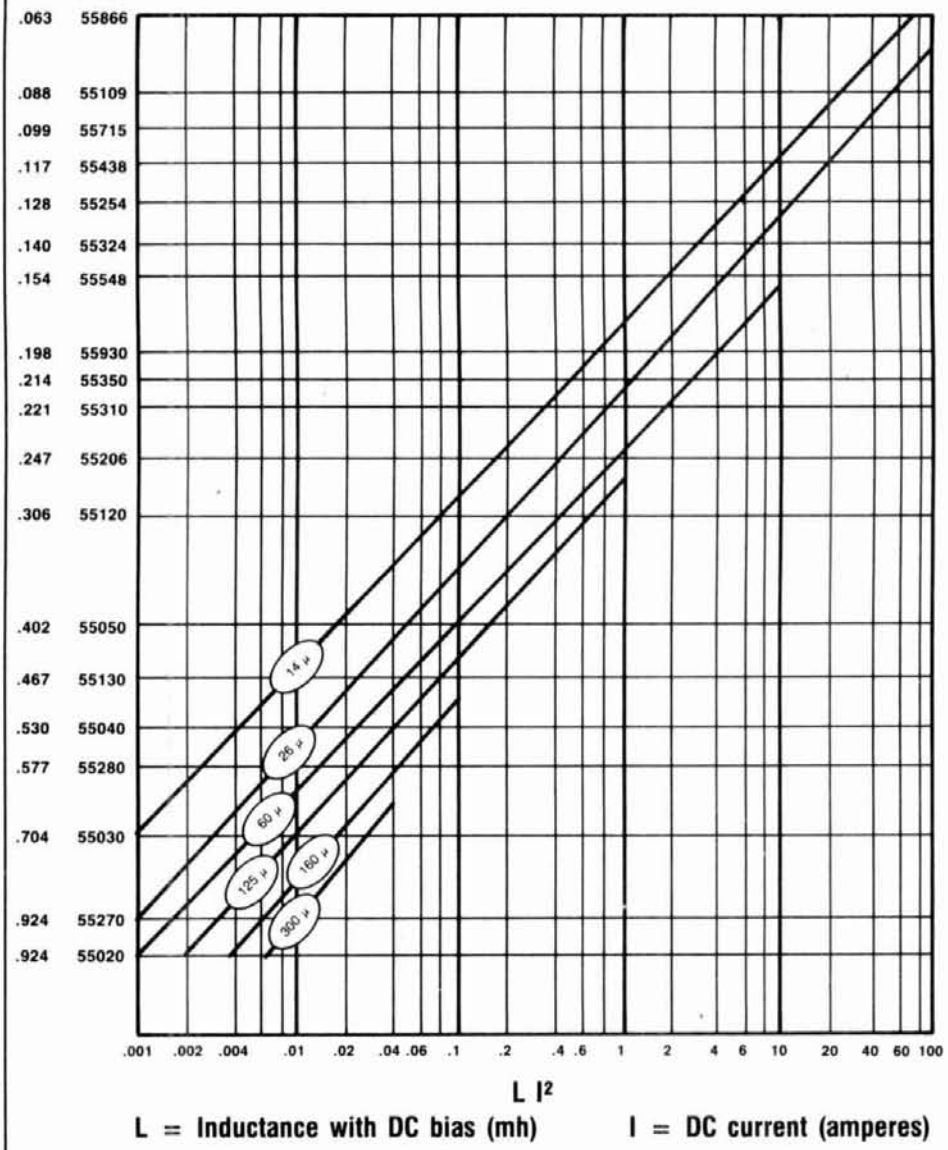
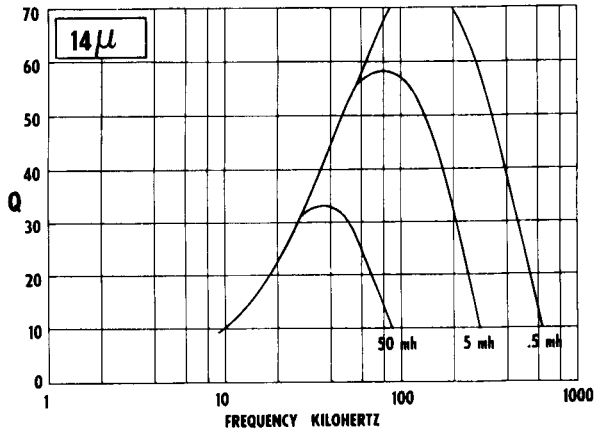
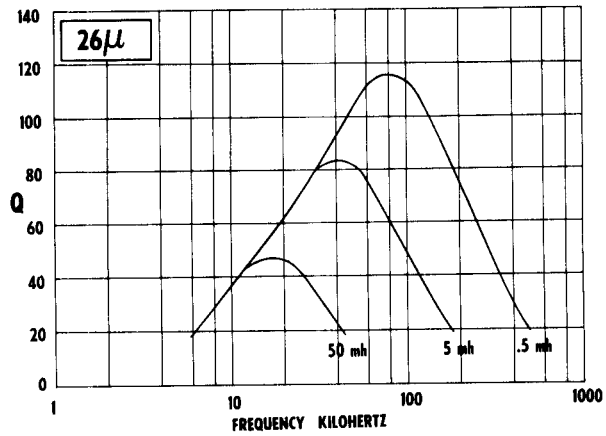
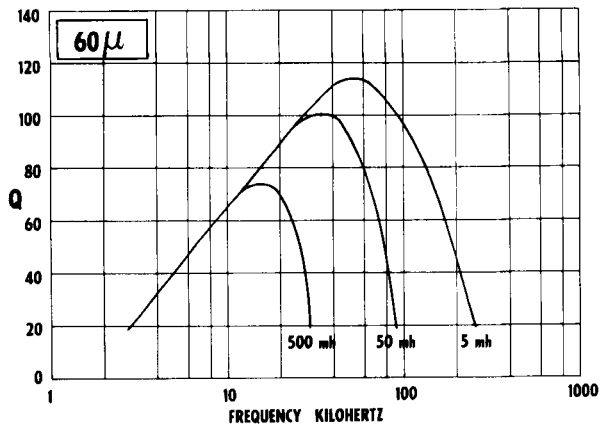
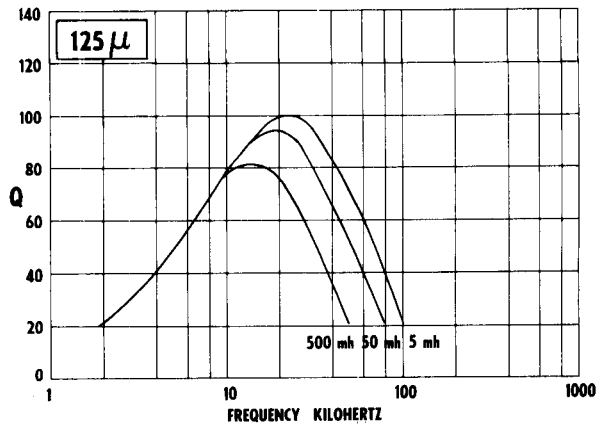


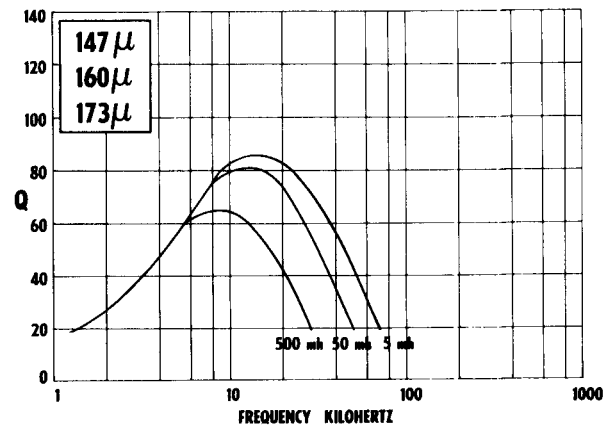
fig. 2. DC bias core selector chart.

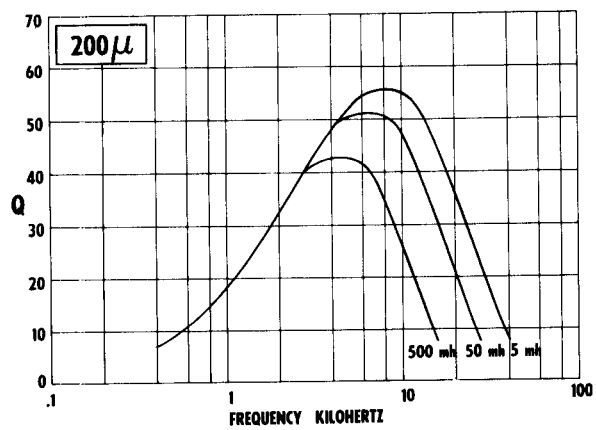


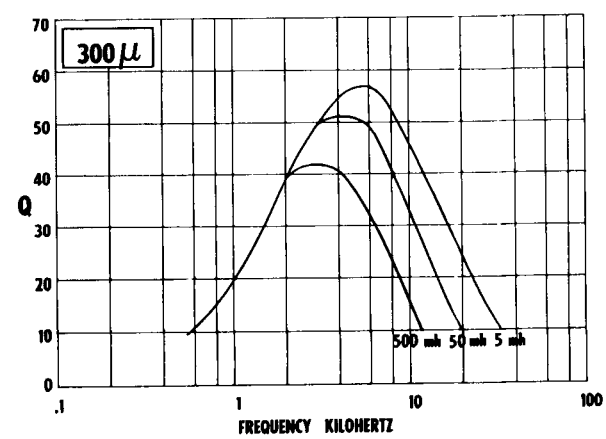












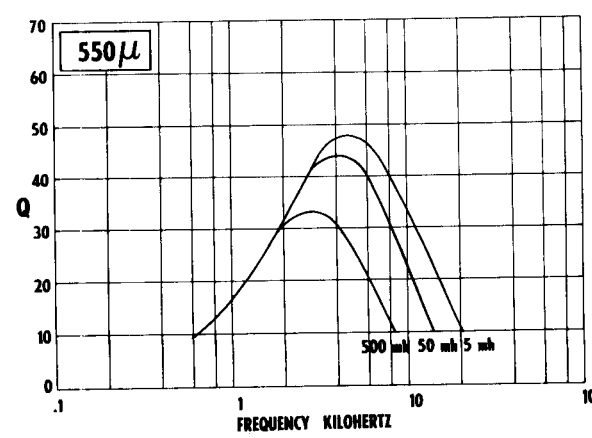
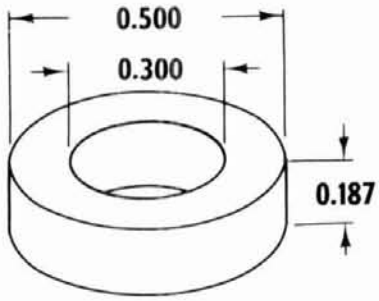


fig. 3. Using *Q* curves helps determine permeability.



WINDOW AREA		75,600 cir. mils
CROSS SECTION	0.01767 in^2	0.1140 cm^2
PATH LENGTH	1.229 in	3.12 cm
WEIGHT	0.11 oz (.0069 lb.)	3.1 gm

WINDING TURN LENGTH

WINDING FACTOR	LENGTH/TURN	
100% (UNITY)	0.0815 ft	2.49 cm
60%	0.0721 ft	2.20 cm
40%	0.0629 ft	1.920 cm
20%	0.0589 ft	1.797 cm
0%	0.0574 ft	1.751 cm

CORE DIMENSIONS AFTER FINISH

OD (MAX.)	0.530 in	13.46 mm
ID (MIN.)	0.275 in	6.99 mm
HT (MAX.)	0.217 in	5.51 mm

WOUND COIL DIMENSIONS

UNITY WINDING FACTOR

OD (MAX.)	0.717 in	18.2 mm
HT (MAX.)	0.451 in	11.5 mm

MAGNETIC INFORMATION

PART NO.	PERM μ	INDUCTANCE @ 1000 TURNS MH±8%	NOMINAL DC RESISTANCE OHMS/MH**	FINISHES AND STABILIZATIONS*	GRADING STATUS 2% BANDS	B/NI GAUSS PER AMP TURN
55053–	14	6.4	2.67	A2	*	5.64 (< 1500 gauss)
55052–	26	12	1.42	A2	*	10.5 (< 1500 gauss)
55051–	60	27	0.633	ALL	*	24.2 (< 1500 gauss)
55050–	125	56	0.305	ALL	YES	50.4 (< 1500 gauss)
55049–	147	67	0.255	ALL	YES	59.2 (< 1500 gauss)
55048–	160	72	0.237	ALL	YES	64.5 (< 1500 gauss)
55044–	173	79	0.216	ALL	YES	69.7 (< 1500 gauss)
55047–	200	90	0.189	ALL	YES	80.6 (< 600 gauss)
55045–	300	134	0.127	A2 and L6	YES	121 (< 300 gauss)
55046–	550	255	0.067	A2	YES	222 (< 50 gauss)

WINDING INFORMATION

FOR UNITY WINDING FACTOR**

AWG WIRE SIZE	TURNS	R_{dc} OHMS	AWG WIRE SIZE	TURNS	R_{dc} OHMS
16	25	0.00826	31	646	6.90
17	31	0.0129	32	788	10.40
18	39	0.0203	33	977	16.40
19	48	0.0318	34	1,244	26.5
20	61	0.0500	35	1,543	41.6
21	76	0.0789	36	1,905	64.4
22	93	0.1233	37	2,327	97.1
23	116	0.1925	38	2,909	153.6
24	144	0.302	39	3,744	258
25	178	0.470	40	4,727	414
26	222	0.743	41	5,817	626
27	280	1.173	42	7,414	1,003
28	344	1.829	43	9,003	1,570
29	420	2.81	44	10,360	2,186
30	525	4.45			

fig. 4. Core data.

More Details? CHECK—OFF Page 110

*** TORCHK1 PROGRAM ***

CORE O.D.: .53

160 PERM.

WIRE SIZE	FULL COIL TURNS	DC RES OHMS	CU WT	I PEAK AMPS	INDUC MHY
12	5.4	0	.01	9.19	1.6E-03
13	6.7	0	.01	7.41	2.5E-03
14	8.4	0	.01	5.91	4E-03
15	10.5	0	.01	4.72	6.3E-03
16	13.2	0	.01	3.76	.01
17	16.3	0	.01	3.04	.0153
18	20.5	0	.01	2.42	.0242
19	25.4	.01	.01	1.95	.0371
20	31.8	.02	.01	1.56	.0582
21	39.4	.03	.01	1.26	.0894
22	49.1	.05	.01	1.01	.1388
23	61	.08	.01	.81	.2143
24	75.7	.14	.01	.65	.33
25	93.6	.21	.01	.53	.5046
26	116	.34	.01	.42	.775
27	145.9	.54	.01	.34	1.2261
28	181.2	.85	.01	.27	1.8912
29	220.4	1.29	.01	.22	2.7979
30	275.6	2.06	.01	.18	4.375
31	339.2	3.2	.01	.14	6.6272
32	413.4	4.82	.01	.12	9.8438
33	512.7	7.61	.01	.09	15.1408
34	652.7	12.28	.01	.07	24.5385
35	809.9	19.32	.01	.06	37.782
36	999.7	29.9	.01	.04	57.5654
37	1221.2	45.07	.01	.04	85.9005
38	1526.5	71.3	.01	.03	134.2196
39	1964.8	119.96	.01	.02	222.3612
40	2480.6	193.11	.01	.02	354.4344
41	3053	290.49	.01	.01	536.8785
42	3891.1	465.59	.01	.01	872.1019
43	4724.9	728.86	.01	.01	1285.9015
44	5436.9	1015.04	.01	0	1702.6491
45	7488.6	1807.25	.01	0	3230.1578
46	9020.4	2735.47	0	0	4686.7746

fig. 6. Table of inductor designs.

glossary of terms

Winding factor is the ratio of the total area of copper wire in the center hole of a toroid to the window area of the toroid.

Window Area, CMIL • 1E6 circular. The unit "Circular MIL" is the area of a circle 1 mil in diameter. The number of circular mils in a square inch is, therefore $\frac{4}{\pi} \times 10^6$, or 1,273,237. Since 1 mil is the thousandth part of an inch; there are 1,000,000 square mils in a square inch. Thus the area of a cross-section expressed in circular mils is always bigger than the true area expressed in square mils, because the unit area to which the name "Circular Mil" has been given is smaller than the square mil.

Heavy Enamel is a magnet wire having an extra heavy film of enamel insulation (i.e., double coated). Its abrasion resistance is somewhat greater than regular enamel (i.e., single coated) magnet wire.

MLT — full winding. MLT is the mean length of a single turn of wire. This will vary considerably between a single layer of wire and a core *full* of wire. The values of MLT are listed on each core size data sheet (see **fig. 4**).

HDC (peak) Max. (core bias). DC current = peak current. If current is not direct continuous, then the peak (momentary) value is used to determine core operating conditions.

$$H = \frac{0.4\pi \cdot turns \cdot peak\ magnetizing\ current}{mean\ magnetic\ path}$$

or $H = \frac{0.4\pi \cdot NI}{\ell}$ *Oersteds*

bias range Oersteds	recommended permeability
below 6	500
6 to 22	300
22 to 35	200
22 to 35	173
22 to 35	160
35 to 70	147
40 to 140	125
70 to 150	60
150 to 330	26
above 330	14

core O.D.	0.53
core ID	0.275
core height	0.217
core permeability	160
MHY/1000T (mH)	72
magnetic path	1.229
window area	0.0756
mean turn	0.865
HDC peak maximum	20
percentage MU @ HDC peak maximum	0.8
wound OD	0.56
wound ID	0.18
wound height	0.31

Note: Temperature rise for No. 30 AWG (copper loss only) is approximately 10.53 degrees C.

fig. 5. Input summary and wound inductor dimensions for a powdered iron core that is carrying maximum peak current.

fig. 7. Basic program compensates for core permeability.

```
10 REM   ************************************************************************
20 REM          POWDERED IRON CORES
30 REM       PROGRAM GENERATES INDUCTOR
40 REM         DESIGNS CARRYING MAX.
50 REM         VALUES OF PEAK CURRENT.
51 REM             FEBRUARY23,1985
52 REM           WALTER KUNDE,P.E.
59 :
60 REM          TORCHK1 PROGRAM NOTES
70 :
80 REM    1.USES WIRE SIZES 12AWG TO 46AWG.
120 REM   2.USE DATA FROM MAGNETICS, BUTLER, PA CATALOG MPP-303S.
121 REM   3.CALCULATED I PEAK CONSIDERS CORE HDC MAX. ONLY.
122 REM     CURRENT CAPACITY OF WIRE IS SEPARATE CONSIDERATION AND INVOLVES THE
123 REM     DUTY CYCLE ALSO.
130 :
140 REM  ************************************************************************
150 :
170 DIM L(35),N(35),CMHEVY(35),PDS(35),IDAGE(35)
180 DIM OHMS(35),FEET(35),RDC(35),CUWT(35),APKMAX(35)
190 :
192 REM   CMHEVY DATA (INCLUDES WIRE INSULATION)
193 :
200 DATA 73.18E+2,58.52E+2,46.79E+2,37.58E+2,30.03E+2,24.21E+2,19.36E+2
210 DATA 15.60E+2,12.45E+2,10.05E+2,8.007,.650,.524,.424,.342,.272,.219,.100.
220 DATA 144.,117.,96.0,77.4,60.8,49.0,39.7,32.5,26.0,20.2,16.0,13.0,10.2,8.4
230 DATA 7.3,5.3,4.4
240 :
250 REM   OHMS/FT DATA
260 :
270 DATA 1.59E-3,2.00E-3,2.52E-3,3.18E-3,4.02E-3,5.05E-3,6.39E-3,8.05E-3
280 DATA 10.1E-3,12.8E-3,16.2E-3,20.3E-3,25.7E-3,32.4E-3,41.0E-3,51.4E-3
290 DATA 65.3E-3,81.2E-3,104.E-3,131.E-3,162.E-3,206.E-3,261.E-3,331.E-3
300 DATA 415.E-3,512.E-3,648.E-3,847.E-3,108.E-2,132.E-2,166.E-2,214.E-2
310 DATA 259.E-2,3.348,4.207
320 :
330 REM   POUNDS/FT DATA
340 :
350 DATA 20.1E-3,15.9E-3,12.6E-3,10.0E-3,7.95E-3,6.33E-3,5.03E-3,3.99E-3
360 DATA 3.18E-3,2.53E-3,2.00E-3,1.60E-3,1.26E-3,1.00E-3,0.794E-3,0.634E-3
370 DATA 0.502E-3,0.405E-3,0.318E-3,0.253E-3,0.205E-3,0.162E-3,0.127E-3
380 DATA 0.101E-3,0.805E-4,0.655E-4,0.518E-4,0.397E-4,0.312E-4,0.254E-4
390 DATA 0.203E-4,0.157E-4,0.131E-4,9.40E-6,7.50E-6
400 :
401 :
410 REM   IDAGE DATA
420 :
430 DATA 12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34
440 DATA 35,36,37,38,39,40,41,42,43,44,45,46
450 :
470 :
471 PRINT "[CLR]       *** TORCHK1   INPUTS ***"
472 PRINT
480 INPUT "CORE OUTSIDE DIA.IN.";OD
481 PRINT
490 INPUT "CORE INSIDE DIA.IN.";ID
491 PRINT
500 INPUT "CORE HEIGHT IN.";HT
501 PRINT
510 INPUT "CORE PERMEABILITY";U
511 PRINT
520 INPUT "CORE MHY/1000 TURNS";MHY
521 PRINT
530 INPUT "MAGNETIC PATH IN.";MMP
531 PRINT
540 INPUT "WINDOW AREA CMIL@1E6 ";AW
541 PRINT
550 INPUT "MLT-FULL WINDING-IN.";MLT
551 PRINT
560 INPUT "HDC (PEAK) MAX.";HPK
561 PRINT
570 INPUT "% NOM PERM @ HDC (PK) MAX.";P
571 PRINT
580 PRINT "          ** CALCULATING ** "
590 :
600 REM **** CALCULATE CHARACTERISTICS OF FULL COIL FOR EACH WIRE SIZE ****
610 :
620 :
640 :   FOR J=1 TO 35
650 :   READ CMHEVY(J)
660 :   N(J)=INT((10)*((AW*0.525*1000000)/(CMHEVY(J))))/(10)
670 :   NEXT J
679 :
690 :
700 REM 0.525=.70(FILL FACTOR)*.75(AVAILABLE AREA) = WINDING FACTOR
710 REM NOW CALCULATE DC RESISTANCE OF WINDINGS @ 25 DEGREES C.
720 :
740 :   FOR J =1 TO 35
750 :   READ OHMS(J)
760 :   FEET(J)=INT(0.5+(10^2)*(MLT*N(J)/12))/(10^2)
770 :   RDC(J)=INT((10^2)*(FEET(J)*OHMS(J)))/(10^2)
780 :   NEXT J
790 :
800 REM  NOW CALCULATE COPPER WEIGHT OF WINDINGS.
820 :   FOR J =1 TO 35
830 :   READ PDS(J)
840 :   CUWT(J)=INT(0.5+(10^2)*(FEET(J)*PDS(J)))/(10^2)
850 :   NEXT J
860 :
870 REM *** NOW CALCULATE PEAK CURRENT IN AMPERES ***
880 :
900 :   FOR J=1TO35
910 :   APKMAX(J)=INT((10^2)*(HPK*MMP*2.82/N(J)))/(10^2)
920 :   NEXT J
940 :
941 :   FOR J=1 TO 35
942 :   READ IDAGE(J)
943 :   NEXT J
944 :
950 REM *** NOW CALCULATE INDUCTANCE FOR EACH COIL AND CORE COMBINATION ***
960 :
980 :   FOR J=1TO35
990 :   L(J)=INT((10^4)*((N(J)/1000)^2)*MHY/P)/(10^4)
1000 :  NEXT J
1020 :
1030 REM **NOW CALCULATE WOUND DIMENSIONS & TEMP RISE USING 30AWG AS AVERAGE**
1040 :
1050 :  WOD=INT(100*SQR((OD^2)+(0.56*(ID^2))))/100
1060 :  WID=INT(100*SQR((ID^2)-(0.56*(ID^2))))/100
1070 :  WHT=INT(100*(HT+ID-WID))/100
1080 :
1090 :  SIDES=3.14156*WOD*WHT
1100 :   TP=(3.14156*WOD^2)/4
1110 :
1120 REM **ASSUMES 8MW RADIATED/SQ.IN./DEGREE CENTIGRADE**
1130 :
1140 TEMRIZ=INT(100*(APKMAX(19)^2*RDC(19)*125/(SIDES+TP)))/100
1150 :
1160 REM *** OUTPUTS TO PRINTER ***
1170 :
1180 OPEN 4,4:PRINT#4,CHR$(147);CMD4
1190 PRINT
1200 PRINT
1201 PRINT TAB(25)"***   TORCHK1   PROGRAM    ***"
1202 PRINT
1210 PRINT TAB(25)"*** TOROID INDUCTOR DESIGN ***"
1220 PRINT
1230 PRINT TAB(32)"POWDER IRON CORE"
1240 PRINT
1250 PRINT TAB(36)"CARRYING"
1260 PRINT
1270 PRINT TAB(29)"MAXIMUM  PEAK  CURRENT"
1280 PRINT
1290 PRINT"          ********************************************************";
1291 PRINT"******"
1300 PRINT
1310 PRINT
1320 X=44:Y=13
1330 PRINT TAB(Y)"CORE O.D.:";SPC(X-LEN(STR$(OD)));STR$(OD)
1340 PRINT TAB(Y)"CORE I.D.:";SPC(X-LEN(STR$(ID)));STR$(ID)
1350 PRINT TAB(Y)"CORE HT. :";SPC(X-LEN(STR$(HT)));STR$(HT)
1360 PRINT TAB(Y)"CORE PERM.:";SPC(39-LEN(STR$(U)));STR$(U)
1370 PRINT TAB(Y)"MHY/1000T:";SPC(40-LEN(STR$(MHY)));STR$(MHY)
1380 PRINT TAB(Y)"MAG. PATH:";SPC(43-LEN(STR$(MMP)));STR$(MMP)
1390 PRINT TAB(Y)"WINDOW AREA:";SPC(41-LEN(STR$(AW)));STR$(AW)
1400 PRINT TAB(Y)"MEAN TURN :";SPC(42-LEN(STR$(MLT)));STR$(MLT)
1410 PRINT TAB(Y)"HDC PK MAX:";SPC(39-LEN(STR$(HPK)));STR$(HPK)
1420 PRINT TAB(Y)"XMU @ HDC PK MAX:";SPC(36-LEN(STR$(P)));STR$(P)
1430 PRINT
1440 PRINT TAB(Y)"WOUND O.D:";SPC(43-LEN(STR$(WOD)));STR$(WOD)
1450 PRINT
1460 PRINT TAB(Y)"WOUND I.D:";SPC(43-LEN(STR$(WID)));STR$(WID)
1470 PRINT
1480 PRINT TAB(Y)"WOUND HT.:";SPC(43-LEN(STR$(WHT)));STR$(WHT)
1490 PRINT
1500 PRINT TAB(22)"TEMP. RISE FOR 30AWG(CU LOSS ONLY)"
1501 PRINT TAB(27)"IS APPROX:";TEMRIZ;" DEG C."
1510 PRINT
1520 PRINT"          ********************************************************";
1521 PRINT"******"
1530 PRINT#4,CHR$(19);CMD4: REM SKIP TO TOP OF NEXT PAGE
1540 PRINT
1541 PRINT"************************************************************"
1543 PRINT TAB(16)"***   TORCHK1   PROGRAM    ***"
1544 PRINT
1545 PRINT TAB(21)"CORE O.D.:";SPC(9-LEN(STR$(OD)));STR$(OD)
1546 PRINT
1550 PRINT TAB(25);U;"PERM."
1570 PRINT "                FULL                                    I"
1580 PRINT "  WIRE       COIL          DC RES        CU       PEAK        INDUC  "
1590 PRINT "  SIZE       TURNS          OHMS         WT       AMPS         MHY "
1620 PRINT
1640 PRINT"************************************************************"
1650 PRINT
1670 FOR J=1 TO 35
1680 PRINT SPC(6-LEN(STR$(IDAGE(J))));STR$(IDAGE(J));
1681 PRINT SPC(10-LEN(STR$(N(J))));STR$(N(J));
1682 PRINT SPC(14-LEN(STR$(RDC(J))));STR$(RDC(J));
1683 PRINT SPC(8-LEN(STR$(CUWT(J))));STR$(CUWT(J));
1684 PRINT SPC(10-LEN(STR$(APKMAX(J))));STR$(APKMAX(J));
1710 PRINT SPC(12-LEN(STR$(L(J))));STR$(L(J))
1740 NEXT J
1750 PRINT
1760 PRINT
1770 PRINT"************************************************************"
1780 PRINT#4:CLOSE4
1790 END
READY.
```

age reduction of permeability desired. The remaining core data is obtained from the selected core data sheet (**fig. 4**).

Enter all inputs and run the program. Outputs are shown in **figs. 5** and **6**.

When zeros are printed, it means that the calculated values are less than the number of decimal places in the printing format. These small values are not practical to measure in most cases.

ham radio

VHF/UHF WORLD

Joe Reisert W1JR

meteor scatter communications

It's been two years since my first article on improving meteor scatter communication appeared in this column.[1] That article generated lots of interest and many readers have used the techniques described to improve their own meteor scatter QSO success rate. In that column, I described a method and a computer program designed to help pinpoint the peak of each of the major meteor showers. The predicted peak for upcoming meteor showers you see listed at the end of each monthly column is derived using this method.

Since that column was written, many new improvements in prediction have taken place: shower peaks can now be predicted with greater accuracy, and computer programs that help optimize scheduling are readily available. Because the summer months — along with a short peak from December through early January — are prime time for meteor scatter communications, it seems this would be a good time to present some additional tips on improving meteor scatter communications.

a quick review

Meteor scatter communications uses the ionized trails left by meteors as they enter the earth's ionosphere. There are two basic types of meteors, *sporadic* and *shower*. Sporadic meteors are random in nature. They peak daily at about 6 AM and are at their minimum at about 6 PM local time. Shower meteors, on the other hand, peak at specific times of the year and can begin at any time of the day, depending on the radiant (the place in the sky from which the meteors seem to emanate).

Amateurs in North America most often use the shower types, believed to be the remnants of old or extinct comets. These meteors generally provide more ionization and their time of arrival is more predictable than that of sporadic meteors. Shower meteors usually are in greater quantity than sporadic meteors; the typical shower lasts from 12 hours to several days (for at least 25 percent of the peak time). As a result, meteor showers are more reliable for completing a QSO than sporadic types.

"That's fine," you say. "I've looked at the meteor shower peak prediction method in reference 1 and even ran schedules during the peak hours listed at the end of 'VHF/UHF World' each month with only limited success. What am I doing wrong?"

Several questions must be answered. First and foremost, was the other station definitely on the air during the schedule? Was it on the right frequency and using the correct timing sequence? Was all your gear and the other station's gear operational — or did one of the stations have a transmitter or receiver sensitivity problem? Was the transmitted power and antenna gain sufficient at each end of the path? "Of course," you insist. Then read on!

One potential problem is the distance between stations. Generally, the optimum distance for meteor showers is between 700 and 1000 miles (1125-1610 km). Distances less than about 700 miles are a problem because your antenna must be elevated for maximum signal strength and the bursts are usually shorter.

Longer distances out to about 1400 miles (2250 km) are possible using meteor scatter. However, for best results use only the high-speed meteor showers, which have increased ionization higher in the E region. (More on this later.)

The most productive schedules are usually run during the hours or days when the meteors are above 25 percent of the peak of the shower; this is called the *peak time* of the shower. Running a day or so ahead or behind the peak may be less productive, especially if the shower is one of short duration.

The procedure for determining the shower peak time and date was described in detail in reference 1, so it won't be repeated here, though **table 1** has been revised to show the latest ecliptic longitude at 0000 UTC. For those who don't care to work out the peaks or use the computer program listed in reference 1, the predictions of major showers are listed each month at the end of this column.

W9IP mentioned that the ecliptic longitude tables shown in reference 1 may not be accurate enough to be reused every four years as originally suggested. This is true because the tables may vary by up to several hours over a four-year period. So I've updated the daily ecliptic longitude in **table 2** and made appropriate corrections.

If a "fudge factor" of about 0.12 (equivalent to about three hours in four years) is added to the values shown in the tables every four years hence, the tables can be used for many years with a high degree of accuracy. For example, the 1986 table can be reused for 1990 by simply adding 0.12 to each value. Hence January 3, 1990 has a

Table 1.

Shower name	E.L.*	Best dates	Duration**	Hourly rate†	Velocity (km/sec)	Local time‡ rise/set
Quadrantids	282.855	January 2-4	14 hrs	110	41.5	2300-1800
April Lyrids	31.8	April 20-24	2.3 days	15	47	2100-1100
Eta Aquarids	44.5	May 2-7	3 days	20	67	0300-1200
Arietids	76.5	June 1-15	8 days	60	37	0300-1530
June Lyrids	84.5	June 10-21	7 days	10	31	2100-1100
Delta Aquarids	126.0	July 26-30	7 days	35	42	2200-0600
Perseids	139.3	August 10-14	4.6 days	65	60	(Note 1)
Orionids	207.4	October 18-23	2 days	30	67	2230-0930
Taurids	221.0	October 30-November 10	20 days	10	30	1900-0630
Leonids	234.7	November 14-19	4 days	20	71	2300-1230
Geminids	261.2	December 10-15	2.5 days	50	36	1800-1000
Ursids	270.5	December 20-24	2.2 days	15	33	(Note 2)

*Ecliptic longitude in 1950 coordinates.
**Duration is the amount of time that the meteors are above 25 percent of the peak of the shower.
†Estimated meteors per hour at maximum. Can vary greatly from year to year depending on shower.
‡Local time for northern mid-latitudes.

Note 1. Never sets. Minimum at 1730.
Note 2. Never sets. Minimum at 2030.

corrected ecliptic longitude of 282.43; 1994, a corrected value of 282.55. For maximum precision, the computer program shown in reference 1 is recommended, since it contains an algorithm for continuously updating the daily ecliptic longitude with minimal error, regardless of dates.

However, *the primary factor in increasing the probability of a successful QSO is determining the optimum time of the day for the desired path direction during or near* (± 12 hours) the predicted peak of a meteor shower. W4LTU provided guidelines in his tables in references 2 and 3, but they were only guidelines and no specifics on distances or probabilities were included.

Why is this consideration so important? Meteors enter the ionosphere in a specific geometry, depending on where they're encountered by the earth in its orbit around the sun. If the meteors are entering on the opposite side of the earth from your QTH, the chance of a completed meteor scatter QSO is slim.

If the geometry of the meteor shower is favorable, there will be a time when the meteors enter the ionosphere in the optimum direction at the best entry angle, yielding specular (i.e., mirror-like) reflection to radio signals on a specific path as explained by Bain.[2,3]

Villard, et. al., described this geometry in detail in reference 4. Meeks and James further defined the ideal geometry for specular reflection on forward scatter, suggesting that the ideal geometry occurs when the meteors cross at right angles to the great circle path between the transmitter and receiver and enter the ionosphere at an elevation angle of 45 degrees.[5] Meeks and James then derived a complicated set of formulas for determining the decrease in performance from the ideal case. They called this term "effectivity."

This can best be visualized as a mirror reflecting the wave to the proper point. Whenever the trail is properly oriented (consider the reflection region to be the mirror), the incident wave will be reflected directly back to the desired destination. Furthermore, the angle the incident wave makes with a perpendicular to the mirror will be the same as the angle the reflected wave makes with the perpendicular. As the mirror is moved from this ideal orientation, only a portion of the incident wave will be projected onto the correct region of the mirror for reflection back to the desired location.

Thus as the reflection mirror is tipped away from the ideal orientation, the amount of reflected signal in the desired direction falls off. By calculating the amount the reflecting surface is tipped away from the ideal orientation, it's possible to evaluate the "effectiveness" of the reflection process.

Damboldt simplifed the equations for effectivity.[6] With the help of Chip Brown, KR1P, I have simplified these equations even further to yield a percentage of probability from the ideal case as follows:
Effectivity = 200• [Sin H•Cos H•Sin(p-a)]. Where Effectivity is a percentage from 0-100 percent, *H* is the

elevation angle of the meteor entry path, *p* is the azimuth of the great circle path, and *a* is the azimuth of the meteor path.

For example, if the great circle path from the transmitting to the receiving station is 225 degrees, the meteor path is 135 degrees, and the meteor enters the ionosphere at an elevation angle of 45 degrees, the effectivity is 100 percent. However, if the meteor enters on an azimuth path of 180 degrees at a 30-degree elevation angle, the effectivity is only about 62 percent. *Generally speaking, effectivities of greater than 50 percent are desired. If the effectivity drops below 25 percent, the path is very poor and probably not worth your precious time.*

finding the best time for a path

As mentioned above, one of the most important considerations in setting up a schedule is choosing the optimum time for the desired path direction. Some of this information is included in the table prepared by W4LTU.[2,3] However, it is incomplete and doesn't list all the optimum times or all path directions, or cover different distances .

A computer program that calculates the most "effective" time for a meteor scatter path between your station and the station scheduled during any of the well-known annual meteor showers has been written. Even if you don't have a computer, read on; there will be useful information for you!

The program first determines the location (above the great circle path) in the E region where the scattering from the meteor trail will occur, provided that the meteor trail passes through this region in the correct direction. Either of W4LTU's *QST* articles[2,3] illustrate this meteor trail geometry for a given beam heading. The heading to the other station can be easily found using the equations for determining the great circle bearing direction.[7]

The program works out all the astronomical calculations necessary for the meteor shower selected. Armed with these three known quantities (the location of the reflection point, the great circle path, and the direction of the path of the meteors as they enter the E region), the program will evaluate the "effectiveness" (or the orientation of the ionized trails in providing a properly positioned layer or surface on which the specular reflections can occur.)[5]

The orientation of the ionized meteor trails in this particular location in the E region varies as the earth rotates; the program will indicate the optimum or most "effective" time of the day for the use of the path. Because some showers are from radiants of high declination while others are from lower declination, it follows that some showers are better suited for particular great circle paths.

The program also calculates the beam offset angle from the great circle bearing path as a function of time for those who need to compensate for this effect.[2,3]

The astronomical calculations begin with the equations found in the annual *American Epherimis and Nautical Almanac*. These equations are used to determine the day of the year when the earth passes through the shower and the "right ascension" of the shower at the start of that day. This information is then used to determine the direction of the meteors, since they'll be passing through the E region scattering location or volume. Moreover, because of the earth's rotation and its orbit about the sun, this location in the E region will continuously sweep

Table 2. Updated Ecliptic longitudes at 0000 UTC for selected days (from the American Epherimis and Nautical Almanac for the year of interest). The tables can be used over every four years if a small correction is applied as described in the text.

Date	1986	1987	1988	1989
Jan 3	282.31	282.13	281.91	282.68
Jan 4	283.33	283.15	282.93	283.70
Jan 5	284.35	284.17	283.95	284.72
Apr 21	30.61	30.43	31.20	30.97
Apr 22	31.58	31.41	32.18	31.94
Apr 23	32.56	32.38	33.15	32.92
May 4	43.25	43.08	43.84	43.61
May 5	44.22	44.04	44.81	44.58
May 6	45.19	45.01	45.78	45.54
Jun 5	74.06	73.89	74.65	74.41
Jun 6	75.02	74.84	75.60	75.37
Jun 7	75.98	75.80	76.56	76.32
Jun 14	82.67	82.50	83.25	83.02
Jun 15	83.62	83.45	84.20	83.97
Jun 16	84.58	84.41	85.16	84.93
Jul 27	123.69	123.52	124.27	124.04
Jul 28	124.65	124.47	125.23	125.00
Jul 29	125.60	125.43	126.18	125.96
Aug 11	138.05	137.88	138.63	138.40
Aug 12	139.01	138.84	139.59	139.36
Aug 13	139.97	139.80	140.55	140.32
Oct 20	206.31	206.13	206.90	206.67
Oct 21	207.30	207.12	207.90	207.67
Nov 2	219.28	219.09	219.88	219.64
Nov 3	220.28	220.09	220.88	220.67
Nov 4	221.28	221.09	221.88	221.67
Nov 16	233.34	233.15	233.94	233.70
Nov 17	234.32	234.16	234.95	234.71
Nov 18	235.35	235.17	235.96	235.72
Dec 12	259.66	259.48	260.27	260.03
Dec 13	260.68	260.50	261.29	261.05
Dec 14	261.70	261.51	262.31	262.06
Dec 21	268.82	268.64	269.43	269.19
Dec 22	269.84	269.65	270.45	270.21
Dec 23	270.85	270.67	271.47	271.23

throughout the swarm of meteors in an ever-changing direction. The ideal direction of the trails as they pass through the E region will be such that specular reflections will take place over the desired path.

For some paths and some showers, these ideal direction situations may be reached. Though it sometimes lasts for only an hour, this near-ideal situation can persist for many hours in other combinations of paths and showers. For some showers this occurs only once a day; for others, it occurs twice during the same day.

The computer program recalculates all of these geometric changes of the path in the E region with respect to the desired propagation path at every 15-minute interval throughout the day. At each 15-minute interval the "effectiveness" of the path geometry is also evaluated.

The final output of the program is a tabulation and plot of the path's "effectiveness" at each 15-minute interval. Thus the "effectiveness" plot indicates the time of day when astronomical orientation of the meteor trails is most favorable for providing specular reflection along the desired path. The actual value of the plot is a measure of how near specular the reflections will be for the time of the calculation.

computer programs

A copy of this program is being offered for IBM or IBM-compatible PCs at a nominal fee to cover cost of reproduction and mailing.* A floppy disk copy of the program is also available.

Credit for writing this program goes to Chip Brown, KR1P, who spent many hours customizing and debugging it so that the results would be as accurate as possible.

A typical printout of the program is shown in **fig. 1**. This shows a southwesterly path of approximately 900 miles (1450 km) during the Perseids meteor shower from a latitude of 40 degrees north and a longitude of 76 degrees west (the corner of VUCC grid squares FM19, FM29, FN10 and FN20), approximately in the middle of the Eastern Standard Time (EST) zone. This path can be duplicated or correlated later if you obtain the program.

GMT	OFST	Path Effectivity (%)	GMT
0000	1.2	21	0000
0015	1.3	20	0015
0930	14.6	20	0930
0945	15.2	23	0945
1000	15.6	27	1000
1015	15.8	31	1015
1030	15.7	36	1030
1045	15.2	40	1045
1100	14.3	45	1100
1115	13.2	50	1115
1130	11.8	54	1130
1145	10.2	59	1145
1200	8.7	64	1200
1215	7.3	68	1215
1230	6.1	73	1230
1245	5.0	77	1245
1300	4.1	81	1300
1315	3.3	85	1315
1330	2.7	88	1330
1345	2.3	91	1345
1400	1.9	93	1400
1415	1.6	95	1415
1430	1.4	97	1430
1445	1.2	98	1445
1500	1.1	98	1500
1515	1.0	99	1515
1530	1.0	98	1530
1545	0.9	97	1545
1600	0.9	96	1600
1615	0.9	94	1615
1630	0.9	92	1630
1645	0.9	90	1645
1700	0.9	87	1700
1715	0.9	84	1715
1730	0.9	80	1730
1745	0.9	77	1745
1800	0.9	73	1800
1815	0.9	69	1815
1830	0.9	65	1830
1845	0.9	61	1845
1900	0.9	58	1900
1915	0.9	54	1915
1930	0.9	50	1930
1945	0.9	47	1945
2000	0.9	44	2000
2015	0.9	41	2015
2030	0.9	39	2030
2045	0.9	36	2045
2100	0.9	34	2100
2115	0.9	32	2115
2130	0.9	31	2130
2145	0.9	29	2145
2200	1.0	28	2200
2215	1.0	27	2215
2230	1.0	26	2230
2245	1.0	25	2245
2300	1.1	24	2300
2315	1.1	23	2315
2330	1.1	22	2330
2345	1.2	21	2345
2400	1.2	20	2400

fig. 1. This is a printout of the predicted effectivity of the Perseids meteor shower for a southwesterly path from latitude 40 degrees north and longitude 76 degrees west as generated by the computer program mentioned in the text. Time shown is UTC. See text for further use and interpretation.

*A copy of the meteor shower effectivity program written in BASIC for IBM or IBM-compatible PCs is available for $2.00 from Gary Field, WA1GRC, 2 Pluff Avenue, Reading, Massachusetts 01824. A floppy disk with the same program is available for $15.00, which includes cost of the disk and mailing.

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102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282	294	306	318	330	342
103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283	295	307	319	331	343
104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284	296	308	320	332	344
105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285	297	309	321	333	345
106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310	322	334	346
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316	328	340	

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Because no real meteor shower enhancement is indicated from 0015-0930 UTC, this wouldn't be a good time to run this path direction. However, note that the path effectivity exceeds 50 percent (the typical minimum criteria as stated earlier) from about 1115 UTC (0615 EST) until after 1930 UTC (1430 EST). A long-duration smooth peak that reaches maximum at about 1515 UTC (1015 EST) is evident.

Figure 1 is also valid by simply scaling the time for schedules where one of the stations is near the 40th parallel but at a different longitude. A station located near a longitude of 91 west can use this path directly by just adding one hour to the times shown. Since the geometry moves westerly at a rate of 15 degrees per hour, a station near a longitude of 106 west can add two hours.

Beam offset is also shown on the printout for those who want to optimize this geometry. W4LTU has explained this principle in references 2 and 3. Normally this isn't important unless you're on the bands above 2 meters or if the gain of your antenna is high (narrow beamwidth). However, every little bit of help is worthwhile, especially on the higher bands.

using the effectivity graphs

Judging from the many letters and questions received, there seems to be a lot of interest in finding the optimum time for a particular path during a meteor shower. The program described will do this for anyone with the appropriate computer. But some Amateurs interested in meteor scatter don't have computers; others are interested only in certain paths. Still others are interested only in some of the typical optimum paths for the major showers.

Tabulating all path possibilities like the one shown in **fig. 1** would be a monumental task. Consequently, I've decided to provide optimum path data for three of the major meteor showers. Since much of the Amateur communications activity during meteor showers in North America has at least one of the stations near the 40th parallel, this is the data I tabulated. Other stations even several hundred miles north or south will often experience similar effectivity. Although it may be shifted an hour one way or the other, there probably won't be a great deal of change if you're running near the peak effectivity points. If you don't have the computer capability, maybe the other station or a friend with the appropriate computer can run a listing for your specific shower and path.

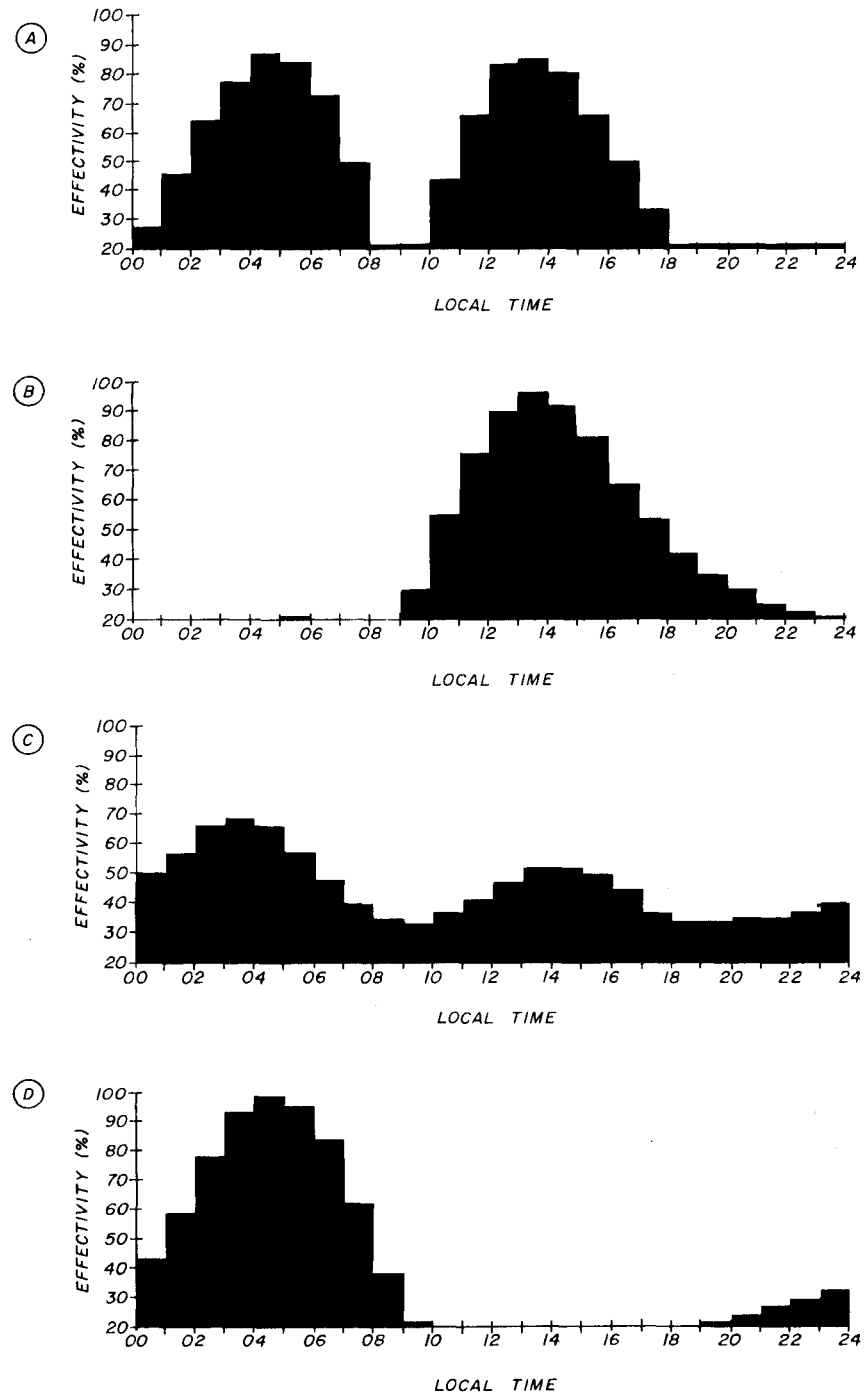

fig. 2. These graphs show the predicted effectivity for the Quadrantids meteor shower. All times shown are local. Original data was taken from latitude 40 degrees north and longitude 76 degrees west but can be used at other locations as explained in the text. Paths shown are as follows: A) north, B) northeast, C) east, D) southeast, E) south, F) southeast, G) west, H) northwest.

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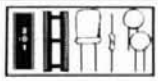

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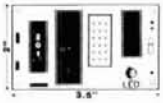

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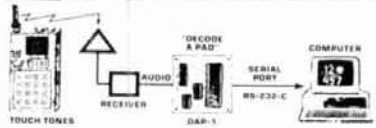

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The data shown on **figs. 2, 3,** and **4** is for a nominal path length of 900 miles (1450 km). The times listed are local standard time. All the data was run from a latitude of 40 degrees north and a longitude of 76 degrees west, right in the middle of the Eastern time zone of the United States.

Because it's normalized to local time (even though the computer program uses UTC) the data in **figs. 2, 3,** and **4** is directly usable in all time zones. In addition, eight different directions have been shown so that you can pick the optimum time based on the direction desired.

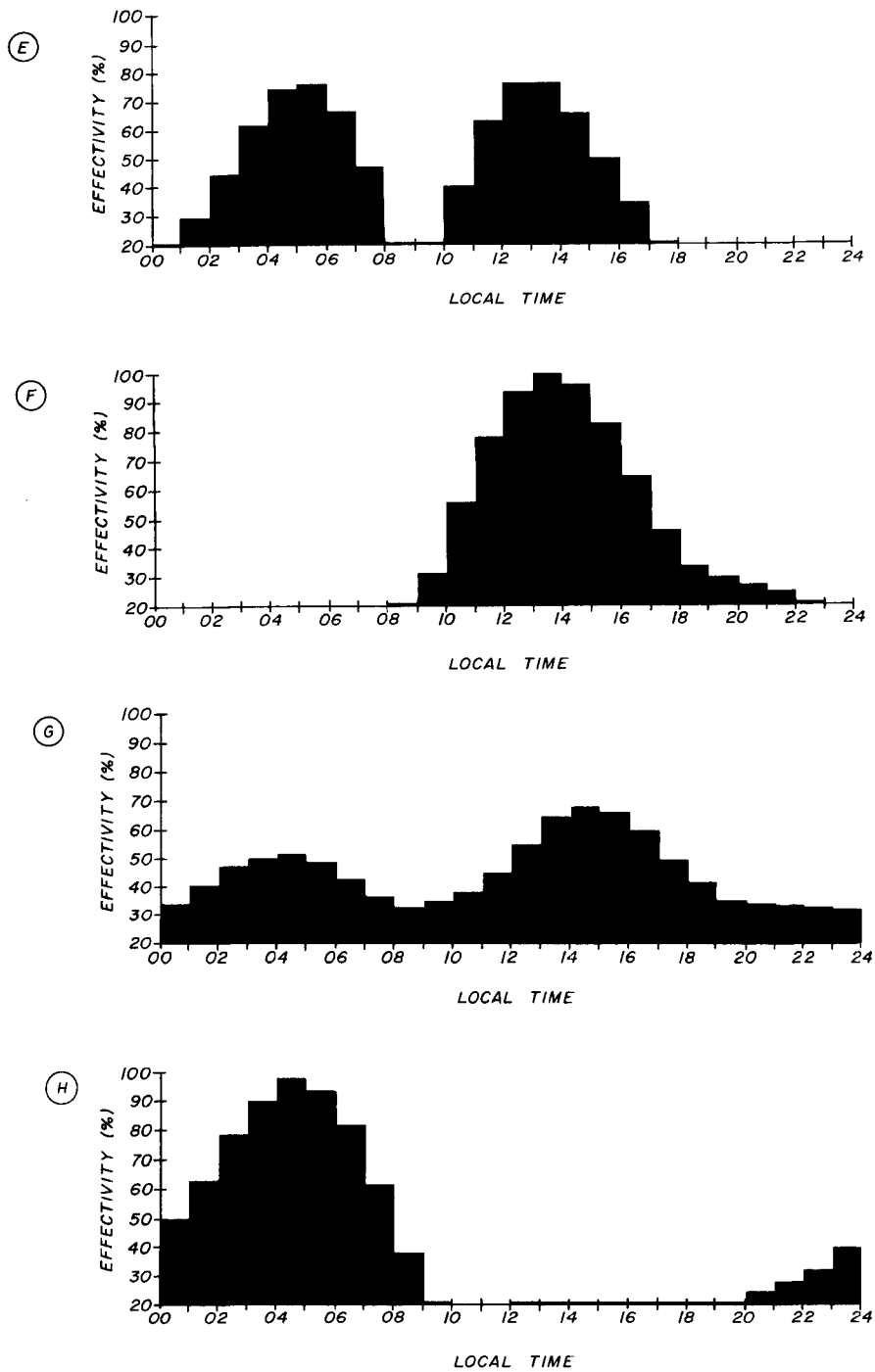

fig. 2. cont.

With these graphs, you'll be able to easily discern any path differences by comparing one with another. For instance, examine the graphs for the Perseids shower (**fig. 3**). You'll see that the east and west paths are fair at two different times per day while the southeast and southwest paths are good only once a day. You'll also notice that the east and west as well as the southeast and southwest paths are identical except for a time shift! However, the latter paths are better when open than the former paths. Other information can be gleaned by examining the graphs for the other paths and showers.

monitoring a shower

Several suggestions about monitoring showers were made in reference 1. Lower frequencies can be monitored. Some Amateurs have suggested 75 MHz because the FAA has thousands of landing beacons on this frequency. Others prefer the FM band, 88-108 MHz.

If you use a lower frequency for monitoring, the lower directivity of your receiving antenna and the presence of bursts don't necessarily indicate that 2 meters or higher frequencies are optimum. Random meteors that will easily ionize up to 108 MHz are often present regardless of the time of day or year. Therefore, I still feel that it's better to use the video carriers on TV channels 12 or 13 as explained in reference 1. These frequencies are good indicators since they also show that the path is open up to at least 200 MHz, simplifying determination of the optimum path.

Furthermore, the speed of a meteor shower and the size of its particles are good indicators of the distance you can communicate. More specifically, because of the earth's velocity of rotation, meteors enter the ionosphere at approximately 15-70 km/second. The entering speed of the particles during a meteor shower is fairly well known and is tabulated in **table 1.**

Meteors typically ionize a fairly narrow region of the ionosphere between 50 and 75 miles above the earth.

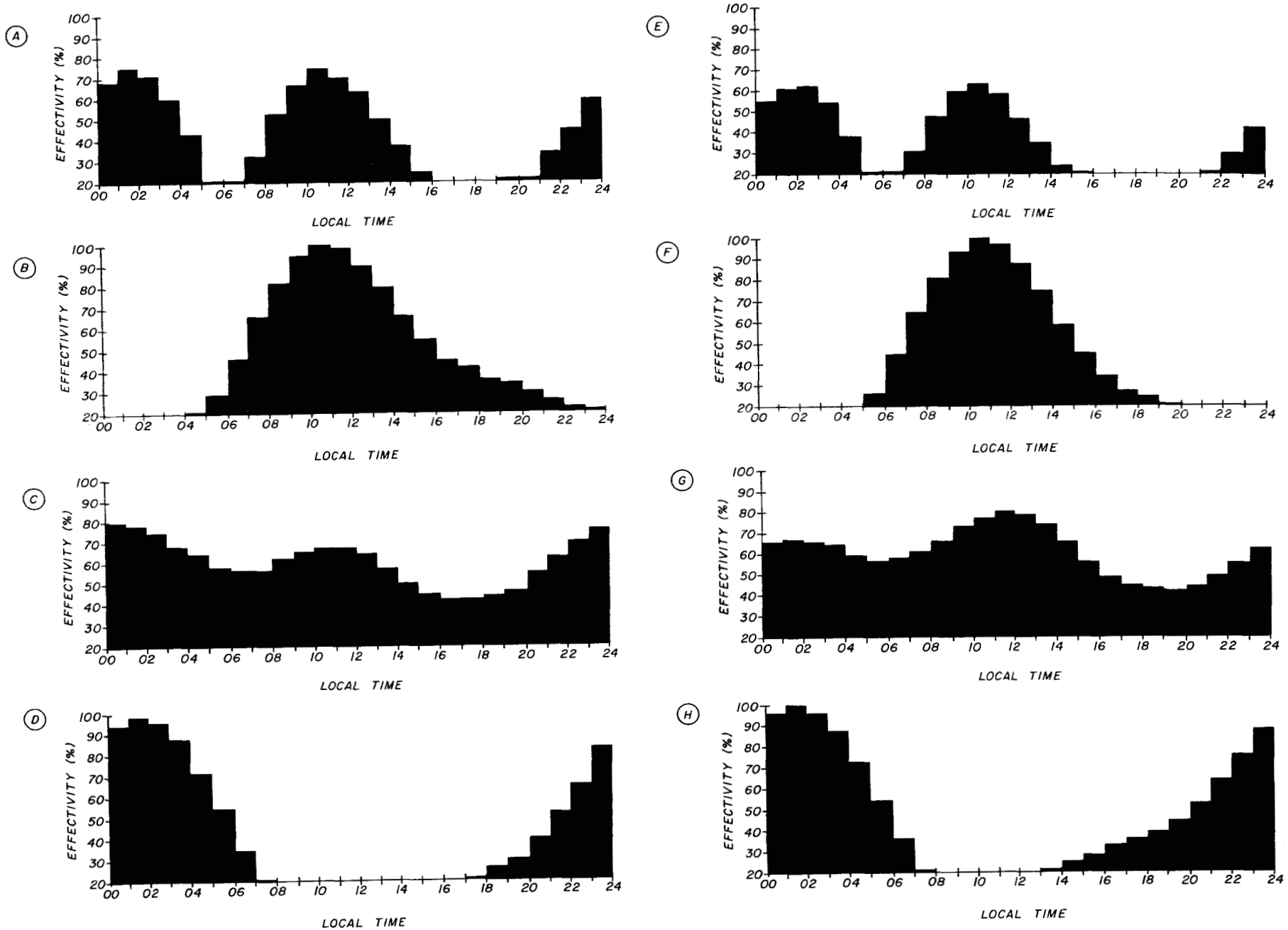

fig. 3. These graphs shown are the predicted effectivity for the Perseids meteor shower. All times shown are local. Original data was taken from latitude 40 degrees north and longitude 76 degrees west but can be used at other locations as explained in the text. Paths shown are as follows: A) north, B) northeast, C) east, D) southeast, E) south, F) southeast, G) west, H) northwest.

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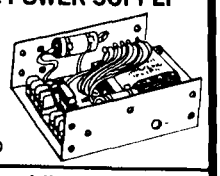

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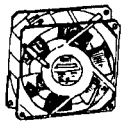

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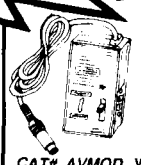

T.I. # UM1381-1. Designed for use with T.I. computers. Can be used with video sources. Built-in A/B switch. Channel 3 or 4 selection switch. Operate on 12 vdc. Hook-up diagram included.

CAT# AVMOD WERE $10.00 REDUCED TO $5.00 EACH

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ALL ARE 1.56" SPACING.

22 EDGE CONNECTOR $1.25 ea
solder lug style *10 for $11.00*
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$2.00 ea P.C. style **10 for $16.00**
22/44 EDGE CONNECTOR
solder lug style **$2.50 each**
28/56 EDGE CONNECTOR
$2.50 ea P.C. style **10 for $22.00**
36/72 EDGE CONNECTOR
P.C. style **$3.00 each**
43/86 EDGE CONNECTOR
P.C. style **$4.50 each**

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2N706	4 for $1.00
2N2222A	3 for $1.00
PN2222A	4 for $1.00
2N2904	3 for $1.00
2N2904	3 for $1.00
2N2905	3 for $1.00
MJ2955	$1.50
2N3055	$1.00
PMD 10K40	$1.00
TIP 121	75¢
TIP 125	75¢

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120 volt primaries

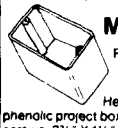
5.6 volts @ 750 ma.	$3.00
6 volts @ 150 ma.	$1.25
6.3 volt @ 600 ma.	$3.00
12 V.C.T. @ 200 ma.	$2.00
12 V.C.T. @ 400 ma.	$3.00
12 V.C.T. @ 1 amp	$4.00
12 V.C.T. @ 2 amp	$4.85
12 V.C.T. @ 4 amp	$7.00
18 volts @ 650 ma.	$3.50
24 V.C.T. @ 200 ma.	$2.50
24 V.C.T. @ 1 amp	$4.85
24 V.C.T. @ 2 amp	$6.75
24 V.C.T. @ 3 amp	$9.50
24 V.C.T. @ 4 amp	$11.00
36 V.C.T. @ 135 ma.	$3.00

WALL TRANSFORMERS

all plug directly into 120 vac outlet

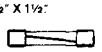
4 VDC @ 70 ma.	$2.00
6 VAC @ 500 ma.	$3.50
6 VDC @ 750 ma.	$4.50
9 VDC @ 500 ma.	$5.00
12.5 VAC @ 265 ma.	$3.00
18 VAC @ 18 VA and 8.5 VAC @ 1.28 VA	$4.50
24 VAC @ 250 ma.	$3.00
MULTI-VOLTAGE @ 500 ma. 3,4½,6,7½,9 or 12 VDC	$7.50

MINI-BOX



Pomona #2104
$1.00 EACH
Heavy-duty black phenolic project box with cover and screws 2¾" X 1½" X 1½"

FUSES



3AG (AGC) SIZE
1, 1½, 2, 2½, 3, 4, 5, 6 AMP
GMA SIZE
1, 2, 3, 4, 5 AMP
5 of any ONE amperage 75¢

SPECIALS

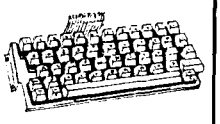
1 AMP 50 VOLT DIODES
IN4001 TAPE AND REEL
100 for $4.50
1000 for $30.00

SOLDER TAIL I.C. SOCKETS
24 PIN **10 for $2.50**
100 for $22.00
1000 for $200.00

SPECIAL PRICE TRANSISTOR

plastic transistor
PN3569 TO-92 N.P.N.
100 for $8.00
1000 for $60.00
LARGE QUANTITIES AVAILABLE

48 KEY ASSEMBLY FOR COMPUTER OR HOBBYIST



NEW T.I. KEYBOARDS. Originally used on computers, these keyboards contain 48 S.P.S.T. mechanical switches. Terminates to 15 pin connector. Frame 4" x 9"
CAT # KP-48 **$6.50 each**
2 for $11.00

MICRO-CASSETTE MECHANISM

Micro-cassette tape transport for standard MC60 or MC45 micro-cassettes. 3 Vdc operation. Contains: drive motor, belt, head, capstan, pinch wheel and other components. 3 1/2" X 2 1/4" X 5/8"
CAT# MCMEC **$3.00 each 10 for $27.50**

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2,000 mfd. 200 Vdc 1 3/4" x 5" high	$2.00
6,400 mfd. 60 Vdc 1 3/8" x 3 3/4" high	$2.50
9,700 mfd. 50 Vdc 1 3/8" x 4 1/2" high	$3.00
31,000 mfd. 15 Vdc 1 3/4" x 4" high	$2.50
50,000 mfd. 40 Vdc 3" x 5 3/4" high	$4.50
66,000 mfd. 15 Vdc 3" X 3 3/4" high	$3.00
60,000 mfd. 40 Vdc 3" x 5" high	$3.50
66,000 mfd. 15 Vdc 3 " x 3 3/4" high	$3.00
86,000 mfd. 30 Vdc 3" x 5 1/4" high	$3.50
5,500 mfd. 30 Vdc 1 3/8" x 3 1/2" high	$1.00
5,900 mfd. 30 Vdc 1 3/8" x 2 1/4" high	$1.00
9,300 mfd. 50 Vdc 2" x 4 1/2" high	$1.00
18,000 mfd. 10 Vdc 1 3/8" x 2 5/8" high	$1.00
48,000 mfd. 10 Vdc 2 1/2" x 3 1/4" high	$1.00
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$1.00 SPECIALS

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10 AMP SOLID STATE

CONTROL: 3 - 32 vdc
LOAD: 140 vac 10 amp
SIZE: 2½" x ¾" x ⅞"
$9.50 EACH 10 FOR $90.00

ULTRA-MINIATURE 5 VDC RELAY

Fujitsu # FBR211NED005M20
High sensitivity
COIL: 120 ohms
CONTACTS: 1 amp
Mounts in 14 pin DIP socket
$1.25 each 10 for $10.00

MINIATURE 6 VDC RELAY

Aromat #RSD-6V
Super Small
S.P.D.T. relay
GOld colbalt contacts rated 1 amp @ 30 vdc. Highly sensitive. TTL direct drive possible. 120 ohm coil.
Operate from 4.3 - 6 vdc.
COIL: 120 ohms **$1.50 each**
1⅜" x 13/32" x 7/16" **10 for $13.50**

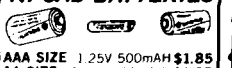
13 VDC RELAY

CONTACTS: S.P.N.C.
10 amp @ 120 vac
Energize coil to open contact
COIL: 13 vdc 650 ohms
SPECIAL PRICE $1.00 each

4PDT RELAY

14 pin KH style
3 amp contacts
USED but fully tested **$1.70 each**
Specify coil voltage desired
Either 24 vdc or 120 vac
LARGE QUANTITIES AVAILABLE
SOCKETS FOR KH RELAY 75¢ each

RECHARGEABLE NI-CAD BATTERIES



AAA SIZE 1.25V 500mAH	$1.85
AA SIZE 1.25V 500mAH	$1.85
AA with solder tab	$2.00
C SIZE 1.2V 1200mAH	$3.50
SUB-C SIZE solder tab	$3.50
D SIZE 1.2V 1200mAH	$3.50

UNIVERSAL CHARGER

Will charge 4-AA, C, D, or AAA ni-cads or one 9 volt ni-cad at one time...
$11.00 per charger

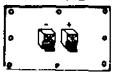
220 Vac COOLING FAN

ROTRON # MX77A3
Muffin XL
220 Vac
4 1/8" square metal frame fan.
CAT# CF-220 **$6.50 ea**
10 for $60.00 / 100 for $500.00
QUANTITIES AVAILABLE

3½" SPEAKER

8 ohm impedance. Full range speaker. 8 oz magnet 4" diagonal mounting centers.
$2.50 each 10 for $20.00

SPRING LEVER TERMINALS



Two color coded terminals on a sturdy 2¾" x 3¾" bakelite plate.
Great for speaker enclosures or power supplies.
75¢ EACH 10 for $6.00

LINE CORDS

TWO WIRE
6' 18/2 SPT-1 flat **3 for $1.00**
6' 18/2 SPT-2 flat **2 for $1.00**
6' 16/2 SJT round **$1.25 each**
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6' 18/3 flat **$1.50 each**
8' 18/3 round **$2.00 each**

7 CONDUCTOR RIBBON CABLE

Spectra-strip red marker strip, 28 ga. stranded wire.
$5.00 per 100' roll

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ALL ARE RATED 5 AMPS @ 125 VAC

S.P.D.T. (on-on)
P.C. style *non-threaded bushing*
75¢ each
10 for $7.00

S.P.D.T. (on-on)
Solder lug *terminals*
$1.00 each
10 for $9.00
100 for $80.00

S.P.D.T. (on-off-on)
Solder lug terminals.
$1.00 each
10 for $9.00
100 for $80.00

S.P.D.T. (on-off-on)
P.C. style non-threaded bushing
75¢ each
10 for $7.00

S.P.D.T. (on-on)
P.C. lugs threaded bushing.
$1.00 each
10 for $9.00
100 for $80.00

D.P.D.T. (on-on)
Solder lug terminals.
$2.00 each
10 for $19.00
100 for $180.00

STANDARD JUMBO DIFFUSED T 1-3/4

RED **10 for $1.50 100 for $13.00**
GREEN **10 for $2.00 100 for $17.00**
YELLOW **10 for $2.00 100 for $17.00**

FLASHER LED
5 volt operation
red jumbo T 1¾ size **$1.00 each**
NEW GREEN FLASHER
CAT # LED-4G $1.00

BI-POLAR jumbo T 1¾ size **2 for $1.70**

LED HOLDERS
Two piece holder for jumbo LED
10 for 65¢ **100 for $5.00**

CLEAR CLIPLITE LED HOLDER
Make LED a fancy indicator. Clear
4 for $1.00

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115 vac lighted rocker, snap mounts in ⅞" x 1⅛" hole. Orange lens. 16 amp contact.
$1.50

MINI-PUSH BUTTON

S.P.S.T. momentary normally open ¼" bushing. Red button.
35¢ each
10 for $3.00

SNAP ACTION SWITCH

Cherry elect. #E-21, N.O. or N.C. 0.1A contacts. Suitable for alarms and other low energy circuits. 1⅛" lever.
45¢ EACH 10 FOR $4.20

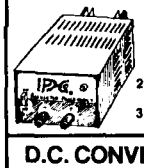
ROTARY ACTION MICRO

OMRON #C 5G3-C41
Clockwise action micro used in coin operated mechanisms and low torque operations.
RATED .5 amps @ 125 Vac.
$1.25 each 10 for $11.00
LARGE QUANTITIES AVAILABLE

TI SWITCHING POWER SUPPLY

Compact, well-regulated switching power supply designed to power Texas Instruments computer equipment.
INPUT: 14 - 25 vac @ 1 amp
OUTPUT: + 12 vdc @ 350 ma.
+ 5 vdc @ 1.2 amp
– 5 vdc @ 200 ma.
SIZE: 4¾" x 4¼" x 1¼" high
SPECIAL PRICE **$3.50 each**

13.8 VDC REGULATED POWER SUPPLY



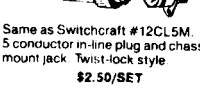
These are solid state fully regulated 13.8 vdc power supplies. Both feature 100% solid state construction, fuse protection, and L.E.D. power indicator. U.L. listed.

2 amp constant, 4 amp surge ***$20.00 each***
3 amp constant, 5 amp surge **$27.50 each**

D.C. CONVERTER

Designed to provide a steady + 5 vdc @ 240 ma. from a battery supply of 3.5 to 6.25 volts.
2⅛" x 1⅛" x 1⅛"
$1.50 each

TWIST-LOCK CONNECTOR



Same as Switchcraft #12CL5M. 5 conductor in-line plug and chassis mount jack. Twist-lock style.
$2.50/SET

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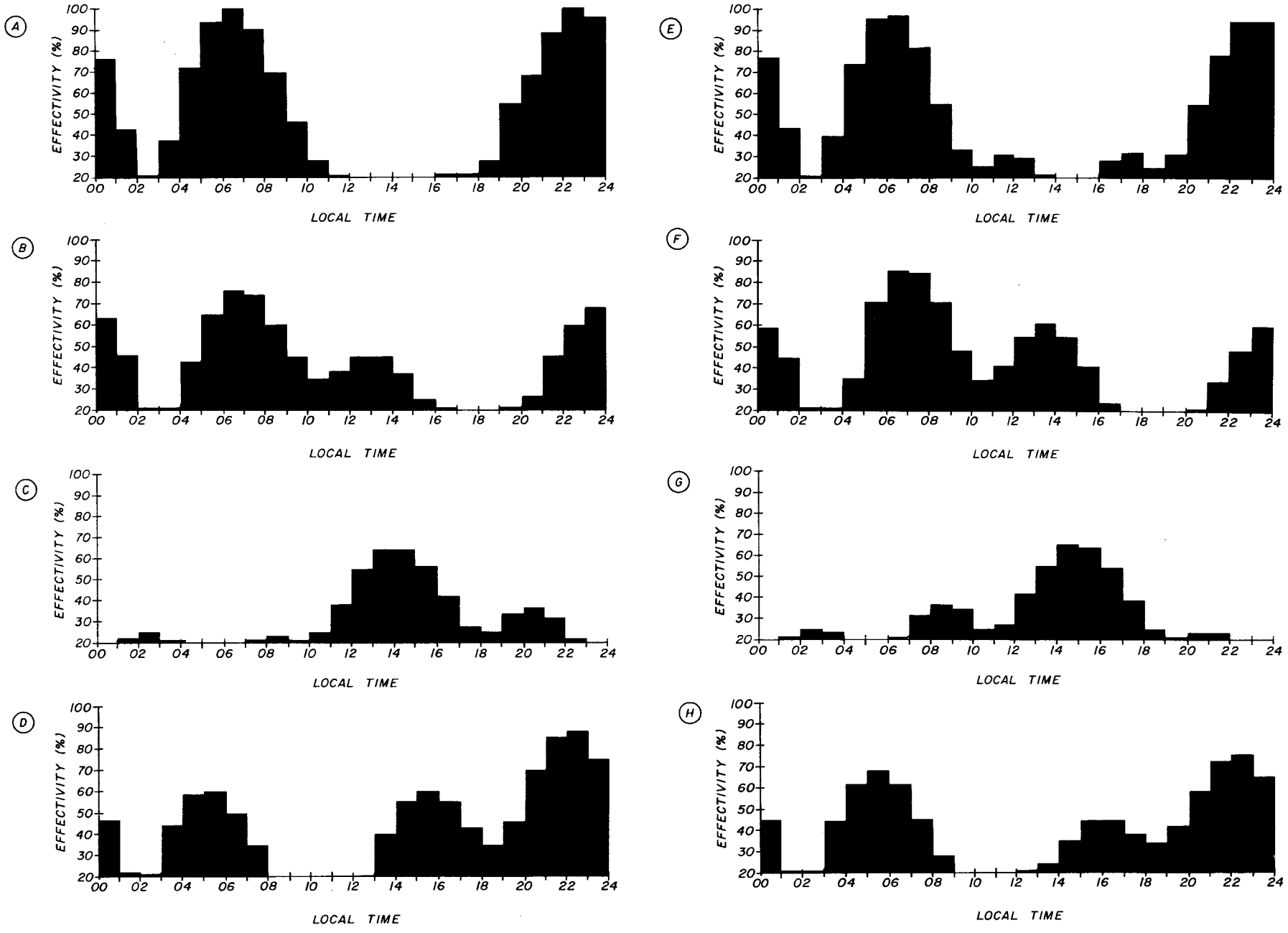

fig. 4. These graphs show the predicted effectivity for the Geminids meteor shower. All times shown are local. Original data was taken from latitude 40 degrees north and longitude 76 degrees west but can be used at other locations as explained in the text. Paths shown are as follows: A) north, B) northeast, C) east, D) southeast, E) south, F) southeast, G) west, H) northwest.

Generally speaking, the higher-speed showers ionize at the upper height and the lower-speed showers at the lower height. Also, those meteors with larger particles tend to ionize in the lower regions. What this means is that the lower the ionization takes place in the ionosphere, the shorter the DX path. The Geminids meteors, for example, have relatively large particles; they're also a relatively slow shower. Consequently, 1100 miles (1770 km) is about the maximum reliable distance.

The Perseids, Orionids, Eta Aquarids, and Leonids, on the other hand, are fast showers and therefore yield the longest communications distances — up to about 1400 miles (2250 km).

I've been trying to integrate this information for some time. Gritting my teeth, I prepared the graph shown in **fig. 5**. While it may not be technically accurate, especially at the upper end, it will at least show a trend based on my meteor shower speed and propagation observations.

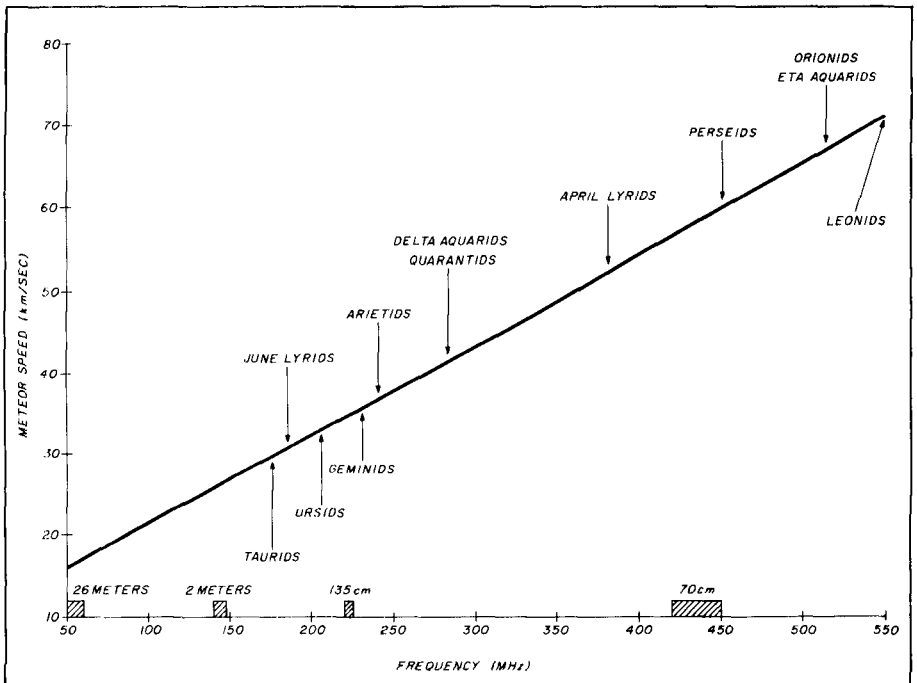

fig. 5. This graphs shows the relative speed of the major meteor showers. By comparing speeds the various showers can be judged to see which will be optimum for your schedules as explained in the text.

From **fig. 5** it should be obvious that the Perseids, Eta Aquarids, Orionids, and Leonids are preferred for 135- and 70-cm operation. However, remember that *lots* of meteors are also desirable. Table 1 shows that among these four showers, only the Perseids has a high hourly rate, a necessary ingredient for completing a QSO. Don't fret. The Leonids are due to peak again in the late 1990s — so be ready!

meteor scatter records

In last July's column, I listed North American meteor scatter records in **table 4.**[8] None exceeded 1470 miles (2365 km). Since then, several stations have sent me reports of being heard further than this distance, but it appears that no QSOs have been successfully completed. All of these contacts were during the Perseids meteor shower.

Ironically the 2-meter meteor scatter record has just been shattered by a great distance and during the Geminids meteor shower! Congratulations to K5UR in Cabot, Arkansas, and KP4EKG near San Juan, Puerto Rico, who on December 13, 1985 completed a meteor scatter QSO during a schedule from 0400-0530 UTC. The length of this path was an incredible 1960 miles (3153 km)!

How can this long distance path exist? Since it took several bursts to complete the QSO and signals were moderate at best, the only plausible explanation is that they used double-hop meteors. This is probable since the quantity of the meteors in the Geminids shower is high and therefore would support such a theory. Does anyone have a better explanation?

summary and conclusion

To improve your chances of successful meteor scatter communications, it's most important to use the optimum time for the desired path based on the geometry of the meteor shower. You can use the graphs and other information generated by the "effectivity"-predicting computer program to determine these optimum times.

Operating during the peak encounter of the shower with the earth is important, but it will be useless if the meteors are on the other side of the earth, if the path of the shower was perturbed by an encounter with one of the other planets in the shower orbit, or if you're not properly oriented to increase the path "effectivity."

Packet radio is now a reality; 1986 should be the year in which many 2-meter QSOs will be completed using this relatively new mode. Europeans have been using a type of packet radio for many years in the form of high speed CW, sometimes exceeding 100 words per minute with great success — even in the absence of showers and at almost any hour of the day. At this high speed the bursts may be short, but if they're tape-recorded and played back at lower speed, a lot of information can be extracted from even a very short burst.

acknowledgments

This month's column would not have been possible without the help of Chip Brown, KR1P, who provided the meteor scatter effectivity program discussed. I'd also like to thank Gary

Field, WA1GRC, who has volunteered to distribute this program, and Mike Owen, W9IP, who pointed me towards new references that yielded improved meteor shower data.

important VHF/UHF events:

June 6: *Predicted peak of the daytime Arietids meteor shower at 0100 UTC*

June 7-8: *ARRL VHF QSO Party*

June 15: *Predicted peak of the June Lyrids meteor shower at 2100 UTC*

June 21: *EME perigee*

June 21: *Mean date ± one month for the peak of sporadic-E propagation*

July 2: *± 2 weeks — look for European openings on 6 meters.*

July 18-20: *CQ Magazine VHF WPX contest*

July 19: *EME perigee*

July 20: *Look for 2-meter sporadic E ± 2 weeks of this date.*

July 25-27: *Central States VHF Conference in St. Louis, Missouri. (Contact N0IS for details.)*

July 29: *Predicted peak of the Delta Aquarids shower at 0845 UTC.*

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1. Joe Reisert, W1JR, "Improving Meteor Scatter Communications," *ham radio*, June, 1984, page 82.
2. Walter F. Bain, W4LTU, "VHF Meteor Scatter Propagation," *QST*, April, 1957, page 20.
3. Walter F. Bain, W4LTU, "VHF Propagation by Meteor-Trail Ionization," *QST*, May, 1974, page 41.
4. O.G. Villard, Jr., et. al., "The Role of Meteors in Extended-Range VHF Propagation," *Proceedings of the IRE*, October, 1955, page 1473.
5. M.L. Meeks and J.C. James, "On the Influence of Meteor-Radiant Distributions in Meteor-Scatter Communications," *Proceedings of the IRE*, December, 1957, Page 1724.
6. T. Damboldt, DJ5DT, "Meteor Scatter Communications," *VHF Communications*, winter issue, 1974, page 194.
7. *The ARRL Antenna Book*, 14th edition, chapter 16.
8. Joe Reisert, W1JR, "VHF/UHF World: Propagation Update," *ham radio*, July, 1985, page 86.

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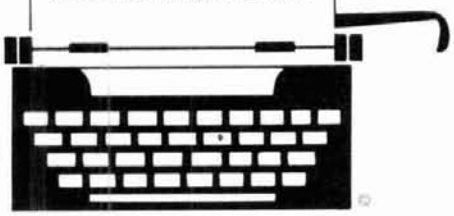

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$19.95 test leads and battery included

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CT-70 kit $99.95
BP-4 nicad pack 8.95

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CT-50 8 DIGIT 600 MHz COUNTER

$169.95 wired

CT-50 kit $139.95
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Converts any TV to video monitor. Super stable, tunable over ch 4-6. Runs on 5-15V accepts std. video signal. Best unit on the market! Complete kit. VD-1 ..... $7.95

Led Blinky Kit

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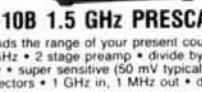

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a universal analog breadboard

Even at its best, breadboarding is always a problem, particularly when a little circuit complexity is involved. Digital breadboarding has been made easier by the availability of various commercial breadboards that nicely accommodate the digital DIP packages; analog breadboarding, however, remains an art of arranging, in seemingly random fashion, a multitude of varied components on some substrate material.

Although digital breadboards can be used for analog breadboarding, the component leads just don't seem to fit properly and the interelectrode capacitance is much too high for analog circuits operating much above 1 MHz or so. Other materials such as perf-board work well for anyone who's organized enough to fully lay out the assembly carefully before starting, but if you're going to go to all that trouble, you might as well lay out a PC board. Also, if the circuit being breadboarded is RF in nature, a ground-plane substrate is necessary; this requires tedious cutting and peeling off the ground plane to fabricate a functional breadboard.

The primary value of the breadboard lies in its ease of preparation and use; if a great amount of planning is required for just building the breadboard, much of the advantage of its use is lost.

An analog breadboard system has to be versatile enough to accommodate the wide variety of analog component types, yet provide for very simple fabrication of the circuit. Stray capacitance and inductance must be made very low; good ground plane construction is a must. Changes, additions, and deletions must be simple to make.

choosing a breadboard type

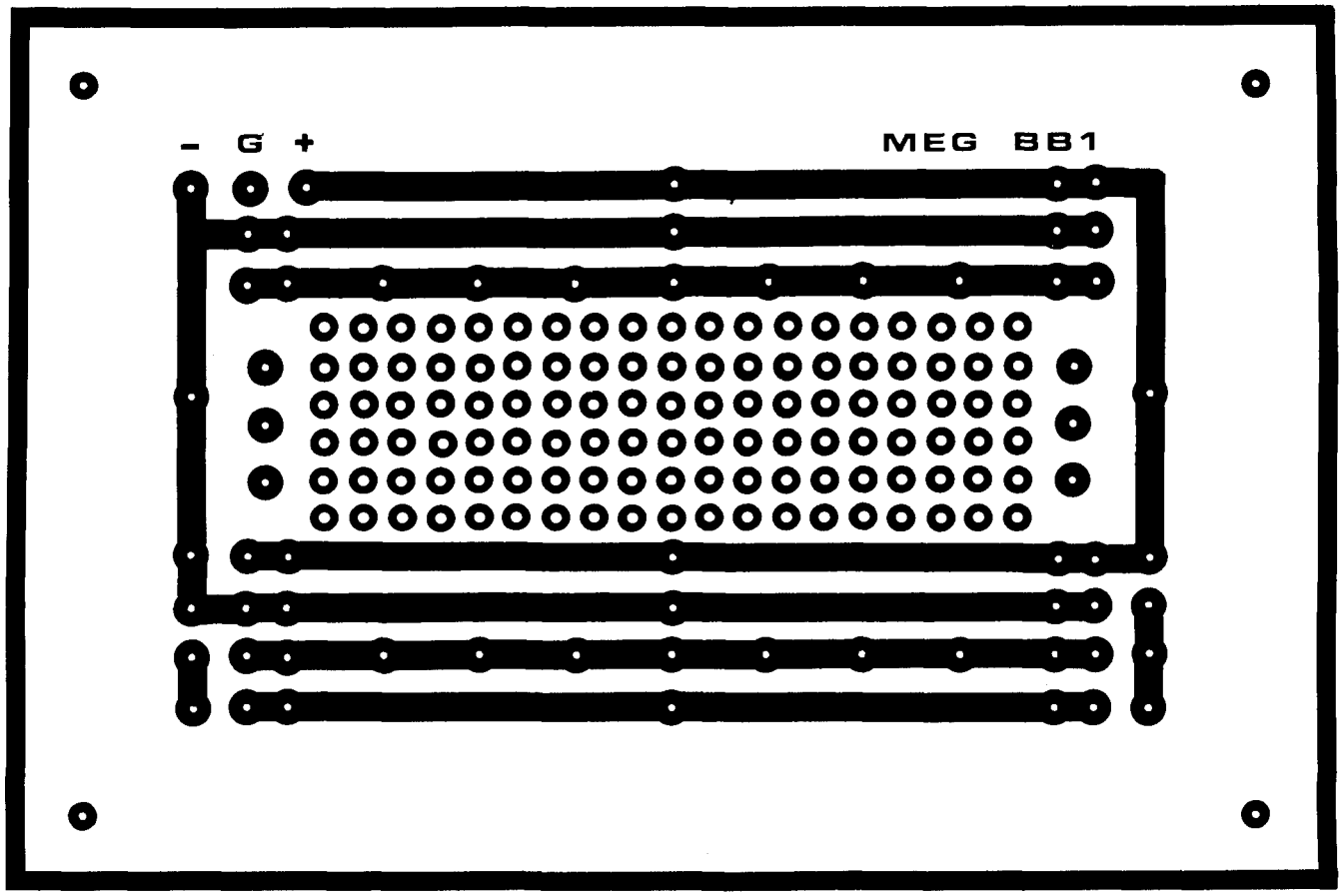
Having tried a variety of breadboards — from commercial spring-boards to nails driven into a piece of plywood — I thought a slightly different approach might be in order. One of my principal requirements was that the breadboard be adequate for simple RF designs. Generally, complex RF circuits such as complete receivers or high-gain amplifiers require more elaborate construction than a simple breadboard will allow because of the difficulty in controlling unwanted coupling. However, crystal oscillators, single-stage RF amplifiers, and modulators, for example, should be appropriate applications for this breadboard technique.

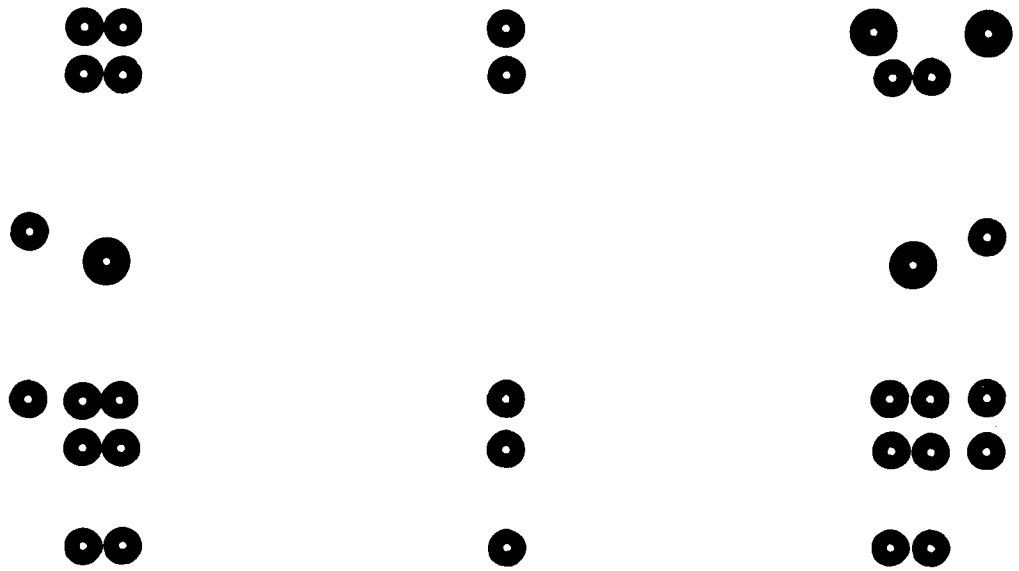
The artwork for a good basic design, a 1/16 inch (0.16 cm) thick PC board with a ground plane on the bottom side and dot and trace pattern on the top side, is shown in **fig. 1**. The traces allow two power supplies and ground to be conveniently bussed around the breadboard. Running power to all the various points where it's needed always seems to present a problem in any breadboard, particularly when you're making a lot of changes as you try out different circuit configurations. The power busses provide a convenient means of accessing the power supplies without having to daisy-chain the power conductors.

Grounding in analog designs is particularly important. Daisy-chaining ground can lead to some very unusual performance (for example, when your amplifier works better as an oscillator than an amplifier). The ground bus provides a good ground for all but the most demanding circuit designs. Power and ground are brought onto the breadboard at the three terminals at the edge of the board. This keeps the power leads out of the circuit area, preventing disturbances that could be caused by the leads lying in the circuitry. It also helps prevent power leads from deciding to detach and fall on the most critical (or expensive) components, generally with spectacular results.

A set of pads for installing power supply bypass capacitors has been provided at the lower left and right-hand corners of the trace pattern. Since long leads are often used to supply power to an experimental circuit, good bypassing of the supplies on the breadboard is very important. The bypass capacitors are often rather large and inconvenient to have in the middle of the breadboard circuit. Placing them at the lower edges of the work space gets them out of the way.

By Michael Gruchalla, 4816 Palo Duro N.E., Albuquerque, New Mexico 87110





GND

fig. 1. Breadboard artwork.

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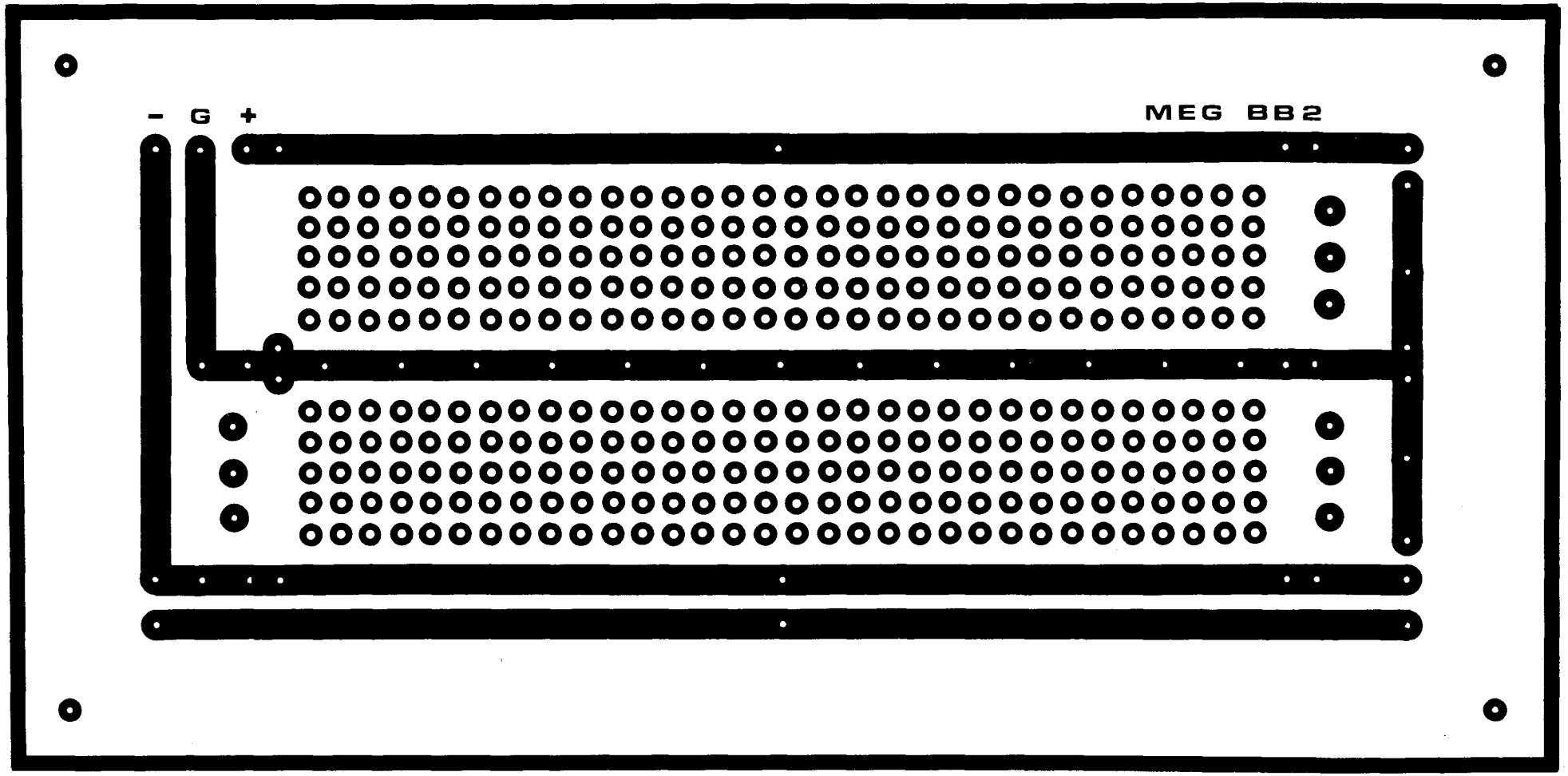

fig. 2A. Artwork for trace side for the larger breadboard.

The actual circuit nodes are simply PC dots arranged in rows and columns, allowing circuit components to be soldered directly to them without the need for holes to accommodate the component leads. The particular dot used has a very large center hole compared to normal PC dots of its size; this minimizes the capacitance of the dot to the ground plane and provides a dot large enough to solder to. The capacitance of each of the pads to the ground plane is about 0.5 pF, which is generally low enough to be usable up to 1 GHz.

Circuit ground can be provided in two ways. The ground bus is adequate for DC and low-frequency applications. High-frequency circuits generally require very tight grounding of various points, and in these cases the ground bus cannot be used very effectively because of the inductance of the wire that must be tied from the node to be grounded to the ground bus. Good grounding can be obtained by drilling through the board in the center of the pad that must be grounded, running a piece of bus wire through the hole, and then soldering it to both the ground plane and the pad. This grounding technique will provide good performance in circuits operating at frequencies as high as L-band (1.0 GHz).

breadboard construction

A few pointers will help you build a more professional-looking breadboard. **Figure 1** shows 1:1 art work for one version of the breadboard, a small unit that's quite convenient for single-stage amplifiers, oscillators, and other small projects. **Figure 2** shows artwork for a larger version with the same basic design but with different features. Art for both the trace and ground plane sides are shown. If you don't have the capability for making double-sided PC boards, you can omit the ground plane art, leaving a full ground plane on the bottom side. You can then use a drill bit (about 1/4 inch) to cut away the ground from the few penetrations where needed — at the power terminals, for example. Use the bit by hand and cut just deep enough to remove the cladding. Though doing this requires some care, it's really quite simple.

The breadboard should be fabricated from high-quality PC board material. Epoxy-glass materials with 2-ounce copper are about the best. The pads will lift off very easily if an inexpensive material such as a phenolic base is used; eventually, after much use, the pads will tend to lift off even the best materials, but if you start with quality material, the pads shouldn't begin to separate until it's about time to retire the breadboard anyway. If possible, the board should be tin-lead plated to minimize oxidation of the conductors with time. After all, old breadboards may lie around in the junk box for years before being resurrected for a quick weekend project, and they're certainly expected to be as useful at that time as they were when they were new.

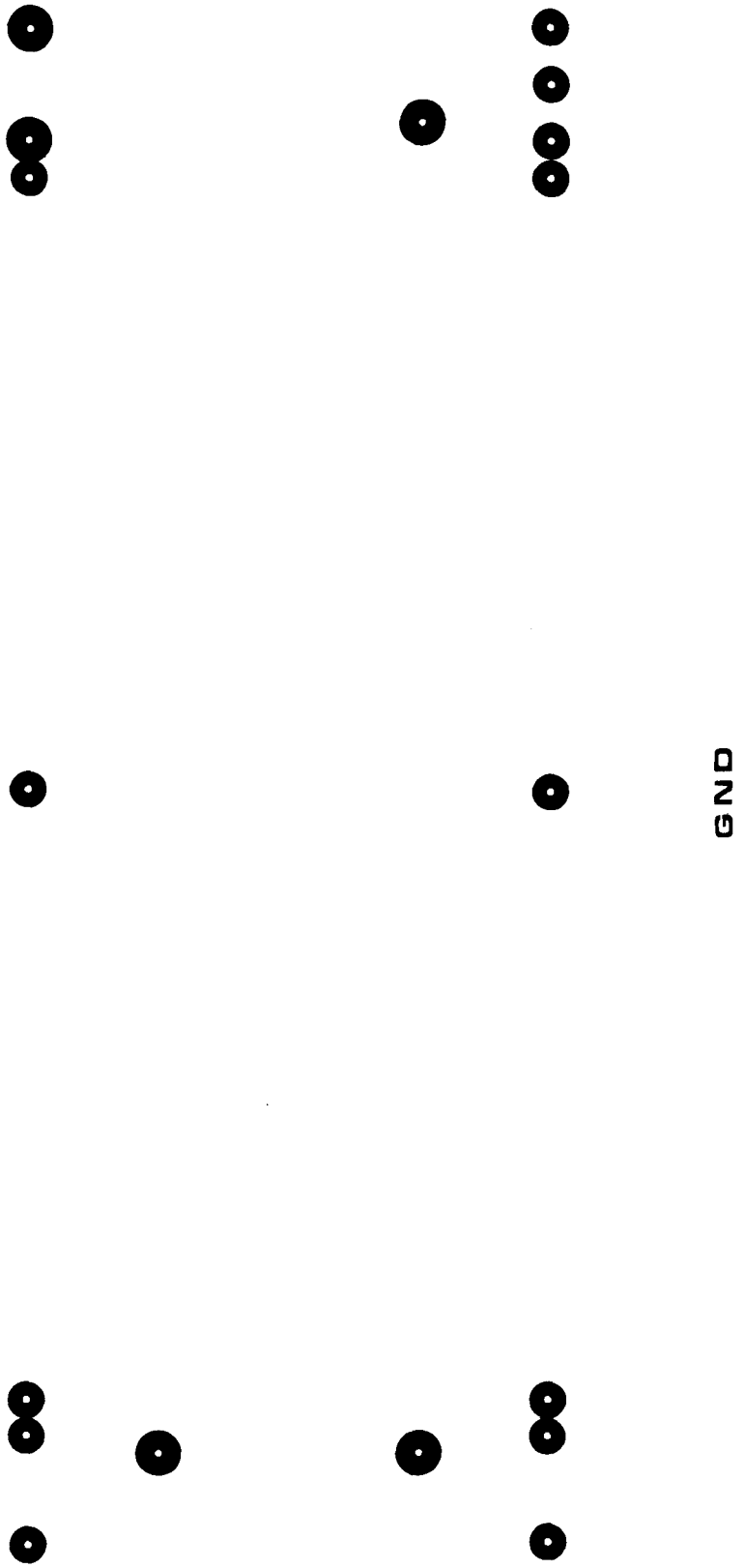

fig. 2B. Artwork for the ground side of the breadboard.

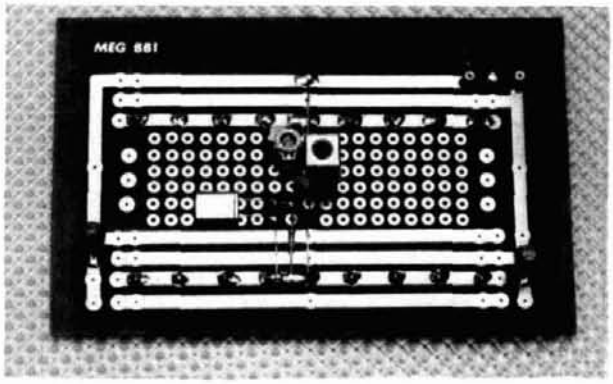

fig. 3. Crystal oscillator example.

If you have the breadboard fabricated commercially, don't have any holes drilled; this will reduce the cost and provide a good general-purpose board.

Before using the breadboard, tend to a few details to assure professional results. The three power terminals should be mounted at the indicated pads (+, G, and-). Drill a suitable hole through the center of the pads and swage in the terminals. Solder the two power terminals at the pad and the ground terminal at both the pad and ground. If you can't find terminals, you can use a loop of heavy bus wire; about 18 gauge works well. Solder the bus wire to the ground pad and ground plane. Make about a 1/4-inch (0.64 cm) loop in the wire and solder the end back to the ground pad. At the two power pads, solder the bus wire to the pad and loop it around to the corresponding conductor, making about a 1/4-inch loop, and then solder it to the trace. This will help prevent the power pads from pulling off because of the stress exerted by the external power leads. Next, drill holes in the bypass capacitor mounting pads and mount the two bypass capacitors. (A good choice of value is a 47μF, 35 V tantalum.) Be sure to observe the capacitor polarity when mounting. Even if you don't intend to use both supplies, at least drill the holes — you may eventually need an additional power supply, bias supply, or something similar, and having the holes there will prevent shorts that could be caused by metal chips trapped in a completed circuit. The two ground conductors aren't committed to be used as ground. They can be used for any type of bus, but at least one should be used as a ground. The lower is generally the most practical one. Drill holes in all the pads in the chosen ground bus, place bus wire in each hole, and solder to both the ground plane and the pad. Solder the ground plane first. (If you were to solder the pad side first, the piece of wire would probably fall out, since more heat is needed at the ground plane.)

Now, since several solder connections have been made to the ground plane, the board won't sit nicely on your work bench and the wire pieces are likely to scratch your work surface — not a desirable result if your work surface happens to be the dining room

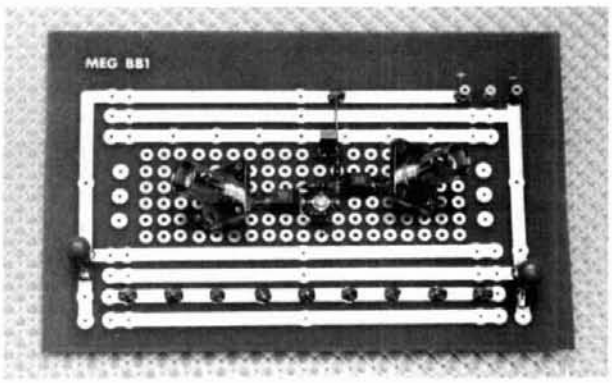

fig. 4. RF amplifier example

table). Adding four small rubber feet to the corners of the board eliminates this problem and gives the breadboard a pleasing appearance and better stability. Either self-adhesive feet or standard screw-mounted feet can be used. Small pads are included at the corners of the breadboard as markers for drilling foot mounting holes. Even standoff spacers can be used with rubber feet to provide space under the board if needed. For example, you could mount the bypass capacitor and power entry terminals under the board to provide more working space on the top side. You could even stack several breadboards together with spacers to form a multicircuit system.

Several extra pads and a bus are included on the artwork. Suffficient space is allowed around the edges of the board to allow for mounting of potentiometers, variable capacitors, connectors, and similar items.

There's nothing magic about the breadboard design, but I find this one quite useful for many analog circuits. **Figure 3**, for example, shows a crystal oscillator operating on TV channel 4 in a television interface application. **Figure 4** shows an amplifier that has a bandwidth of 100 Hz to 1.2 GHz and 15 dB gain; this amplifier was assembled to demonstrate that the breadboard can be used to L-band. From these figures, it can be seen that although these are only breadboards, they make an attractive finished design. Carefully completed and nicely packaged, a relatively handsome finished product can result.

Don't be afraid to experiment with the basic design to find the best configuration for you. The variety is limitless and the configurations shown here are just two possibilities. Remember, for analog breadboards the most important features are low stray capacitance and inductance and good grounding and bypassing of the supplies at the board. Other features such as pad arrangement and size, number of nodes, bus structure, and space for peripheral elements are very much a matter of the specific requirements of the circuit and your personal preference. The basic design presented here should prove to be a good basis for other configurations as well.

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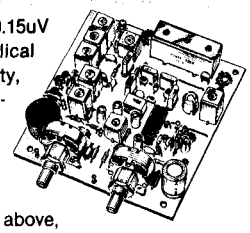

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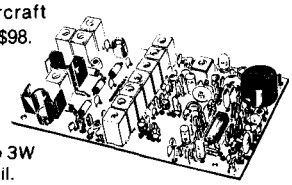

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50-54	144-148
144-146	28-30
145-147	28-30
144-144.4	27-27.4
146-148	28-30
220-222	28-30
220-224	144-148
222-226	144-148
220-224	50-54
222-224	28-30
902-928	422-448

UHF MODELS	
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435-437	28-30
432-436	144-148
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	28-29	145-146
	28-30	50-52
	27-27.4	144-144.4
	28-30	220-222*
	50-54	220-224
	144-146	50-52
	144-146	28-30
For UHF, Model XV4 Kit $79 Wired $139	28-30	432-434
	28-30	435-437
	61.25	439.25
	144-148	432-436*

*Add $20 for 2M input

VHF & UHF LINEAR AMPLIFIERS. Use with above. Power levels from 10 to 45 Watts. Several models, kits from $78.

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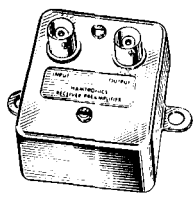

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MODEL	TUNES RANGE	PRICE
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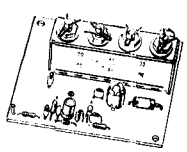
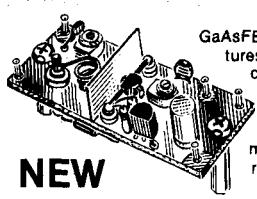


MODEL	TUNING RANGE	PRICE
HRA-144	143-150 MHz	$49
HRA-(*)	150-174 MHz	$49
HRA-220	213-233 MHz	$49
HRA-432	420-450 MHz	$64
HRA-(*)	450-470 MHz	$64

**Specify Center frequency desired*

MINIATURE PREAMPS



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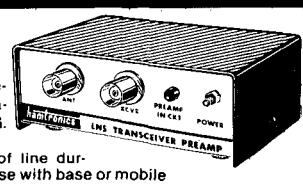

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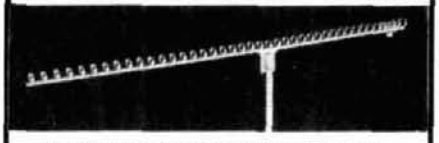

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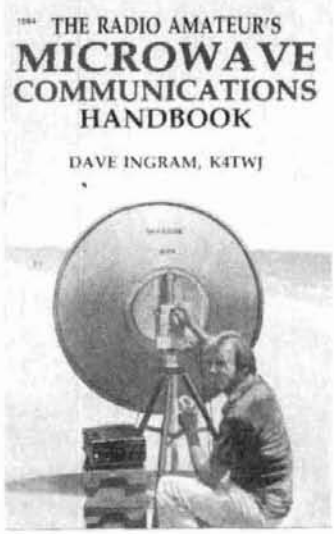

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PRACTICALLY SPEAKING ... Joe Carr K4IPV

selecting and using the right multimeter

Sooner or later almost everyone with more than a minimal interest in electronics begins to look at the various multimeters now on the market. These instruments are more than an aid in troubleshooting — they can be your right arm! A multimeter is a combination instrument that offers the benefits of several meters in one: a DC voltmeter, DC milliammeter, AC voltmeter, and an ohmmeter (plus other functions on certain premium-priced instruments). This month we're going to talk about the various instruments on the market, and what you should look for when selecting a particular one. Next month we'll examine some typical applications and problems.

types of multimeters

Over the years several different forms of meters have been developed. There's also more than one way to classify meters. For example, we could classify them by their active elements: none, vacuum tubes, FETs, and so forth.

We could also classify them according to the display mechanism: analog or digital? Analog meters use a regular pointer-type meter movement based on either the D'Arsonval or Taut-Band designs (there are others, but they're found only rarely, if ever, in multimeters). Their scales are printed on the panel behind the movable pointer. The digital meter, on the other hand, uses digital techniques to make the measurement and displays the result on digital numerical readouts (either LED or LCD).

world's oldest multimeter

Figure 1 shows a modern example of perhaps the oldest form of multimeter: the Volt-Ohm-Milliammeter, or "VOM." Based on an analog meter movement, this meter has switch-selectable ranges for DC volts, AC volts, DC milliamperes and resistance (ohms). Classical VOMs don't contain any active devices and don't require any power at all except for a single battery for measuring resistance.

Sensitivity is a determining factor in the purchase of such an instrument. The "sensitivity figure," a measure of the voltmeter's input impedance, tells us how much load the meter places on the circuit being tested. In the case of **fig. 1**, the sensitivity is 20,000 ohms/volt. If we multiply the full-scale voltage on any given range by the sensitivity, we find the input impedance. For example, when the 50-volt scale is selected, the input impedance is (50 V x 20,000 ohms/V), or 1,000,000 ohms.

The disadvantage of the VOM is that it sometimes loads circuits too much for practical use. In vacuum tube circuits, the meter works fine most of the time; in solid-state circuits, however. there are often problems. For example, when measuring the base voltage of an NPN common-emitter transistor amplifier (if operated from a single positive power supply), we expect to find a base-to-emitter voltage of 0.2 to 0.3 for germanium and 0.6 to 0.7 for silicon transistors. So, using the 1.5 volt DC scale, we find that the meter input impedance is (1.5 V x 20,000 ohms/V), or 30,000 ohms. Unfortunately, this resistance is on the same order of magnitude as bias resistances in transistor circuits, so the application of the meter probes changes the bias conditions — and renders the measurement invalid.

fig. 1. The oldest form of multimeters — the VOM.

The advantage of the VOM is that it is truly a minimum-hassle instrument to keep, store, and use. It's also very portable. These factors make the VOM popular with people who work for long periods in remote areas without easy access to fresh batteries.

Finally, people who work around high-power RF amplifiers might want to keep one of these instruments in their tool kits even if they normally use a modern digital instrument. The classical VOM, without any active devices to be misbiased by strong RF fields, will work in the presence of transmitters, where other, more expensive instruments might fail.

FET multimeters

Figure 2 *shows another form of* multimeter, the field effect transistor (FET) mulitimeter (FETVM or FETMM). This type is representative of a larger class of electronic voltmeters, and is a member of the class that includes vacuum tube voltmeters (VTVMs) and transistor voltmeters (TVMs). These devices are sometimes referred to collectively as electronic voltmeters, or EVMs. The names for these instruments are derived from the input circuit device: vacuum tube, transistor, or field effect transistor.

The purpose of the input amplifier device is to increase the input impedance, thereby reducing circuit loading. *For example, a typical specification for* the VTVM was an input-Z of 10 megohms, with an additional 1 megohm in the probe, for a total of 11 megohms. There is usually also 50 pF of capacitance shunting the input resistance. Modern FETVM and other EVM types sometimes sport input impedances even higher than 11 megohms — I can recall seeing 100 megohms advertised.

Like the VOM, the FETVM is a multirange meter that uses a front panel switch to select range, although in this case the functions (DC volts, AC volts, ohms, etc.) are selected by pushbutton switches. Unlike the VOM, the FETVM *(and all EVMs) require* DC power supplies for their active devices. In most cases, the DC power supply is a battery, although some 115 VAC line operated models are available. Unlike the classical VOM, EVM instruments are somewhat sensitive to RF fields, so many of them will not work well around high power transmitters and other RF generators such as electrosurgery machines, diathermy, or inductive heating devices, for example.

Both the FETVM and VOM have an AC volts scale. Even where there's a low range scale for the AC mode, the AC voltmeter in these instruments is not a substitute for the AC voltmeter *called for in the measurement, align*ment, and troubleshooting of audio circuits and devices. The AC scales in these multimeter instruments are generally accurate only at power line frequencies. Beyond an upper limit of 400 Hz or so, the accuracy of these instruments falls off rapidly as frequency *increases.*

fig. 2. High input impedance is — provided by the FET multimeter.

Examples of some representative digital multimeters are shown in **figs. 3 and 4**. These instruments use an internal analog-to-digital converter to convert the input voltage to seven-segment digital display output. Like the EVM and VOM, the digital multimeter (DMM) offers DC volts, AC volts, milliamperes, and ohms ranges.

what's a "half-digit?"

You'll see DMMs advertised as "2-1/2 digit," "3-1/2 digit," or "4-1/2 digit." Care to guess what a "half-digit" is? Because the most significant digit (the one all the way to the left) *can be just 0 or 1, it's billed as a half-*digit. Consider, for example, the 3-1/2 digit instruments. The basic range of these instruments is 0 to 999 units, with 100 percent overrange, for a total of 0 to 1999 units. The number of digits is a rough measure of precision, although a load of digits doesn't necessarily guarantee a quality meter. Generally, most Amateur and hobby *applications require no more* than 3-1/2 digits. There are cases in which 2-1/2 digits isn't enough, yet the 4-1/2

digit instrument may be more expensive than warranted by the application. Emotionally, I prefer to have as many digits as possible, but when it comes to laying out my bucks I prefer to pay due regard to the realities of measurement making — and economics. Dollar for dollar, quality for quality, there is an optimum instrument for each application.

But don't more digits mean more accuracy? And isn't it true that DMMs are in fact inherently more accurate than VOM and other EVM instruments? No! In both caes, the statement is false. The accuracy of the meter depends less on the number of digits in the display than on the quality of the internal workings of the instrument. For example, the accuracy of the internal A/D converter and its voltage reference have considerable effect on accuracy. In general, ethical manufacturers don't display more digits than they can support, but the size of the display cannot be taken at face value as an indicator of meter quality.

Now, regarding the really big heresy: "Whaddya mean my Digital Frammitzenfritzer DMM isn't necesarily more accurate than your crummy old VOM?" Please, before you boil me in oil, let me assure you that I *am* digitally oriented. I sit here writing this article on an Apple IIe personal computer while my IBM-PC sits on the other side of the room, chattering out Chapter 8 of my next TAB book. While it's true that DMMs have the potential for greater initial and long-term accuracy than VOMs, it depends on the implementation, the quality of internal circuits and other factors. There's also the fact that noisy signals tend to be heavily integrated (i.e. low-pass filtered) by the damping inertia of the analog meter pointer, but these same signals will fool many digital meters.

In regard to accuracy and resolution, I recommend buying from a reputable manufacturer and *reading the spec sheet BEFORE you plunk down the money*. Also, be wary of over-spec'ing the instrument. When you're in the market for a troubleshooting instru-

ment, don't let that gleam in your eye as you view the high-priced super-accurate laboratory models reach down as far as your wallet. Instruments such as those shown in **fig. 4** are very much in evidence in any electronic parts store you visit. Various low-priced models that not only make the classical measurements of the VOM, but do certain other things as well, are available. For example, I recently bought a handheld DMM that measures capacitance. The capacitance measurement scales run from 2000 pF full-scale (with 1 pF resolution) to 2000 μF full-scale. In addition, that model is ruggedized enough to withstand my clumsy work habits . . . no small attribute for *any* practical instrument!

Other features to look for on DMMs are the "Diode" or "High Power" mode and a continuity tester with an aural indicator. The Diode mode is used to test PN junction diodes and bipolar transistors (NPN and PNP). The normal ohmmeter mode in DMMs uses a very low voltage, too low to forward-bias PN junctions. The Diode mode (usually indicated by a diode symbol on the function switch) is a resistance mode, but with a source voltage that's high enough to forward-bias PN junctions. The DMM can be used to measure resistances in-circuit while in the low-power mode, and then test the semiconductors out of circuit in the Diode mode.

The aural continuity tester is basically a resistance scale that goes "beep" when the meter sees a low resistance across the probes. Why is this feature important? Try ringing out a multi-conductor cable while managing the probes in your fingers. Or worse yet, try ringing out an intercom cable while standing on a ladder — or a transmission line while you're hanging off a tower. However clever you may be, you simply can't watch the meter scale and manage the probes — or your own safety — at the same time. The "beep" of the meter tells you when the connection is made, and its absence warns you of an open circuit.

fig. 3. Bench-type digital multimeter.

fig. 4. Handheld digital multimeter.

which one to buy?

"OK, Carr, so you're a Certified Bright Guy (CBG) writing for a hot-shot national ham radio magazine — what kind of multimeter did *you* buy?" Believe me, I wish it were that easy! What *you* should buy depends on what kind of work you do, and to some extent, on what you can afford. Fortunately, the cost of a good quality troubleshooting-grade DMM instrument is way down from what it was a couple of years ago. Almost everyone can afford to buy one of those instruments.

Let me describe what I own and what type of work I use them for. The work consists of troubleshooting electronic equipment occasionally and developing small projects for Amateur Radio and electronic hobbyist magazine articles.

Because I have a ham radio set with a 2 kW linear amplifier, it's possible that the meter will have to work in high RF environments. As a result, I own a classical VOM that's almost older than I am. The old VOM has a 25 kV probe as an accessory, although I loaned it out and can't remember who borrowed it. I also own a handheld Beckman DM-25 that measures capacitance in addition to the other "normal" parameters. This last feature turns out to be of immeasurable value in developing projects for publication.

If I were doing any extensive audio work, then I'd probably also buy an AC voltmeter of audio grade. I suspect that most electronic workbench-oriented readers will opt for a small collection of meters that nearly matches my own . . . . **ham radio**

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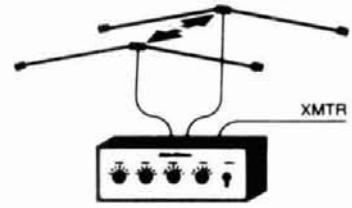

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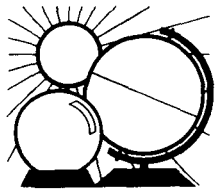

DX FORECASTER

Garth Stonehocker, KØRYW

sporadic E DX

In last month's column we discussed the characteristics (in terms of location and propagation) of Sporadic E, or E_s. This month, let's take a look at how Sporadic E (E_s) propagation can be used for DX operation.

Because E_s propagation normally provides short-skip conditions — i.e., 1000 miles (1600 km) maximum hop length, with typically one or two hops at best, the range of communications is limited in this mode. The take-off angle must be low (5 to 10 degrees) in order to obtain the maximum distance per hop. Signal attenuation increases with more hops because of D-region absorption and lossy ground reflections. On the higher frequency bands where horizontal beam (Yagi) antennas are used, this means towers exceeding 60 feet — or even better, more than 100 feet. At the lower frequencies (below 10 MHz) vertical antennas on unobstructed, treeless sites, situated over moist earth and equipped with sufficiently large ground systems are needed to obtain 5- to 10-degree take-off angles. These are the antenna systems DXers dream about and a few build.

To obtain the highest probability of "reflecting" from an E_s "cloud," a fairly wide beamwidth should be used. Because the beamwidth of Yagis (50 to 60 degrees) is greater than the beamwidth of rhombics (20 to 30 degrees), Yagis are preferred for "hitting the clouds." E_s clouds usually measure about 6 by 60 miles (10 by 100 km) in length and about 1 mile (1.6 km) in thickness. They are oriented along the geomagnetic field line direction — i.e., roughly north-south over the United States. Their thin, dense configuration results in mirror-like *reflections* rather than the hundreds of kilometer thickness *refractions* that are characteristic of the F-region of the ionosphere. Signal strengths are, on the average, 25 dB higher due to the reflective as compared to refractive mode.

Another rule of thumb for E_s operation is to use the *lowest* frequency that still doesn't have excessive absorption. (For example, during daytime, don't use 10 meters if 20 is usable.) The probability of a good E_s opening occurring is greater with the lower frequency band.

There are trade-offs involved, however, in choosing either the lower or higher bands. You may, for example, want to select a lower band where E_s openings, though more probable, are limited by a higher take-off angle, more hops, and more loss. Or you might choose to go to a higher band for that occasional E_s opening, taking advantage of smaller take-off angles, fewer hops, and diminished losses (since the antenna is proportionately higher, with respect to wavelength, than the lower band version). Of course, if you're a 6-meter DXer, there's no choice — you'll have to wait for the E_s opening.

Early indications of E_s openings on the higher-frequency bands can be obtained by monitoring beacons on 6 and 10 meters and on CB channel 19. You can also monitor locally unused TV channels 2 through 5 for 6-meter openings. You may want to try W3ASK's system described in the June, 1985 "DX Forecaster." The lower frequency bands don't need beacon monitoring because E_s openings (sunrise and sunset hours) are available most of the time.

last-minute forecast

DX conditions are expected to be best for the higher frequency bands (10 to 30 meters, which are daytime bands) from the 12th through the 21st of the month, providing long and short skip openings. Look for short skip conditions the remainder of the month. The lower frequency bands (30 to 40 meters) should be best the first and the last weeks of the month, including daytime signals when the solar flux is below 70 units. The 80- and 160-meter bands will provide only fair DX conditions because of atmospheric noise build-up, except for some E_s short skip openings toward the end of the month.

The Aquarid meteor shower starts around the 18th, peaks about the 28th, and lasts until approximately August 7th. The maximum radio-echo rate will be approximately 34 per hour. The full moon is on June 29th, lunar perigee on the 21st, and summer solstice on the 21st at 1630 UT.

band-by-band summary

Six meters will provide occasional openings to South Africa and South America around local noontime via the E_s short-skip propagated mode.

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

Twenty, thirty, and forty meters will be useful for DX operation from most areas of the world during the daytime and into the evening almost every day, either long-skip to 2500 miles (4000 km) per hop or short-skip E_s to 1000 miles (1600 km) per hop. Since the period of daylight is now at its peak, high maximum usable fequencies will be practical for many hours of distance operation.

Thirty, forty, eighty and one-sixty meters will provide opportunity for nighttime DX operation. However, there will be many nights later this month when only 30 and 40 meters will be usable because of high thunderstorm QRN on 80 and 160. Nevertheless high signal levels, the result of short-skip E_s conditions, may help to overcome the static toward the end of the month.

JUNE

WESTERN USA

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

MID USA

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

EASTERN USA

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

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

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

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COMING EVENTS

Activities — "Places to go . . ."

CALIFORNIA: Flea Market/Boneyard Sale. Foothill College, Los Altos Hills. March-Sept. 2nd Saturday of every month 7 AM Sellers. 7:15 AM buyers. Talk in 145.27(-) or 147.570 simplex. FCC exams (408) 255-9000.

WASHINGTON: Central Washington Hamfest sponsored by the Apple City Amateur Radio Club, W7TD. June 14 and 15, Rocky Reach Dam near Wenatchee. Registration $5 for Amateurs. Others $1.00. Under 12 free. Banquet $7.00. Equipment displays, Swap Shop, ARRL VE license exams. Free camper/trailer space with power provided by Park. Talk in on 146.07/67 or 146.49 simplex.

NEW YORK: The Mt. Beacon Amateur Radio Club Hamfest, Saturday, 12, Arlington Senior High School, Poughkeepsie/LaGrange. Tickets $3.00 (hams and computer hobbyists). Tailgating space $4.00. Tables $6.00—one free table and admission. Doors open 8 AM. Talk in on 146.37/97and 146.52. For more info: Julius Jones, W2IHY, RR 2, Vanessa Lane, Staatsburg, NY 12580 (914) 889-4933.

INDIANA: The Lake County Amateur Radio Club's 14th annual Fathers' Day Hamfest, Sunday, June 15, Lake County Fairgrounds Industrial Building. Free parking. Tables available. Admission $3.00. No advance. 8 AM to 2 PM. Setup 6 AM. MARS, ARRL, ARES information. Refreshments. Overnight accommodations nearby.Talk in on Lake County ARC repeater 147.84/24 or 146.52 simplex. For further information: Bill DeGeer, W9TY, 3601 Tyler Street, Gary, IN 46408 (219) 887-5413 evenings after 6 PM.

NEW HAMPSHIRE: Fly-in to New Hampshire's 2nd largest Amateur Radio/electronic flea market, Saturday, June 21, Manchester Municipal Airport. Sponsored by the New Hampshire FM Association. Rain date Sunday, June 22. Starts 9 AM. General admission $1.00. Sellers $5.00, bring own tables. Commercial displays welcome. Refreshments available. Preregistration to 123 Woodlawn Circle, Portsmouth, NH 03801. Talk in on 146.52 FM. For information: Doug Aiken, K1WPM, (603) 622-0831 or Pete Henriksen, WA1RCF, 123 Woodlawn Circle, Portsmouth, NH 03801. (603) 431-5432.

WISCONSIN: The South Milwaukee Amateur Radio Club's annual Swapfest, Saturday, July 12, American Legion Post 434, 9327 South Shepard Avenue, Oak Creek. 7 AM to 4 PM. Parking, picnicking, food and refreshments available. Admission $3.00 includes "happy time" with free beverages. The Milwaukee Volunteer Core Group will conduct Amateur Radio exams during the day. For more details, including a map, write: South Milwaukee ARC, PO Box 102, South Milwaukee, WI 53172-0102.

1986 "BLOSSOMLAND BLAST" Sunday, October 5, 1986. Write "BLAST", PO Box 175, St. Joseph, MI 49085.

CALIFORNIA:FCC exams, Novice-Extra. Sunnyvale VEC ARC. (408) 255-9000 24 hour. 73, Gordon, W6NLG, VEC

PENNSYLVANIA (Meadville) -- July 5. Firecracker Hamfest by Crawford Amateur Radio Society. Electronics, radios, computers. New location at Meadville Recreation Center just off Rt. 27 E in Meadville. All indoors; no rain out. One olympic and two child-size deluxe swim pools with lockers and showers and other sports available in Center. Free indoor fleamarket space; bring table. Dealers: free indoor space and table(s) available by preregistration; reserve early. Admission adult $2.00, children free, swimming for small extra. Talk in 144.53/145.13, W3MIE/R. For information write CARS Hamfest-86, PO Box 653, Meadville, PA 16335 or call Ben Ferer, KF3F, 814/724-2432.

KENTUCKY: The Antique Radio Club of America (ARCA) will hold a convention, June 11 through 14 in Louisville. Club members collect and restore antique wireless and radio equipment from before World War I through the 40's and 50's. At this year's convention there will be speakers, tours of radio collections and also tours of the Louisville area. Massive flea market and auction. Louisville offers much in the way of recreation for the entire family. For information: ARCA, 81 Steeplechase Road, Devon, PA 19333 or call (215) 688-2976.

ILLINOIS: The Egyptian Radio Club will hold its 57th annual Hamfest, Sunday, June 8, 8 AM to 3 PM, at their clubhouse. Free 10' flea market spaces available on first come basis. Additional spaces $5.00. Tickets $1.00 advance, $2.00 each or 3/$5.00 at the door. Talk in on 146.16/76 or 146.52 simplex. For information or tickets SASE to Egyptian Radio Club, PO Box 562, Granite City, IL 62040.

BRITISH COLUMBIA: Maple Ridge Hamfest, July 12 and 13, St. Patricks Center, 22589 121 Avenue, Maple Ridge. Admission Hams $6.00; non-hams over 12 $3.00. Under 12 free. Two hams in family $9.00. Commercial displays, flea market, food, children's programs. Nearby shopping and recreation areas. Camper space, no hookups. Talk in on 146.20/80 and 146.34/94. For more information: Bob Haughton, VE7BZH, Box 292 Maple Ridge, BC V2X 7G2 or phone (604) 467-4915.

NEW YORK: Ham Family Day, June 1, Becks Grove, Blosvale. Sponsored by the Rome Radio Club. QRP contest, flea market, tech talks. Non-ham activities. Talk in on 146.28/88 and 146/34/94. For information: Rome Radio Club, Box 721, Rome, NY 13440 or call William Effland (315) 853-5700.

MINNESOTA: The North Area Repeater Association's Swapfest and exposition, Saturday and Sunday, June 7 and 8, Minnesota State Fairgrounds in St. Paul. Free overnight parking for SC campers June 6 and 7. Exhibits, commercial dealers, giant outdoor flea market. Amateur license exams will be given. Admission $4 advance, $5 at gate. For more information, tickets, etc: Amateur Fair, PO Box 857, Hopkins, MN 55343 or call (612) 566-4000.

NEW JERSEY: The Raritan Valley Radio Club's 15th annual Hamfest, Saturday, June 21, Columbia Park, Denellen. Gates open 8 AM. Sellers spots $5.00/space or $10.00 multiple spaces. No tables supplied. Lookers $3.00 donation. Spouse and kids free. Food and drink available. Talk in on Club repeater W2QW/R 146.025/.625 and 146.52 simplex. For information call Dave, KA2TSM (201) 763-4849 or Bill, N2AZX (201) 467-7342, 8 AM to 5 PM.

PENNSYLVANIA: Harrisburg annual Firecracker Hamfest, Friday, July 4, Bressler Fire Company picnic grounds. Sponsored by the Harrisburg RAC. Tailgating no charge with admission of $3.00. XYL and kids free. Nearby restaurants and motels. Parking on grounds. Talk in on 52-52 simplex or local repeaters. For details/table info: Dave, KC3MG, 131 Livingston St, Swatara, PA 17113 or call (717) 939-4957.

WEST VIRGINIA: The 8th annual TSRAC Wheeling Hamfest/Computer Fair, Sunday, July 20, Wheeling Park. 9 AM to 4 PM. WV's largest. Dealers welcome. 30,000 sq. ft under roof. 5 acres of flea market. Family activities at Park. Admission $3.00 *in advance, $4.00 at door. To reserve space contact:* Jay Paulovicks, KD8GL, RD 3 Box 238, Wheeling, WV 26003 (304) 232-6796. For tickets, TSRAC, Box 240, RD 1, Adena, OH 43901 (614) 546-3930.

MARYLAND: The Frederick Amateur Radio Club's 9th annual Hamfest, June 15, Frederick Fairgrounds. 8 AM to 4 PM. Admission $3.00. Tailgaters $2.00 extra. YL's and kids free. Gates open for exhibitors 8 PM June 14. Exhibitors tables $10.00 first, $5.00 each extra. For information: Jim Kasunic, KA3LPC, 9419 Highlander Ct, Walkersville, MD 21793.

INDIANA: The 16th annual Indiana ARRL Convention and Indianapolis Hamfest, Saturday and Sunday, July 12 and 13, Marion County Fairgrounds, Indianapolis. Featuring the largest electronic flea market and new Amateur Radio equipment display in the state. Gate fees $5.00 with free parking on grounds. Gates open 6 AM. Large covered flea market. Inside tables $8 each. 2m Fox Hunt, homebrew contest. QSL card contest. Free camper hookups available on grounds. Nearby restaurants and motels. For information contact Bill Evans, WB9BEN (317) 745-6389

MASSACHUSETTS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday, June 18, 7 PM, MIT Room 1-134, 77 Mass Avenue, Cambridge MA. Reservations requested 2 days in advance. Contact Ron Hoffmann (617) 253-0160/646-1641 or Craige Rodgers (617) 494-1986. Exam fee $4.25. Bring copy of current license (if any), two forms of picture ID and completed form 610 available from FCC in Boston (223- 6609)

PENNSYLVANIA: The 12th annual Warminster Amateur Radio Club's Hamfest, Sunday, June 8, Middletown Grange Fairgrunds, Penns Park Road, Wrightstown. Gates open 7 AM (vendors 6 AM). Donation $3.00. XYL's and kids free. Outdoor tailgating $5.00 per space. Indoor space $5.00 with 8' table and power available. Talk in on 147.69/09 and 146.52. For information and preregistration: Chuck Dunn, KA3FQQ, 1414 Bradley Lane, Warminster, PA 18974.

OPERATING EVENTS
"Things to do . . ."

The LINCOLN TRAIL ARC will operate W4BEJ from Abraham Lincoln Birthplace National Historic Site near Hodgenville Kentucky during Field Day June 28 and 29. For a commerative certificate send QSL and SASE to LTARC, PO Box 342, Vine Grove, KY 40175.

ACB RADIO AMATEURS a special-interest affiliate of the American Council of the Blind (ACB) will operate special event station KW4U from 0000Z June 29 to 2400Z July 5 from the Hilton Hotel in Knoxville, TN in conjunction with ACB's silver anniversary convention. Submit QSL card confirming QSO with KW4U during convention week and receive an attractive commemorative certificate. Send QSL's to John McCann, KW4U, 2105 N. Illinois Street, Arlington, VA 22205.

BUZZARD ROOST REPEATER will operate special event station WB0UPK,1500Z July 4to 0100Z July 5, from the Neligh Mills, a state historical site. QSL's may be obtained by sending SASE to WB0UPK, 804 East 1st Street, Neligh, NE 68756.

EASTERN CONNECTICUT ARA will operate special event station, K1MUJ, to help celebrate the Woodstock Connecticut Tercentenary on July 4. For a commemorative certificate send SASE and QSL card to KB1SP.

ARGONNE ARC will operate W9QVE, June 21 from 11 AM to 4 PM CST to commemorate the 40th anniversary of the establishment of the US National Laboratory System of which, Argonne is the first. Send QSL and SASE to AARC, PO Box 275, Argonne, IL 60439.

SOUTH JERSEY RADIO ASSOCIATION, the oldest radio club in the US, will operate a special event station, K2AA, from 1200Z June 7 to 0400Z June 16 to celebrate its 70th birthday. For a commemorative QSL send SASE and QSL or log info to South Jersey RA, PO Box 1026, Haddonfield, NJ 08033.

product REVIEW

500 MHz Pocket Counter

Here's a neat little product every ham will want to have: a 500-MHz counter from Digitrex that fits into a shirt pocket, measures just 1 x 3.5 x 2.7 inches, and weighs less than 8 ounces *with* the 9-volt battery installed. The LED readout display measures 0.14 inch; the unit draws less than 100 mA. Battery life is estimated to be several weeks in normal use. The unit uses six ICs, five transistors, three diodes, and a 2.56 MHz internal crystal oscillator.

The counter has a sensitivity of less than 50 millivolts, 1-500 MHz, 1.5 volts RMS maximum and the resolution is four digits (switchable to six) down to 1 kHz. A seven-digit modification that gives resolution down to 100 Hz is available. The counter has a short-term accuracy of 1 ppm when calibrated against a known signal using an internal trimmer capacitor. Over the long term, its accuracy is 1 kHz at 500 MHz over a temperature range of 10-40 degrees C.

To use the unit, you first install a 9-volt transistor battery, extend the internal 19-inch antenna, select the MHz range, and depress the counter's on/off button, which also functions as a press-to-read control. All you do is read the frequency — it's really as simple as that!

Not having a lab-grade frequency generator with which to compare readings limits the scope of this review to using the VFOs (and internal frequency calibrators) of several different transmitters as frequency standards. All readings were found to be within manufacturer's specifications.

This is really a "neat" product and at the price, it's one good value for your dollar. While you can't expect lab-grade measurements, you'll be pleased with the unit's accuracy.

The price is $49.95 plus $2 shipping and handling. For more information, contact: Digitrex, 1005 Bloomer, Rochester, Michigan 48063.

— **N1ACH**

NEW products

triple output power supply

MFJ Enterprises, Inc. has announced the release of its Triple Output Lab Power Supply. For $149.95 (plus $6.00 shipping and handling), the MFJ-4002 offers two variable 1.5 to 20 VDC outputs at 0.5 amp and one fixed 5 VDC output at 1 amp. It's designed for heavy duty commercial use to give years of trouble-free service.

There's plenty of voltage and current for both analog and digital circuits. It's ideal for education, circuit design, product development, testing and repair, quality control and production.

Separate transformers are used for completely isolated outputs. This allows the outputs to be connected in series or parallel for higher voltage or current. It's short circuit protected, has excellent line regulation (typically 0.1 percent V) and load regulation (typically 0.1 percent) and has very low ripple.

Two lighted 3-inch precision meters are provided for monitoring voltage and current simultaneously. Rugged 5-way binding posts are used for all outputs. A separate binding post is used for chassis ground.

The MFJ-4002 is made in America and built with heavy guage aluminum to take lots of abuse. It measures 12x36x6 inches, uses 110 VAC with a 3-wire safety power cord and fast acting pop-out fuse. For details, contact MFJ Enterprises, Inc., 921 Louisville Road, Starkville, Mississippi 39759.

Circle #301 on Reader Service Card.

new heathkit catalog

A wide variety of electronic products in kit form and assembled versions are showcased in the new Heathkit Catalog from Heath Company of Benton Harbor, Michigan. A new 2-meter handheld/mobile system featuring greater ease of operation and greater flexibility is offered, as is a low-cost, user-installed satellite sytem featuring the General Satellite Dish and the Norsat Satellite Receiver.

The HW-6502 2-Meter Hand-held Transceiver comes complete with a built-in CTCSS encoder, S/BATT meter, squelch control and thumbwheel channel selector switches with +5 kHz switch. The operating frequency range is 144 MHz to 147.995 MHz and sensitivity is 0.25μV. The mobile console unit, HWA-6502-2, houses the transceiver and is able to provide 25-watt mobile operation with the optional 25-watt 2-meter amplifier. The console, which includes power, UHF and VHF switches and lit frequency display, measures 2-1/4 x 6-1/2 x 8-1/2 inches (excluding projection).

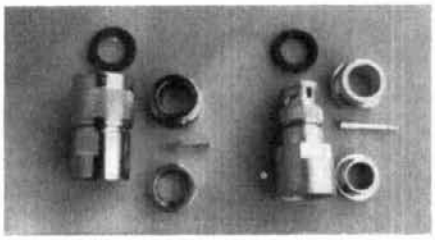
The Heathkit Satellite System combines the Norsat receiver and the General Satellite Dish for the user to install and receive satellite relayed programming. The Heathkit Site Survey kit is used to determine acceptable sites for positioning the system's dish antenna.

Over 400 electronic products are offered in the new Heathkit Catalog. To receive a free copy, contact Heath Company, Benton Harbor, Michigan 49022.

Circle #302 on Reader Service Card.

cable connectors

Nemal Electronics International has introduced a new line of connectors designed to fit the Belden 9913- and 8214-type cables. The new connectors are available from stock in both type N (part #NE720) and BNC (part #NE860) series and will accommodate the 9-1/2 to 11 gauge center conductors in these and other similar cables.



Both series of connectors meet the electrical and mechanical requirements of MIL-C-39012 and incorporate silver plated contacts and teflon insulation. Each connector is fully compatible with all other standard connectors in its series.

For information, contact Nemal Electronics International, 12240 NE 14th Avenue, North Miami, Florida 33161.

Circle #303 on Reader Service Card.

new VOM

Mercer Electronics, a division of Simpson Electric Company, has introduced a new VOM; Model 9120 has 25 ranges including dB, 20,000 ohms/volt DC sensitivity (5,000 ohms/volt AC) and a frequency response up to 100 kHz on 3, 12, and 60-volt AC ranges. It will measure up to 12 Amperes DC, has a 3-volt AC range, and provides excellent resolution. DC accuracy is ±3 percent fs. Convenience features include a front panel polarity reversal switch, single-knob range/function switch with an "off" position, an output jack for DC isolation, and a large, easy-to-read, 3.5- inch mirrored, color-coded scale.

Also included is a high-energy fusing system along with standard fusing and diode meter protection. The unit measures 4 x 6 x 1-3/4 inches and weighs 13 ounces. It comes complete with batteries, test leads and an operator's manual.

For details, contact Mercer Electronics, 859 Dundee Avenue, Elgin, Ilinois 60120.

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SAY YOU SAW IT IN HAM RADIO

THE GUERRI REPORT

by Ernie Guerri, W6MGI

new communications satellites will use laser links

A new concept in communications satellites is in the development stages in European laboratories. The large data capacity of optical communications links will be exploited by incorporating a carbon dioxide laser into a geosynchronous satellite. The CO_2 laser operates in the far infrared region, at a wavelength of about 11 microns (27,000,000 MHz).

In spite of substantial technical hurdles, its benefits are thought to justify the effort. Advantages include simultaneous bi-directional data capacity of more than 1 gigabit/sec., with an accuracy of about 10 bits (an error rate of 1 part in 10^8) at an altitude of about 37,000 km. The transmissions would have high resistance to interference and jamming because the frequencies are removed from present high-density traffic, and the laser beam is very narrow — less than 1 km wide at geosynchronous altitude.

The choice of the CO_2 laser is based on the fact that highly sensitive detectors already exist, the technology for the needed power levels is well advanced, and relatively conventional optics can be used. The system would consume about 250 watts in order to produce a little more than 1 watt of modulated power. Transmitter bandwidth will be about 5 GHz, permitting higher data rates as technology and traffic demand mature. Two technical areas will need considerable attention in order to achieve successful operation. The optical receivers need to be cooled to −173 degrees C (100 degrees K) for optimum sensistivity, and the pointing and tracking system must be able to keep the very narrow beam centered on the respective receivers. Present technology is marginal in each of these areas.

Components for the planned satellite will begin to be assembled as a laboratory breadboard as early as 1987. The first flight tests are planned for 1990-91, and an operational satellite is contemplated for 1994-95.

emergency transmitter gives directions when lost

The Federal Aviation Administration requires that all aircraft carry an emergency locator transmitter (ELT) that can help pinpoint the aircraft's location in the event of a crash. The device is a small battery-powered unit that transmits on 121.5 and 243.0 MHz. A newly-developed unit takes full advantage of today's IC's to greatly enhance the data sent by the beacon.

As the aircraft flies, a circuit in the locator continuously enters the current position of the plane from the aircraft's LORAN-C navigation system. In the event of a crash, the locator broadcasts a synthesized speech message beginning with the word "mayday" and stating the aircraft's registration number, its longitude/latitude, the elapsed time since impact (very important in harsh environments), and other key information — all in plain English. This improvement will simplify search and rescue operations and expand the number and type of observers who can participate in radiolocation searches — Amateurs, SWLs, scanner buffs, and so on.

chip inductors join new component ranks

Since the beginning of the era of solid-state circuits, component manufacturers have been quick to keep pace with designers' needs. Components of all types have shrunk in size and taken on the shapes appropriate to the application. Inductors have resisted most attempts at going "monolithic" and have caused a lot of otherwise elegant designs to be much larger and less reliable than the designer might have wished.

We still haven't found any magic way to solve the problem, but there has been significant progress in magnetic materials combined with creative new packaging techniques. Given incentive by the move to surface-mounted components, leadless "chip" inductors are making their debut. Using ceramic or ferrite cores, these ultra-miniature inductors can be made with very small gauge wire because of the low power levels associated with modern IC circuits. Eliminating leads also reduces stray capacitance and parasitic inductance, thereby making the component a little closer to ideal.

Chip inductors have evolved in a few "standard" packages, which makes the layout job easier for the circuit designer. Inductance values cover the full range from about 3 nH to 1 mH, and include both fixed and variable type. Because these inductors mount directly on the circuit substrate, great care must be taken in the choice of temperature coefficients. If the inductor is not matched to the substrate, expansion and contraction can cause severe lead stress, and in the worst cases can actually lift the inductor from the substrate. Shielding poses serious problems on all but small inductance values. At present, shielding simply takes up real estate — which of course defeats the purpose of using the chip inductors. Notwithstanding the difficulties, before long you can expect to be staring at a totally unfamiliar-looking component on a circuit board — a "chip" inductor.

ham radio

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(617) 372-3442

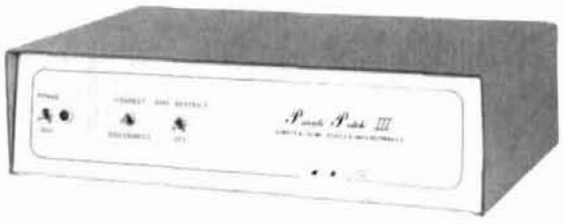
184

THINGS TO LOOK FOR *(AND LOOK OUT FOR)* IN A PHONE PATCH

- One year warranty.
- A patch should work with any radio. AM, FM, ACSB, relay switched or synthesized.
- Patch performance should not be dependent on the T/R speed of your radio.
- Your patch should sound just like your home phone.
- There should not be any sampling noises to distract you and rob important syllables. The best phone patches do not use the cheap sampling method. (Did you know that the competition uses VOX rather than sampling in their $1000 commercial model?)
- A patch should disconnect *automatically if the number* dialed is busy.
- A patch should be flexible. You should be able to use it simplex, repeater aided simplex, or semi-duplex.
- A patch should allow you to manually connect any mobile or HT on your local repeater to the *phone system for a fully* automatic conversation. Someone may need to report an emergency!
- A patch should not become erratic when the mobile is noisy.
- You should be able to use a power amplifier on your base to extend range.
- You should be able to connect a patch to the MIC and EXT. speaker jack of your radio for a quick and effortless interface.
- You should be able to connect a patch to three points inside your radio (VOL high side, PTT, MIC) so that the patch does not interfere with the use of the radio and the VOL. and SQ. settings do not affect the patch.
- A patch should have MOV lightning protectors.
- Your patch should be made in the USA where consultation and factory service are immediately available. **(Beware of an inferior offshore copy of our former PRIVATE PATCH II.)**

ONLY
PRIVATE PATCH III
GIVES YOU ALL OF THE ABOVE

PRIVATE PATCH III
SIMPLEX SEMI-DUPLEX INTERCONNECT



The telephone is the most powerful mode of communications . . . PRIVATE PATCH III gives you full use of your home telephone from your mobile and HT radios!

With only three simple connections to your base station radio, PRIVATE PATCH III will give you more communications power per dollar than you ever imagined possible.

Suddenly the utility of your radio is drastically increased. There are new sounds . . . dial tones, ring tones, CW ID and the sound of voices you never expected to hear on your mobile or HT radio! What a convenience!

PRIVATE PATCH III frees you from memberships, cliques and other hassles common to many repeater autopatches. You can call who you want, when you want and for as long as you want. You can even receive your incoming calls!

VOX . . . the right choice!

VOX based phone patches offer many perfo mance and operational advantages over th sampling method. These include operatio through repeaters, compatibility with an radio, no lost words or syllables, greater range smooth audio free of continual noise bursts etc., etc.

Most amateurs are not aware that the compet tion's top of the line patch is VOX based. (Yo *know . . . the $1000 model they enthusiasticall* call **"our favorite commercial simplex patch** on page 3 of their SP brochure.)

PRIVATE PATCH III offers about the sam capability, performance and features as the top model but is priced closer to their bottor of the line (SP) model!

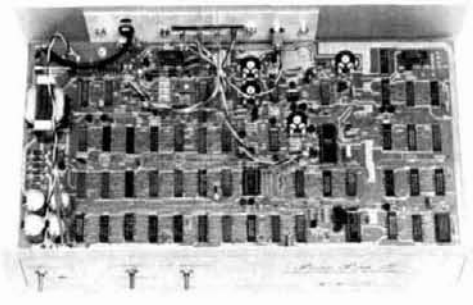
So why settle for SP when top of the line cost little more?

To Learn more about PRIVATE PATCH III and the advantages of the VOX concept, call or write fo our four page brochure today!

PARTIAL LIST OF FEATURES

• OPERATES SIMPLEX, THROUGH REPEATERS, OR DUPLEX ON REPEATERS • VOX BASED • TOL RESTRICT *(Digit counting and programmable first digit lockout)* **• SECRET CODE DISABLES TOL RESTRICT FOR ONE TOLL CALL**—Automatic re-arm **• AUTOMATIC BUSY SIGNAL DISCONNEC • CONTROL INTERRUPT TIMER** (Maintains positive mobile control) **• CW ID** When you connect again o disconnect. Free ID chip. **• SELECTABLE TONE OR PULSE DIALING • MOV LIGHTNING PROTECTORS THREE DIGIT ACCESS CODE** (e.g. ✱91) **• RINGOUT** (Reverse patch) Ringout inhibit if channel bus **• RESETTABLE THREE MINUTE TIMER • SPARE RELAY POSITION • 115VAC SUPPLY**

Options:
FCC approved coupler
12 VDC or 230 VAC power



DEALERS

AMATEUR ELECTRONIC SUPPLY
Milwaukee WI, Wickliffe Oh, Orlando FL, Clearwater FL, Las Vegas NV

BARRY ELECTRONICS CORP.
New York, NY

COLES COMMUNICATIONS
San Antonio TX

EGE, INC.
Woodbridge, VA

ERICKSON COMMUNICATIONS
Chicago IL

HAM RADIO OUTLET
Anaheim CA, Burlingame CA, Oakland CA, Phoenix AZ, San Diego CA, Van Nuys CA

HENRY RADIO
Los Angeles CA

INTERNATIONAL RADIO SYSTEMS
Miami, FL

JUNS ELECTRONICS
Culver City CA

MADISON ELECTRONICS SUPP
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MIKES ELECTRONICS
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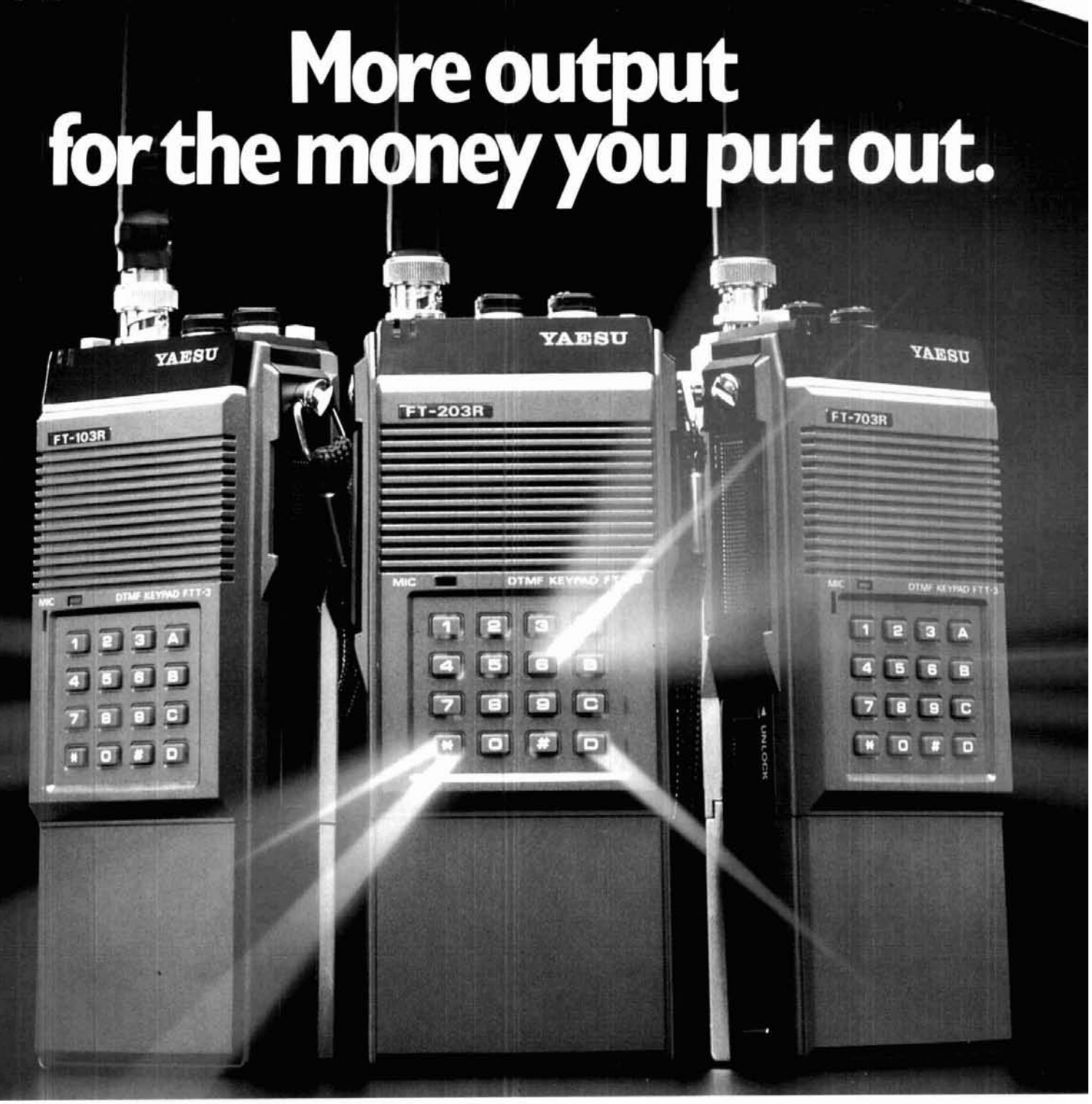
CONNECT SYSTEMS INCORPORATED

(213) 373-6803
23731 Madison St., Torrance, CA 9050

More output for the money you put out.



Why buy a low-power thumbwheel HT when Yaesu's high-power handhelds are available for virtually the same price?

Ours give you 2.5 watts RF output right off the shelf. Or 3.7 watts with the optional FNB-4 battery pack.

Ours come with a hi/low power switch. A relative signal strength/PO meter with nightlight. And built-in VOX capability. (Optional headset required.)

Plus ours offer options like a DTMF keypad. And a plug-in subaudible tone board with both encode *and* decode capability.

And thanks to our unique robotic assembly of surface mount components, it's all enclosed in a lightweight and compact case, measuring just 2.6 x 1.4 x 6.1 inches.

Choose from three models: the FT-203R for 2 meters, the FT-703R for 440 MHz, and the FT-103R for 220 MHz.

As standard equipment you get a rechargeable battery, AC wall charger, rubber duck, earphone, belt clip and soft case.

Plus a wealth of optional accessories. Including a fast charger, VOX headset with boom mic. Mobile radio hanger. Speaker/microphone. DC car adapter. And much more.

So don't settle for low power in a thumbwheel HT.

Go with Yaesu. The best way to get more power for your dollar.

YAESU

Yaesu USA
17210 Edwards Road, Cerritos, CA 90701
(213) 404-2700

Yaesu Cincinnati Service Center
9070 Gold Park Drive, Hamilton, OH 45011
(513) 874-3100

Prices and specifications subject to change without notice.

KENWOOD

...pacesetter in Amateur radio

Here Now! 220 MHz

220: Kenwood Style!

TM-3530A

The first comprehensive 220 MHz FM transceiver

TM-3530A—25 watts of 220 MHz FM—Kenwood style! Features include built-in 7-digit telephone number memory, auto dialer, direct frequency entry and big LCD. All this makes the TM-3530A the most sophisticated rig on 220 MHz!

- **First** mobile transceiver with telephone number memory and auto-dialer (up to 15 seven-digit telephone numbers)
- Frequency range 220-225 MHz
- Automatic repeater offset selection—**a Kenwood exclusive!**
- Direct keyboard entry of frequency
- 23-channel memory for offset, frequency and sub-tone
- Big multi-color LCD and back-lit controls for excellent visibility
- Optional front panel programmable 38-tone CTCSS encoder **includes 97.4 Hz**
- Frequency lock switch
- Digital Channel Link (DCL) option
- **Unique** offset microphone connector—relieves stress on microphone cord

- 16-key DTMF pad, with audible monitor
- Center-stop tuning—**another Kenwood exclusive!**
- **New** 5-way adjustable mounting system
- High performance GaAs FET front end receiver
- HI/LOW power switch (adjustable LOW power)

TM-3530A optional accessories:

- **PS-430** DC power supply
- **TU-7** 38-tone CTCSS encoder
- **MU-1** DCL modem unit
- **VS-1** voice synthesizer
- **PG-2K** extra DC cable
- **PG-3A** DC line noise filter
- **MB-10** extra mobile bracket
- **CD-10** call sign display
- **MC-60A/MC-80/MC-85** desk mics.
- **MC-48** extra DTMF mic. with UP/DOWN switch
- **MC-42S** UP/DOWN mic.
- **MC-55** (8 pin) mobile mic. with time-out timer
- **SP-40** compact mobile speaker
- **SP-50** mobile speaker
- **SW-200B** SWR/power meter
- **SW-100** compact SWR/power meter

TH-31AT/31A

Kenwood's advanced technology brings you a new standard in pocket/handheld transceivers!

- 1 watt high, 150 mW low
- Super compact and lightweight (about 8 oz. with PB-21!)
- Frequency range 220-224.995 MHz in 5-kHz steps
- Repeater offset: ±1.6 MHz, reverse, simplex
- **Supplied accessories:** rubber flex antenna, earphone, wall charger, 180 mAH NiCd battery and wrist strap
- Quick change, locking battery case
- Rugged, high-impact case

TH-31AT/31A optional accessories:

- **HMC-1** headset with VOX
- **SMC-30** speaker microphone
- **PB-21** NiCd 180 mAH battery
- **PB-21H** NiCd 500 mAH battery
- **DC-21** DC-DC converter for mobile use
- **BT-2** manganese/alkaline battery case
- **EB-2** external C manganese/alkaline battery case
- **SC-8/8T** soft cases with belt hook
- **TU-6** programmable sub-tone unit
- **AJ-3** thread-loc to BNC female adapter
- **BC-6** 2-pack quick charger
- **BC-2** wall charger for PB-21H
- **RA-9A** StubbyDuk antenna
- **BH-3** belt hook

TH-31AT with DTMF pad shown. Optional RA-9A attached.

KENWOOD

TRIO-KENWOOD COMMUNICATIONS
1111 West Walnut Street
Compton, California 90220

Complete service manuals are available for all Trio-Kenwood transceivers and most accessories. Specifications and prices are subject to change without notice or obligation.