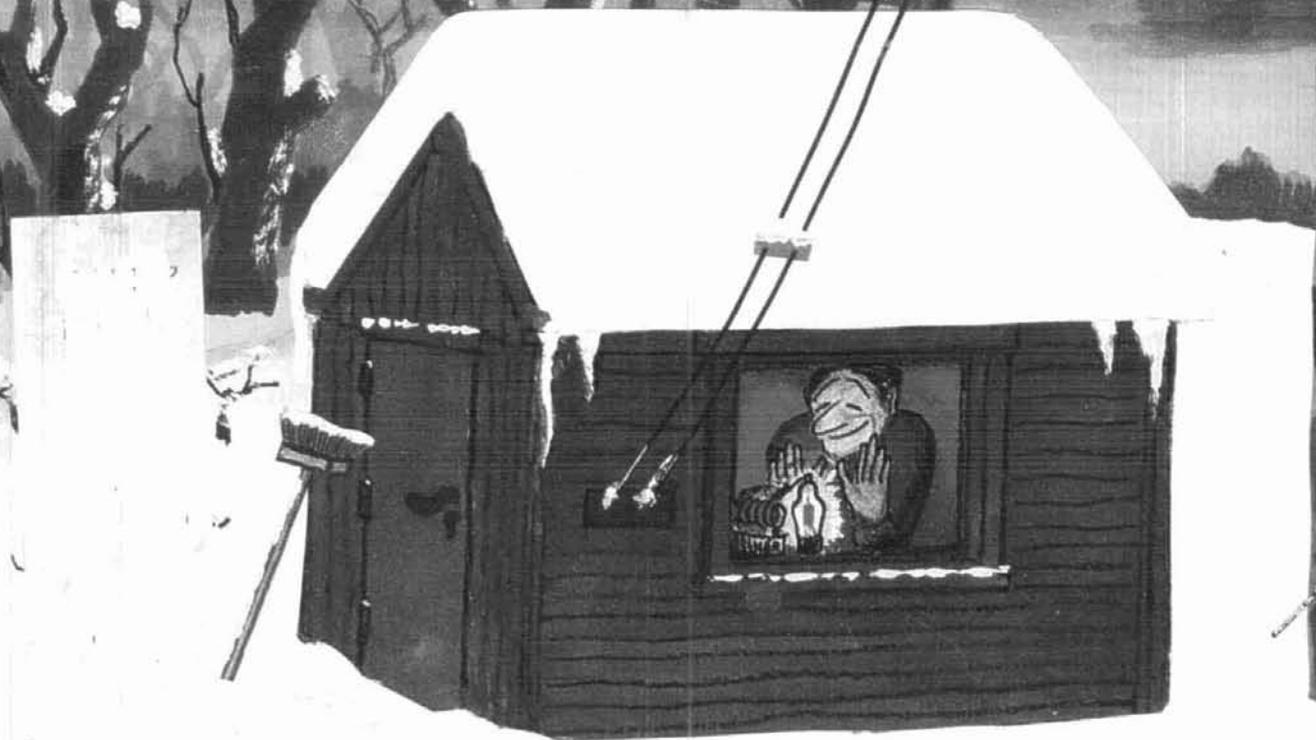


DECEMBER 1987 / \$2.50

Season's Greetings

# ham radio magazine

ham radio • December 1987



**nr**

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Hand Keel PA0CX



**Tired of all the traffic on your band?**

**Discover the wide open spaces on 220MHz.**

ICOM has a commitment to 220MHz.

ICOM has the most complete line of 220MHz gear to take you away from the traffic on other bands.

The IC-03AT Handheld reflects uncompromised top-of-the line quality and performance. Ultimately deluxe, with 10 full function memories, scanning, 32 built-in subaudible tones, three watts output (five watts optional) and an LCD readout. Direct frequency entry via DTMF keypad and adjustable offsets for non-standard repeaters.

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Discover the wide open spaces on 220MHz. ICOM will help take you to the excitement.

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Mobile



IC-38A  
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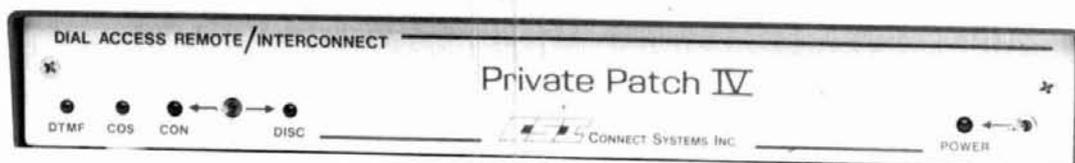
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# THE ALL NEW PRIVATE PATCH IV BY CSI HAS MORE COMMUNICATIONS POWER THAN EVER BEFORE

- Initiate phone calls from your HT or mobile
- Receive incoming phone calls
- NEW! • Telephone initiated control...
  - ✓ Operate your base station with complete control from any telephone
  - ✓ Change frequencies from the controlling telephone
  - ✓ Selectively call mobiles using regenerated DTMF from any telephone
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  - ✓ Use as a wire remote using ordinary dial up lines and a speaker phone as a control head.



The new telephone initiated control capabilities are awesome. Imagine having full use and full control of your base station radio operating straight simplex or through any repeater *from any telephone!* From your desk at the office, from a pay phone, from a hotel room, etc. You can even change the operating channel from the touchpad!

Our digital VOX processor flips your conversation back and forth fully automatically. There are no buttons to press as in phone remote devices. And you are in full control 100% of the time!

The new digital dialtone detector will automatically disconnect Private Patch IV if you forget to send # (to remotely disconnect) before hanging up. This powerful feature will prevent embarrassing lock-ups.

The importance of telephone initiated control for emergency or disaster communications cannot be overstated. Private Patch IV gives you full use of the radio system from any telephone. And of course you have full use of the telephone system from any mobile or HT!

To get the complete story on the powerful new Private Patch IV contact your dealer or CSI to receive your free four page brochure.

Private Patch IV will be your most important investment in communications.

✓ = NEW FEATURE

- ✓ \*/# or multi-digit connect/disconnect
- ✓ Fully regenerated tone dialing
- Pulse dialing
- Toll protection
- Secret toll override code
- Busy signal disconnect
- ✓ Dialtone disconnect
- CW identification
- Activity timer
- Timeout timer
- ✓ Telephone initiated control
- ✓ Regenerated DTMF selective calling
- Ringout
- ✓ Ringout or Auto Answer on 1-8 rings
- Busy channel ringout inhibit
- ✓ Status messages
- ✓ Internally squelched audio
- MOV lightning protection
- ✓ Front panel status led's
- ✓ Separate CW ID level control
- ✓ 24 dip switches make all features user programmable/selectable.

- Connects to MIC and ext. speaker jack on *any* radio. Or connect internally if desired.
- Can be connected to any HT. (Even those with a two wire interface.)
- Can be operated simplex, through a repeater from a base station or connected directly to a repeater for semi-duplex operation.
- 20 minutes typical connect time
- Made in U.S.A.

## OPTIONS

1. 1/2 second electronic voice delay
2. FCC registered coupler
3. CW ID chip



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NEW!

## Compact Breakthrough!



### TH-25AT/45AT

#### New Pocket Portable Transceivers

The all-new TH-25 Series of pocket transceivers is here! Wide-band frequency coverage, LCD display, 5 watts plus...

- Frequency coverage: **TH-25AT:** 141-163 MHz (Rx); 144-148 MHz (Tx). (Modifiable for MARS/CAP Permits required.)  
**TH-45AT:** 438-450 MHz.
- Automatic Power Control (APC) circuit for reliable RF output and final protection.
- 14 memories; two for "odd split".
- Automatic offset selection (TH-25AT).
- 5 Watts from 12 VDC or PB-8 battery pack.
- Large multi-function LCD display.
- Rotary dial selects memory, frequency, CTCSS and scan direction.
- T-ALERT for quiet monitoring. Tone Alert beeps when squelch is opened.
- Band scan and memory scan.
- Automatic "power off" circuit.
- Water resistant.
- CTCSS encoder built-in (TSU-6 decoder optional).
- **Supplied accessories:** StubbyDuk, battery pack, wall charger, belt hook, wrist strap, water resistant dust caps.



#### Optional accessories:

- PB-5 7.2 V, 200 mAh NiCd pack for 2.5 W output • PB-6 7.2 V, 600 mAh NiCd pack • PB-7 7.2 V, 1100 mAh NiCd pack
- PB-8 12 V, 600 mAh NiCd for 5 W output • PB-9 7.2 V, 600 mAh NiCd with built-in charger • BC-10 Compact charger
- BC-11 Rapid charger • BT-6 AAA battery case • DC-1/PG-2V DC adapter • HMC-2 Headset with VOX and PTT • SC-14, 15, 16 Soft cases • SMC-30/31 Speaker mics • TSU-6 CTCSS decode unit • WR-1 Water resistant bag

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DECEMBER 1987

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# REFLECTIONS

## *Season's Greetings*

**One afternoon not long ago**, Skip and I were discussing the latest video to come to our attention. No, it wasn't the latest flick from our local magnetic media emporium, but rather a professionally produced video entitled "The New World of Amateur Radio" in VHS format.

You're right — it's that 30-minute video from the League that explains what Amateur Radio is all about. I'm sure you're familiar with most of the key players. In fact, in some of the scenes you might even recognize yourself.

It's quite well done, and we enjoyed watching it. I'm not going to go into a scene-by-scene description; instead, I'll just pass on an idea Skip suggested.

*What if quite a few of us each obtained a copy (it costs only \$20, and what else can you buy for \$20 these days, anyway?) and offered it to our local family video center for free?* The ARRL could prepare a poster or other in-store display piece for distribution to hams willing to undertake this effort. I'm pretty sure the family video center that I'm a member of would be willing to at least try it for a while. While there'd be no money exchanged, store owners could offer a free rental of the ARRL tape with the rental of any other. Everybody I know likes a bargain. Used as a promotional item, it's conceivable that the tape might actually help business.

Wait a second. Wasn't this film meant to be distributed to ham clubs, schools, etc.? Absolutely. *But hams clubs already have hams.* Wouldn't it make sense to make the tape available to the general public? Doing this might have several positive effects: first, it might encourage some of our younger generation to find out something about Amateur Radio; second, it can't hurt our image. Maybe one of those people borrowing the tape will just happen to be that neighbor who's been so critical of your tower or your operation. It might explain a few things to him. By jingo, I can see it now — an 80-meter, double-extended zepp strung between your property and his!

A possibility? Contact the American Radio Relay League's Publication Sales Office, Dept. NW/HR, 225 Main Street, Newington, Connecticut 06111, for your copies of "The New World of Amateur Radio" — one for you, one for your neighborhood video store, and five or ten more for all the lucky people on your holiday gift list.

Happy Holidays!

**Rich Rosen, K2RR**  
Editor-in-Chief

# KENWOOD

...pacesetter in Amateur Radio

New  
220 MHz

## 220: FM for All!



Kenwood brings you a wide range of 220 MHz gear designed for every need. Choose from two types of mobile and two types of HT. The TH-315A is a

full-featured HT covering 220–225 MHz. Ten memory channels and 2.5 watts of power. (5 W with PB-1 or 12 V DC.) Uses the same accessories as the TH-215A for 2 meters or TH-415A 440 MHz. For truly "pocket portability," choose the TH-31BT, a thumb-wheel programmable, 1 watt unit. For mobile use, select the TM-321A or TM-3530A.

The TM-321A is the 25 W, 220 MHz, 14-channel version of the super popular, super compact TM-221A. The 25-watt TM-3530A has 23 channels, a 15 telephone number memory and auto dialer. Direct keyboard frequency entry and front panel DTMF pad enhances operating convenience. Novice to Amateur Extra, these transceivers will put everyone on the air "Kenwood Style"!

TH-315A  
Full-featured HT

TM-321A  
Compact mobile transceiver

TH-31BT/31A  
Pocket-held HT



New

New

TM-3530A  
Full-featured mobile transceiver

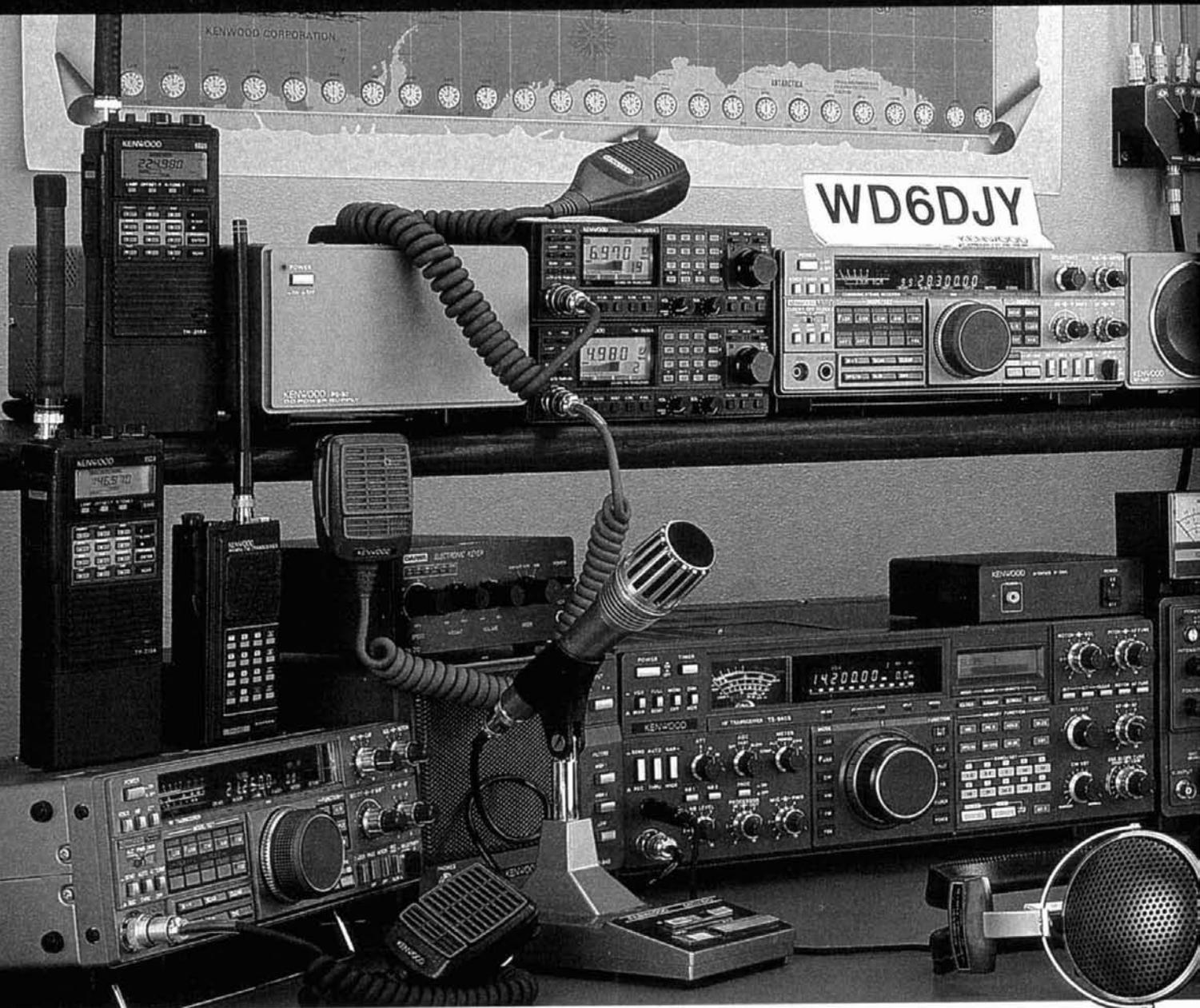
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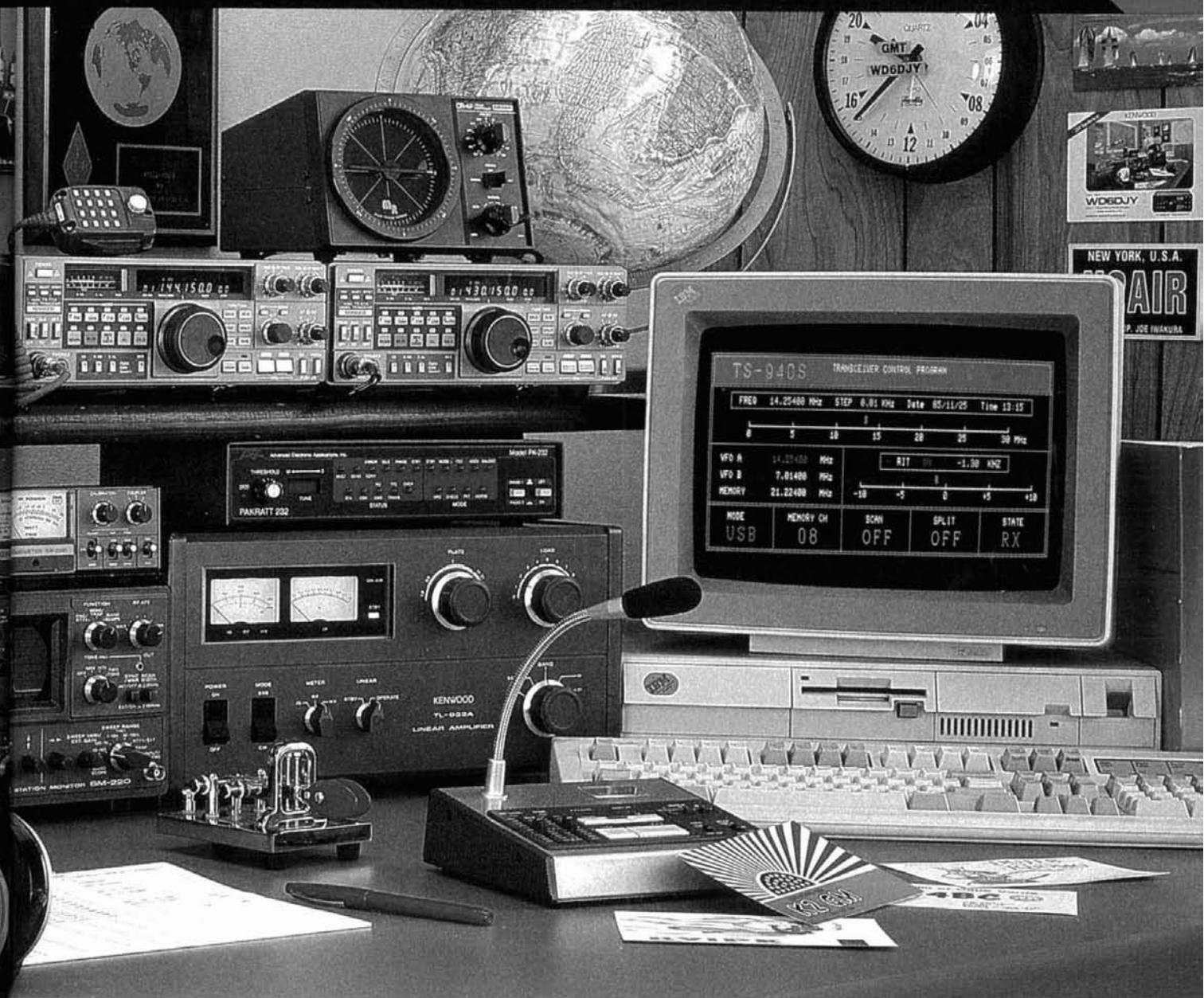
When you are on the air with a Kenwood rig, fellow Amateurs recognize that "Kenwood Sound"—it separates you from

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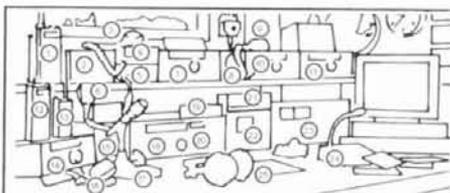
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# to Amateur Extra Class!



(1) TH-315A: 220 MHz Hand-held Transceiver. (2) PS-50: DC Power Supply. (3) MC-43S: UP/DWN Microphone included with (4) TM-2530A: Deluxe 25W 2m FM Transceiver. (5) TM-3530A: Deluxe 25W 2m Transceiver (also comes with MC-43S mic.). (6) MC-48B: 16-key DTMF Microphone.

(7) R-5000: High Performance Receiver. (8) SP-430: Matching External Speaker for TS-430S/TS-440S. (9) MC-48B: (10) TS-711A: 2m, 25W All Mode Base Transceiver. (11) TS-811A: 70cm, 25W All Mode Base Transceiver. (12) TH-215A: 2m, Full-featured HT. (13) TH-218T: Pocket sized, 2m FM Transceiver. (14) TS-440S: HF Transceiver (with AT-440 installed). (15) SP-940: Matching External Speaker for TS-940S. (16) MC-48B: (17) MC-60A: Base Station Microphone with UP/DWN controls. (18) TS-940S: Competition Class HF Transceiver with General Coverage Receiver (AT-940 installed). (19) IF-232C: Computer Interface Level Translator. (20) IF-10B: Computer Interface Module (installed inside TS-940S). (21) SW-2000: SWR Power Meter. (22) SM-220: Station Monitor with pan display option BS-II installed. (23) TL-922A: HF Linear Amplifier. (24) MC-85: Multi-function Desk Microphone with Graphic Equalization and three outputs. (25) HS-5: Deluxe Headphones.

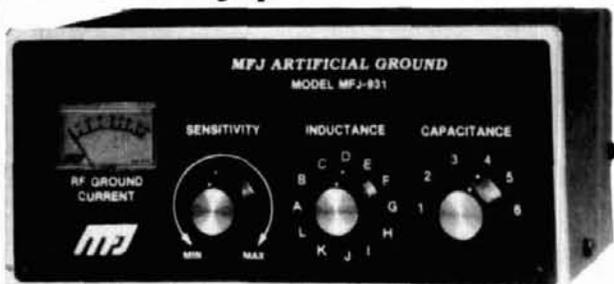
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# NEW FROM MFJ

**MFJ-931 creates artificial RF ground with random wire, also electrically places a far away ground directly at your rig**



**\$79<sup>95</sup>**

**MFJ-931**

Eliminate RF bites, hotspots, feedback, TVI, RFI and other problems due to an inadequate RF ground -- and at the same time -- improve your signal and radiation pattern for more DX.

**Use the new MFJ-931 to create an artificial RF ground!** The MFJ-931 resonates a random length of wire thrown along the floor and produces a tuned counterpoise, producing an artificial RF ground. This presents a low impedance to your rig and effectively places your rig near actual earth ground potential even if your rig is on the second floor or higher with no earth ground possible.

**Also, the MFJ-931 electrically places a far away RF ground directly at your rig -- no matter how far away it is.** It reduces the electrical length of the ground connection wire to virtually zero by tuning out its reactance.

It covers 1.8 to 30 MHz and has a built-in RF ammeter for indicating RF ground current. It's ruggedly built in an all aluminum cabinet with a brushed aluminum front panel and measures 7 1/2 x 3 1/2 x 7 inches.

## HANDHELD SPEAKER/MIC

**MFJ-284 \$24.95**

Once you've tried this new MFJ-284 Speaker/Mic you'll never want to be without it. You'll conveniently carry your handheld on your belt and never have to remove it to monitor calls or talk.

You'll never have to turn up your audio annoyingly loud because its handy lapel/pocket clip lets you place it close to your ears for easy listening.

It comes with a lightweight retractable cord that eliminates the "dangling cord problem" and fits most Icom, Yaesu and other handhelds. **Outstanding audio on both transmit and receive.** Dark grey.

## 144/220 MHz VHF ANTENNA TUNERS

**MFJ-920 \$49.95**

**MFJ-921 \$69.95**



Get cool efficient operation, maximum power output and minimum SWR with these dual band VHF antenna tuners that cover both 2 meters and the new Novice 220 MHz band.

Both handle 300 watts PEP, match a wide range of impedances for coax fed antennas, and are suitable for both mobile and base operation.

MFJ-921 has SWR/Wattmeter and is 8x2 1/2 x 3 inches. MFJ-920 is 4 1/2 x 2 1/2 x 3 inches.

## DROP-IN RAPID BATTERY CHARGER

Be prepared! Keep your handheld ready for instant use with the new MFJ-290

Drop-in Rapid Desk Charger **MFJ-290 \$59.95**

for all ICOM rechargeable battery packs. It's made of high quality high impact plastic with ventilation holes for cool operation and measures just 7x4x3 inches. On/Off switch, power ON and charging LEDs. Uses 110 VAC. IC-u2 series battery packs require ICOM AD-10 charger adapter.

## MORSE CODE TUTOR

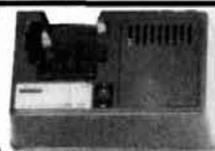
**MFJ-1266 disk \$19.95**

**MFJ-1267 cartridge \$29.95**

This new Morse Code Tutor for the Commodore 64/128 not only teaches code but is also a full fledged **iambic keyer and Morse keyboard!** Optional MFJ-76 Interface (\$19.95) lets you plug in an iambic paddle and the C-64/128 key a transmitter.

You can send all alphabet, numbers and punctuation randomly or choose certain letters, send a **plain English** message as given on an FCC test or received on-the-air, store a message for sending or send code directly from your keyboard. FCC-like Novice code test included.

Use ARRL's "Tune in the World" or MFJ supplied course for both individual and classroom study.



## IBM Starter Pack for PACKET MFJ-1284 \$19.95

Ready to join the PACKET fun with an MFJ TNC or TAPR clone? MFJ's newest IBM Starter Pack for PCs and compatibles with serial port gets you on packet immediately with no hassles. You get a computer interfacing cable, complete "How To" instructions and the fabulous PTP (Packet Terminal Program) on disk by N4PY -- everything you need to get on packet FAST.

PTP gives you split screen with keyboard buffer, user defined function keys, disk save, printing, file upload and download, WORLI BBS/mailbox and WDCG PBBS support, help screen, automatic command strings, automatic time set, connect alarm, full screen editor, NTS traffic generation, complete documentation plus more.

## COMPACT MOBILE SPEAKER MFJ-280 \$18.95

Enjoy crisp, clear audio and ultimate convenience with this tiny, low cost mobile speaker. Just plug in the 3.5 mm phone plug, set the base on any magnetic surface and it's ready. Two auxiliary mounting plates with two-sided tape allow mounting on a car dash or other non-magnetic surface (screws also included). A 30 inch cord and tilt bracket give you extra versatility.

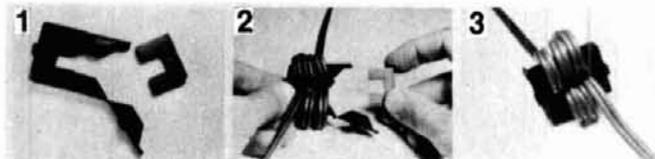
It works with all 8 and 4 ohm impedances and handles up to 3 watts of audio. Its dark grey military color matches nearly all rigs. Measures just 2 1/2 x 2 x 3 inches and weighs less than half a pound!



## MFJ-701 RFI-FREE CHOKE KIT MFJ-701 \$14.95

**eliminates RFI easy as . . .**

**Package of four (4)**



Everyone has RFI problems affecting radios, TVs, computers, telephones and other electronic devices. The new MFJ-701 RFI-Free Choke Kit makes it easy

to eliminate common RFI problems. It's based on the highly effective technique of winding the offending cable or wire around a ferrite toroid to choke off RFI.

The problem is finding a toroid with the proper characteristics -- one that actually eliminates RFI -- and one that has a big enough hole to pass through the end of a power cord or AC adapter or microphone or telephone, etc.

The MFJ-701 RFI-Free Choke Kit gives you four square toroids that have the right properties for eliminating RFI from .5 to 200 MHz. Each toroid separates into halves and mounts in a tough snap-together plastic frame. This makes it easy to wind around the toroid nearly any kind of wire or cable -- computer ribbon cable, coax cable or a power cord with an AC adapter on its end can be wound around the toroid easily. The individual toroids also snap together into a stack. This increases effectiveness for large diameter wires where only a few turns can be used or for rigid cables where the cable is simply passed through a stack of toroids. "How to Eliminate RFI" instructions included.

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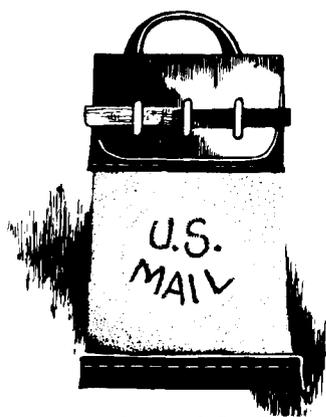
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## comments

### sentimental technocrats speak

Dear HR:

The "Reflections" column of September 1987 ("A Sentimental Technocrat Speaks") was the best thing written about Amateur Radio in 20 years. Mr. Zavrel, W7SX, captured my feelings as well as those of most of my friends with his well-written article . . . he forgot one dislike, however: *ready-made coax with crimp-on connectors*.

**J. R. Sheller, KN8Z (ex WA8ZDF)**

Dear HR:

I loved Bob Zavrel's editorial (September 1987). It's my turn now — but aren't we too young to be talking like this?

What about the warm glow of the tubes, the click of the big antenna relay switching from receive to transmit, the smell of wax capacitors and carbon resistors cooking, the drifting of the old receiver, the steadfastness of that rockbound 6146, the heterodynes of the a-m bands, the quality of the audio on those signals, all those homebrew radios and amplifiers with those weird, unheard-of tubes, the vibrating transmitter cabinet tops, the occasional job of peaking those slug coils in the rf section of the receiver and that "plastic" tuning wand used to do so? How about the old tube tester down at the K&B, the ease of changing tubes, and the reliability of the fact that if a tube wasn't lit, *that* was the problem? (This is why I dis-

like metal tubes.) And what about the deep red glow of an overloaded 6146, the pop of a high voltage arc, blown fuses, the smell and sting of finger skin on a hot tube, the smell and heat of natural convection; the burned spots on painted cabinet tops and the smell of cooking bakelite pc boards? The smell of a new roll of wire, of hot solder flux — and the memory of running home after school to turn the rig on, after you'd been given a 50-foot length of coax . . . the thrill of that first QSO, of wondering who might answer a CQ — and most of all, *old radio friends*.

**Richard W. Thimmesch, WA5NYG  
Belle Chasse, Louisiana 70037**

### romantic whining?

Dear HR:

I'd like to take this opportunity to respond to Rich Rosen's editorial, "Evolution" (August 1987).

My experience with readers and kit buyers indicates that he is correct; most avid builders *are* older. Many, having already lost wives and the ability to focus beyond 8 inches, are dying off even as we speak. Others of us simply never recovered from the war, and make little radios for therapeutic reasons.

Nevertheless, acknowledging that fact touches a raw, primal nerve-ending in my Amateur Radio soul. It makes me want to fire up, grab my rusty old J-38, and take a stand. "Don't hide behind that 940, you paper-crazed DX junkie," I'd pound. "Pull your iron, and let's see if you've got what it takes to call yourself a REAL ham!"

But alas, such romantic whining from the island of QRP would only be lost in a turbid sea of mixer-crushing affluence. Perhaps, more constructively, I could simply ask that a quiet spot be reserved for my bones . . . in the ARRL museum.

**Rick Littlefield, K1BQT  
Barrington, New Hampshire 03825**

### moon bounce

Dear HR:

While it is correct that "moon bounce" first occurred in 1946 (see W1JR's "VHF/UHF World," August 1987), the radar used was not commercial, but military. The event took place at the United States Army Signal Corps Laboratories at Belmar, New Jersey. *The New York Daily Mirror* of Friday, January 25, 1946 (2 cents a copy!) covered the story of Project Diana under the headline, "Army Contacts The Moon."

*ham radio* continues to be outstanding. But how could you miss with Msrs. Reisert, Orr, Beers — and others — all contributing to a single issue?

**Len Sheer, W7WRO  
Phoenix, Arizona 85018**

### UHF/SHF newsletter

Dear HR:

I enjoyed the July issue of *ham radio* very much, and agree completely with WA2LQQ's view on the use of bands from 13 cm "upward" (Vern Riportella, "13 cm: Onwards and Upwards," page 4).

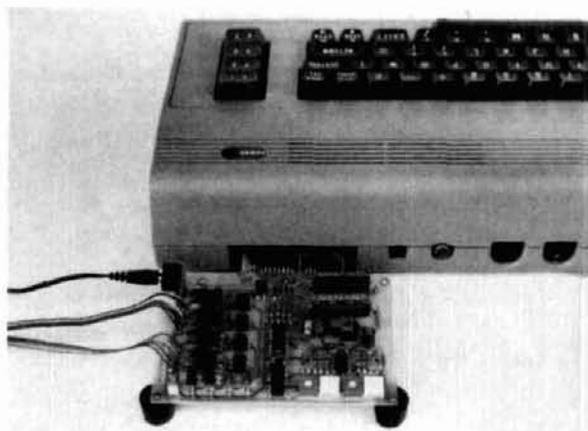
I'm really concerned that publications available in the United States don't hold a candle to some of the European publications in terms of their presentation of UHF/SHF technical material. Take any edition of *Dubus*, for example, and you'll see what I mean.

I'm doing what little I can with *VHF-Plus Update*, and I know you're doing quite a lot with *ham radio*, but there's a long way to go, and I hope that other major Amateur publications will get wise to the importance of our UHF/SHF bands!

**Jack C. Parker, KC0W  
4016 Narrows Road  
Erlanger, Kentucky 41018**

*Note: Jack publishes a fine newsletter called KC0W's VHF-Plus Update. It's well worth subscribing to. — Ed.*

Track satellites with  
your personal computer



## a simple rotor interface board for the C-64 and the VIC-20

The **AUTOTRAK project** combines three of my favorite subjects — Amateur Radio, computers, and Amateur satellites.

It began several years ago when I purchased a ZX81 (later to become the Timex 1000) computer, taught myself BASIC, and developed a program for tracking satellites. Shortly afterward, AMSAT chose the ZX81 to be part of its AMS81 project to develop tracking software and a companion hardware board to control rotors for automatic antenna aiming. Though I was privileged to be one of the beta testers of the software, the hardware board never appeared; I assume it couldn't be produced for the "under \$100" figure that had been targeted.

Seeing a real need for automatic rotor control, I decided to try to design one to interface to the tracking program I'd developed. It had to be simple, inexpensive, and easy to use. The AUTOTRAK board meets these criteria, and is adaptable to many different rotors and a variety of computers. While the board was sold commercially by Spectrum West and although I still build and market them, I'm pleased to share the design with others.

This article describes its use with the Commodore 64 and VIC-20, but the design can be made to work with any computer that allows you access to the address and data lines. The board will interface with many light-duty rotors that use a linear pot to "sense" antenna direction — for example, the Kenpro 400/500/5400 and HD73. The board output can also be configured to support the new computer-ready Kenpro 5400A/5600A.

Designed to be powered by an 11.0- to 15-volt ac wall transformer, AUTOTRAK won't operate rotors with brakes or those of the chunk-chunk style. Accuracy is within a couple of degrees, which is sufficient for all but very large arrays. Its overall cost should be only about \$70.

The software consists of a couple of short program lines, written in BASIC, which you can add to your favorite tracking program. (The new SUPER VR85 tracking program has the coding already built in.) A short operating program and software information are supplied at the end of the article.

### theory of operation

Your tracking program will calculate where the satellite is supposed to be at a particular time and provide azimuth and elevation bearings to the satellite for that time. The new program lines you add to your program will calculate a number (between 0 and 255) representing your azimuth and elevation bearings. These numbers are POKEd onto your computer's data bus, where they're latched by D-to-A converters and changed to an analog voltage corresponding to the direction in which the computer says your antennas should be pointing. Meanwhile, the actual direction of each antenna is brought onto the board via the direction "sense" lines from the rotor controllers. After being processed, these voltages, and those of the D-to-A converters, are summed together and applied

By Neil Hill, K7NH, 22104 66th Avenue W.,  
Mountlake Terrace, Washington 98043

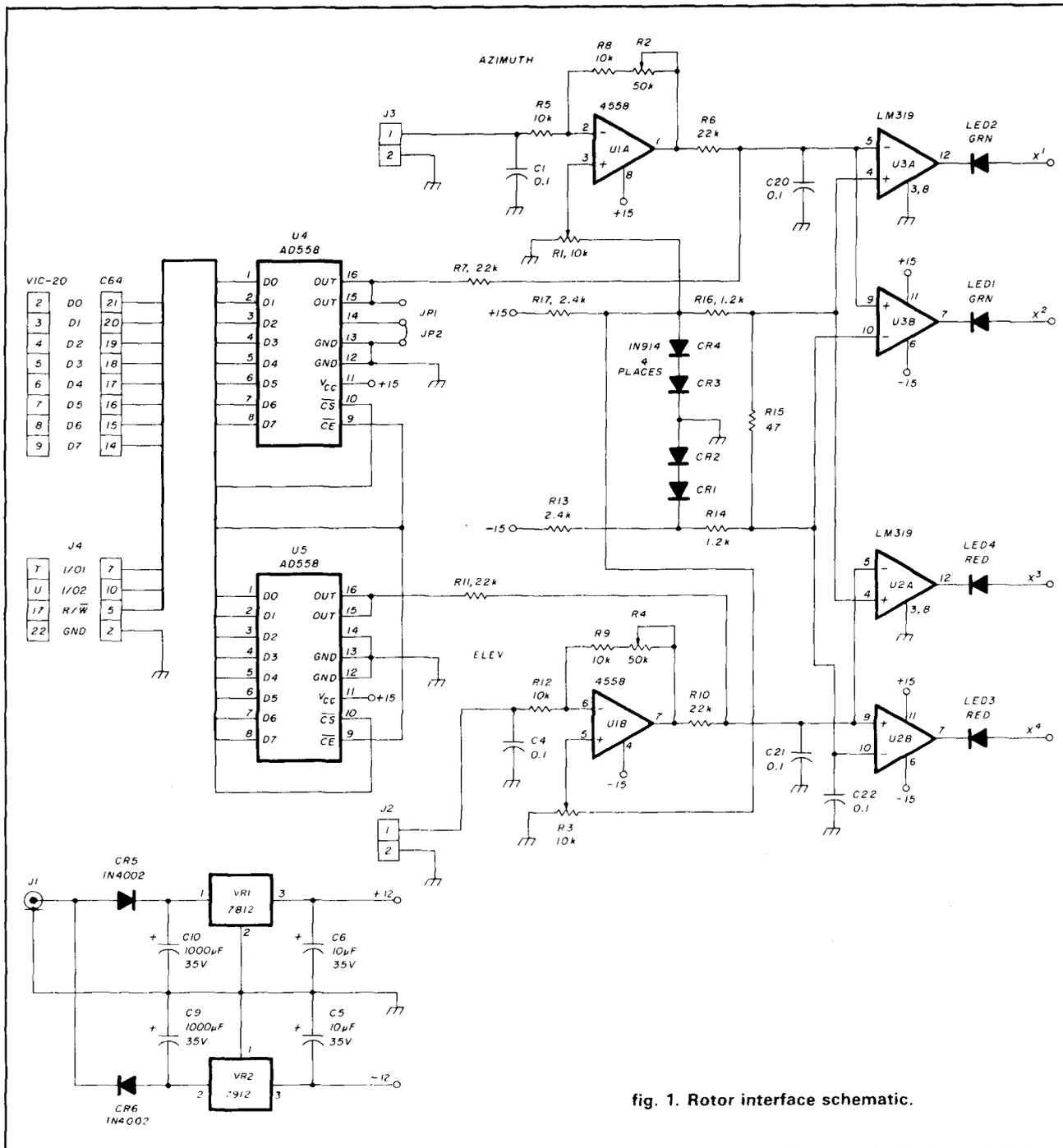


fig. 1. Rotor interface schematic.

to "window" comparators. If the output voltage of the summing circuit is at or near zero, it will fall into the window and the antenna will not move. However, if the voltages are unequal, there will be a voltage and polarity difference and one of the two comparators making up the window comparator will be turned on. Through an appropriate output circuit, the antenna will then be rotated until the output of the summing circuit reaches zero, at which time the comparator will

turn off, leaving the antenna pointing where the program says it should.

For details, refer to the schematic (fig. 1) and follow along. As noted above, two AD558 D-to-A converters continuously monitor the data lines and will latch and hold whatever data is ready whenever their read and enable lines are low. The AD558 was chosen for three important reasons: it provides a voltage rather than current output; the full-scale voltage can

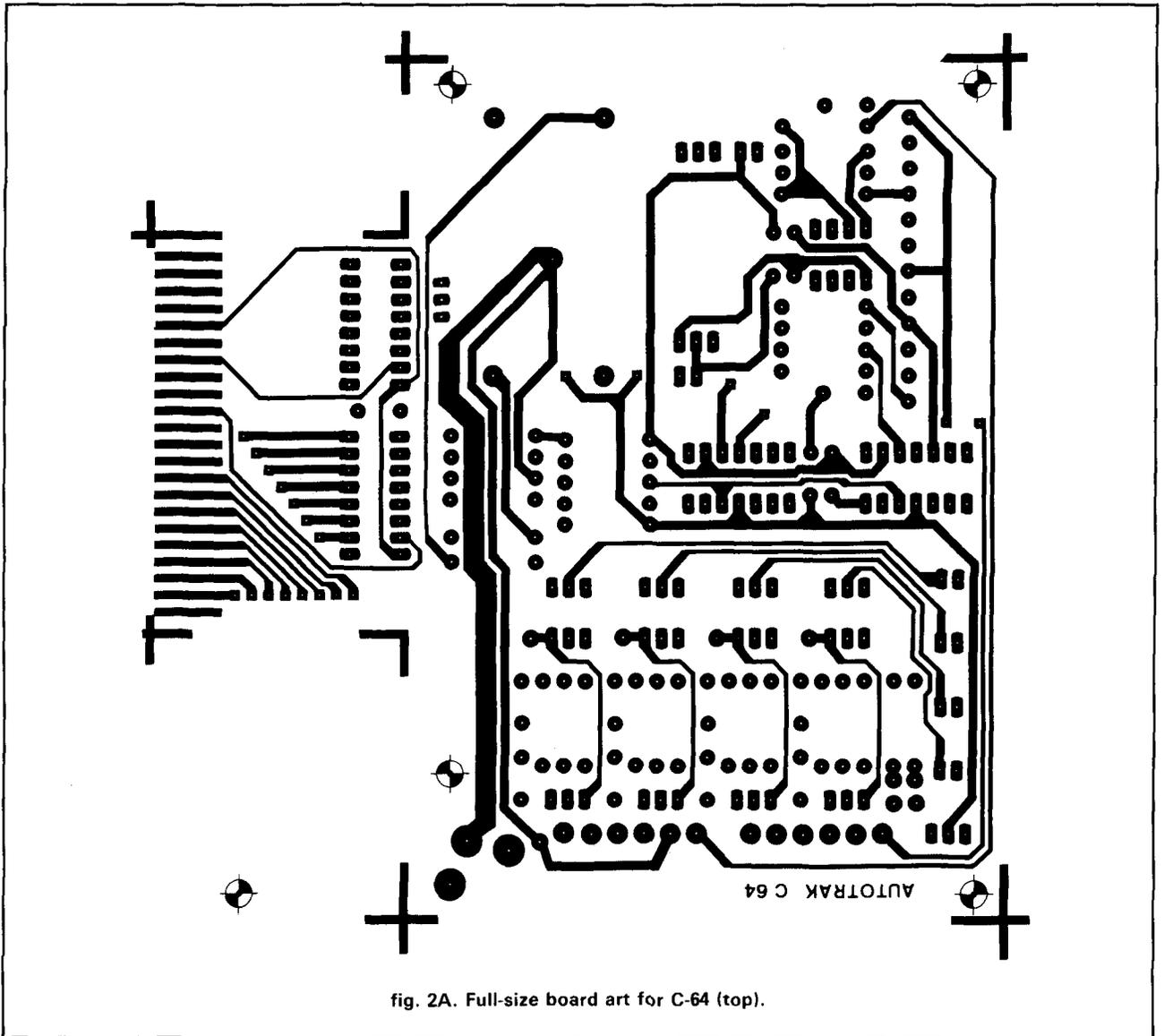


fig. 2A. Full-size board art for C-64 (top).

be set for either 2.5 or 9.75 volts; and it has a built-in latch, which allows the computer to go on its way once the chip has received the information it needs.

Part of the simplicity of the AUTOTRAK design is attributable to the presence, on the Commodore 64 and VIC-20, of two 1-K wide I/O sections that aren't normally used. I simply POKE an address in each section to activate the azimuth and elevation D-to-A converters momentarily. (On other brands of computers, you'll probably need to decode the address lines, but this should require only a couple of ICs.) The output of each D-to-A converter is applied to one side of a summing circuit consisting of two 22-k resistors. The other side of each summing circuit is fed by the output of one half of an LM4558 op amp, which accepts the sense voltage from the associated rotor, inverts it, and "matches" it to the voltage range of the corresponding D-to-A converter.

Adjustment of the + input of the op amp sets the low or CCW end of rotation, and its gain adjustment sets the high or CW end. The outputs of the summing circuits are tied to window comparators, each formed by both halves of an LM319. The high speed of the LM319 is important for accuracy, but it's very sensitive to noise and ac signals on its inputs, so special care must be taken to control the input signals. The size of the window determines the accuracy of the board. I found a 47-ohm resistor to be about the right value. Increasing this value widens the window, and decreasing it causes it to close; however, too small a value causes both halves of the comparator to be on at the same time, which can cause problems.

The outputs of these comparators in turn operate a pair of optoisolators, one for each rotor direction, and LEDs that indicate which direction is active. These LEDs are also used when making the setup adjust-



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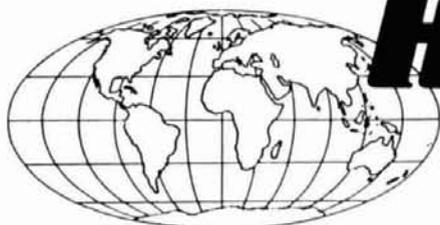
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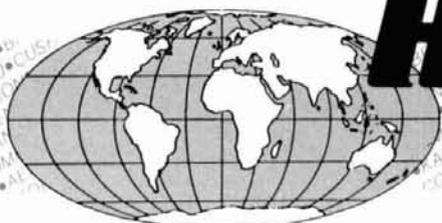
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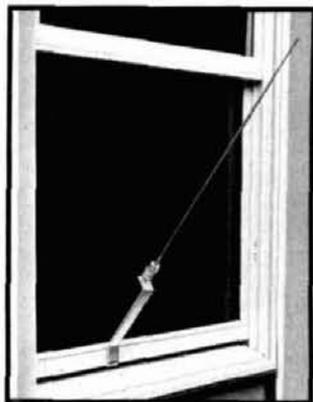


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### parts list

C1-4, 7, 8, 11*, 13*, 15*, 17*, 19-22	0.1µF, 50 volts, 0.2-inch CTC
C5, 6	10 µF, 35-volt electrolytic
C9, 10	1000µF, 35-volt electrolytic
C12*, 14*, 16*, 18*	0.01µF, 500-volt disc
D5, 6	1N4002 200-volt PIN diode
D1-4	1N914 diode
J1	Power connector
R1, 3	10-k pot, 1/2-inch square, 1 turn (Bourns 3386W, 103K)
R2, 4	50-k pot, 1/2-inch square, 1 turn (Bourns 3386W, 503K)
R5, 8, 9, 12	10-k, 1/4-watt
R6, 7, 10, 11	22-k, 1/4-watt
R13, 17	1.2-k, 1/4-watt
R14, 16, 21, 24, 27, 30	2.4-k, 1/4-watt
R15	68 ohms, 1/4-watt
R18, 19	680 ohms, 1/4-watt
R20*, 23*, 26*, 29*	180 ohms, 1/4-watt
R22*, 25*, 28*, 31*	39 ohms, 1/4-watt
SW1	DPST (miniature)
U1	RC4558 dual op amp
U2, 3	LM319 dual comparator
U4, 5	AD558 D-to-A converter (available from Analog Devices, Route 1, Industrial Park, Box 280, Norwood, MA 02062)
U6*, 7*, 8*, 9*	MOC3011 optoisolator
U10*, 11*, 12*, 13*	TIC226B triac
VR1	7812 voltage regulator (+ 12)
VR2	7912 voltage regulator (- 12)
Green LED	TIL222
Red LED	TIL220
Cable	10-conductor multicolored (5 feet)
Transformer	11.0- to 15-volt ac, wall mounted
Autotrak pc board	Available from NH Enterprises, 22104 66th Avenue West, Mountlake Terrace, Washington 98043

Parts needed for computer-ready controllers: U6-9, Optoisolators (TIL113); 4 2N7000 FETlingtons.

(\* ) designates parts to be omitted in computer-ready controller.

ments. The actual circuit used to interface to your rotor system depends on what kind of rotor you use. Most small rotors use ac motors, so an optoisolator triac driver such as an MOC 3011 and triacs are used. This acts as a remote ac switch for the rotator motor. However, by using TIL113 optoisolators and 2N7000 FETlingtons (in which FETs are substituted for a Darlington transistor pair) the board acts like a low-power on/off switch to ground so that computer-ready rotors can be controlled. If you need more voltage or current to be controlled, just substitute power MOSFETS such as the IRF 520 series for the FETlingtons.

Voltage for the board is provided by a simple dual-voltage (+ 15 and - 15)-volt supply using inexpensive regulators and powered by a small 11.0- to 15-volt ac transformer that plugs into a wall outlet.\* A switch is employed to disconnect voltage to the optoisolators, thus disabling the board when manual control of the rotor controllers is desired.

### ESD caution

As in all such projects, it's important to minimize the possibility of electrostatic discharge (ESD) damage to components. The AD558 D-to-A converters are quite expensive, and also sensitive to ESD damage, so take the appropriate precautions. (One friend covers his work area with aluminum foil before starting a project.) When handling the AUTOTRAK board, try not to touch the end that plugs into the computer; the "fingers" go directly to the AD558s.

\* + NS - 12 volt regulators and a 12-volt ac transformer may be substituted if more readily available.

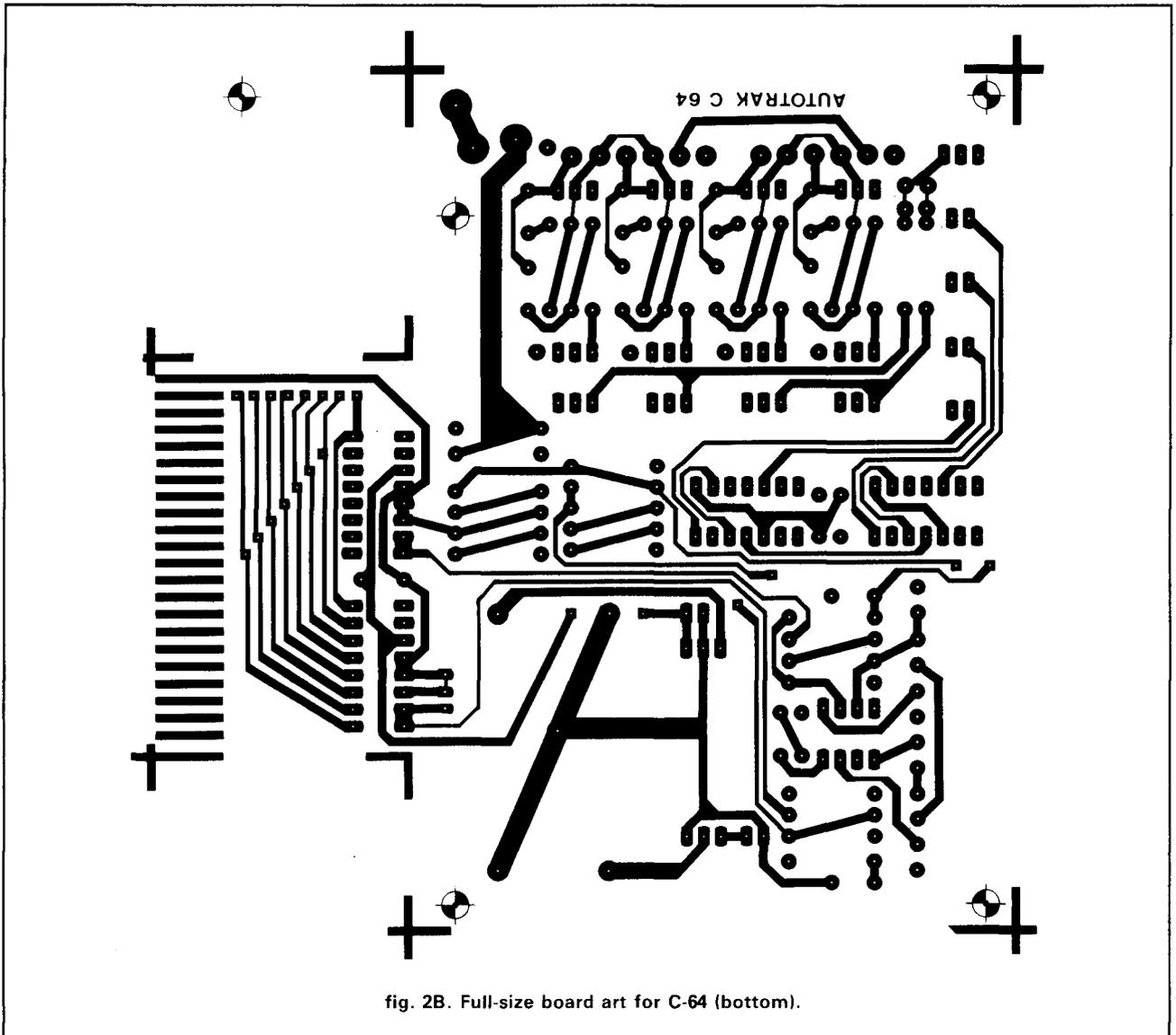


fig. 2B. Full-size board art for C-64 (bottom).

## building the board

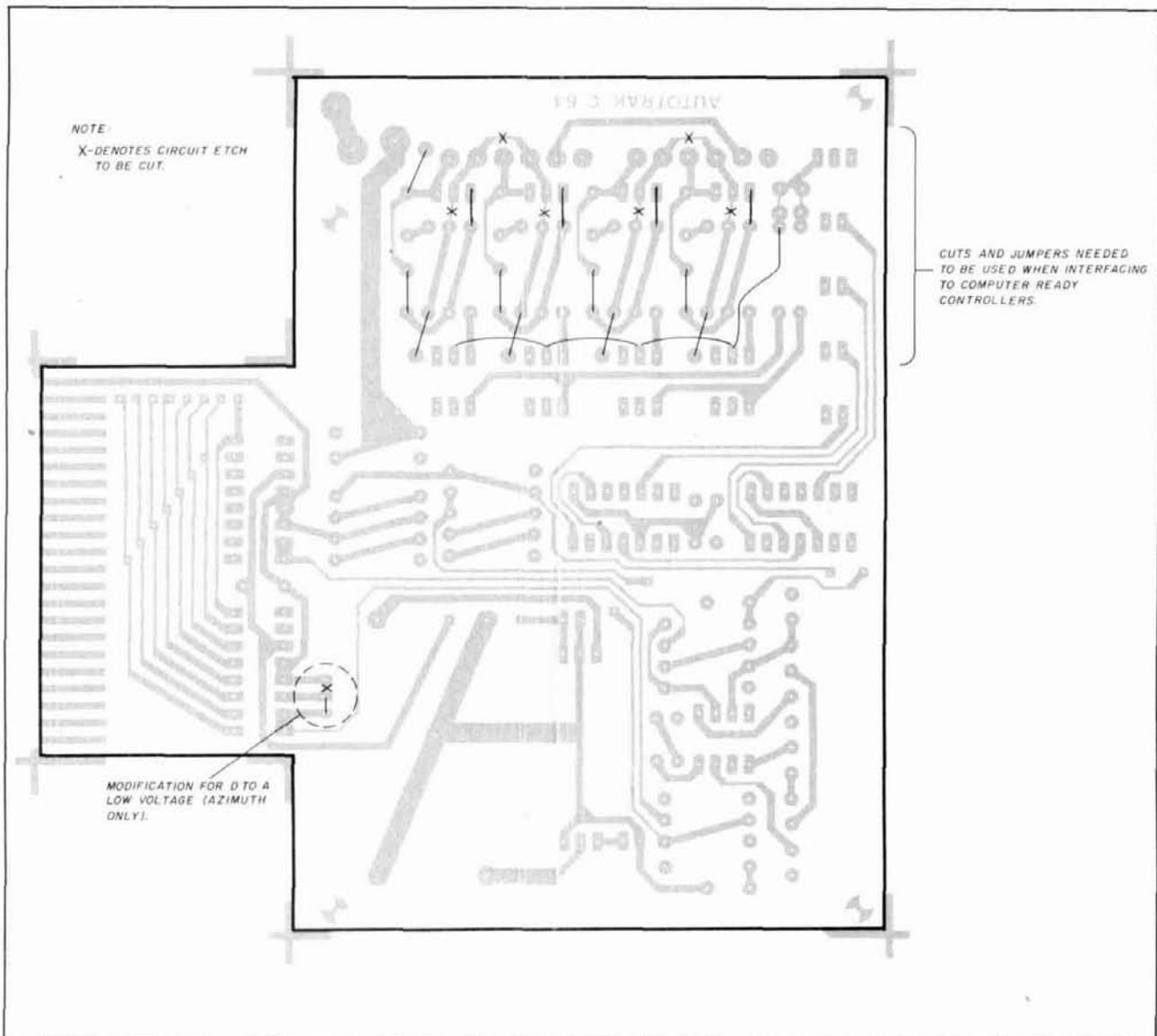
Assembling the board is straightforward. The C-64 and VIC-20 AUTOTRAK boards are identical except for the computer connector. For those of you who are making your own boards from the supplied artwork (see **figs. 2** and **3**), there are two things to remember: first, unless your boards have through-hole plating, you must supply the through hole connections with a wire placed in the through holes and soldered on both sides; and second, any trace to component connections on the top of the board must be soldered on top of the board rather than on the bottom.

I use the "layer" method when assembling the boards. First I insert the shortest parts, normally the resistors and diodes, and cover them with something flat and stiff (like a piece of corrugated cardboard). Holding this "sandwich" together, I turn the board up-

side down, leaving the component legs sticking up, ready for soldering. After soldering, I clip the leads and move on, inserting the next tallest group of parts such as ICs, small capacitors, and variable pots. The switch, LEDs, filter capacitors, and the input power connector are mounted last. For parts placement and orientation, see **fig. 4**.

Note that the voltage regulators are installed upside down (metal side up) in order to conserve board space. After mounting the variable pots, turn them to the center of their range to prevent confusion later, during testing. When installing the electrolytic capacitors, make sure their polarity is correct.

All components are mounted on the top of the board except C20-C22. Keep the leads on these capacitors short because they're used to shunt to ground any noise or ac voltage, which might confuse the operation of the comparators. Each of the four LEDs



should be mounted with its flat spot towards the edge of the board. If there's no flat spot, note the length of the mounting leads and mount the shorter one towards the edge. *No cuts or jumpers are necessary when assembling the standard ac motor version of the board.*

Differences for the computer-ready version concern only the output circuitry (**fig. 5**). Everything else stays the same. See **fig. 5(B)** for parts changes and **fig. 2C** for the six cuts and various jumpers needed. All cuts are made on the bottom side of the board and are easily accomplished with an X-acto<sup>®</sup> knife or equivalent. Jumpers can be mounted from the top or bottom side of the board, but should not be run over an exposed trace unless they're insulated. Don't forget the +15 volt lead to pin 5 of each of the TIL113s, and watch the lead placement of the 2N7000s. (See **fig. 4(B)**.)

After the board is completely assembled, give it a

careful visual inspection, especially for solder shorts. *Are the part values correct? Are the solder connections smooth and shiny? Did you miss any? Is the polarity correct on the electrolytic capacitors and diodes? Are the LEDs mounted with their flat sides toward the edge of the board, and the voltage regulators upside down and bent over? How about the three 0.1- $\mu$ F capacitors mounted across the pins of the LM319s on the bottom side of the board; did you forget them? All correct? Great — let's move on.*

### preliminary testing

Be sure to test your work *before* you plug the AUTOTRAK board into your computer and before running any wires to your rotors. First verify that the four variable pots are somewhere in the middle of their ranges. Next turn on the enable switch (with the handle toward the top edge of the board) and connect

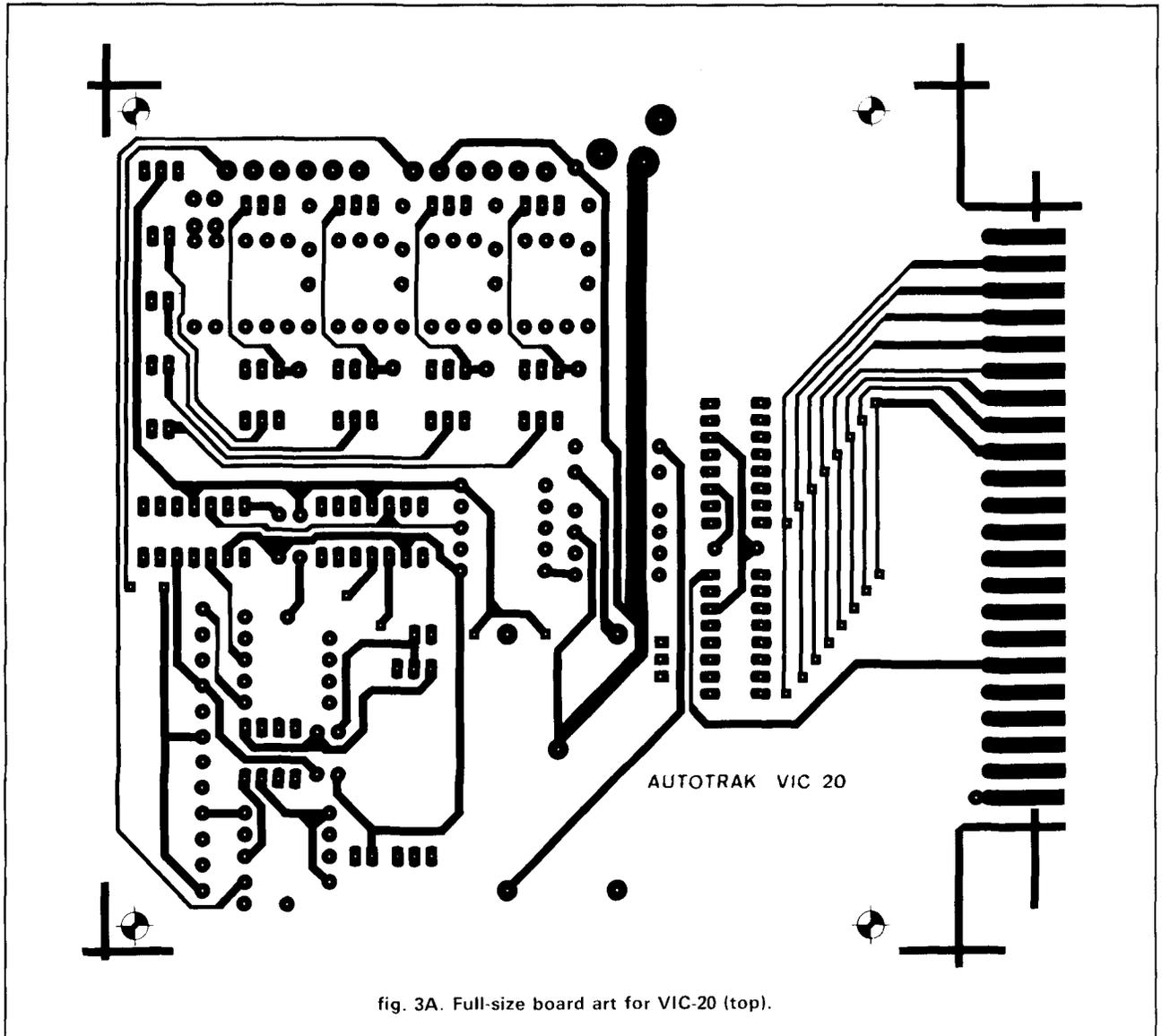


fig. 3A. Full-size board art for VIC-20 (top).

the 15-volt ac input power to the ac power connector (J1). Make sure one of each color LED is lit. If they're not, remove the ac power and recheck the parts, their orientation, and their solder connections before proceeding. If everything looks all right, reconnect the ac and check the output of the regulators for + and - 15 volts.

If the voltage is correct but the LEDs still don't operate correctly, check to confirm that either pin 7 or 12 of the LM319s is near 14 volts. If neither is, check the polarity of the LEDs. If both pins are near 14 volts, look for trouble in the LM319 circuitry. When the LEDs operate correctly, you're ready to proceed. The operation of the D to A converters, op amps and triacs will be checked later.

To complete the board, connect the 10-wire (or 8-wire for the computer-ready version) multicolored rotor interconnect cable and mount two 5/8-inch rub-

ber feet (or equivalent) to the rear holes of the board for support.

### rotor preparation

Unless your rotors are the new computer-ready type, you may need to make a small modification to allow access to both sides of the direction switches. Note **figs. 6** and **7**, then consult the schematic in your rotor manual and identify the following: the line from the rotor head to the controller used for sensing direction, the ground return for the sensing line, and the direction switch lines.

Identify the ac common wire from the transformer to the rotor direction switches; if it isn't brought out to a terminal, the controller wiring must be modified to allow access (see **fig. 7**). Wire it to an unused terminal at the rear of your controller if one is available, or supply one to which it can be attached. An alter-



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NEW TX70-1 ATV TRANSMITTER contains the KPA5 and T/R relay ready to go in a small 6x5.2x2.5" shielded cabinet. Has both the 10 pin "VHS" camera & RCA phono jack video/audio inputs. If you are one of those with just a downconverter, saw some pictures and was bitten by the ATV bug, then this ATV transmitter is for you. No need to sell your downconverter and get a transceiver, just connect its input to the downconverter BNC connector on the back of the TX70-1. \$229 delivered.



NEW TX70-1 \$229 delivered



KPA5-c board still \$159\*



### KPA5-c 70CM ATV XMTR BOARD FEATURES:

- >1 WATT P.E.P. RF OUTPUT ON SYNC TIP.  
Run barefoot for portable. Output properly matches Mirage D15N 15 watt or Mirage D24N-ATV 50 watt linear amp for full output and the Mirage D1010N-ATV to over 50 watts p.e.p.
- FULL COLOR AND SOUND on a small 3.25x4" board
- Wired and tested board runs on external 13.8vdc @ 300ma. supply or 12 V battery
- Accepts composite video from cameras, VCRs, computers, etc.
- 2 audio inputs, one for low Z dynamic mic, & one line level from most cameras & VCRs
- Supplied with one xtal on 426.25, 434.0, or 439.25. 2nd xtal add \$15. Specify freq. when ordering, check with local ATVers, ARRL Repeater Directory or call us. Only 2 channels available in any given area due to video bandwidth of 9.1 mHz.
- \* Price still \$159 delivered via UPS surface in contiguous USA. Transmitters sold only to licensed Technician class or higher amateurs for legal purposes. We verify name, call letters, & QTH in the Callbook. If recently licensed or upgraded send a copy with order.

### KPA5 APPLICATIONS:

- PORTABLE CORDLESS TV CAMERA. Think of it as a video HT. Place the KPA5 in one of the Hammond Dicast aluminum boxes, 1/4 wave (6.5") whip on top or half wave at the end of 50Ω coax attached to a headset. Plug into a 12-14 v source such as the Radio Shack 12v 5Ah battery power pack (23-182). Depending on terrain & receiving antenna DX is typically over 1 mile. With KLM 440-27s at both ends DX is 22 miles snow-free line-of-sight.
- Transmit the video to a remote VCR rather than lug it.
- Great for public service events: marathons, parades, damage assessment, search & rescue, CAP, etc.
- Mount in a R/C airplane or robot to enable remote control when the vehicle is out of sight.
- Put it in your own cabinet for base, portable or mobile. When more power is needed, connect to either the Mirage D15N for over 15 watts or to the Mirage D24N or D1010N-ATV amps for over 50 watts.
- Place a KPA5 in a dicast box with a VOR (video operated relay) to make a hill top video repeater. Repeat other ATVers, weather radar or Space Shuttle video.

WHAT IS REQUIRED FOR A COMPLETE OPERATING SYSTEM? Either a TVC-2G or TVC-4G downconverter connected to any TV set tuned to channel 3, and coax cable to a good 70cm antenna to receive. Connect up the TX70-1 or package up the KPA5, add 12 to 14 vdc, antenna, and any home TV camera, VCR, or computer with composite video output. **It's that easy!**

### ACCESSORIES:

- TVC-2G GaAsfet downconv. board wired & tested....\$59  
varicap tuned, 420-450 MHZ to ch3. Req 12vdc
- TVC-4G (TVC-2G in cabinet with 120vac supply).....\$99
- TVCX-70 crystal controlled GaAsfet downconv.....\$99  
specify in freq. & out on ch 3 or 45mhz IF. 2 freq.....\$114
- Hammond 1590D Use for KPA5. 7.3x4.7x2".....\$17
- 1590C 4.6x3.6x2" aluminum box. Fits TVCX-70.....\$11
- 800J 10 pin VHS color camera chassis connector.....\$10
- VOR Video (horiz sync) operated relay board.....\$25

- MIRAGE D15N-ATV 1in /15 out all mode amp.....\$119
- MIRAGE D24N-ATV 1in / 50 out all mode amp.....\$219
- 450 ISOPOLE omni 4dbd vert. gain antenna.....\$65
- KLM 440-6X 8.9dbd ant., 28" boom, >50 deg BW....\$51
- KLM 440-10X 11.2dbd, antenna, 64" boom.....\$65
- KLM 440-27 14dbd, 36 deg. BW antenna.....\$107
- SAXTON 8285 100ft 50 ohm coax 3.5db/C loss.....\$41
- UG21 type N male connectors for larger ID coax.....\$5

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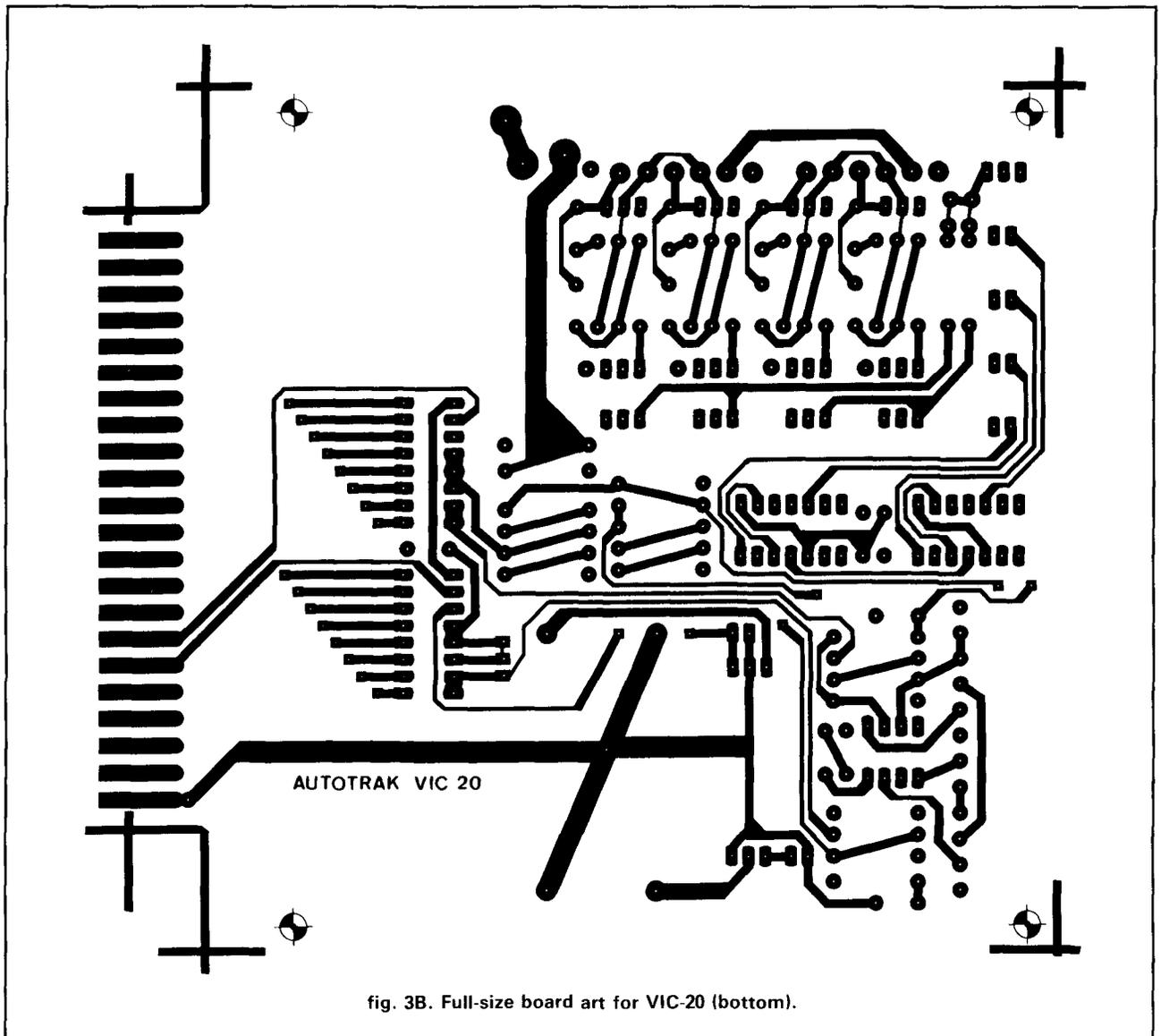


fig. 3B. Full-size board art for VIC-20 (bottom).

native would be to wire in a multiwire "pigtail" to your controller with a connector so that the AUTOTRAK wires can be disconnected.

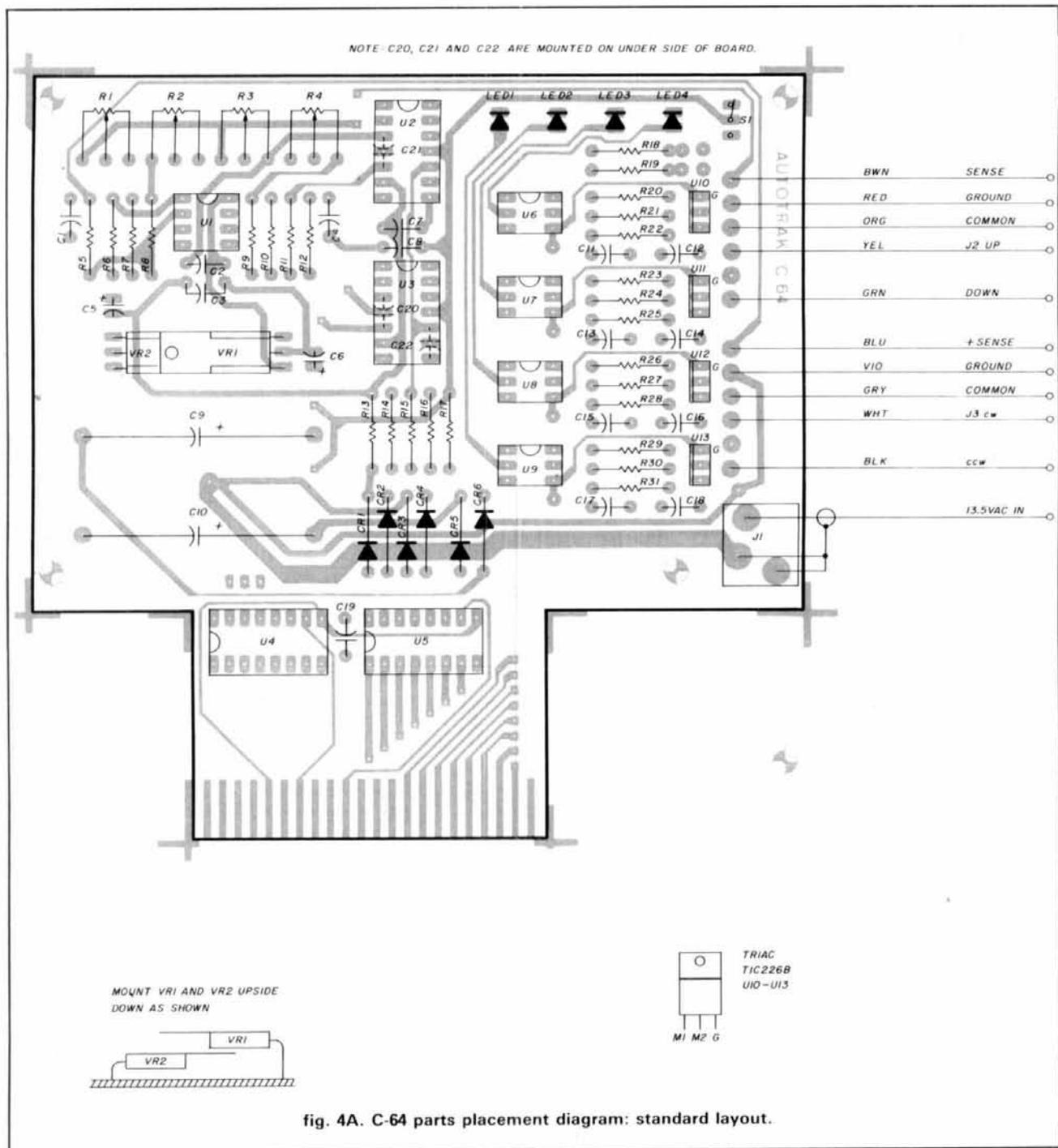
You'll also need to check the voltage of your rotor's sense lines. The AUTOTRAK board can work with sensing lines between 0.5 and 9.5 volts. If the voltage is higher, a simple voltage divider (see fig. 8) can be built into the board to bring it to about 8 volts. If the voltage is less than 2 volts, remove the short across JP1 (see fig. 1 for location) with an X-acto® knife and install JP2, using a small piece of wire. This changes the maximum output of the D-to-A converter to approximately 2.5 volts, where your low-sensing voltage can be more easily matched.

### calibration

Calibration should be done one rotor at a time, starting with bearing. Turn your computer off. Then plug

the AUTOTRAK unit into the expansion port. Turn your computer on, connect the ac to the board, and turn on the enable switch. On the rotor controller, locate the direction-sensing voltage terminal and its ground return line (or the equivalent pins on a computer-ready rotor) and connect the wires from J3, pins 1 and 2 respectively, to them. Using its controller, move your rotor to its ccw end. Now type in the following POKE command for the C-64: **POKE 56832,0** (for the VIC-20, use **POKE 39936,0**) and press RETURN. Notice the green LEDs; one should be lit. Adjust R1 (the leftmost pot) back and forth. You should find you can light either green LED, with a neutral spot, or window, showing between them when neither is lit. If adjusting R1 causes both LEDs to light, it may be that you have too much noise (or ac ripple) on the sense line from your rotor. Try putting a 10- to 100- $\mu$ F cap between the sense line and ground (see fig. 9).

NOTE: C20, C21 AND C22 ARE MOUNTED ON UNDER SIDE OF BOARD.



Adjust R1 to the center of the window. If this can't be done, check for these conditions: U5 (the azimuth D-to-A converter) pin 14 should be at or near zero volts; the input sense line from your rotor should also be near zero volts; correspondingly, U1 (the inverting op amp), pin 1 should be near zero volts or slightly negative and somewhat adjustable by R1. The POKE value mentioned above sets the output of U5 to zero. The ccw end of rotor rotation should be the low-voltage end. R1 sets the op amp to match the output

of U5, but with opposite polarity. When these conditions are met, you're ready to proceed. Move the rotor manually to its cw end, enter **POKE 56832,255** (**POKE 39936,255** for the VIC-20) and press RETURN. Again, one green LED should light. This time, adjust R2 (the second pot from the left) to the window where neither LED is on. This adjusts the cw end of rotation. If you can't find a window, check U5 pin 14 for approximately 9.5 volts (the maximum output of the D-to-A converter); U1 pin 1 should be adjustable by R2

NOTE C20, C21 AND C22 ARE MOUNTED ON UNDER SIDE OF BOARD.

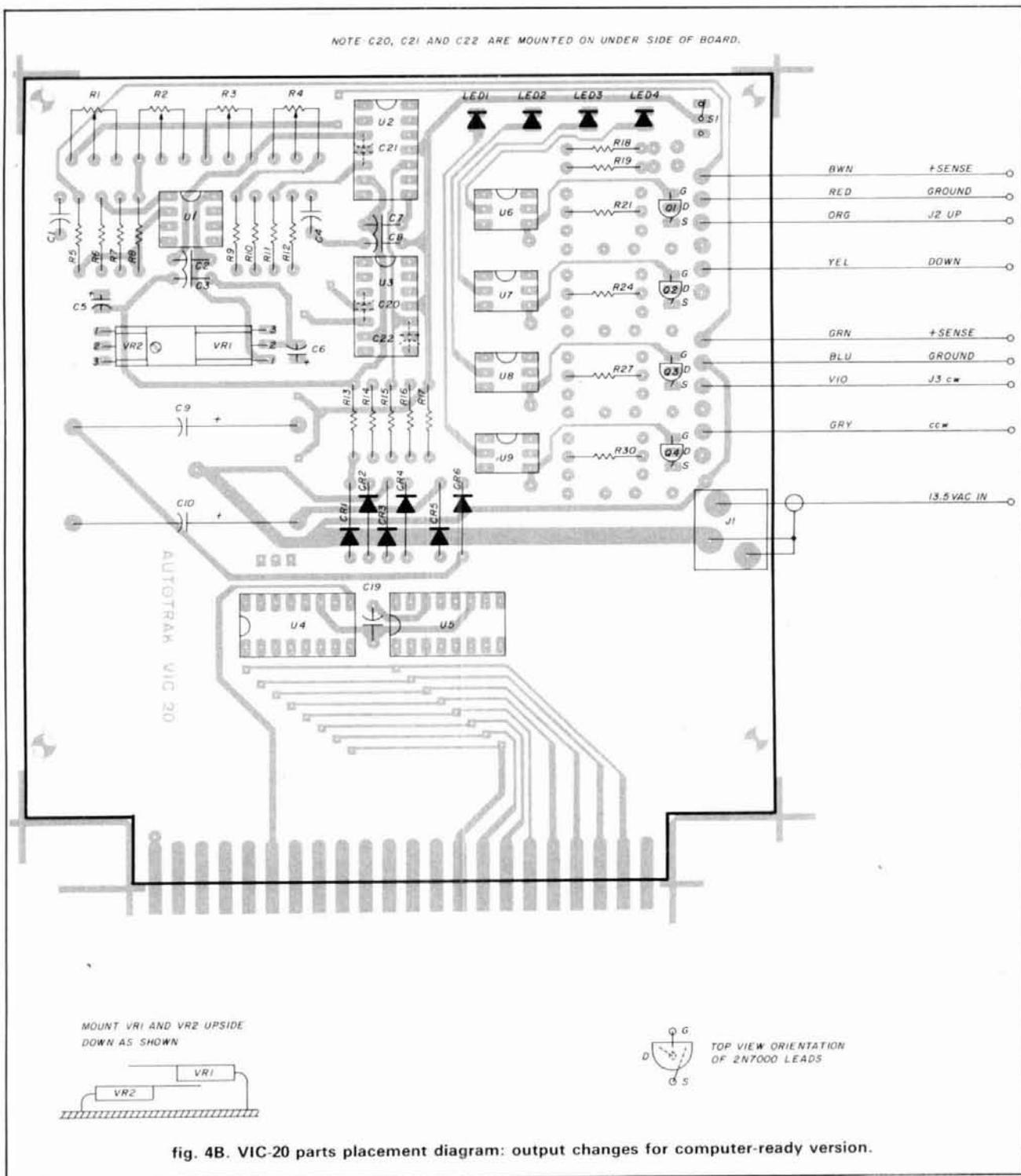
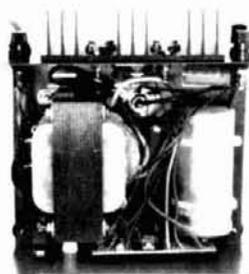


fig. 4B. VIC-20 parts placement diagram: output changes for computer-ready version.

to a negative value matching this voltage. Because there's some interaction between adjustments, it's important to repeat the calibration steps at least twice. You may want to make these adjustments with the rotor positioned several degrees in from the extreme ends to allow some slack for changes due to time and/or temperature.

Now you can connect the wires to the direction switches. Be careful to hook them up correctly and use POKE commands to verify that they rotate in the correct direction. Reverse them if they seem to operate backwards.

To hook up the elevation rotors, use the same procedure as with the azimuth rotor, but connect the



INSIDE VIEW — RS-12A

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- INPUT VOLTAGE: 105-125 VAC
- OUTPUT VOLTAGE: 13.8 VDC  $\pm$  0.05 volts (Internally Adjustable: 11-15 VDC)
- RIPPLE Less than 5mv peak to peak (full load & low line)
- Also available with 220 VAC input voltage



MODEL RS-50A



MODEL RS-50M



MODEL VS-50M

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MODEL RM-35M

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MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H $\times$ W $\times$ D	Shipping Wt. (lbs.)
RM-12A	9	12	5 1/4 $\times$ 19 $\times$ 8 1/4	16
RM-35A	25	35	5 1/4 $\times$ 19 $\times$ 12 1/2	38
RM-50A	37	50	5 1/4 $\times$ 19 $\times$ 12 1/2	50
• Separate Volt and Amp Meters				
RM-12M	9	12	5 1/4 $\times$ 19 $\times$ 8 1/4	16
RM-35M	25	35	5 1/4 $\times$ 19 $\times$ 12 1/2	38
RM-50M	37	50	5 1/4 $\times$ 19 $\times$ 12 1/2	50

### RS-A SERIES



MODEL RS-7A

MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H $\times$ W $\times$ D	Shipping Wt. (lbs.)
RS-3A	2.5	3	3 $\times$ 4 1/4 $\times$ 5 1/4	4
RS-4A	3	4	3 1/4 $\times$ 6 1/2 $\times$ 9	5
RS-5A	4	5	3 1/2 $\times$ 6 1/2 $\times$ 7 1/4	7
RS-7A	5	7	3 3/4 $\times$ 6 1/2 $\times$ 9	9
RS-7B	5	7	4 $\times$ 7 1/2 $\times$ 10 3/4	10
RS-10A	7.5	10	4 $\times$ 7 1/2 $\times$ 10 3/4	11
RS-12A	9	12	4 1/2 $\times$ 8 $\times$ 9	13
RS-12B	9	12	4 $\times$ 7 1/2 $\times$ 10 3/4	13
RS-20A	16	20	5 $\times$ 9 $\times$ 10 1/2	18
RS-35A	25	35	5 $\times$ 11 $\times$ 11	27
RS-50A	37	50	6 $\times$ 13 1/4 $\times$ 11	46

### RS-M SERIES



MODEL RS-35M

MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H $\times$ W $\times$ D	Shipping Wt. (lbs.)
RS-12M	9	12	4 1/2 $\times$ 8 $\times$ 9	13
RS-20M	16	20	5 $\times$ 9 $\times$ 10 1/2	18
RS-35M	25	35	5 $\times$ 11 $\times$ 11	27
RS-50M	37	50	6 $\times$ 13 1/4 $\times$ 11	46

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- Separate Volt and Amp Meters • Output Voltage adjustable from 2-15 volts • Current limit adjustable from 1.5 amps to Full Load

MODEL	Continuous Duty (Amps)			ICS* (Amps) @13.8V	Size (IN) H $\times$ W $\times$ D	Shipping Wt. (lbs.)
	@13.8VDC	@10VDC	@5VDC			
VS-12M	9	5	2	12	4 1/2 $\times$ 8 $\times$ 9	13
VS-20M	16	9	4	20	5 $\times$ 9 $\times$ 10 1/2	20
VS-35M	25	15	7	35	5 $\times$ 11 $\times$ 11	29
VS-50M	37	22	10	50	6 $\times$ 13 1/4 $\times$ 11	46
• Variable rack mount power supplies						
VRM-35M	25	15	7	35	5 1/4 $\times$ 19 $\times$ 12 1/2	38
VRM-50M	37	22	10	50	5 1/4 $\times$ 19 $\times$ 12 1/2	50

### RS-S SERIES



MODEL RS-12S

- Built in speaker

MODEL	Continuous Duty (Amps)	ICS* Amps	Size (IN) H $\times$ W $\times$ D	Shipping Wt. (lbs.)
RS-7S	5	7	4 $\times$ 7 1/2 $\times$ 10 3/4	10
RS-10S	7.5	10	4 $\times$ 7 1/2 $\times$ 10 3/4	12
RS-12S	9	12	4 1/2 $\times$ 8 $\times$ 9	13
RS-20S	16	20	5 $\times$ 9 $\times$ 10 1/2	18

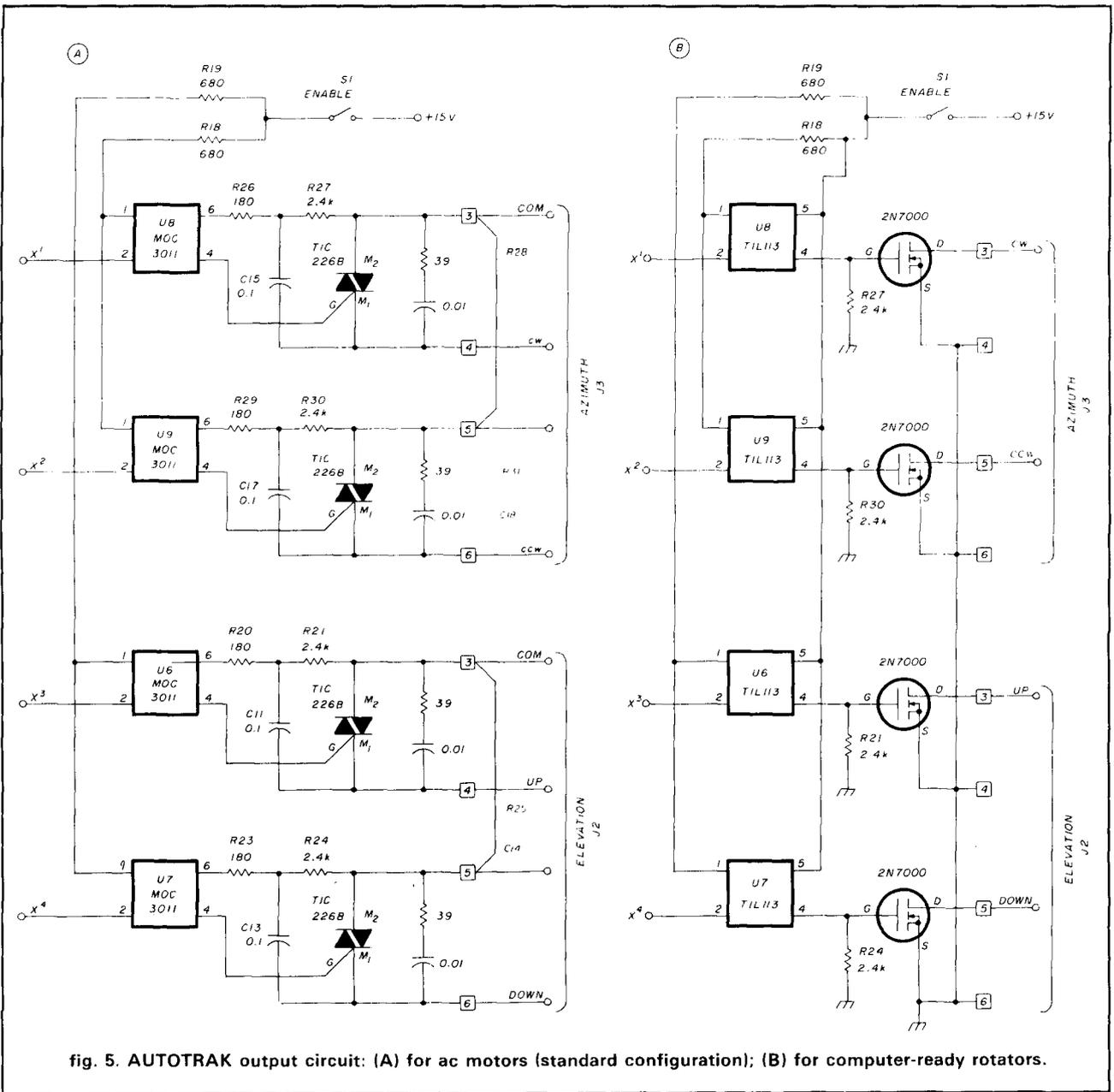


fig. 5. AUTOTRAK output circuit: (A) for ac motors (standard configuration); (B) for computer-ready rotators.

wires to J2 and follow these POKE commands: for down (horizon), use **POKE 57088,0** (**POKE 38912,0** for the VIC-20) and for straight up (90 degrees), use **POKE 57088,127** (**POKE 38912,127** for the VIC-20). Adjust R3 (the second pot from the right) for zero-degree adjustment and R4 (the rightmost pot) for the 90-degree adjustment. Watch the *red* LEDs this time.

**quick check**

Here's a quick calibration sequence for checking or occasional recalibration.

•Azimuth:

**POKE 56832,0** (**39936,0** for the VIC-20).

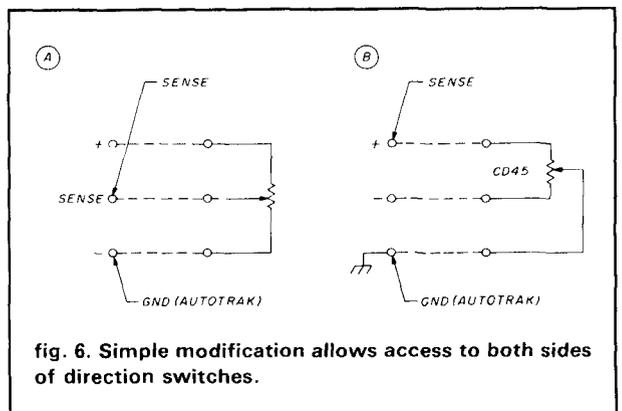


fig. 6. Simple modification allows access to both sides of direction switches.

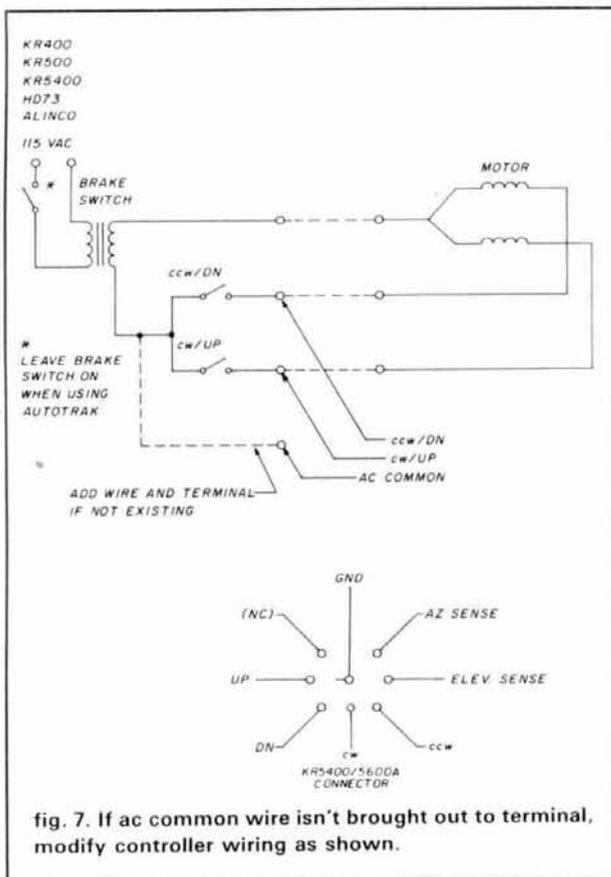


fig. 7. If ac common wire isn't brought out to terminal, modify controller wiring as shown.

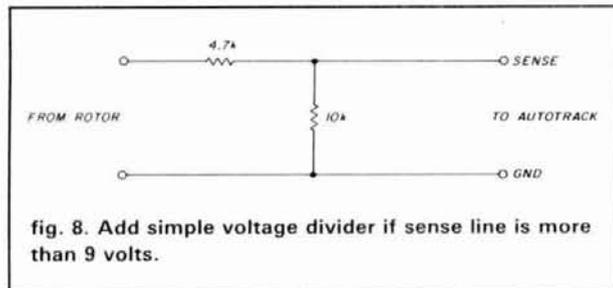


fig. 8. Add simple voltage divider if sense line is more than 9 volts.

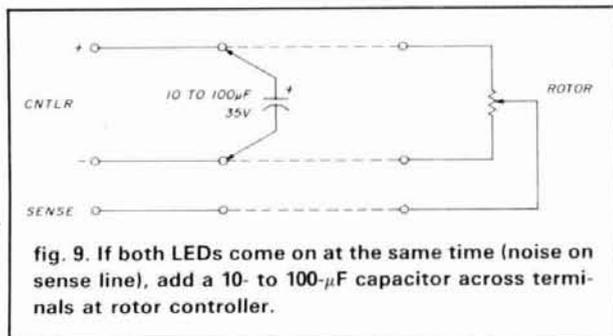


fig. 9. If both LEDs come on at the same time (noise on sense line), add a 10- to 100-µF capacitor across terminals at rotor controller.

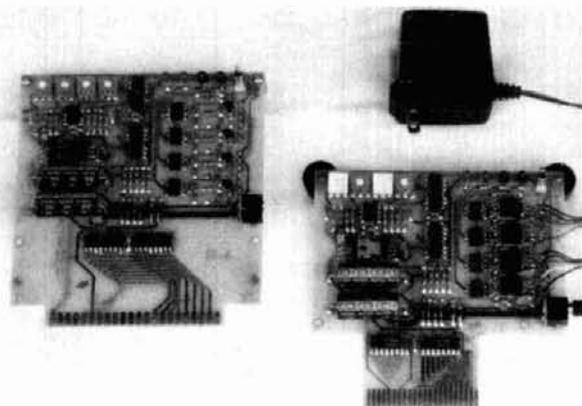


Photo A. Top view, VIC-20 (left) and C-64 (right) AUTOTRAK boards. 15-volt wall-mounted transformer is shown at upper right.

Adjust R1 for both green LEDs out with rotor at ccw end.

POKE 56832,255 (39936,255 for the VIC-20).

Adjust R2 for both green LEDs out with rotor at cw end.

•Elevation:

POKE 57088,0 (38912,0 for the VIC-20).

Adjust R3 for both red LEDs out with rotor at 0 degrees (horizon).

POKE 57088,127 (38912,127 for the VIC-20).

```

10 REM MANUAL AUTOTRAK PGM BY NEIL HILL, K7NH
20 PRINT "          MANUAL AUTOTRAK MODE"
30 PRINT "ENTER AZIMUTH (0 TO 359), PRECEDE WITH B"
40 PRINT "    EXAMPLE: B0, B45, B335"
50 PRINT "OR ELEVATION (0 TO 90), PRECEDE BY E"
60 PRINT "    EXAMPLE: E0, E45, E87"
70 PRINT
80 INPUT AD$: AD=VAL(MID$(AD$,2)): IF LEFT$(AD$,1)="E" THEN 130
90 IF LEFT$(AD$,1)<>"B" THEN PRINT "PRECEDED BY B OR'E? TRY AGAIN": GOTO 80
100 IF AD>=360 THEN PRINT "AZIMUTH 0 TO 359? TRY AGAIN": GOTO 80
110 AB=(180+AD)*.71: IF AB>255 THEN AB=AB-255
120 POKE 56832,AB: PRINT "OK": GOTO 80
130 IF AD>90 THEN PRINT "ELEVATION 0 TO 90? TRY AGAIN": GOTO 80
140 AE=AD*1.4: POKE 57088,AE: PRINT "OK": GOTO 80
  
```

fig. 10. Program for manual operation of AUTOTRAK using the C-64.

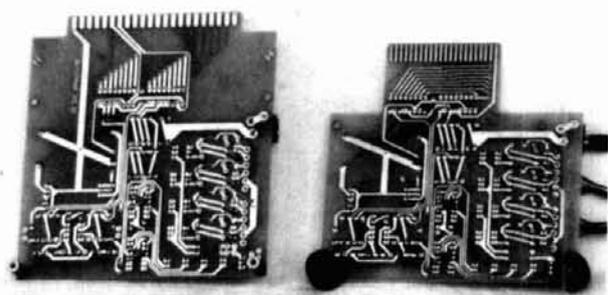


Photo B. Bottom view, VIC-20 and C-64 AUTOTRAK boards. Note two 0.1-k capacitors mounted across pins of LM319 comparators.

Adjust R4 for both red LEDs out with rotor at 90 degrees (straight up).

*Warning: always turn the enable switch OFF when the AUTOTRAK board is not in use. If for any reason the computer goes off, the board will have no control and will automatically drive your rotors to one end, leaving the rotor windings energized while trying to find the window. This could eventually damage the windings of the motor.*

## software

The program lines that need to be added to the "real time" section of your program are very simple. You take the desired azimuth, multiply it by 0.71 to make it fit into the range 0 to 255 (as high as you can count using 8 bits) and POKE it to address 56832 (39936 for the VIC-20). It would look like this:

**BG = AZIMUTH\*.71**

**POKE 56832,BG**

Use 39936 instead of 56832 for the VIC-20.

This will work very well for rotors that turn clockwise from north to north again. However, most are set up to travel from south to south, so a 180-degree offset is needed. For a south-to-south rotor, the program lines look like this:

**BG = (180 + AZIMUTH)\*.71:**

**IF BG > 255 THEN BG = BG - 255**

**POKE 56832,BG**

Use 39936 instead of 56832 for the VIC-20.

For elevation bearing, simply multiply your elevation by 1.4 and POKE it to 57088 (38912 for the VIC-20). This gives you a number between 0 and 127 for horizon to straight up, and provides enough accuracy and some safety; in case a number as high as 255 were accidentally POKEd, your antenna would move only to the far horizon, not through the roof. The program lines should look like this:

**EL = ELEVATION\*1.4**

**POKE 57088,EL**

Use 38912 instead of 57088 for the VIC-20.

A brief but complete program for manual operation of AUTOTRAK using the C-64 is shown in fig. 10.

## boards available

Readers who would like to build the AUTOTRAK modules but don't want to make their own boards may order them from me. For \$20 each, I'll provide high quality glass epoxy double-sided printed circuit boards with plated-through holes and full assembly instructions. I also have assembled and tested boards as well as world map-style tracking programs for the C-64 and VIC-20 (expanded and unexpanded) that work in real time and are designed to operate the AUTOTRAK boards. The SUPER VR85 mentioned earlier is available from RLD Research. For information on any of these items, please write to me at the address given at the beginning of the article.

## acknowledgments

I'd particularly like to thank Al Chandler, K6RFX, Vice President of Engineering for AEA, for taking my prototype drawings and concepts and turning them into a practical design. Thanks also to John Moriarity, K6QQ, and Dick Bartells, WA7ZIH, for their encouragement, suggestions, time, and effort in helping with the preparation of this article.

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XF-9B-10	SSB	2.4 kHz	10	145.00
XF-9C	AM	3.75 kHz	8	89.00
XF-9D	AM	5.0 kHz	8	89.00
XF-9E	FM	12.0 kHz	8	89.00
XF-9M	CW	500 Hz	4	62.00
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ELECTRICAL:	
BANDWIDTH.....	420-460 MHz
GAIN.....	8.9 dBd
VSWR.....	1.5:1
F/B.....	20 dB
BEAMWIDTH.....	60°
FEED IMP.....	50 ohm
BALUN.....	4:1 coax

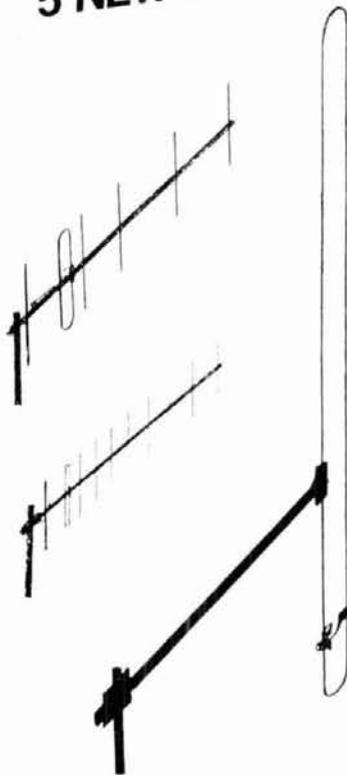
MECHANICAL:	
ELEMENT LENGTH.....	13½" max.
BOOM LENGTH.....	28"
TURN RADIUS.....	28"
WINDLOAD.....	2 sq. ft.
WEIGHT.....	1 lb.
MAST.....	1½" o.d.
MOUNT.....	Rear

### 440-10X

ELECTRICAL:	
BANDWIDTH.....	420-460 MHz
GAIN.....	11.2 dBd
VSWR.....	1.5:1
F/B.....	20 dB
BEAMWIDTH.....	48°
FEED IMP.....	50 ohm
BALUN.....	4:1 coax

MECHANICAL:	
ELEMENT LENGTH.....	13½" max.
BOOM LENGTH.....	64"
TURN RADIUS.....	64"
WINDLOAD.....	4 sq. ft.
WEIGHT.....	1½ lbs.
MAST.....	1½" o.d.
MOUNT.....	Rear

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VSWR.....	1.5:1
FEED IMP.....	50 ohms

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MECHANICAL:	
HEIGHT.....	61"
WEIGHT.....	2½ lbs.
MAST.....	1½" o.d.

#### CJ220

ELECTRICAL:	
BANDWIDTH.....	220-224 MHz
GAIN.....	1.8 dBd
VSWR.....	1.5:1
FEED IMP.....	50 ohms

NO GROUND PLANE REQUIRED

MECHANICAL:	
HEIGHT.....	40"
WEIGHT.....	2 lbs.
MAST.....	1½" o.d.

#### CJ440

ELECTRICAL:	
BANDWIDTH.....	420-470 MHz
GAIN.....	1.8 dBd
VSWR.....	1.5:1
FEED IMP.....	50 ohms

NO GROUND PLANE REQUIRED

MECHANICAL:	
HEIGHT.....	19¼"
WEIGHT.....	1 lb.
MAST.....	1½" o.d.

# the weekender



## a RAM drive for packet radio

Like many Amateurs, I've been spending more time at my computer and less time on the hf or VHF bands. Because packet radio looked like a way to combine both interests and enjoy both activities, I recently purchased a used Heathkit model HD-4040 TNC and decided to try packet radio.

There are times when I found myself missing transmissions, however — or on other occasions, having to wait for activity to pick up. One solution to these problems, I concluded, would be to capture the passing packets onto a disk file and read or print the contents later. But I had no need to fill up floppy disks with transient files; all I wanted was a way to collect and read packets monitored by the computer when I couldn't be there.

A better way, I found, is to divide my random access memory (RAM) into two sections: a storage area (called a RAM drive) and a free section that remains available to the terminal program. I send packets to the RAM drive for storage and read them periodically. One recent 90-minute collection session resulted in the creation of a 20K file for my review.

My frequency-synthesized 2-meter transceiver is connected to the TNC by two cables: one provides audio input and the other enables the microphone connection. The terminal unit contains an internal program (AX.25 protocol) to run the packet receive and packet transmit features for the system. A third cable runs from the TNC to my computer's RS-232 connector

By Thomas M. Hart, AD1B, 54 Hermaine Avenue, Dedham, Massachusetts 02026

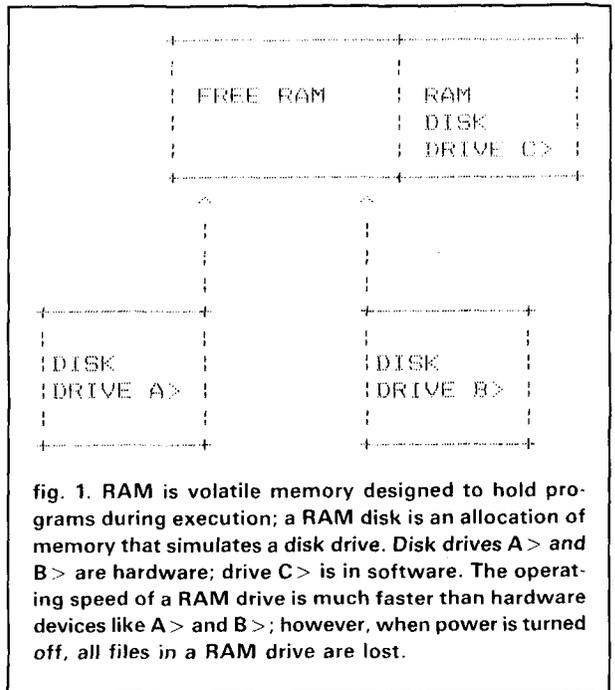


fig. 1. RAM is volatile memory designed to hold programs during execution; a RAM disk is an allocation of memory that simulates a disk drive. Disk drives A> and B> are hardware; drive C> is in software. The operating speed of a RAM drive is much faster than hardware devices like A> and B>; however, when power is turned off, all files in a RAM drive are lost.

(the serial port); the computer acts as a terminal for the packet system.

The computer itself requires a terminal program to permit the computer to "talk" to the TNC; I selected ProComm, a "shareware" program with outstanding features. ProComm has many functions, including one that writes information to a designated file on disk or in RAM for future use.

A RAM drive disappears when the power is shut off; this is not a concern because I use the RAM drive only for capturing information when the system is running and I can't be there. If I need to save a file, it's easy enough to copy the data to one of the regular disk drives.

My RAM drive system is running on a Zenith computer, using MS-DOS version 3.2. However, the same basic approach should work on a wide range of computers using DOS 2.0 or above. Some older versions of MS-DOS may not have a RAM drive file; if yours doesn't, you should be able to obtain one from any users' group.

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<b>NEW</b> 1409G	144-148	2	160	.6	15	13.6	25	UHF
1410G	144-148	10	160	.6	15	13.6	25	UHF
1412G	144-148	30	160	.6	15	13.6	20	UHF
2210G	220-225	10	130	.7	12	13.6	21	UHF
2212G	220-225	30	130	.7	12	13.6	16	UHF
4410G	420-450	10	100	1.1	12	13.6	19	N
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## customizing the RAM

The steps I took in customizing a RAM drive are described below; you should be able to follow the same approach on your own system.

My ProComm working disk is self-booting. An AUTOEXEC.BAT file starts the program. A CONFIG.SYS file on the disk consists of a single line:

**DEVICE = VDISK.SYS.**

This cryptic statement sets up the RAM drive when the computer is booted.

The following statement appears when my computer starts up:

**Microsoft RAMDrive version 3.2 VIRTUAL disk c:**

**Disk size: 256 KB**

**Sector size: 256 bytes**

**Allocation unit: 1 sectors**

**Directory entries: 64**

If you've never prepared a CONFIG.SYS file, the process is simple; just place the terminal program in the default disk drive. When the DOS prompt appears on the screen, enter the following commands:

**A > COPY CON:CONFIG.SYS (RETURN)**

**DEVICE = VDISK 256 256 (RETURN)**

**F - 6 (FUNCTION KEY 6)**

These simple steps will create a new file on the terminal emulation disk. If you want to check the file, do the following:

**A > TYPE CONFIG.SYS (RETURN)**

The contents of the file will be printed on the screen and should state:

**DEVICE = VDISK.SYS 256 256**

Copy the file VDISK.SYS from your DOS disk (probably on disk 2) to the terminal disk. This is the RAM disk program, which is installed by the newly created CONFIG.SYS file when the computer is booted.

With the terminal program still in the default drive, reboot the system. This will start the program normally and set up the RAM drive in the process.

When the packet system is running, use the command that your program requires to write information to a file (i.e., the file download command). In ProComm, the commands are:

**PAGE-DOWN** (start download)

**ASCII FORMAT** (create text file)

**ENTER FILE NAME** (I use C:\P)

These few steps will send all packets that the system monitors off to a single file (P) on the RAM drive (C:\). You'll find the system very convenient for passive packet monitoring, and there'll be no reason to miss any of the action in your area.

ham radio

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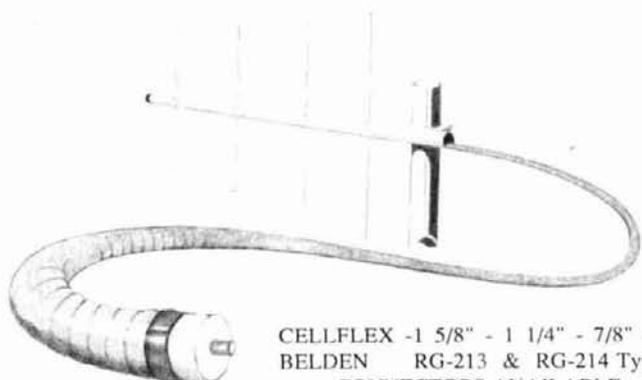
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# design an amplifier around the 3CX1200A7

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The 3CX1200A7 high- $\mu$  triode was introduced about three years ago by the Salt Lake City division of Varian/EIMAC\* as an extension of a series of zero-bias tubes of the kilowatt variety. Used predominantly in grounded-grid applications, the '1200 owes its electronic design to the 3-1000Z, which is its direct ancestor. It is a new type, however: air-cooled, possessing slightly different electrical characteristics, but offering increased plate dissipation. Its most notable differences are the anode construction and the resulting increased inter-electrode capacitances. Also, its maximum rated plate voltage is 500 volts less than that of the 3-1000Z.

I bought one of these tubes during the initial EIMAC sales promotion. What follows is a summary of the results of my efforts to generate, for my personal use, design methods for the 3CX1200, as well as for other tubes. Approximately two years of intermittent work were dedicated to this project.

In addition to the published tube characteristics, several aids are available to help designers; some of these were used in the preparation of this work.<sup>1,2</sup> The methods and numbers were transformed, drastically in some cases, without affecting either their content or their applicability. In their places are a few BASIC programs and several figures that greatly reduce the amount of effort necessary to complete a design. Graphs are presented for those without access to a personal computer.

## how do we start?

Initially, the following five parameters must be determined: drive impedance and drive power, dc plate current and power input, PEP output, plate dissipation, and plate load resistance. Later, we'll determine air cooling requirements, input matching circuits, and output matching circuits.

Figure 1 shows a stylized version of the constant-current curves supplied by the manufacturer for design purposes. Representative of all curves of the type, it provides information we can use to make very good estimates of operating parameters. Reference 2 provides the standard expressions for them. For "two-tone" conditions, the most important approximations are:

$$\text{dc plate current, } I_b = 2i_p/\pi^2, \quad (1)$$

$$\text{plate input (watts), } P_{in} = 2i_p E_b/\pi^2, \quad (2)$$

$$\text{average output (watts), } P_o = i_p e_p/8, \quad (3)$$

$$\text{PEP output (watts), } P_o = i_p e_p/4, \text{ and} \quad (4)$$

$$\text{plate efficiency, } E_{eff} = (e_p/E_b)(\pi/4)^2. \quad (5)$$

Two-tone calculations, which appear throughout this article, are more representative — though not precisely — of single-sideband voice operating conditions. In any event, the PEP output is the same for both two-tone and single-tone conditions.

Figure 1 shows that the points  $i_p$  and  $Q$  are at opposite ends of a load line.  $Q$  represents the quiescent condition of no drive. Therefore the plate voltage is exactly the supply voltage,  $E_b$ . The value of the quiescent plate current is also determined. At the other end of the load line is the point  $i_p$ , representing the maximum instantaneous plate current ( $i_p$ ), the minimum instantaneous plate voltage  $E_{min}$ , and the peak grid voltage. The positions of these points are arbitrary; the plate supply voltage is what you have available, and the peak plate current ( $i_p$ ) is your choice. The latter affects the plate load resistance, drive power, drive impedance, PEP output, and virtually everything else of consequence.

The dc plate current may be estimated by the use of eqn. 1. Equations 2 through 5 will yield other essential numbers. The grid current, however, isn't usually available from the curves. It can be calculated by using the EIMAC Tube Performance Computer<sup>3</sup> or by calculating the transfer curve up the load-line and then integrating the grid current.

By W. J. Byron, W7DHD, P.O. Box 2789,  
Sedona, Arizona 86336-2789

\*Varian EIMAC, 1678 Pioneer Road, Salt Lake City, Utah 84104.



```

5 REM SAVED AS 1200B
10 FOR EB = 4000 TO 2500 STEP 500
20 EM = 500
30 LPRINT"=====
40 LPRINT"          3CX1200A7 TWO-TONE; EB =";EB;" Volts"
41 LPRINT"          GROUNDED GRID"
50 LPRINT"          Emin. = ";EM;" Volts"
60 IF EB >= 3500 THEN LPRINT"          (Fixed Bias = 16 Volts)"
70 IF EB >=3000 AND EB<3500 THEN LPRINT"          (Fixed Bias=8.2 Volts)"
80 IF EB >=2500 AND EB<3000 THEN LPRINT"          (Fixed Bias=8.2 Volts)"
90 IF EB < 2500 THEN LPRINT"          (Zero Bias)"
100 LPRINT"-----"
110 LPRINT" ip      Zi      Pdrive      ep      Ib      DC in      PEP      Pl.Dis.  RL"
120 LPRINT" Amps  Ohms  Watts    Volts  Amps    Watts    Watts    Watts    Ohms"
130 LPRINT"-----"
140 FOR IP =1 TO 2.5 STEP .1
150 IF EB >=3500 THEN EK= 511 -4.16666*IP+20*IP^2-3.3333*IP^3
160 IF EB >=3000 AND EB<3500 THEN EK= 43.2 -4.16666*IP+20*IP^2-3.3333*IP^3
170 IF EB >=2500 AND EB<3000 THEN EK= 43.2 -4.16666*IP+20*IP^2-3.3333*IP^3
180 IF EB <2500 THEN EK= 351 -4.16666*IP+20*IP^2-3.3333*IP^3
190 P1=3.14159
200 IB = 2*IP/(PI^2)
210 EP = EB-EM
220 PFT = EK*IP/4
230 PEP =(IP*EP/4)+PFT
240 ETA = (EP/EB)*(PI^2/16)
250 ZI = 2*EK/IP
260 RL = 2*EP/IP
270 PD = EK^2/ZI
280 WI = IB*EB
290 DIS = (WI)*(1-ETA)
300 AS = "###.## ###.## ###.## ###.## ###.## ###.## ###.## ###.## ###.##"
310 LPRINT USING AS;IP;ZI;PD;EP;IB;WI;PEP;DIS;RL
320 NEXT IP
330 LPRINT"-----"
340 LPRINT" Note: Overall Plate Efficiency is ";INT(10000*ETA)/100;" per cent."
360 LPRINT" Drive feed-through is added to PEP out."
400 LPRINT:LPRINT
410 NEXT EB
420 END

```

fig. 2. BASIC program solves eqns. 1 through 5, plus others, producing tables of tube operating parameters.

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```

=====
          3CX1200A7 TWO-TONE; EB = 4000 Volts
          GROUNDED GRID
          Emin. = 500 Volts
          (Fixed Bias = 16 Volts)
=====

```

ip	Zi	Pdrive	ep	Ib	DC in	PEP	Pl.Dis.	RL
Amps	Ohms	Watts	Volts	Amps	Watts	Watts	Watts	Ohms
1.00	127.0	31.75	3500	0.203	810.6	890.9	373.1	7000
1.10	120.3	36.40	3500	0.223	891.6	980.7	410.4	6364
1.20	115.1	41.42	3500	0.243	972.7	1070.7	447.7	5833
1.30	110.9	46.84	3500	0.263	1053.7	1160.9	485.0	5385
1.40	107.5	52.65	3500	0.284	1134.8	1251.3	522.3	5000
1.50	104.7	58.88	3500	0.304	1215.9	1341.9	559.6	4667
1.60	102.4	65.50	3500	0.324	1296.9	1432.8	596.9	4375
1.70	100.4	72.54	3500	0.344	1378.0	1523.8	634.2	4118
1.80	98.7	79.97	3500	0.365	1459.0	1615.0	671.5	3889
1.90	97.3	87.80	3500	0.385	1540.1	1706.4	708.8	3684
2.00	96.0	96.00	3500	0.405	1621.1	1798.0	746.1	3500
2.10	94.8	104.56	3500	0.426	1702.2	1889.8	783.4	3333
2.20	93.8	113.45	3500	0.446	1783.3	1981.7	820.8	3182
2.30	92.7	122.66	3500	0.466	1864.3	2073.8	858.1	3043
2.40	91.8	132.14	3500	0.486	1945.4	2166.1	895.4	2917
2.50	90.8	141.88	3500	0.507	2026.4	2258.4	932.7	2800

Note: Overall Plate Efficiency is 53.97 per cent.  
 Drive feed-through is added to PEP out.

fig. 3. Example of the output of the BASIC program of fig. 2.

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these, change **line 140** to read, "FOR  $i_p = 2.0$  TO 2.1 Step .01". Then you'll get one panel with eleven lines, representing conditions for drive powers from 96.0 to 104.56 watts. Remember that the supply voltage is a "loaded" value; that is, the plate voltage under load. Typically, it will be between 5 and 10 per cent below the no-load value.

A prospective builder probably has only a few factors under control at the outset of a design. He has the tube, an exciter, a power transformer or a power supply, and maybe a surplus centrifugal blower. He therefore has only two pertinent inputs; plate-supply voltage and drive power. It's possible to rearrange the program to accommodate only those two inputs.

While the program shown in **fig. 2** can do all that's necessary, it was modified so that those two factors are the only inputs; **fig. 4** lists that program. First it requests "PLATE SUPPLY VOLTAGE," and "MAX DRIVE POWER." It then begins with an  $i_p$  of 1 ampere and incrementally steps the value, in this case by 5 milliamperes, and calculates  $Z_i$  and  $P_D$  (drive impedance and drive power). It then compares the calculated  $P_D$  until it's in a "window" of  $A \pm 0.5$  watts width, where  $A$  is the exciter drive power. When this is reached, it then performs all the other calculations and produces one panel with one line — the only one that meets the requirements of the inputs. Though it doesn't print a hard copy, one can be obtained by using the screen dump facility (mine is simply SHIFT/PRINT.) An example of the program output is shown in **fig. 5**.

At this point it's very important to emphasize that although modern exciters are of the "100-watt PEP minimum" variety, many — and perhaps most — will exceed 100 watts PEP output. The programs above require that the designer know the characteristics of the exciter. It isn't good design if one enters 100 watts for the PEP drive power, when in reality it might be 120 watts. Almost all exciters will deliver more PEP output under voice conditions than they will under "key-down" on CW. The leading cause of power-grid tube destruction is excessive grid dissipation. The most important single instrument in an amplifier is the grid-current meter.

### **completing the design**

The major difference between the '1200 and the 3-1000Z is in the cooling, another factor not yet faced. If you have a surplus blower in the shack, it's essential to know beforehand if it will be sufficient. The best way to determine this is to test the blower in a separate measurement.

Find a cardboard carton large enough to hold the tube, and sturdy enough to allow the blower to be taped onto the side. Cut a circular hole large enough



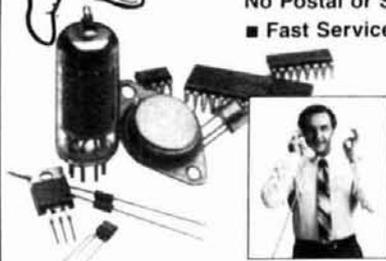
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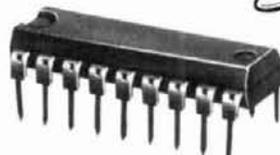


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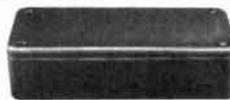
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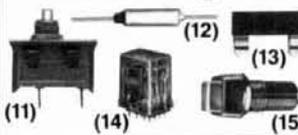


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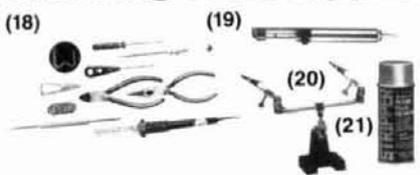


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```

10 REM SAVED AS 1200X
20 INPUT "PLATE SUPPLY VOLTAGE";EB
30 INPUT "MAX DRIVE POWER";A
40 EM = 500
50 PRINT "=====
60 PRINT "          3CX1200A7 TWO-TONE; EB =";EB;" Volts"
70 PRINT "          GROUNDED GRID"
80 PRINT "          Emin. = ";EM;" Volts"
90 IF EB >= 3500 THEN PRINT "          (Fixed Bias = 16 Volts)"
100 IF EB >=3000 AND EB<3500 THEN PRINT "          (Fixed Bias=8.2 Volts)"
110 IF EB >=2500 AND EB<3000 THEN PRINT "          (Fixed Bias=8.2 Volts)"
120 IF EB < 2500 THEN PRINT "          (Zero Bias)"
130 PRINT "-----"
140 PRINT "ip  Zi  Pdrive  ep  Ib  DC in  PEP  Pl.Dis.  RL"
150 PRINT "Amps Ohms  Watts  Volts  Amps  Watts  Watts  Watts  Ohms"
160 PRINT "-----"
170 IP=1
180 IF EB >=3500 THEN EK = 51 - 4.16666*IP+20*IP^2-3.3333*IP^3
190 IF EB >=3000 AND EB<3500 THEN EK = 43.2 - 4.16666*IP+20*IP^2-3.3333*IP^3
200 IF EB >=2500 AND EB<3000 THEN EK = 43.2 - 4.16666*IP+20*IP^2-3.3333*IP^3
210 IF EB <2500 THEN EK = 35 - 4.16666*IP+20*IP^2-3.3333*IP^3
220 ZI = 2*EK/IP
230 PD = EK^2/ZI
240 IF PD >=(A-.5) AND PD<=(A+.5) THEN 260 ELSE 250
250 IP = IP+.005:GOTO 180
260 PI=3.14159
270 IB = 2*IP/(PI^2)
280 EP = EB-EM
290 PFT = EK*IP/4
300 PEP = (IP*EP/4)+PFT
310 ETA = (EP/EB)*(PI^2/16)
320 RL = 2*EP/IP
330 WI = IB*EB
340 DIS = (WI)*(1-ETA)
350 AS = "*****
360 PRINT USING AS;IP;ZI;PD;EP;IB;WI;PEP;DIS;RL
370 PRINT "-----"
380 PRINT " Note: Overall Plate Efficiency is ";INT(10000*ETA)/100;" per cent.
390 PRINT " Drive feed-through is added to PEP out."
400 PRINT:PRINT,
410 END
    
```

fig. 4. BASIC program modified to accept two inputs, plate supply voltage, and PEP drive power.

```

RUN
PLATE SUPPLY VOLTAGE? 3250
MAX DRIVE POWER? 110
=====
          3CX1200A7 TWO-TONE; EB = 3250 Volts
          GROUNDED GRID
          Emin. = 500 Volts
          (Fixed Bias=8.2 Volts)
-----
ip  Zi  Pdrive  ep  Ib  DC in  PEP  Pl.Dis.  RL
Amps Ohms  Watts  Volts  Amps  Watts  Watts  Watts  Ohms
-----
2.255 86.3 109.69 2750 0.457 1485.1 1605.2 710.0 2439
-----
Note: Overall Plate Efficiency is 52.19 per cent.
Drive feed-through is added to PEP out.
    
```

Ok

fig. 5. Example of the output of fig. 4.

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10 REM SAVED AS "AIR-4" - WORKS FOR BOTH 3CX1500A7 (8877) AND 3CX1200A7
20 PRINT"ENTER '1' FOR 3CX1200A7 OR '2' FOR 3CX1500A7/8877"
30 INPUT "1200 OR 8877";A$
31 IF A$ <"1" THEN 30
32 IF A$ >"2" THEN 30
35 IF A$ = "" THEN 30
40 INPUT "WHAT IS THE CALCULATED PLATE DISSIPATION (KW)";PW
50 IF A$ = "1" THEN 70
60 IF A$ = "2" THEN 80
70 PD = -9.999991*.001+7.266617*.01*PW+.088*PW^2+.149333*PW^3:GOTO 100
80 PW = PW*1000
90 PD = .00031*PW - 3.6*.0000001*PW^2 + 2.8*1E-10*PW^3
100 INPUT "WHAT TEMPERATURE (DEGREES CELSIUS)";T
110 Q1 = .91502 +3.398895E-03*T + 2.980232E-08*T^2 - 4.656613E-10*T^3
120 INPUT "WHAT IS YOUR ALTITUDE (FEET ABOVE SEA-LEVEL)";A
130 Q2 = .9999999 + 3.333335E-05*A + 1.400004E-09*A^2 - 1.33333E-14*A^3
140 H = INT(100*PD*Q1*Q2+.5)/100
150 PRINT "THE MANOMETER READING AT THESE CONDITIONS IS";H;"IN. WG"
160 END
RUN
ENTER '1' FOR 3CX1200A7 OR '2' FOR 3CX1500A7/8877
1200 OR 8877? 1
WHAT IS THE CALCULATED PLATE DISSIPATION (KW)? .710
WHAT TEMPERATURE (DEGREES CELSIUS)? 50
WHAT IS YOUR ALTITUDE (FEET ABOVE SEA-LEVEL)? 4300
THE MANOMETER READING AT THESE CONDITIONS IS .18 IN. WG
OK

```

fig. 6. BASIC program to calculate air differential pressure across tube anodes for both the 3CX1200A7 and the 3CX1500A7 (8877). It is valid for temperatures from zero to 50 degrees C, and for altitudes from sea level to 15,000 feet.

to hold the tube anode, but tight enough to hold the tube by friction alone. With masking tape, tape the tube in place. Now do the same for the blower. Tape all seams so that the system is tight.

Make a water manometer using Tygon™ tubing of at least 3/16 inch ID. (Be sure to use tubing large enough to prevent a meniscus problem.) Push one end of the tubing into the box and tape it in place. Add one drop of food coloring for visibility, and one drop of liquid detergent to the water to aid surface-wetting. Then start the blower. The vertical difference between the two levels in the manometer is the  $\delta P$  in inches w.g. If the levels don't return to zero differential after the blower is turned off, the measurement is probably faulty, and you should find tubing of a larger diameter.

The differential pressure required is a function of power dissipation, ambient temperature of the inlet air, and its density (altitude). Figure 6 shows a BASIC program that calculates the  $\delta P$  for both the 3CX1200A7 and the 8877. The solution is based on fig. 5 and my QTH, which is 4300 feet above sea level. An ambient temperature of 50 degrees C is conservative — and this should be the designer's goal. For 710 watts plate dissipation and an altitude of 4300 feet, the required differential pressure is 0.18 inches w.g. That's the mini-

imum acceptable reading; because overcooling prolongs tube life, I'd strive for 0.2 or 0.25 inches for this QTH. Don't accept anything less than the calculated number at your QTH. It is assumed — and essential — that the manufacturer's recommended socket and chimney be used.

The manufacturer permits zero-bias operation of the '1200 even for plate supply voltages up to 4000. The plate quiescent power dissipation under this condition is 900 watts! See what that does to the calculations in the paragraph above. That is the main reason for bias voltages (Zeners) up to 16 volts in both programs and graphs.

Figures 7, 8 and 9, derived from the programs, are included as guides for those without a personal computer. They're usable, provided the exciter PEP doesn't exceed the 110 watts specified in the figures.

The hypothetical design in fig. 5 gives a cathode drive impedance of 86.3 ohms, a PEP output of 1605 watts, and a plate load resistance of 2439 ohms (round off to 2440). These are for a drive power of 110 watts and a plate supply voltage of 3250. Now we can design the input and output matching circuits.

### cathode drive circuit

The calculations were all done for grounded-grid

operation. The computed drive impedance at the cathode is, for the example, 86.3 ohms. Since the 3CX1200 is a filament-type tube, it requires a filament choke, and a hefty one at that, because the filament current is 21 amperes. The rule of thumb for such devices is that the reactance of the choke (a bifilar filament choke) must be no smaller than  $5 \cdot 83.8$  ohms. Assume about  $+j500$  ohms at the lowest frequency contemplated; 86.3 ohms in parallel with  $+j500$  ohms equals  $83.8 + j14.5$  ohms, which is easily compensated by a Pi-section. The problem desolves to the design of an impedance matching circuit that converts 50 ohms to 84 ohms. I recommend a Pi-section with a  $Q_r$  of about 3.5. The reactance values appear in fig. 10.

### output matching

The plate load resistance from the program is 2440 ohms. There are many ways to match that to 50 ohms. The example worked out here will be the PI-L, which

is just what it implies: a Pi-section followed by an L-section. The Pi converts the resistance (or impedance) to an intermediate value, and the L further converts it to the desired 50-ohm load. The intermediate impedance (the junction between the L and the Pi) is, by convention, between 10 and 15 percent of the input impedance. A typical value would be 300 ohms. The attractiveness of the PI-L is in that it has a series inductance in the output side, and provides greater harmonic attenuation than the usual PI-section. Methods for designing both Pi- and L-sections are available from many sources. The reactance values for the Pi-L also appear in fig. 10.

Harmonic attenuation, however, is greatly dependent on the  $Q$  of the tank circuit, no matter what type is used. It should be somewhere between 15 and 20 for the lower frequencies, but because of distributed circuit capacitances it may be forced above 20 at, say, 29 MHz. The reason is that the component capacities to ground (switches, busses, and coils) plus the out-

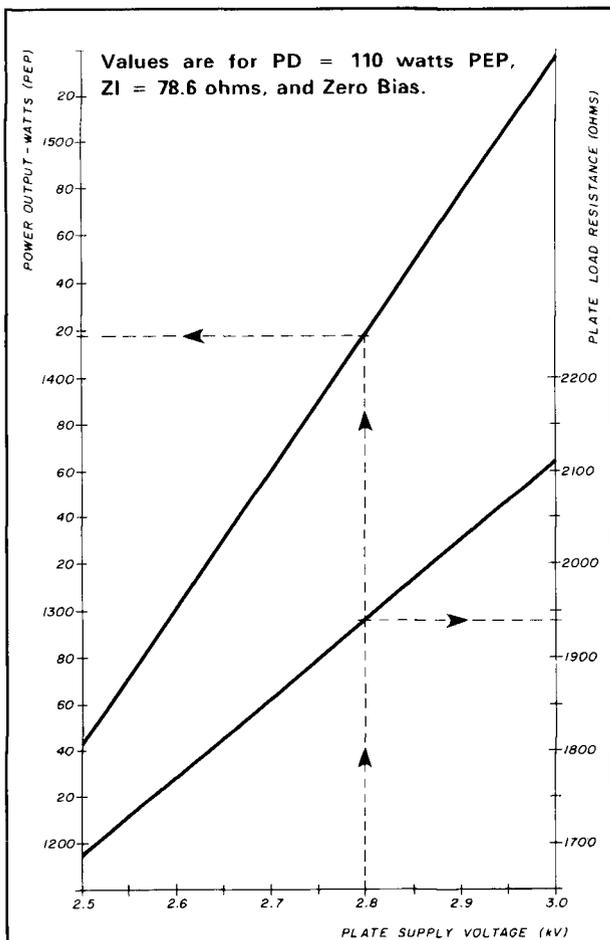


fig. 7. Amplifier parameters for plate supply voltages from 2.5 to 3.0 kV.

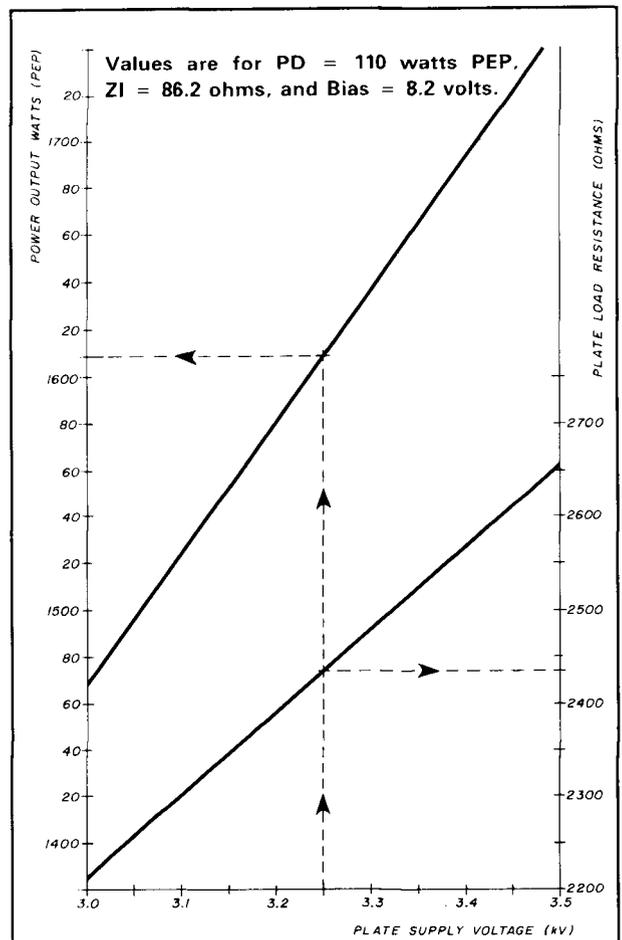


fig. 8. Amplifier parameters for plate supply voltages from 3.0 to 3.5 kV.

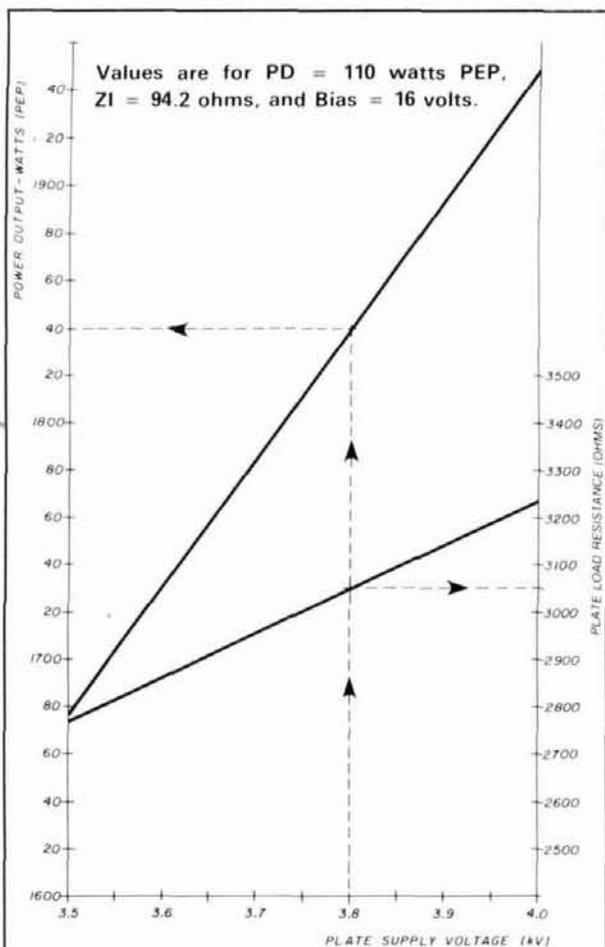


fig. 9. Amplifier parameters for plate supply voltages from 3.5 to 4.0 kV.

put capacitance of the tube itself frequently constitute the major part of the total input capacitance of the tank circuit. To give the tuning capacitor more control over resonance, a higher  $Q$  usually is selected. Try a  $Q$  of 25 as a first guess for the 10-meter band.

### operation

When the design is completed and the construction is nearly finished, I find that an additional step is extremely valuable. For example: the design is based on a  $Q$  of 15 and a load resistance of 2440 ohms. But when a load (near 50 ohms) is placed on the output, it's possible to "load" the amplifier with many positions of the input and output capacitors. Which ones are correct?

The programs developed and the background work done require that the amplifier be operated according to design. There is only one value each for  $C_1$  and  $C_2$  in the PI-L tank that will assure that the plate is looking at 2440 ohms. There is an easy way — and a rela-

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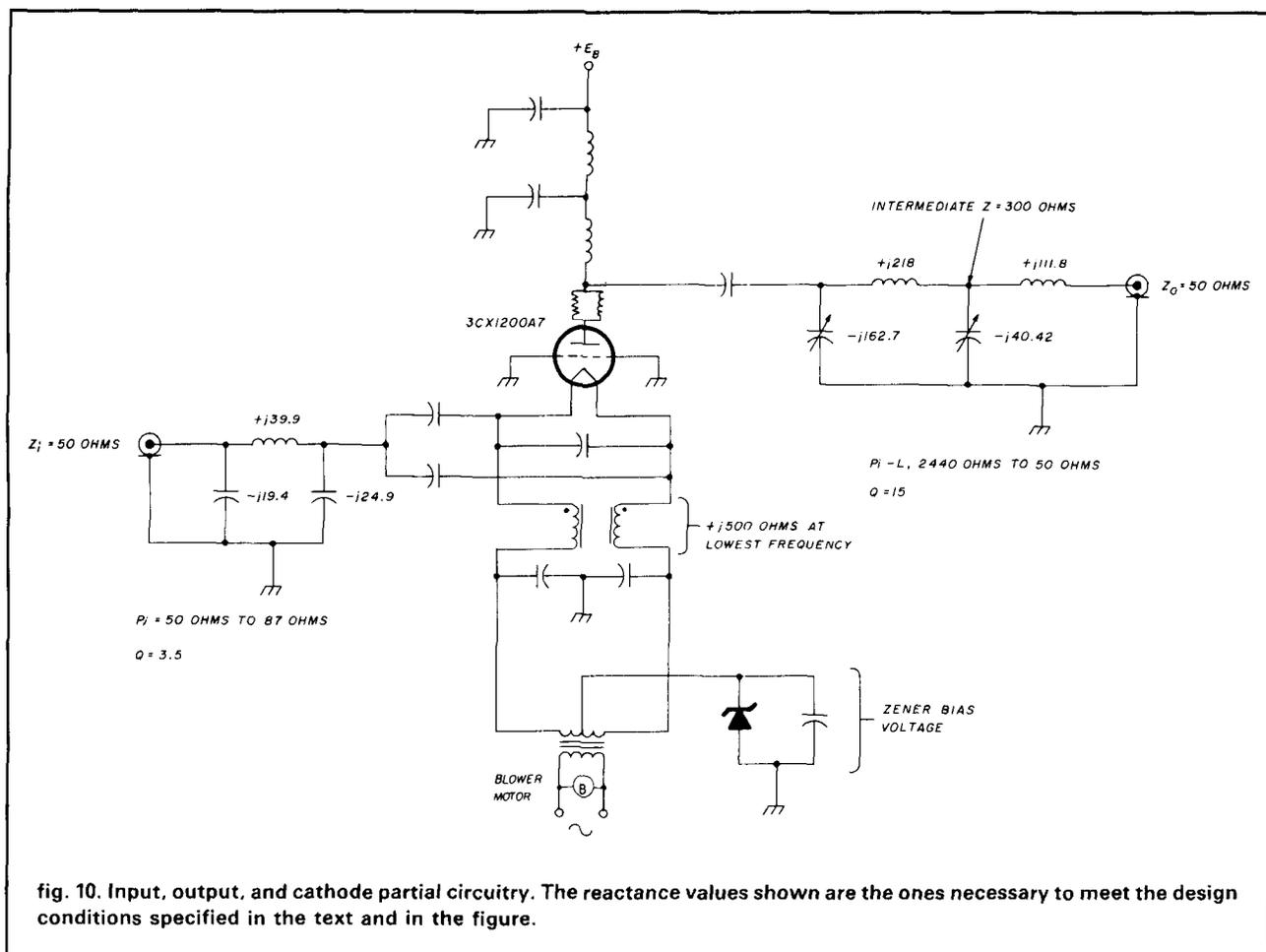
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A method I have used for years requires only a noise bridge and some carbon (non-inductive) resistors. Series-parallel combinations are perfectly acceptable. First, balance the noise bridge with a 50-ohm resistor. Then, without touching either the R or X knobs (leave the bridge at the balance position), connect the "Unknown" port to the output of the amplifier. Temporarily connect a 2440-ohm resistance from the plate to ground. Adjust C<sub>1</sub> and C<sub>2</sub> until the bridge is again balanced. Those are the correct settings for the amplifier during operation. Mark their position on the dials or the panel. Just so that there's no misunderstanding, leave all amplifier voltages off during this test! The same methods are very useful in adjusting baluns, transmission-line transformers, and transmatches — which I recommend using no matter what is on the other side of the transmatch. If the amplifier is looking at something other than 50 ohms, the measurements, regardless of how carefully they've been made, mean very little.

## conclusion

The programs and methods presented here are simplified versions of those I've developed over the past two years or so, but which are too complicated to be presented in full. The 3CX1200A7 is a new tube type that is of interest to Amateurs, and the simpler programs offer a way to help interested hams to do some design work of their own. I've also described some techniques (fan-testing and the pretuning of an amplifier) which should be useful in other projects. I built an amplifier about six years ago that used a variometer-type link coupling. If it weren't for the special use of a noise bridge, I would never have been able to determine for certain where the proper load conditions were. I hope these hints and techniques will be useful to you, too.

## references

1. *Amateur Single Sideband*, Ham Radio Publishing Group, Greenville, New Hampshire 03048.
2. "Care and Feeding of Power Grid Tubes," Laboratory Staff, Varian EIMAC, 1678 Pioneer Road, Salt Lake City, Utah 84104.
3. "Tube Performance Computer (or their specific brochure title)," Bulletin No. 5, Varian EIMAC, 301 Industrial Way, San Carlos, California 94070.

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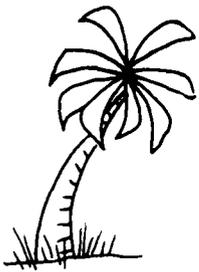
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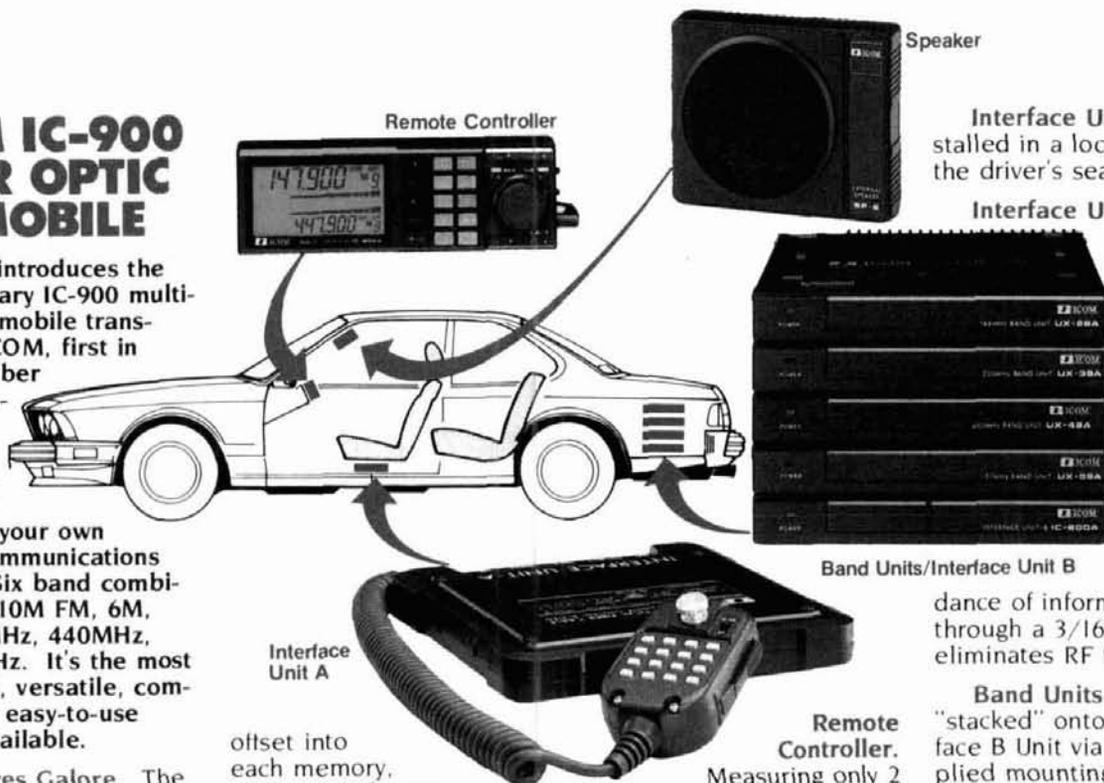
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UX-39A	25W/5W	216-236MHz Rx; 220-225MHz Tx
UX-49A	25W/5W	440-450MHz
UX-59A	10W/1W	50-54MHz
UX-129A	10W/1W	1240-1300MHz

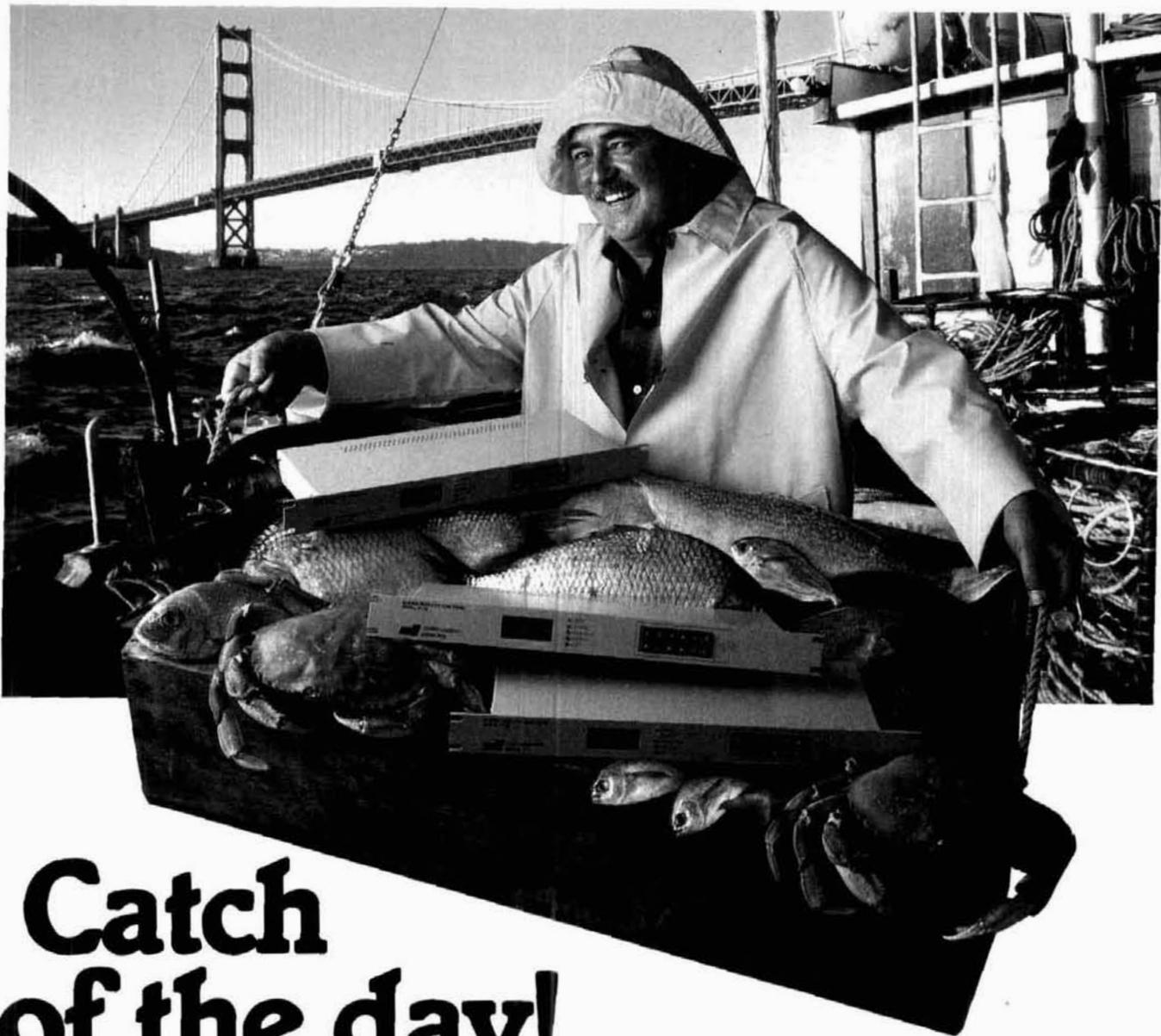
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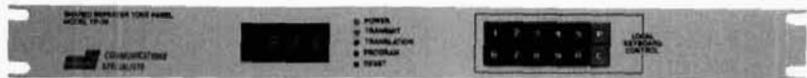


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## generating low i-f frequencies from an hf signal generator .

Like many Amateurs, I own several older signal generators that were once used in engineering laboratories, professional service shops, or maintenance repair organizations (MROs), and other places where high-quality rf signal sources are needed. Mine was traded from a local Amateur for a broken SB-34; he'd rescued it from the dumpster in back of our engineering school. That old Measurements Model 80 still has plenty of life in it, and works a lot better than some of the cheap signal generators that I could afford brand new.

Amateurs who want to build a collection of good test equipment often do well with these industry castoffs. I've seen top-of-the-line instruments from Boonton, Hewlett Packard, Measurements, Inc., and other notable manufacturers at hamfests for prices that were quite low. A very clean Boonton 202H am/fm/CW signal generator (which covers the 220-MHz band) was offered for only \$50 because the frequency range was, at the time, of less interest than other ranges. Similarly, an HP 608 in apparently good shape fetched only \$175.

But there's a problem with my Model 80 and many other signal generators. Though they work well on hf and VHF, they don't provide signals below hf. My Model 80, for example, operates over the range of 2 to 400 MHz. Yet there are times when I'd want it to provide signals in the lower end of the spectrum — above audio, but less than 2 MHz. For example, how do you align or troubleshoot a 455 kHz i-f amplifier without a good signal generator?

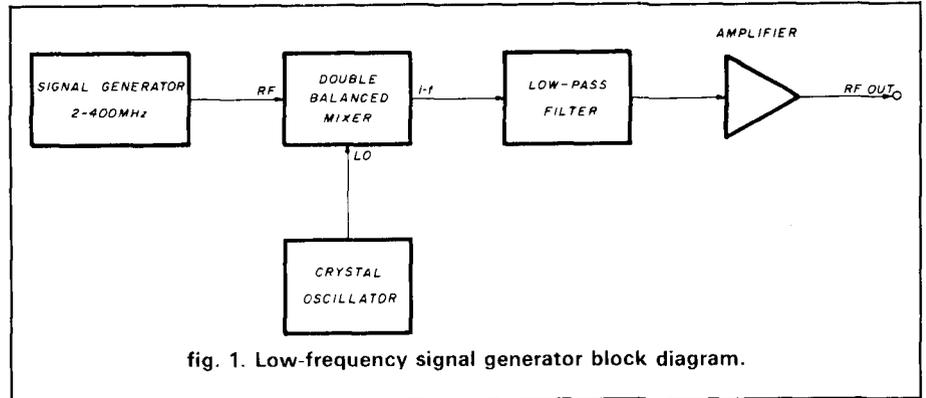


fig. 1. Low-frequency signal generator block diagram.

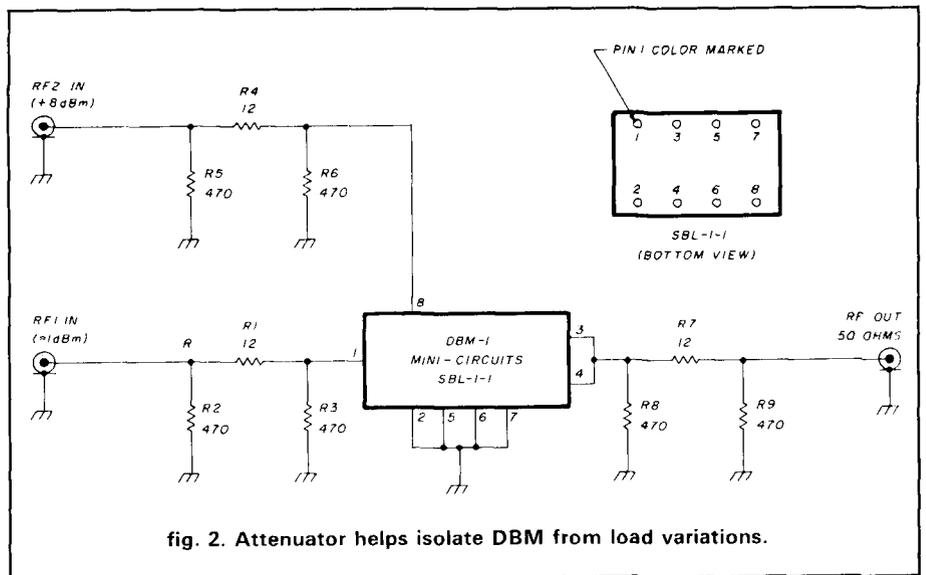
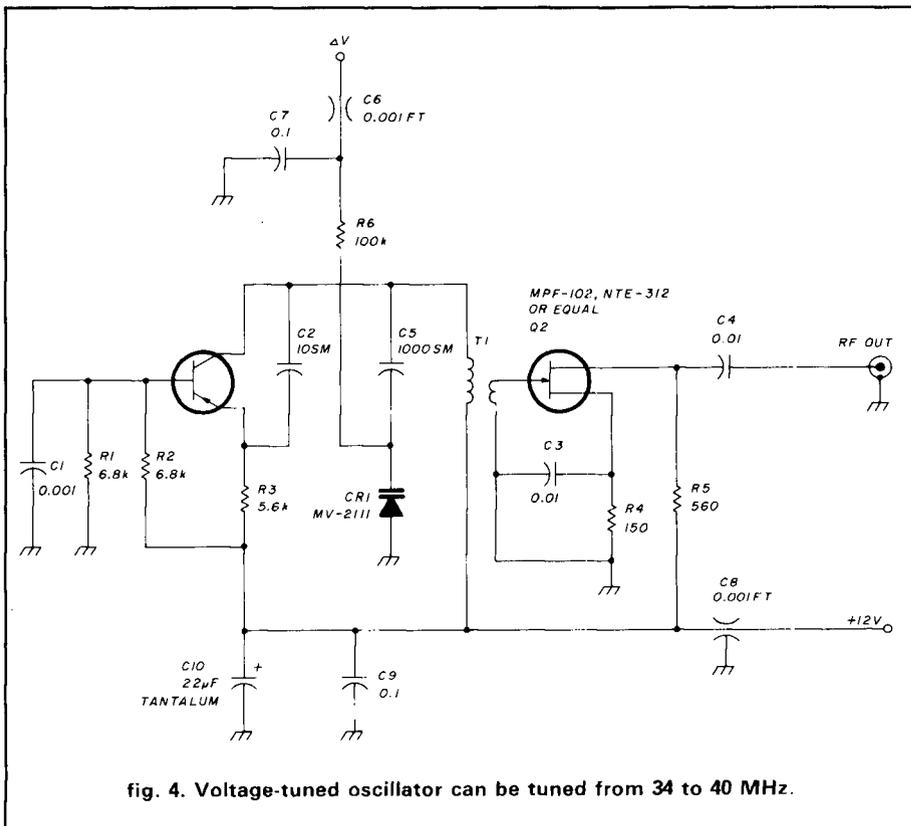
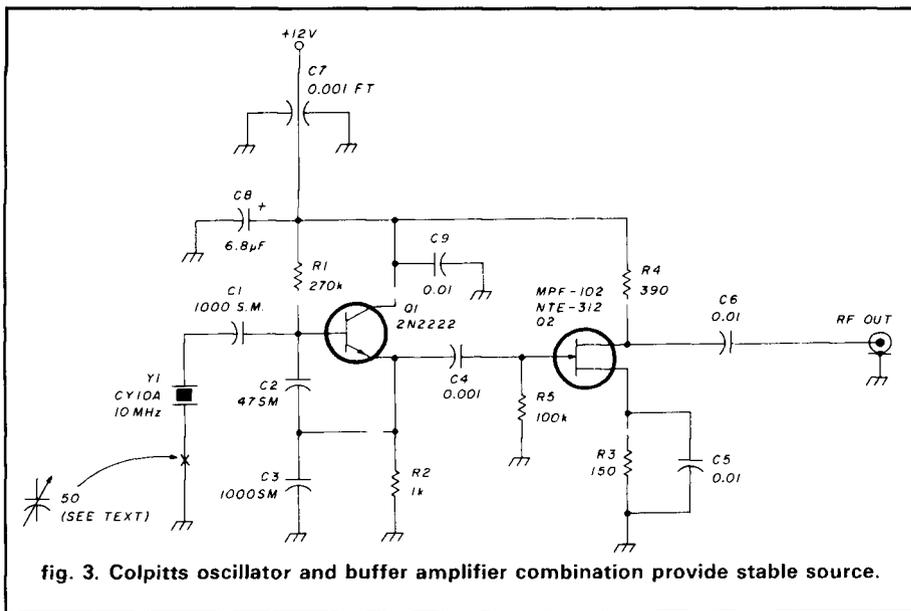


fig. 2. Attenuator helps isolate DBM from load variations.

Some instrument manufacturers addressed that need with separate signal generators that had overlapping ranges. I suspect that was a sales strategy to get us to buy two instruments instead of one (some makers did, however, offer "full range" signal sources inside a single box). Others, such as Boonton (later bought out by Hewlett-Packard), offered additions such as the Univerter. That interesting

device took the output of the Boonton 202 series of signal generators and down-converted it to a frequency between 10 kHz and 2 MHz, at the same rf level that was input. This latter feature allowed the user to set the rf level with the master attenuator on the front panel.

A basic but effective method of solving the problem is by heterodyning the output of the signal generator to a lower frequency. Figure 1 shows a block diagram of the system. The



double balanced mixer (DBM) receives the output of the signal generator at its "rf" port, and a stable local oscillator signal at its "LO" port. The difference signal appears at the i-f port. The output of the DBM should be low-pass

filtered to remove residual high-frequency signals. In my own case, I wanted to generate frequencies up to 1.9 MHz, so I used a 2-MHz low-pass filter described in reference one.

The amplifier at the output of the

low-pass filter is optional. I didn't find it necessary for my application because the entire gain of a communications receiver i-f amplifier was behind the signal generator. For others, however, some form of amplifier is recommended. Perhaps the easiest approach to a wideband (2 MHz) amplifier is a bandpass-limited version of the MMIC amplifiers discussed in Joe Reisert's column recently.<sup>2,3,4</sup> These amplifiers are low in cost, easy to construct, and already have a 50-ohm input/output impedance.

### construction

Over the past few years I've built several modules on my workbench for use in various projects or as "test gear," and these were usable in this project. These modules are a double-balanced mixer with wideband output, a 10-MHz crystal oscillator, and a 34- to 40-MHz voltage controlled oscillator. The DBM (fig. 2) is built from a Mini-Circuits SBL-1-1.\* This model of the well-known MCL product is able to work over a range of 0.1 to 400 MHz, which matched my requirements nicely. The inputs and the output terminal are isolated internally with 2-dB resistive attenuators, which are sometimes used in wideband circuits to overcome difficulties that can be caused by changing impedances over a wide frequency range. Because no tuning is used at the i-f output, the DBM of fig. 2 is wideband. I built it in a die-cast shielded Pomona box that provides a reasonably good seal against rf leakage in or out. The input and output connectors are BNC. The rf input (RF1) will accept signals up to +1 dBm (1.26 mW), while the local oscillator (RF2) input requires +7 dBm (5 mW) to work properly.

The crystal oscillator (fig. 3) was originally built for use as a marker (generator) in an alignment job. The 10.7-MHz crystal was subsequently replaced with a 10.00-MHz crystal to allow the oscillator to be used as time-base source in a digital project, and as

\* Mini Circuits Laboratories, Inc., P.O. Box 166, Brooklyn, New York 11235.

a crystal calibrator in a receiver. The CY-10A 10-MHz crystal was obtained from a Jim-Pack display at a local electronics shop for only a few dollars.\*

The oscillator circuit uses a 2N2222 NPN transistor, although almost any replacement rf transistor similar to the 2N2222 will also work well. In fact, I've used this same circuit with both PNP and NPN transistors selected at random from a variety of sources. Although in many cases stability might suffer as a result of a less than rigorous selection of devices, it demonstrates that this circuit is forgiving and easy to construct. The basic circuit is a Colpitts crystal oscillator. The feedback capacitor voltage divider network (C2, C3) should be made from silver-mica capacitors for best stability. This circuit works at frequencies from 2 to 20 MHz.

To enable tuning the crystal frequency to exactly 10.0 MHz, place a 50-pF trimmer capacitor in series with the crystal and eliminate capacitor C1. Adjust the trimmer for exactly 10 MHz output, as measured by a digital frequency counter or by zero-beating WWV.

The output stage is a JFET buffer amplifier. When I found that the oscillator frequency would be pulled slightly when load impedances changed, I decided buffering would be necessary. The JFET is an MPF-102 or equivalent device — for example, an NTE-312, which is widely available from local parts distributors.

The crystal oscillator was built inside a shielded aluminum sheet metal box. Although not as rf-tight as other types of boxes, it is satisfactory. For more critical applications, use die-cast boxes or simply drill a number of extra holes for screws in the sheet metal box (for "buttoning" it up) to improve shielding.

When I needed to generate a 455-kHz signal, I used the 10-MHz crystal oscillator to drive the LO input of the

\* Jim-Packs (blister-packed electronics parts) are available at most local hobby and TV-service parts distributors. The same components are available in non-blister packed from Jameco Electronics.

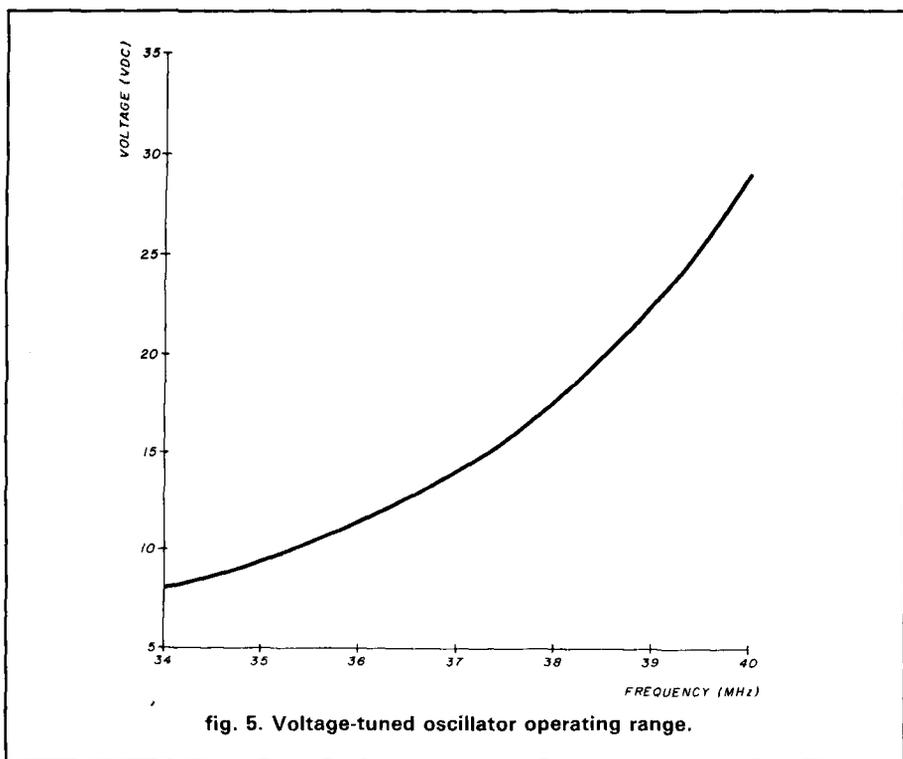


fig. 5. Voltage-tuned oscillator operating range.

DBM module, and the Model 80 signal generator to drive the rf input of the DBM. With a 10-MHz LO, the 0- to 2-MHz output is generated by tuning the signal generator from 10 to 12 MHz.

### additional uses

I built a voltage tuned oscillator that operated over a range of 34 to 40 MHz (see fig. 4). This circuit is a simple variable frequency oscillator circuit in which part of the capacitance used to tune the tank circuit is derived from a variable capacitance diode ("varactor"). In this case, I used an MV-2111 device, which offers 47 pF at 4 Vdc and a C/C<sub>0</sub> ratio of 2.6:1. The inductor is a 49-MHz TV i-f amplifier transformer (Digi-Key part No. TK-209).\*

Figure 5 shows the relationship between tuning voltage and output frequency. Please note that this figure is very rough, and reflects factors such as my choice of layout (stray capacitance), the specific MV-2111 that I used, and the accuracy of the voltmeter and digital frequency meter. Before a curve such as the one shown in

\* Digi-Key Corporation, P.O. Box 677, Thief River Falls, Minnesota 56701.

fig. 5 can be trusted completely, it is necessary to build several such identical circuits and calibrate them several times to obtain enough data points to give one confidence in the calibration. For example, a second oscillator was built using the same circuit operated over a range of 32 to 44 MHz, but it had tighter layout on the wireboard. You'll obviously have to experiment and make your own calibration curve, even though it will probably be close to the one shown in fig 5. The important thing to note is that there is a relationship between voltage and frequency. If we apply a modulating signal to the tuning voltage input (V), then the output signal is frequency modulated (or swept, if a sawtooth is used). Like the crystal oscillator above, the VCO shown in fig. 4 uses an output buffer amplifier to prevent varying load impedances from affecting the operating frequency. The buffer is even more important to this circuit than in the crystal oscillator case.

There are two ways to use the VCO. First, we can replace the signal generator at the rf input of the DBM with the VCO. The output of the DBM then

becomes the difference between the 10-MHz crystal oscillator and the VCO, or a range of 24 to 30 MHz. We could, instead, replace the crystal oscillator with the VCO, making the output frequency the difference between the signal generator and the VCO. Because of the wide range of the signal generator, a wide range of sweep center frequencies is possible.

So of what use is a sweep generator? It is possible to sweep an entire Amateur band in order to inspect the frequency response of a circuit. One can also sweep an antenna over a wide range in order to determine resonance. Of course, devices such as bandpass filters are best inspected using a sweep generator. I suspect that many applications should be apparent.

If you use the method described above to sweep tuned circuits, be sure to keep the sweep frequency rate low. A high sweep frequency will ring high-*Q* tank circuits or filters and cause other problems during measurements. Although audio sine waves to 1000 Hz present no problem, sawtooth, triangle, or squarewave modulation should be kept to 60 Hz or less.

One problem with this circuit is the fact that the output amplitude may not be level over the band swept. In cases where this variation is important, it might prove necessary to use a wide-band automatic gain control (AGC) amplifier at the output. But that's a subject for another column, and is one of the topics I'm currently working on.

*I'd like to hear your suggestions for future columns. You can contact me at P.O. Box 1099, Falls Church, Virginia 22041.*

#### references

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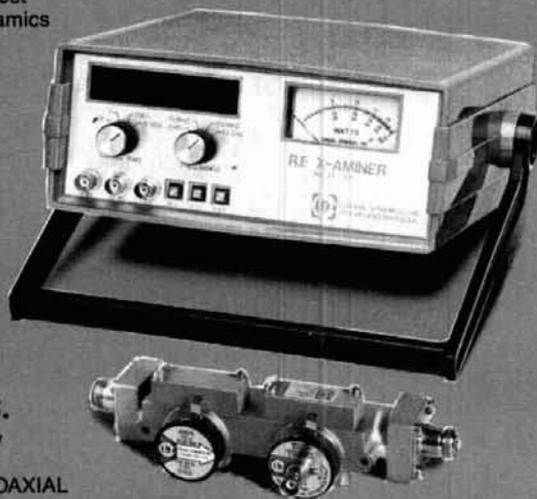
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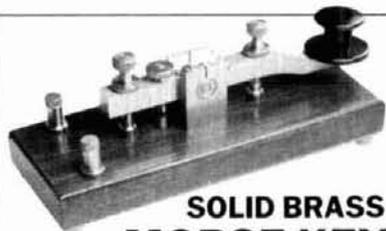
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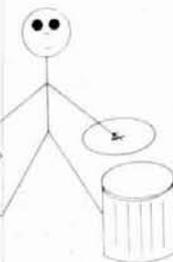
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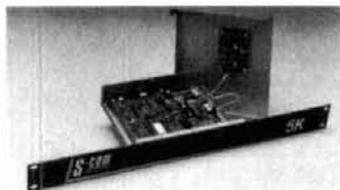
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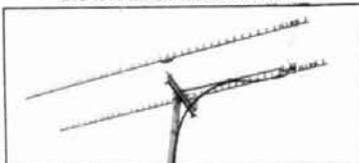


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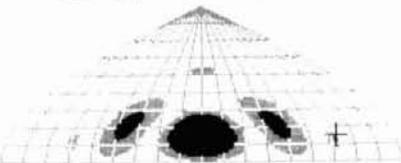
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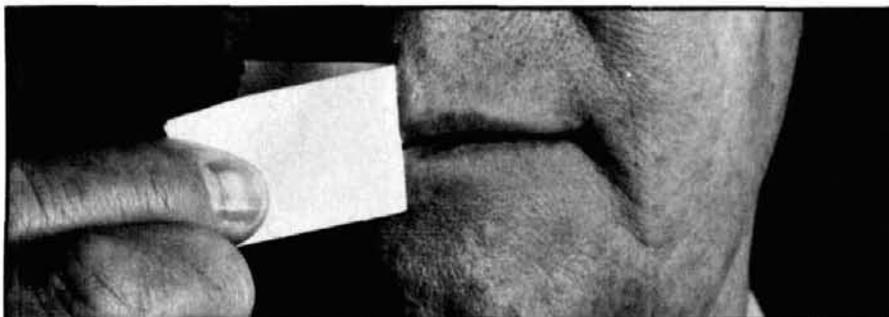
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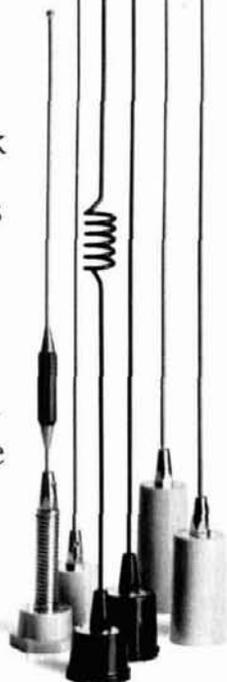
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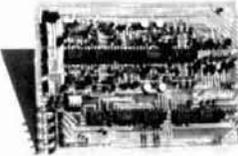
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# the technology of commercial television part 1: historical aspects

Ever wondered how it works?  
Take this ham's-eye tour  
of a commercial tv station

**A television station contains** more different types of electronics in one location than any other enterprise I can think of. Yet in the 20 or so years that I've been reading the literature of Amateur and commercial electronics, I've never seen a comprehensive account of the technical aspects of a commercial television station. I won't pretend that the system we use here in the United States is perfect, but I do believe it represents both the systematic evolution and the efficient use of available technology — and as such, merits attention in the Amateur press.

## what is NTSC?

Most video hobbyists have seen the initials *NTSC* and assumed that it meant "Never The Same Color." Although this aptly describes the American television system when compared with more advanced systems, the acronym actually stands for "National Television Standard Committee," who developed and defined the way a television system should work in 1953. Believe it or not, there haven't been any changes in the NTSC standards

since their adoption, even though the technology for creating these NTSC television signals has obviously changed radically.

## why NTSC?

To explain how a standard such as NTSC, or any other standard, is derived, we must deal with a concept fundamental to all communications: bandwidth, or the range of frequencies necessary to convey a given amount of information. Leaving aside any mathematical definitions of bandwidth, I'll attempt to convey the idea in English instead.

An example of a narrow bandwidth system would be the telephone. To convey speech information by telephone, we need a range of frequencies between about 300 and 3000 cycles per second (Hz). The audio bandwidth in this case is 3000 – 300, or 2700 Hz. When the telephone mouthpiece converts the sound to electrical signals, we still have a bandwidth of 2700 Hz.

High fidelity audio, on the other hand, is an example of a greater (wider) bandwidth. Most audiophiles agree that we need a frequency range of at least 20 to 20,000 Hz in order for sound to qualify as high fidelity, or a bandwidth of 20,000 – 20 (19,980 Hz). Our entire system must be capable of passing electrical signals over a bandwidth of 19,980 Hz in this case.

When we convert visual images to electrical impulses, we also have to deal with bandwidth. Normal video has

**By Eric Nichols, KL7AJ, Box 0, North Pole, Alaska 99705**

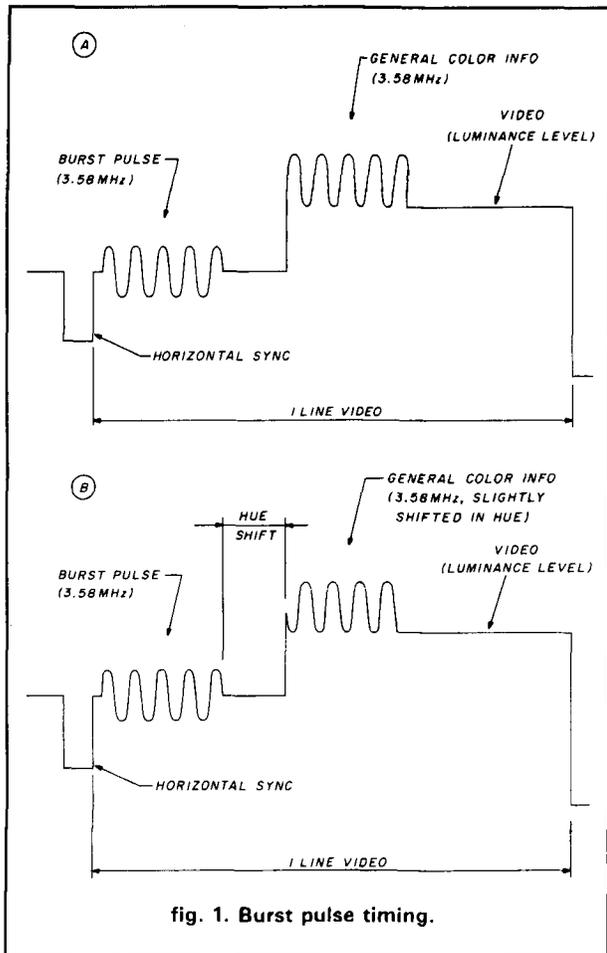


fig. 1. Burst pulse timing.

a frequency range of 0 Hz (dc) to about 4,180,000 Hz, or a 4.18-MHz bandwidth. This is over 200 times the bandwidth required for high fidelity audio, and over 1500 times the bandwidth required for a telephone (voice grade) circuit!

If we were to define a channel as being a slot of frequencies 2700 Hz wide, we'd see that a video picture will use up over 1500 channels! Now, as long as our raw video or audio electrical signals are confined to electrical conductors (i.e., in a closed-circuit system), we don't have to worry (theoretically, at least) about how many channels we occupy. We can duplicate identical channels on separate wires. In other words, the amount of information we carry is limited only by how many audio or video cables we want to run. High-definition television (HDTV), for example, has been available for quite some time on closed-circuit systems, and its bandwidth is several times greater than the NTSC-specified 4.18 MHz.

When we take these same channels and transmit them over the air, every channel of radio spectrum we use must be shared with the entire universe. Radio waves, of course, recognize no geographical, political,

economic, religious, or psychological boundaries; herein lies the necessity for making compromises in bandwidth, and NTSC is the system by which a very good compromise is made with available channel space.

When the NTSC color system was developed, there were already over 40 million monochrome television receivers in operation in the United States! The NTSC's first job, therefore, was to make a color system that would work on black and white receivers; after all, 40 million households could not be expected to take lightly the prospect of having their extremely expensive (at the time) receivers being rendered obsolete by a new television standard! This is one price the United States paid for being first; most of Europe waited for us to develop color television before they had any television, so that they wouldn't have to contend with a compatibility problem. Great Britain and a few other nations still flounder with awkward dual-standard systems (i.e., separate color and monochrome channels).

And yes, France's SECAM system has more than twice the visual resolution as ours, but they have fewer than half the available channels. Their channels are as broad as a barn door, and no other nation can afford to wipe out that much spectrum space, nor can many people afford the receivers.

As numerous as the problems are with the NTSC system, we still have the most uniform and affordable television system in the world, one that is reasonably conservative of spectrum space. The fact that the NTSC system is still widely imitated in much of the world testifies to the foresight and ingenuity of the developers of the NTSC standard.

Given the importance of spectrum conservation, we now see that NTSC had to compromise in the least objectionable fashion, i.e., in the way that would impair image quality as little as possible. A color television signal obviously contains more information than a black and white signal, and since more information requires greater bandwidth, something has to give when you try to force a color signal into a video channel. NTSC discovered gaps in the brightness information in average video program material — in fact, they found almost no video information occurring at about 3.5 MHz in a normal monochrome signal. Subjective tests with thousands of untrained viewers revealed that when a narrow band of frequencies centered near 3.5 MHz was intentionally filtered out, nobody noticed. Color information, therefore, could be slipped into this segment without affecting the perceived quality of the final image.

The NTSC system was television's earliest and best example of what we now call "ergonomic" or human engineering. Every aspect of the new NTSC system was checked for its subjective perceived qualities; even the choice of color phosphors was determined by evaluating the responses of viewers.

## everything but the kitchen sync

Before we can have a quality image, we must have an image — and without synchronization or “sync,” as it’s usually called, we have no image. It’s common knowledge that a television image is created by scanning an electron beam back and forth across a phosphor screen. Few viewers realize, however, just how tight the tolerances relevant to the positioning of that beam must be, particularly with color television. It’s the sync system that controls these tolerances; in fact, most of a television transmitter’s power is devoted to generating sync pulses so that we can have a stable scan or raster. This will be covered in detail next month, when we discuss transmission techniques.

Typical movie theater projectors display 24 frames per second, but the NTSC system specifies 30 complete frames per second. Unlike movie frames, each video frame consists of two interlaced fields. NTSC scans 525 lines per field, but not adjacently; instead, a field of 262-1/2 lines is scanned, with the odd lines “filled in” during the next field. Even experienced television service technicians are sometimes surprised to learn about this interlace scheme; some are amazed that a television works at all when they realize what’s required to achieve accurate interlacing. This interlace achieves two things: first, it reduces flicker to the same level as would be sensed at 60 frames per second without increasing the bandwidth. Second, by flipping the color polarity of the odd lines upside down, the color information “disappears” from monochrome receivers. We use 60 fields per second rather than 53, 65, or 80.4 because in the United States, ac power is 60 Hz, and the ac power is convenient for achieving approximate control of the frame lock (vertical hold).

Another critical element of image quality is synchronization of the horizontal sweep. This means that the left-to-right positioning of the receiver’s scanning beam has to correspond exactly with the scanning beam of the studio camera. So before each scan (video line), a horizontal sync pulse is transmitted at a repetition rate of 15,750 Hz or:

$$30 \text{ frames/second} \times 525 \text{ lines/frame} = 15,750 \text{ lines/second}$$

This is the annoying frequency you sometimes hear emanating from television sets; all the high-voltage circuitry resonates at this frequency.

## color

I mentioned earlier that in a normal monochrome signal, almost no video information occurs at approximately 3.5 MHz. Actually the FCC states that the color information must be centered at 3.579 MHz. For general purposes, the FCC refers to this as 3.579545 MHz; for convenience, broadcast engineers refer to it as simply 3.58 MHz. The greater precision is justified, however,

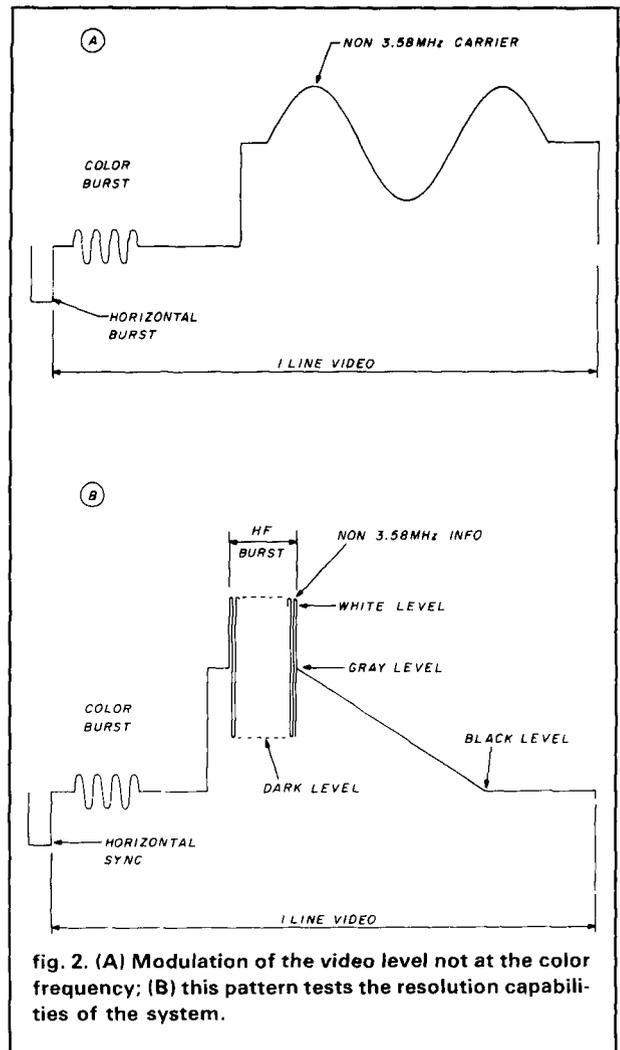


fig. 2. (A) Modulation of the video level not at the color frequency; (B) this pattern tests the resolution capabilities of the system.

in that the subcarrier can be locked to the National Bureau of Standards’ 5-MHz transmission. The 3.58-MHz color subcarrier is the most accurate reference to which the average citizen has access; in fact, many scientific and navigational firms use the color reference from a local television station as a time reference. (For accuracy, the television station must be locked to a satellite network.)

So what do we do to this 3.58 MHz to give us color?

We can change three things about any electrical wave: its height (a-m), its frequency (f-m), or its timing or position relative to a fixed reference wave of the same frequency (phase modulation). Two of these — a-m and phase modulation — are done to the color subcarrier. (F-m is obviously out of the question.)

Changing the amplitude of the wave changes the saturation of the color at that particular period of time. Saturation is what you change when you tweak the “color” control on your television set. Changing the phase or timing of that carrier at that point in the scan

changes the “tint” or “hue.” In other words, the phasing tells the receiver which color to present at that spot on the screen.

The horizontal sync pulse comes just before the color burst. The burst is about 10 cycles of 3.58-MHz signal at the beginning of each and every line. Its phase, compared to every other burst, is absolutely constant. But after the burst, the information changes according to the color we want. **Figure 1** shows two lines of video that are identical except that the phasing of Genuine Color Information in B is shifted slightly from that of A. (How a receiver compares such a subtle thing as a phase shift will be addressed next month.) In reality, unless you’re actually looking at a solid white background, the video line will be wavy all the way across. **Figure 1** shows modulation only at the color frequency.

**Figure 2A** shows modulation of the video level, not at the color frequency. This will have no effect on the color because it’s not 3.58 MHz; instead, it will appear as a gradual increase from gray to white, down through gray toward black, up through gray toward white, then down to gray again. Keep in mind that this is just a single line of video repeated 15,750 times each second.

### the 3.58-MHz tie

**Figure 2B** is very interesting. The section labeled “hf burst” represents what would happen if the camera looked at a very fine black and white pinstripe pattern. Because the video modulation is higher in frequency than color, once again no color appears. This pattern tests the resolution capabilities of the system. In other words, some herringbone suits are very high-frequency suits; such a suit will increase in frequency as the camera backs off or “zooms out.” So if you’re going to be on television, be sure to select your clothes with regard to frequency response. Once in a while, someone will wear a 3.58-MHz tie that displays rainbow patterns on less-than-perfect color televisions. When this happens, the only solution is to change the tie’s frequency by zooming in or out.

After the hf burst, the video goes into a “ramp,” a gradual fade from medium gray to black.

### from studio to receiver

So far, we’ve spoken mostly of the raw video; in other words, we haven’t considered what happens to the video between the studio and the receiver. We did mention that the radio signal path is a limited bandwidth channel, and that the NTSC signal is tailored accordingly. But what does the signal look like after it leaves the transmitter?

The visual portion of a television signal is a modified form of a-m. Television falls in an area between a-m and single sideband called Vestigial Sideband (VSB). A standard a-m transmitter emits a channel which is twice the

bandwidth of the modulating signal. It doesn’t matter what form the modulation takes; if we take a 4.18-MHz wide video signal and put it into an a-m transmitter, our transmitted signal will occupy 8.36 MHz of precious spectrum space.

The emitted channel consists of two sidebands, symmetrically spaced on either side of the carrier frequency. One sideband is redundant; each carries the same information except that one is inverted in frequency — a mirror image, so to speak. The carrier frequency of Channel 2 is around 55 MHz; the carrier frequency of Channel 13 is around 211 MHz. (In every case, the television audio carrier is 4.5 MHz above the visual carrier, but we’ll discuss that later.)

Because one sideband is redundant, we could lop off either one and still have a complete video signal. In SSB radio, we do exactly that, and thus end up with a radio frequency channel of exactly the same bandwidth as our audio modulation channel.

In television, we remove most of the lower sideband, leaving the upper sideband intact. The only reason we don’t completely eliminate the lower sideband is attributable to technical considerations which no longer apply, but since the rules were cast in concrete 35 years ago, it looks like we’re stuck with VSB for the foreseeable future. However, the NTSC made a noble step in the right direction when they opted for VSB instead of full a-m.

Unlike SSB radio — where it’s easy to regenerate the carrier upon reception — in television we leave the carrier untouched because eliminating it would make receiver design hideously complicated. Although our transmitters would be more efficient if we could eliminate it, the carrier doesn’t occupy any spectrum space and is therefore of no concern.

**Figures 3A** and **3B** compare the occupied bandwidth of a-m to VSB. What do we put where the LSB used to be? The upper part of the next lower television channel, of course. It would be nice to leave that lower sideband gap as elbow room, wouldn’t it? Unfortunately, both nature and the FCC abhor a vacuum, and one or the other guarantees that something is going to be there. In most cases, it’s a television station, unless you happen to be talking about channel 7, in which case it happens to be the fm broadcast band as well as most high-band VHF fm communications.

Actually, the lack of elbow room between television stations would never create problems in properly designed television receivers. Unfortunately, nobody makes any. Even though the quality of the video sections of television receivers has improved dramatically in the last three decades, the radio frequency sections, or front ends, have gotten worse. The old tube receivers of the 1950s had far better selectivity than any receivers built now.

*(continued on page 65)*

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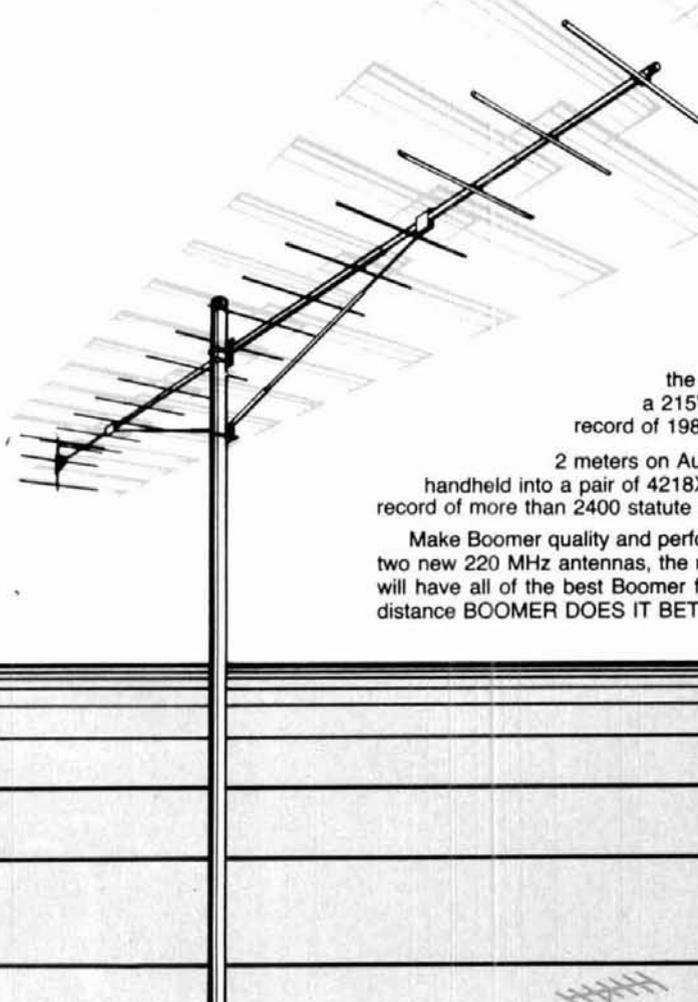
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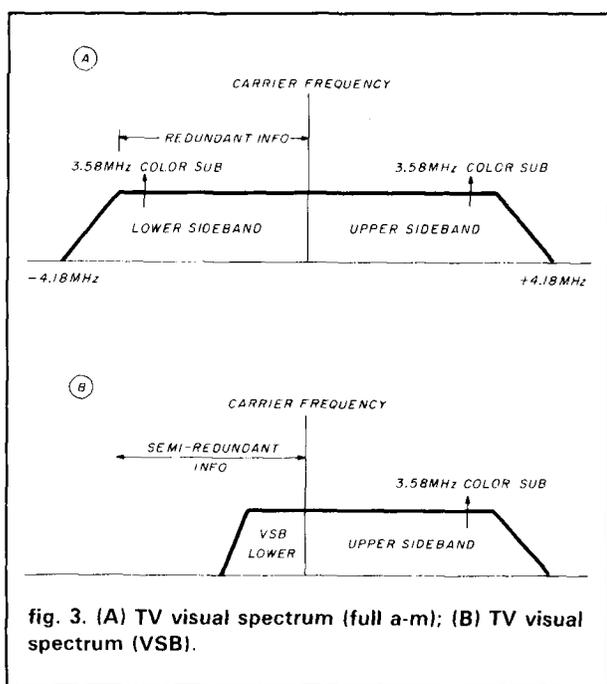


fig. 3. (A) TV visual spectrum (full a-m); (B) TV visual spectrum (VSB).

Referring back to **fig. 1** and **2**, it should be mentioned that these are upside down as far as transmitted power is concerned. In other words, even though the sync pulse is shown at the bottom, it's actually maximum transmitted power and modulation. As a matter of fact, transmitters for television are licensed according to peak power, or sync peak envelope power. There are several good reasons for this practice: first, the sync represents a constant value, which is reasonably simple to measure or calculate. The FCC requires broadcasters to know how much power they're radiating. Because the video waveform is continually changing, it would be practically impossible to represent power output in terms of "average picture modulation" or some other such nebulous term. By putting the sync at the top, in terms of power, we at least have a maximum power measurement. (In "real" television, we never have a condition of unmodulated carrier as we do in radio, so we can't talk about a television station's licensed carrier power.) The second reason for having the sync at the top relates to our original discussion of sync pulses. We mentioned that there's no point in having a nice-looking video image if it isn't stable. By placing the sync pulses at maximum output power, we ensure that as the received signal gets weaker, the last thing to go will be picture stability. This one characteristic, common to television standards around the world, allows us to have a usable picture under much poorer conditions than would be acceptable if the sync pulse were at a lower transmitter modulation.

One thing that does vary from standard to standard is in what direction you go to get from black to white. In NTSC, the blacker you go, the closer you get to sync

power. In the British system and others, white is transmitted near sync level and black is at lower modulation levels. A British picture viewed on NTSC, therefore, would appear as a negative rather than as a positive image.

Each polarity of video offers certain advantages. The NTSC system has a better signal-to-noise ratio in the black region, which translates into less visible "snow" in the darker areas. On the other hand, it's generally easier to achieve linearity on most types of transmitters with the inverted video systems. (Linearity, in this context, refers to the degree of video "fidelity.") A more linear system reproduces luminance levels, or shades of gray, more accurately.

### waveform monitor

The waveform monitor (**fig. 4**) — a vital piece of test equipment common to all television stations — is a specialized form of oscilloscope used to view video signals either line by line or field by field. Actually, any good oscilloscope would be sufficient.

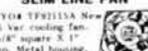
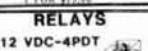
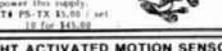
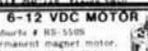
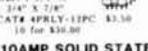
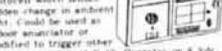
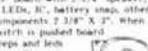
Although many different graticules are used, the IRE is by far the most common. Note that the graticule has two scales. The left scale represents IRE units. The IRE scale of 140 units is divided into 100 units of genuine video information and 40 units of sync. The 0 division or baseline is clamped at 0 volts in most television stations. In other words, anything below 0 is a negative voltage, while anything above 0 is a positive voltage. The right side of the scale indicates the percentage of modulation of an actual television transmitter, assuming everything is working satisfactorily.

I've shown one line of a "window" signal superimposed on the graticule; this appears as a white left half and a very black right half of the screen — television screen, that is; waveform monitor screens are green. Notice that sync is 100 percent modulation, the baseline is 75 percent modulation, and pure white is 12.5 percent modulation. Why isn't white set at 0 percent modulation? Because television receivers need a little bit of visual carrier (12.5 percent) to demodulate the audio signal. Did you ever notice that raspy buzz in the audio when a television station runs credits or other very white characters? This is what happens when the video accidentally gets past 12.5 percent white towards 0. Television receivers use a technique called intercarrier sound demodulation to simplify the receiver tuning circuitry. It's a system I'd get rid of if I were Emperor, but that's unlikely to happen.

The IRE scale is quite convenient for visual quality control. As long as we keep our visual range between 0 and 100 units on the left, we'll have a reasonably pleasant-looking picture. In practice, genuine video information (GVI) should never go below 7.5 IRE units. This tiny setup level prevents our GVI from confusing our

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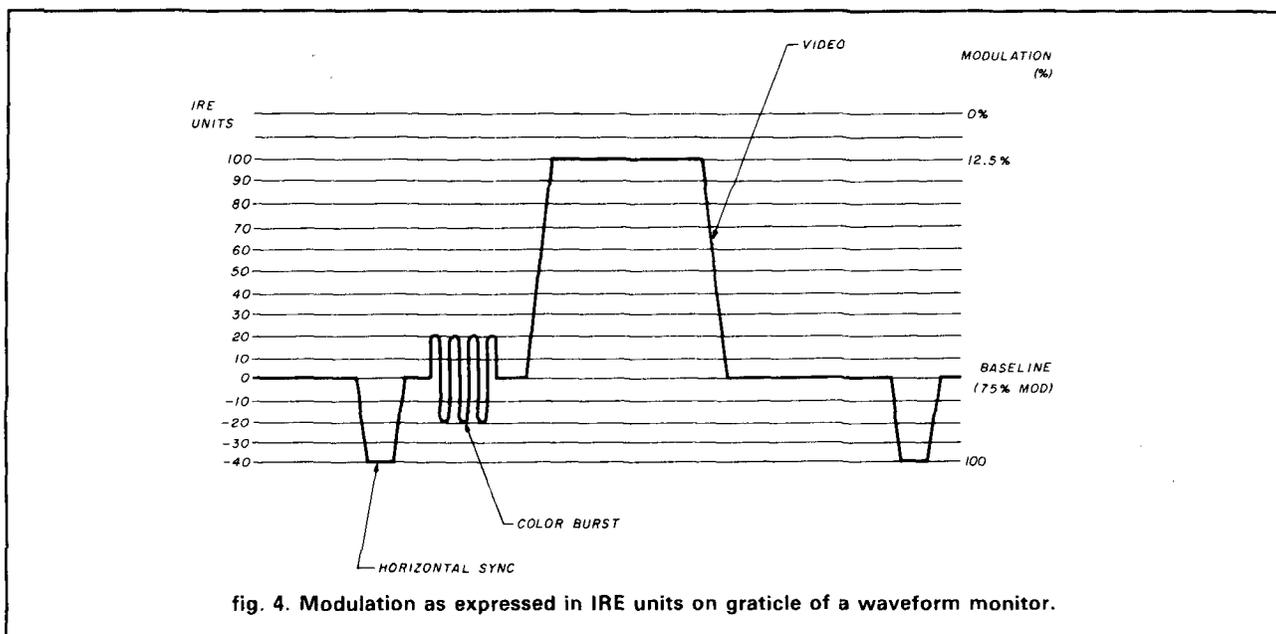
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baseline clamping circuitry. We'll talk more about clamping next month, but for now, let's just say that clamping is there so that television sets know where black ends and sync begins.

## television sound

Although the NTSC had little to do with the development of television audio, television transmitters have always been capable of excellent audio. In fact, the audio section and legal FCC specifications for television audio are essentially identical to those specified for fm radio! Television frequency response uses exactly the same 75-ms pre-emphasis curve as fm broadcasting, for example, and the total harmonic distortion specifications are the same as those for fm radio (monaural).

So why has television audio — until very recently — sounded so poor? There are two weak links in the television audio chain: the first is in production techniques. In most videotaped and live television fare, audio has generally been added on almost as an afterthought. Quality audio has nothing to do with technology; it's simply a matter of quality control and care. The second weak link has been intercarrier sound demodulation, mentioned briefly above. The intercarrier technique is extremely clever, but that's about all I can say for it; too many compromises in overall audio quality are required, so the purpose of transmitting good audio is almost defeated. Intercarrier sound demodulation has greatly complicated the problem of stereo audio transmission, but even so, it seems like it's here to stay.

Visitors to television stations are often amazed by how good the audio sounds. This is because a television audio "modulation monitor" is a discrete (i.e., non-inter-

carrier) tuner and because the monitors in the control room usually use full-size, full-range speakers. So all is not lost when it comes to television audio, and more and more producers — especially with increasing public interest in stereo reception — are beginning to pay some attention to audio techniques and quality control.

The unmodulated sound carrier is exactly 4.5 MHz above the visual carrier. It is frequency modulated  $\pm 25$  kHz under maximum loudness from this carrier. The modulation of an fm carrier results in the generation of some sidebands which overlap into the video portion of the channel. For this reason, most television receivers have a "sound trap" that notches the audio out of the video chain. In general, though, this slopover has minimal detrimental effects on the video, and some high-resolution monitors do not include sound traps.

As far as aural (audio) carrier power is concerned, a typical television station cranks out only one-fifth as much aural power as peak sync power. The reason for this has to do with the bandwidth of the aural compared to the bandwidth of the visual system. A narrowband system, of course, needs less power to do the same job as a wideband channel.

## tune in next month . . .

In the next installment, I'll describe station equipment that processes signals ranging from dc through visible light. Topics covered will include antennas; mechanical, electrical, and audio devices; light transducers; analog and digital electronics; rf and microwave devices; power generation and distribution; wave propagation; and just a tiny bit of nuclear physics.

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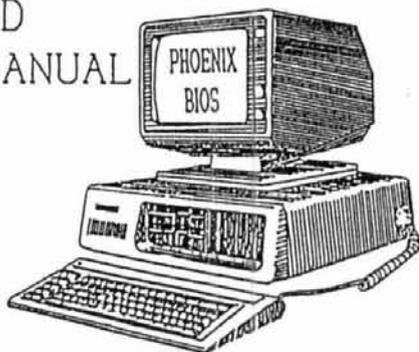
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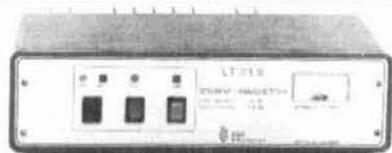
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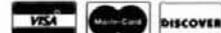
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## low-noise receiver update: part 2

In last month's column,<sup>1</sup> in which we discussed the state of the art (SOA) in low-noise receivers and preamplifiers, I pointed out that some incredibly low noise figures are now possible using very affordable (less than \$10) GaAsFETs. HEMTs (high electron mobility transistors), the latest rage, can cut noise figures by as much as 50 percent; though HEMT prices are pretty steep right now, they are dropping.

Last month's column also discussed ways to decrease noise figure by proper component selection and cooling techniques. This month's column will be more practical, stressing recommended circuitry, stability techniques, and device selection. We'll review testing and talk about improvements that can be expected in the near future.

### recommended circuits

By now you're probably wondering what circuitry to use for GaAsFET preamplifiers. Reference 2 discussed recommended circuits for 144, 220, and 432 MHz. Those circuits still are close to optimum for a simple competitive preamplifier without any special components or tricky techniques.

Reference 3 showed a recommended preamplifier for 903 MHz. Simple to construct and align, it had a noise figure of approximately 0.5 dB when an appropriate GaAsFET was used.

Techniques improve with time. Therefore, before recommending a final circuit, let's first review the major considerations in selecting the individual components and circuit topology.

### input circuits

Last month we discussed recommended input-matching circuits for

GaAsFET VHF and lower UHF region preamplifiers. We emphasized that one of the most practical input-matching circuits is still the step-up resonant transformer with a capacitor tap.<sup>4</sup> This configuration has low insertion loss, a wide adjustment range, and provides reasonable out-of-band rf signal rejection.

Reference 1 also stressed that most of the noise figure in today's typical Amateur preamplifiers is caused by losses in the input impedance matching network. Use only components with the highest possible unloaded  $Q$ . Cavity-type construction may be required, especially if noise figures of less than 0.5 dB are required on 432 MHz and above. However, that is beyond the scope of this month's column.

### output circuits

There are many types of output-matching circuits used in Amateur GaAsFET preamplifiers. Some of them are shown in **fig. 1**. It is desirable when selecting the output circuit to make sure that it has sufficient bandwidth so that it doesn't become the bandwidth-limiting device in the preamplifier.

An output tank circuit similar to the one recommended for input matching is shown in **fig. 1A**. It is *definitely not recommended and should be avoided* for a number of reasons: first, because it will usually increase the gain well above the desired operating level, 15 to 20 dB, as discussed in reference 1; second, because it's very difficult to decouple a high-impedance output tank circuit from an input circuit sufficiently, thus creating a source of feedback and potential oscillations; and third, because the reflected impedance of the following amplifier stage on the tuning of this output circuit may cause

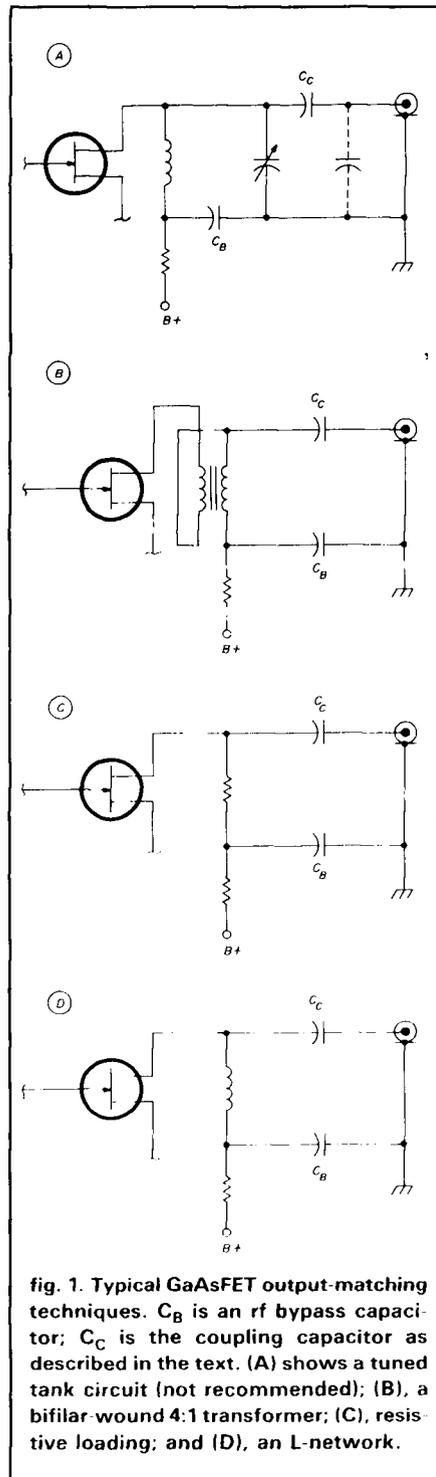


fig. 1. Typical GaAsFET output-matching techniques.  $C_B$  is an rf bypass capacitor;  $C_C$  is the coupling capacitor as described in the text. (A) shows a tuned tank circuit (not recommended); (B), a bifilar-wound 4:1 transformer; (C), resistive loading; and (D), an L-network.

additional instability when the preamplifier is placed in your system.

The bifilar-wound output transformer (fig. 1B), first proposed for GaAsFET preamplifiers by Bob Sutherland, W6PO, has stood the test of time. It's easy to construct and works well up through 432 MHz.<sup>5</sup>

Resistive loading, shown in fig. 1C, has been used in the past, particularly where gain is very high.<sup>6</sup> It certainly calms down hot high-gain devices, but will also lower the output power and the dynamic range of a preamplifier.

In reference 3 I introduced a simple form of L-network that effectively replaces the bifilar type of transformer matching (fig. 1D). It's not only easier to build, but also provides some selectivity. Furthermore, it typically yields slightly higher gain and output power (at the 1-dB compression point) than the bifilar transformer.

## final circuit

Figure 2A shows a recommended GaAsFET preamplifier circuit for the 144, 220, 432, and 903-MHz Amateur bands. It uses a capacitance-coupled input tank circuit as described in reference 1. The output circuit is an L-network as just described. Note that the capacitance of the output coupling capacitor is much lower than typically seen in other GaAsFET preamplifiers.

Source biasing is used because it's simple, effective, and requires only a single power supply. The drain voltage is supplied from an inexpensive three-terminal voltage regulator through a limiting resistor. This provides simple protection to the GaAsFET.<sup>2</sup> The zener diode, CR1, is simply used for over-voltage protection and will be described shortly.

Note that a ferrite bead is placed on the drain lead. At the frequency of interest it dissipates only 0.5 to 1.0 dB of the preamplifier gain. However, in the microwave region where most GaAsFETs still have plenty of gain, it prevents undesirable oscillations.

## component selection

Before building a preamplifier, you should first consider which compo-

Table 1. Typical GaAsFETs popular with Amateurs

Type	Noise figure at frequency (GHz)	Approximate price	Notes
AT 8110	1.1 dB typical at 4	\$27.00	
ATF 10135	0.5 dB typical at 4 1.8 dB typical at 12	\$10.85	
CFY 19	1.8 dB maximum at 6		low cost
MGF 1100	2.5 dB typical at 4	\$7.50	
MGF 1202	2.0 dB maximum at 4	\$10.00	discontinued use MGF 1302
MGF 1302	1.4 dB maximum at 4	\$10.00	replaces MGF 1202
MGF 1402/2SK274	1.4 dB maximum at 4	\$14.00	replaces MGF 1202
MGF 1412/2SK275	0.8 dB typical at 4 1.7 dB typical at 8	\$26.00	
MRF 966	1.2 dB typical at 1	\$2.00	dual-gate
NE 202	1.0 dB typical at 12		HEMT
NE 04583	0.8 dB typical at 8 1.5 dB typical at 12		
NE 41137	1.3 dB typical at 0.9	\$3.00	dual-gate
NE 72084/2SK571	0.6 dB typical at 2 1.4 dB maximum at 4	\$10.00	replaces MGF 1402

nents are to be used. The GaAsFET choice is important, but don't get carried away by using one that is specified well above your operating frequency, because you may end up with a higher noise figure than expected at a price that isn't cost effective.<sup>1</sup>

It's best to choose a GaAsFET that's specified at or just above your band of interest. Many GaAsFETs are now available, especially some that were popular several years ago but are now obsolete by today's standards. Most will operate in the circuit shown in fig. 2 with only slight differences in tuning. Dual-gate GaAsFETs can also be used in this circuit if the second gate is biased as shown in fig. 2B.

Table 1 has been prepared to assist you in GaAsFET selection. Several devices, mostly those that are popular with Amateurs, are listed. While there are many GaAsFET manufacturers, most semiconductor suppliers don't like to deal with individuals except through distributors (for instance, AvanteK and Motorola) or unless a large order (typically greater than \$50) is placed. Fortunately, at least two Amateur suppliers can help — not only with GaAsFETs, but with some of the hard-to-find components.<sup>\*,\*\*</sup>

As described in reference 1, the

input-matching capacitors should have a very high unloaded  $Q$ ; the Johanson or equivalent air variables are appropriate. Likewise, the inductors described in the component list are close to optimum for unloaded  $Q$ . Always use large-diameter (No. 14 AWG or larger) copper or copper-plated wire. Keep inductors away from nearby objects because they can cause the unloaded  $Q$  to decrease.

Low insertion loss connectors with good impedance characteristics are desirable at the preamplifier input. Type N, SMA, or TNC are recommended. However, less expensive connectors can be used for the preamplifier output connector when losses aren't a great concern.

The capacitive values of the source bypasses aren't critical, but they should be chip or leadless ceramic or porcelain types. Suitable inexpensive types are available from Michigan Microwave.<sup>\*,\*\*</sup> The rest of the components don't require further explanation. The type of enclosure to be used will be described shortly.

\* Norm Alred, WA8EUU, Microwave Components of Michigan, 11216 Cape Cod, Taylor, Michigan 48180.

\*\* Steve Kostro, N2CLI, R.D. 1, Box 341A, Frenchtown, New Jersey 08825.

## construction techniques

Just like other low-noise circuitry, GaAsFET preamplifiers require good construction practices if optimum performance is to be achieved. Poor construction will result in mediocre performance indicated by low gain, moderate to high noise figure, and instability — or all of the above.

Choose a shielded enclosure. I prefer cast aluminum boxes such as the Bud model CU123 or CU124, the Hammond 1590A or 1590B, or equivalent. Attach a piece of ordinary double-sided printed circuit board to the cover of the enclosure as shown in **fig. 3A**; it can be held in place by the input-output connectors and the input power connections.

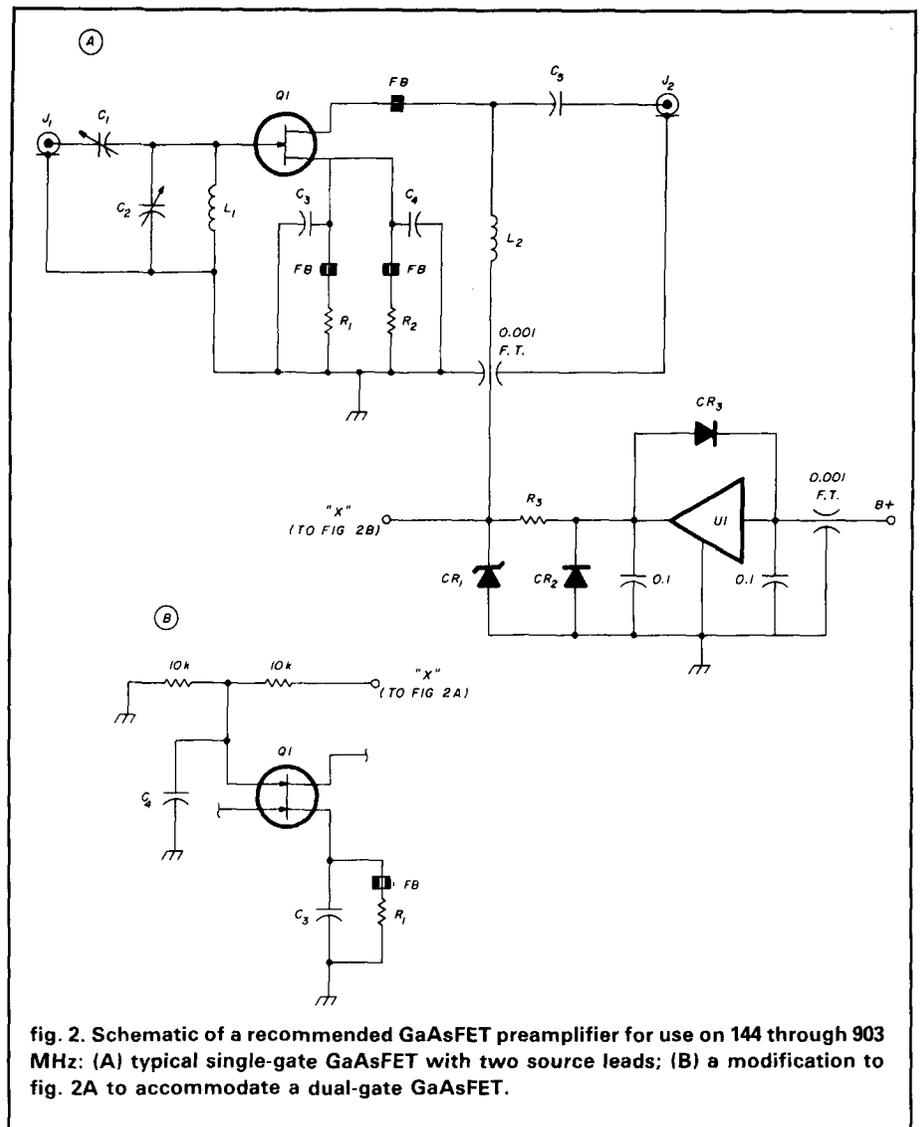
**Figure 3** can be used as a guide to recommended component location for a GaAsFET preamplifier. **Figure 3A** is a top view of the subchassis; **fig. 3B** shows the side view. In particular, note the position of J1, C1, C2, and L1, since their location and proximity to each other help keep input losses (as well as noise figure) low. The raised bracket shown in **fig. 3C** is used to mount the GaAsFET at the proper height so it can be connected directly to the matching network using only its gate lead. At the same time, the leadless or chip capacitors can be easily attached to this bracket.

## stability considerations

Like bipolar transistors, GaAsFETs can be very unstable if they're used improperly. Poor circuit performance can be traced to rf as well as dc instability or both!

When GaAsFETs first appeared on the Amateur scene, dc stability was a real problem. Negative gate biasing was often used, and when it failed (which seemed to be quite often), the expensive GaAsFETs died a quick death. Nowadays, most Amateur circuits use source biasing as shown in **fig. 2**. This way, the drain current of the device is automatically limited.

If source biasing is used, rf bypassing can be a problem. Always use bypass capacitors that have little or no series inductance such as the chip



**fig. 2.** Schematic of a recommended GaAsFET preamplifier for use on 144 through 903 MHz: (A) typical single-gate GaAsFET with two source leads; (B) a modification to **fig. 2A** to accommodate a dual-gate GaAsFET.

type. The actual capacitance value isn't important as long as the capacitive reactance is below 1 or 2 ohms at the operating frequency.

A ferrite bead on the drain lead will help eliminate rf instability in the microwave region, as mentioned previously. Likewise, a ferrite bead on the leads of any resistors or chokes (if used) in the rf path is recommended. I've seen some preamplifiers that have a diplexer incorporated on the output of the preamplifier using a parallel resonant circuit and a 50-ohm resistor.<sup>7</sup>

Sometimes the enclosure can be a problem, since it may act like a waveguide — but the lower the height of the enclosure, the less likely the problem is to occur. Proper compo-

nent layout is, of course, recommended. Shields between the input and output circuits are also suggested. I've seen some commercial suppliers add ferrite absorbers inside an enclosure as a last resort.

GaAsFET preamplifiers have moderately high input and output impedances and usually don't have much isolation between the input and output circuits. Remember that GaAsFETs are like the old triode vacuum tubes that were often neutralized (ugh!). For circuit stability, they rely on a low capacitance between the gate and drain, and on keeping the gain at a reasonable level.

Most Amateurs tune up their preamplifiers in a well-matched environ-

ment with a good (low VSWR) input and output load. Then, when everything looks great, they often insert the preamplifier into a system that's matched at the frequency of operation but highly reactive out of band. If the gain is too high, if the loading of the following stage is the wrong impedance or phase, or if the reverse isolation of the preamplifier is inadequate (more on this shortly), the preamplifier may become unstable and "take off and fly."

For the reasons stated above, many commercial suppliers follow their preamplifiers with a ferrite isolator or circulator which effectively presents a good output impedance match irrespective of the load. This is great, but the cost of such a device is often more than the price of the typical Amateur GaAsFET preamplifier alone! Needless to say, beware of potential instabilities.

### modifications to existing preamplifiers

Often I'm asked if the commercial Amateur GaAsFET preamplifiers can be modified or improved. The answer is usually yes — if there's sufficient room to work within the enclosure.

I recently had one of the 70-cm (432 MHz) EMEers send me his very low noise GaAsFET preamplifier. It worked fine on his bench, but oscillated when it was inserted in his EME system. I tested the circuit and found that it indeed had a good noise figure in a well-matched environment such as the one described above. However, when I looked at the circuit, I was shocked; there was the typical tuned output tank circuit that I lambasted earlier (see fig. 1A)!

I carefully removed the inductor and all the tuning capacitors in the output circuit and replaced them with a simple bifilar-wound transformer (fig. 1B) and a dc blocking capacitor.<sup>1</sup> Sure enough, the gain dropped slightly (which is of no consequence, since it was already too high) and stability returned. There was no measurable change in noise figure. Another distressed preamplifier was rescued.

Often a new, lower noise figure

GaAsFET can be substituted in an existing preamplifier. I'm sure there are other instances when minor circuit

changes can be made to an existing preamplifier following the guidelines in this month's column. After all, who cares if a preamplifier has close to a 0.0-dB noise figure if it won't work in a realistic environment? Jump in and rescue it rather than letting it rest unused in your desk drawer.

### GaAsFET destruction

I still hear horror stories about GaAsFETs that get destroyed. These cases usually involve mast-mounted preamplifiers. More often than not, the problems are caused by poor antenna change over relays or lack of relay sequencing.

Most modern low-noise solid-state devices are moderately reliable and can usually withstand low levels of rf (100 milliwatts, +20 dBm, or less) for at least a few milliseconds, the typical switching speed of a normal T/R relay. However, for best reliability and continued low noise figures, rf levels should be kept at least 10 dB lower — not to exceed 10 milliwatts (+10 dBm).

Many of the commonly available T/R relays used by Amateurs have only 30 to 40 dB of receiver isolation on 144 MHz, with 25 to 30 dB typical at 432 MHz. With 500 watts (+57 dBm) of power and 30 dB of isolation, the leak-through power on the input of the preamplifier would be 0.5 watts (+27 dBm), high enough to blow out even a stiff transistor!

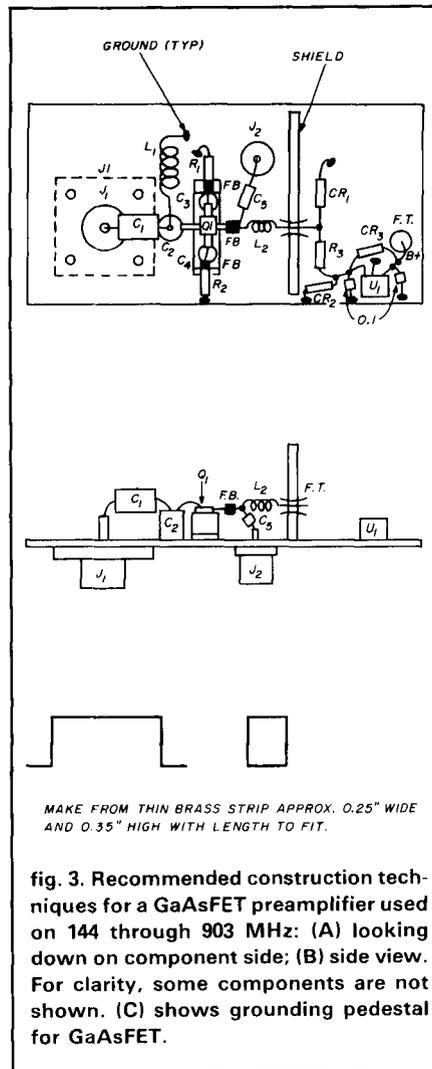


fig. 3. Recommended construction techniques for a GaAsFET preamplifier used on 144 through 903 MHz: (A) looking down on component side; (B) side view. For clarity, some components are not shown. (C) shows grounding pedestal for GaAsFET.

#### parts list

C1,C2	0.5 to 10 pF low-loss air variable (see text)
C3,C4	leadless or chip bypass capacitor, 470-1000 pF (see text).
C5	144 MHz: 6.8-7.5 pF 220 MHz: 4.7-5 pF 432 MHz: 3.9 pF 903 MHz: 3.0 pF
CR1	5.6 volt zener, 1N751 or equivalent
CR2,CR3	1N4001 or equivalent silicon diode
FB	Ferrite bead, Type 3B, 4A, 43, or equivalent
J1	Low-loss input connector, N, SMA or TNC preferred.
J2	Output connector. Type not critical.
L1	144 MHz: 5 turns No. 14 on 3/8-inch ID, 0.5 inch long. 220 MHz: 5 turns No. 14 on 0.25-inch ID, 0.5 inch long. 432 MHz: 1 turn No. 14 on 0.32-inch ID. Length of wire 2 inches overall.
L2	903 MHz: thin (0.02-03 inch) copper strap 1.0 inch long overall. 144 MHz: 10 turns No. 24 on 0.1-inch ID, 0.25 inch wide and 0.5 inch long. 220 MHz: 8 turns of No. 24 on 0.1-inch ID, 0.5 inch long. 432 MHz: 5 turns of No. 24 on 0.1-inch ID, 0.5 inch long. 903 MHz: 3 turns of No. 24 on 0.1-inch ID, 0.25 inch long.
Q1	See text and table 1
R1,R2	200 ohms typical. Select for $I_D$ of 7-10 $\mu$ A (see text).
R3	100 ohms typical (see text).
U1	5.0-volt, three-terminal voltage regulator, 78L05 or equivalent.

You can best limit the rf level on the input of your preamplifier by use of a high isolation relay, typically 50 dB. Better yet, use a dual relay system like the one suggested in references 8 or 9. The second relay can be a low-cost type and will significantly increase relay isolation. Furthermore, on transmit, the preamplifier can be returned to a 50-ohm load, thus preventing any tendency towards oscillation and possible destruction.

As described in references 8 or 9, relay sequencing is highly recommended. Chip Angle, N6CA, has proposed a more sophisticated sequencing scheme built around a quad operational amplifier.<sup>10</sup> It provides several different delay times for switching receivers, exciters, and transmitters and is suggested for extra protection.

Don't overlook the dc biasing conditions just discussed. Source biasing and voltage-regulated power supplies will help GaAsFETs. Remember also that dc spikes are another potential problem. That is why I've always recommended the use of three-terminal voltage regulators with zener diode over-voltage protection as shown in **fig. 2**.

Sometimes I see Amateur preamplifiers with a spike-protection zener diode shunted between the drain and source. If you use this technique, don't forget to use ferrite beads in series with the diode, since it's in shunt with the rf path and could introduce rf feedback.

As I've recommended many times before, provide a dedicated power supply for your low-noise preamplifier and a separate dedicated supply for all relays. Inductive spikes from switching relays can kill any low-voltage unprotected device operating on the same voltage line! If only one supply is used, provide spike-limiting diodes on the relays, as recommended in reference 9.

Another sporadic problem is handling GaAsFETs while inserting or soldering them into circuits. Always use a low-power soldering iron with the tip grounded to the chassis. Also, first ground yourself to the chassis or use

a "wrist strap" before contacting a GaAsFET. Static *kills* GaAsFETs!

Finally, beware of rf and static discharges such as lightning. The best protection is simply removing your preamplifier from the system when it's not in use. Input filtering will go a long way towards protection of a low-noise preamplifier. In this regard, the capacitance-coupled input circuit shown in **fig. 2** is highly recommended.

## TVRO LNAs

The TVRO (TV receive only) LNAs (low-noise amplifiers) are literally everywhere, now that much of satellite TV is scrambled. I've seen them for sale at flea markets for less than \$30! Typically, they have 50 dB of gain specified for operation from 3.7 to 4.2 GHz and use two or three stages of GaAsFETs followed by three to four stages of bipolar transistors.

TVRO LNAs are usually great "as is" for operation on 3456 MHz, and will typically have a 1.5-dB noise figure in the Amateur band. Dave Mascaro, WA3JUF, recently described not only how to use them as receiver preamplifiers, but also how to modify them for use as low-level transmitter amplifiers.<sup>1</sup>

They're also a great source of spare parts, even if they're defective units (which usually makes them cheaper yet!). Many small UHF and microwave components such as tuning and chip capacitors — not to mention several very low noise GaAsFETs and bipolar transistors — are easily removed!

## microwave techniques

On the microwave bands (typically 1296 MHz and above), different matching techniques such as the NRAO lossless feedback circuit are often used.<sup>1</sup> The NRAO/W6PO type preamplifier that uses this technique is popular on 1296 MHz.<sup>7</sup> On the higher microwave bands, dielectric, stub, screw, and empirical matching tuners are often used as described in reference 4. Commercial suppliers often use ferrite isolators or hybrid couplers to improve bandwidth and impedance matching.

This month's column mainly re-

ferred to VHF and lower UHF operation because this is where most of the activity is. Upper UHF or microwave techniques, a completely separate subject, will be discussed in a future column.

## monolithic GaAsFET amplifiers

So far I've mainly addressed homebrew preamplifiers. As I said before, technology moves fast, so it shouldn't be surprising to see that we now have commercial GaAsFET MMICs (Microwave Monolithic Integrated Circuits).<sup>12</sup> Some are simply broadband, moderate-gain (6 to 10 dB) types such as the Microwave Semiconductor Corporation (MSC) CGY-40 and the Nippon Electric Company (NEC) NEPA 1001.<sup>12</sup>

MSC, NEC, Harris Corporation, Pacific Monolithics, and others now supply a broad range of MMIC amplifiers with moderate to high gain as well as entire subsystems through 10 GHz all using GaAsFET technology. These units, typically with 3- to 5-dB noise figures, are usable as medium-performance preamplifiers, but more practically, as second-stage amplifiers. In addition, performance improvements are constantly occurring.

There are a few precautions to observe when using GaAsFET MMICs. Many of these amplifiers require multiple power supplies. Prices are still high, but will drop.

Last month I mentioned the phenomenon of 1/f or low-frequency noise. For illustration, note that the specified noise figure of the Minicircuits Labs model ZHL 1042J broadband GaAsFET amplifier is only 4.5 dB above 100 MHz, but increases to 18 dB at 10 MHz!

## tuning and testing

If you can't tune or test a low-noise preamplifier properly, it won't achieve the low noise and moderate gain values that we've discussed so far. However, as I stated previously in both this column and in reference 2, a GaAsFET preamplifier can easily be tuned in line for maximum gain with



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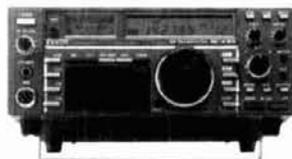
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only a small degradation in noise figure.

A weak signal source can be used for tuning by having a local Amateur radiate a small amount of rf on your favorite frequency. In this case, the preamplifier should be tuned for best signal + noise ratio (SNR), not gain. This can be tricky at best. EMEers often tune their preamplifiers for maximum sun noise referenced to a quiet sky.<sup>13</sup>

Reference 2 also discussed the "reverse isolation" test, which greatly simplifies the testing of the preamplifier stability margin. For system stability, it's important that the reverse gain (really a loss) be at least 6 to 10 dB greater than the forward gain of a preamplifier. For instance, a GaAsFET preamplifier with a gain of 20 dB should have a loss of at least 26 dB when reversed from end to end. If not, it may not be stable when used in a system that isn't 50 ohms from dc to daylight!

If you're lucky enough to own or borrow the use of a noise figure generator, preamplifier tuneup is considerably simplified. If not, attend one of the many VHF conferences often referred to under "Important VHF/UHF Events" at the end of each month's "VHF/UHF World." These conferences often have the latest in noise figure gear available, which you can use to optimize your preamplifier noise figure and measure your performance against that of your peers.

A few precautions about noise figure generators are in order. For best noise figure accuracy, the so-called "excess noise ratio" of the noise source should be only a few dB greater than the noise figure of the device under test. Furthermore, the VSWR of the noise source must be very low both in the "on" and "off" states.

Low VSWR can be assured only with a highly padded down noise source or one followed by a ferrite isolator; both, however, are sources of inaccuracy. Most of the older noise generators have 15 to 16 dB excess noise. A 10-dB attenuator pad can be added in series with the output, but

this will affect absolute accuracy of the results. To solve this problem, Hewlett-Packard has recently introduced the model 346A noise source for use on its popular model 8970 noise figure generator. The 346A noise source has about a 5.2-dB excess noise ratio (versus 15 to 16 dB on the older model 346B) and is highly recommended for optimization of very low noise figure preamplifiers, especially those with GaAsFETs.

Finally, if you really want to "zero in" on the lowest possible noise figure, you must not only tune for optimum noise match, but also optimize the dc operating parameters of the preamplifier. This is most easily accomplished by placing a pot either in series with or as a direct replacement of the source resistor and the resistor in series with the drain (see **fig. 2**).

To prevent excess current, it's advisable to place a small resistor (perhaps 10 to 50 ohms) in series with these pots. This will provide full adjustment capability. With all these "handles" on the preamplifier, you'll have to act like an octopus to tune everything!

### special techniques

As mentioned in last month's column, many techniques are available that will allow you to achieve a low noise figure. The most obvious is to use components with the highest unloaded  $Q$ . Then select a solid-state device with the lowest possible noise figure. This will probably be a GaAsFET below 4 GHz and a HEMT above that frequency. If you can afford a cryogenic cooler, or find one at a surplus sale, they're highly recommended. Don't forget that the optimization of noise figure, as discussed above, is very important.

It should also be obvious from what we've discussed that the temperature of the preamplifier is very important. Therefore, if your preamplifier is mast- or antenna-mounted, it should be shielded from heat or radiation from the sun. The latter is particularly important for EME operation, which often takes place during the day, when

the preamplifier is exposed to sunlight.

### predictions for the future

Low-noise HEMTs will eventually trickle down to Amateurs, as will even lower-noise GaAsFETs. Who knows? Maybe even lower noise-figure devices will be discovered that can surpass present HEMT performance. There are certainly customers waiting in the wings for any improvements, however small, and we all know that improvements are market driven.

One of the brightest and perhaps most rapidly accelerating technologies is the field of ceramic superconductivity. Every month an improved ceramic material seems to be discovered that can operate at an even higher temperature and still achieve zero resistivity. As I write this, the latest reported superconductivity has taken place at just below room temperatures; if this technology can be applied to semiconductors, noise figures may yet go to 0.0 dB at room temperature!

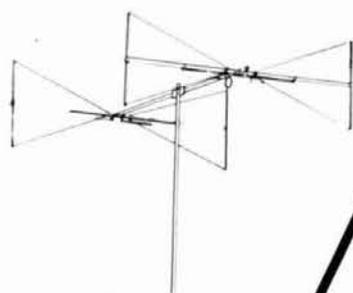
Although it doesn't affect receiver technology, semiconductor manufacturers have made great strides in the production of *power* GaAsFETs. Some presently available devices will deliver 4 to 7 watts of linear output power up through 10 GHz with gains of 7 to 10 dB. Even higher power devices are being developed.

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### summary

The SOA is rapidly changing. Noise figures are rapidly approaching the ultimate of 0.0 dB. Homebrew GaAsFET preamplifiers are now being used by Amateurs up through 3 cm (10.5 GHz) and perhaps higher. Some of the circuit and construction techniques were described in this and last month's columns.

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HGT	28938 km	DOP	-697 Hz	ORBIT	1562
RNG	29571 km	DRFT	5 Hz		78

HOUSTON OSCAR 11 → 1985 JUL 11 03:44:33

LAT	28.2° n	ECHO	8 ms	ELEV	29.5°
LON	93.5° w	FRQ	145,8228	AZIM	9.9°
HGT	591 km	DOP	-2628 Hz	ORBIT	7253
RNG	1245 km	DRFT	-528 Hz		27

LONDON OSCAR 9 → 1985 JUL 11 04:41:24

LAT	49.2° n	ECHO	6 ms	ELEV	28.9°
LON	18.0° w	FRQ	145,8246	AZIM	182.4°
HGT	494 km	DOP	-432 Hz	ORBIT	28859
RNG	929 km	DRFT	-1669 Hz		92

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Commercial Amateur suppliers are now providing SOA GaAsFET preamplifiers up through 10.356 GHz. With the arrival of power GaAsFETs and the use of antenna-mounted receivers and power amplifiers, we'll soon have to rethink our antenna designs and methods to aim our antennas accurately!

**new records**

In last month's column, I reported that the North American 3-cm (10 GHz) DX record had just been broken. Since then, I've been able to confirm that a two-way QSO took place on July 19, 1987 between Glen Elmore, N6GN/6, in Ball Rock, California (CM89PX) and Bob Dildine, W6SFH/6, in Mt. Frazier, California (DM05MS). They used narrow-band CW on 10.368 GHz for a record-setting DX of 413.8 miles (665.7 km). Both stations were running 200 to 300 milliwatts to 4-foot dishes, with 4.0-dB receiver noise figures. This was a joint effort with four other stations located throughout California. Congratulations to Glen and Bob on their new record!

Next I want to apologize to Jim Crow, WA5ICW, for listing his call sign incorrectly in the last publication of the North American 5760-MHz DX records.<sup>14</sup>

Last but surely not least, the North American 6-cm DX record has recently been extended. On July 4, 1987 Tony Bickel, K5PJR, in Grove, Oklahoma (EM26OP) and Larry Nichols, W5UGO/0, in Campbell, Nebraska (EN00PH) had a two-way CW QSO on 5760 MHz over a distance of 322.2 miles (534.6 km). Both stations were running 5 watts to 4-foot dishes with 2- to 4-dB noise figure receivers. Congratulations to Tony and Larry.

**silent key**

It is with great sorrow that I report that Willis (Bill) Conkel, W6DNG, an EME pioneer, passed away on July 13, 1987. Bill was on one end of the first two-way, 2-meter EME QSO. He had developed many novel weak signal techniques and built over 30 different antenna systems before he accomplished this feat. In a letter I just

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received from OH1NL, the other half of his history-making contact, Lennart told me how they had run 74 EME schedules before their first successful QSO. That's persistence!

Bill had since moved from Long Beach to Lindsay, California. Ironically, he was building up a new 2-meter EME station at the time of his death. I'll never forget our meetings together. We've lost a great experimenter and friend. SK.

## important VHF/UHF events:

December 13	Predicted peak of the Geminids meteor shower at 1900 UTC
December 20	New moon
December 21	± 1 month, winter peak of sporadic E propagation
December 22	Predicted peak of the Ursids meteor shower at 2200 UTC
December 22	EME perigee
January 4	Predicted peak of the Quadrants meteor shower at 0030 UTC
January 19	New moon
January 19	EME perigee
January 23-25	ARRL January VHF Sweepstakes Contest

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# ham radio TECHNIQUES

Bill Over  
W6SA1

The magazine was over 50 years old, but the photograph was quite clear. The young man was standing at a desk or drafting board, his head bowed in concentration. Several graphs and a slide rule were visible on the table. He was writing something on a piece of paper, oblivious to the photographer whose picture forever froze in time a glimpse of the young radio engineer at work (see **fig. 1**). Could he possibly have realized that in due course he would found a communications manufacturing empire?

Arthur A. Collins, 9CXX, had embarked upon a risky business — making money manufacturing Amateur Radio equipment. Starting a new company in the depths of the depression was uncertain enough. He was unknown to Amateurs at large, and the market he viewed was very small — fewer than 15,000 hams. And most of them had little money to spend on ham gear! Still, 9CXX's reputation was good — good enough to spur an order for four 1.5-kilowatt, a-m/CW transmitters to be delivered to Admiral Byrd for his forthcoming Antarctic expedition.

Why had the Admiral bought the transmitters from a relatively unknown source? One reason was that 9CXX had handled messages from Byrd at the North Pole when other stations couldn't make the contact. 9CXX had scheduled KEGK, the *S.S. Chantier*, at Spitzbergen on 37.5 meters and had also worked KNN, the *Josephine Ford*,

Byrd's Fokker airplane as it flew towards the pole. The Admiral knew a capable fellow when he met one, and the upshot was that Art Collins built the greater share of the transmitting gear for Byrd's trip to the South Pole.

## design problems

When 9CXX started designing transmitters for sale to hams, his experience in building his own station was invaluable. He knew how unreliable ham transmitters were! It was an ongoing battle, he knew, to keep a 20-meter phone transmitter on the air — even a small one. And Byrd wanted kilowatt capability all the way up to 16 meters!

In 1933 there were only a few 20-meter phone operators in the world. Other Amateurs looked upon these supermen with awe. Building a low-power 20-meter phone was an exercise in frustration. Tubes ran red in the breadboard rigs. RF skipped merrily through rf chokes and ran down power and microphone cables. The audio system squealed with feedback, meters banged against the pin, and very little rf ever reached the antenna. And the idea of building a kilowatt 20-meter phone transmitter? Out of the question! One or two hams knew — or thought they knew — how to do it, but they kept their plans a secret, or so it seemed.

Art Collins, however, had the concept of systems engineering in his mind decades before the term became popular. Years later, he told me that



fig. 1. The young Art Collins, 9CXX and W0CXX, at his drafting table, working on transmitter designs for his new company. (Reproduced from *Radio Magazine*, August 1933).

he had broken the difficult design problem down into four areas: how to keep rf where it belonged in the transmitter; how to provide sufficient drive for proper phone operation; how to couple the energy to the antenna; and finally, how to package the whole transmitter so that it could be shipped in working condition to the buyer.

All of these concepts had been discussed in greater or lesser degree in *The Proceedings of the I.R.E.*, but no one had put the ideas together to construct a practical, inexpensive short-wave transmitter that would work on

a large number of frequencies under difficult operating conditions.

Months before the Byrd contract arrived, a small ad appeared in the January 1932 issue of *QST*, announcing "crystal transmitters" of radically new design and capable of high out-

put on 20 meters (fig. 2). The transmitters were supplied in kit form, with prices starting at \$37.25. The advertiser was Arthur A. Collins Radio Laboratories in Cedar Rapids, Iowa.

The next ad (in the March 1932 edition of *QST*) dropped the kit idea (fig.

3). The lowest priced transmitter (presumably not a kit) was now only \$33.95 and the company name had been changed to Collins Radio Transmitters. A complete line of power supplies, modulators, and "input equipment" was also listed.

The ad in the May 1932 issue of *QST* suggested that the little company was now a successful business. Shown in the ad was a photo of a 150-watt, 20-meter phone transmitter, resplendent with seven meters and mounted neatly in a steel rack (fig. 4). The price? A mere \$285.70. (At the time, I mailed a penny postcard to Collins Radio Transmitters asking for full information. Alas, the \$33.95 transmitter

## Crystal Transmitters

Radically new design suitable for Class B modulation or high output C.W. on 14, 7 and 3.5 M.C.

Consists of crystal-oscillator, buffer amplifier, and Class C output amplifier mounted on polished aluminum and hard rubber chassis with plug-in coils and plug-in crystal holder for quick change of frequency. Complete Kits, less tubes, crystal and power supply:

210 Output . . . . \$37.25      203A Output . . . . \$47.50  
852 Output . . . . \$47.25

The smoothest, neatest little rig you ever saw — and what a Kick she has!

Immediate Delivery

Write for data sheets

**ARTHUR A. COLLINS**

Cedar Rapids, Iowa

Radio Laboratories, Inc., W9CXX

fig. 2. Collins kits? Yes, the first ad Art Collins ran in *QST* advertised transmitter kits. He soon saw the folly of this arrangement and thereafter sold only finished products!

## COLLINS CRYSTAL TRANSMITTERS

are fast becoming the popular choice of both the old-timer who has learned to appreciate the value of trouble-free, efficient performance on all bands — and also the beginner who wants to start right. ● Write at once for full details and photographs. Units from \$33.95 up with carrier powers of 30 to 300 watts. Also a complete line of power supplies, modulator and input equipment, relay racks, quartz crystals, etc.

**COLLINS RADIO TRANSMITTERS**  
CEDAR RAPIDS, IOWA

(Arthur A. Collins, W9CXX)

fig. 3. Collins was now in the transmitter business. Note that he was also selling auxiliary components. The company had clearly outgrown the "laboratory" concept featured in the first advertisement.

## For Really FINE EQUIPMENT



150-Watt  
Phone Transmitter  
Class B  
Modulated

— insist on COLLINS design

Send for **Bulletin 100** describing complete transmitters priced from \$73.60 to \$285.70, with power supplies; or **Bulletin 101** listing relay racks, power transformers and full line of transmitting parts.

**Collins Radio Transmitters**  
CEDAR RAPIDS, IOWA

fig. 4. The 150-watt rack-mounted phone transmitter. Quality was so good that the little transmitter was bought by several South American broadcast stations. The sky-high price of \$287.50 prevented many Amateurs from buying.

was now \$73.60. Regretfully, I concluded I could never afford a Collins transmitter.)

Finally, in early 1933 the Collins company announced the 30W trans-

mitter (fig. 5). This was a neat, two-deck job, with four meters (meters were very important in those days). The price was \$125.00. Almost as an afterthought, a companion modulator

that would "make a phone that really does things" was offered as well.

Interest in the 30W prompted Collins to make a complete, compact phone transmitter — the 32B. The price was held at \$125.00.

By mid-1933 the country was starting to come out of the depression. Business was picking up, unemployment had dropped a bit, and people seemed to have a little money to spend. Enough Amateurs bought the Collins 32B transmitter — and liked it — to make Collins a "big name" in the communication industry (fig. 6).

To hedge his bet, Collins also brought out a simple CW version of the transmitter, but sales were poor in comparison with sales of the phone version.

### rapid expansion

By autumn of 1933 the Collins Radio Company was in full swing. A full-page ad in the November *QST* revealed an impressive line of transmitting components — transformers built to Collins specs by the Chicago Transformer Company. And in early 1933, the company announced the 150B phone

## The COLLINS 30W



has won enthusiastic users throughout the world. Amateurs everywhere have put the 30W through the gruelling test of popular use—and it has proved itself a winner.

There are good reasons for its success: Correct design—Use of only the very best materials—A DX range equal to that of larger transmitters—And a price so attractive that it is no longer an economy to build your own transmitter from composite parts.

Price effective January 1, 1933  
**\$125.**

Send 25c in coin for the complete  
Collins manual

## Collins Radio Company

CEDAR RAPIDS, IOWA

**SPECIFICATIONS:**  
OUTPUT: 30 watts, FREQUENCY RANGE: 20, 40, 80 and 160 meters. Coils for one band standard equipment.  
TUBES: 247 Crystal Oscillator, 247 Buffer, 510 or 530 Output Amp. POWER: Self contained heavy duty dual unit.  
KEYING: Special Clickless Grid-Block. METER: Weston surface type.  
Additional COLLINS units make the 30W convertible into standard CW—Radiophone transmitters with power up to 100 watts.

fig. 5. The 30-watt CW transmitter was a success among well-to-do Amateurs. By redesigning the circuit, Collins produced the famous model 32A and 32B transmitters. Selling at the same price as the obsolete 30W, the 32B was an instant hit among DX phone operators.

## Two New COLLINS TRANSMITTERS 32 A and 32 B



### At New Low Prices!

In addition to retaining the distinctive features of construction and design which have made Collins Transmitters outstanding, these two latest units embody many new refinements. The 32 A and 32 B are fully described with circuit diagrams in a free bulletin. Write for it before you rebuild your present outfit.

32 A CW only  
32 B CW-Phone  
30-25 Watts Output  
3 Stage Crystal Control  
Class B Modulation  
Dual Power Supplies

**COLLINS RADIO COMPANY**  
Cedar Rapids, Iowa

fig. 6. The Collins 32B was the first low-power "all-band" Amateur phone transmitter that worked. Mine is still working — on 160 meters.

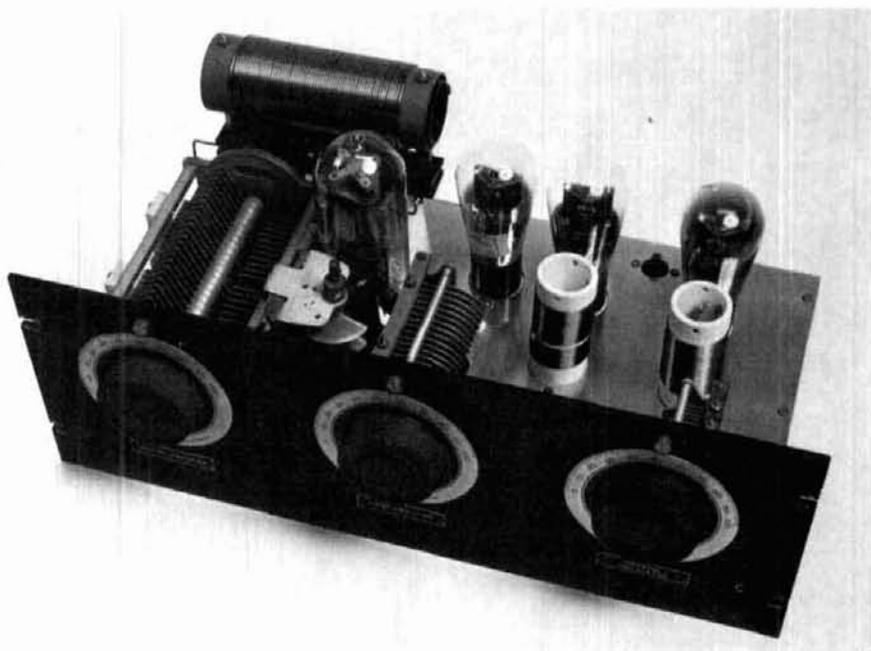


Fig. 7. The popular 150B-series transmitters used a state-of-the-art rf deck that was included in higher power units as well (up to the kilowatt level). The three-stage circuit, built on an aluminum chassis and panel, utilized three plug-in coils to provide operation between 1700 kilocycles and 15 megacycles. Power output was at least 100 watts at any frequency in that range.

transmitter, a 150-watt job that worked on all frequencies up to 14.5 mega-

cycles (MHz). At last a workable 20-meter phone transmitter of moder-

ate power had arrived! It sold for about \$350. Best of all, low-power shortwave broadcast stations were buying the transmitters in increasing numbers!

### the Collins rf deck

The secret of success was Art Collins's knowledge of rf circuitry, as revealed in the 150B. The circuit was quite conventional, and most Amateurs of that period could draw it out on paper from memory. But Art knew the tricks necessary to translate the circuit diagram into a working transmitter (see **figs 7, 8, and 9**).

The basic transmitter was first sold in early 1933, and with a few circuit and cosmetic changes, it remained in production until late 1935, when newer tubes rendered the design obsolete. At the same time, band switching eliminated the old-fashioned plug-in coils.

The circuit consisted of a 47-pentode tube as a crystal oscillator, two 46 high- $\mu$  tubes connected in parallel as a doubler stage, or neutralized amplifier, and a single 203A, 50-watt triode power amplifier. A link coil was used to couple the amplifier to an external antenna tuner.

A circuit similar to this had appeared in the ARRL's *Handbook* for years. But that transmitter was a breadboard affair, and Collins built his on an aluminum chassis to provide better ground return and improved circuit isolation. Interconnecting harnesses ran between the transmitter decks and important power leads were well bypassed to keep the rf where it belonged.

Most important, Art Collins knew about and understood parasitic circuits. Mysterious tube heating, unreliable tuning, and loss of output power — a mystery to most Amateurs and even many manufacturers — were conquered in the 150B rf deck. Mass production of shortwave transmitters heretofore had been costly and frustrating because each transmitter had to be debugged to get it on the air, and each debugging operation seemed different from the previous one!

Not so with the Collins gear. An example of an early parasitic suppression

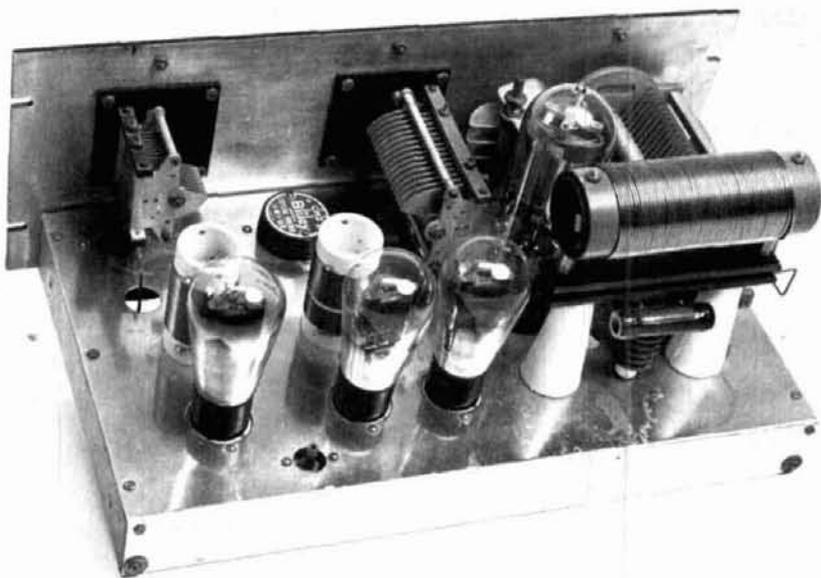


fig. 8. Rear view of the 150B deck. Tuning capacitors were above ground and mounted on insulating plates. Note the wirewound resistor across the power amplifier plate choke. This prevented a parasitic oscillation when the transmitter was operated at the lower frequencies. The buffer neutralization capacitor is mounted below deck, with shaft coming up through the deck. A single 203A "50-watt" triode tube was used in the amplifier stage.

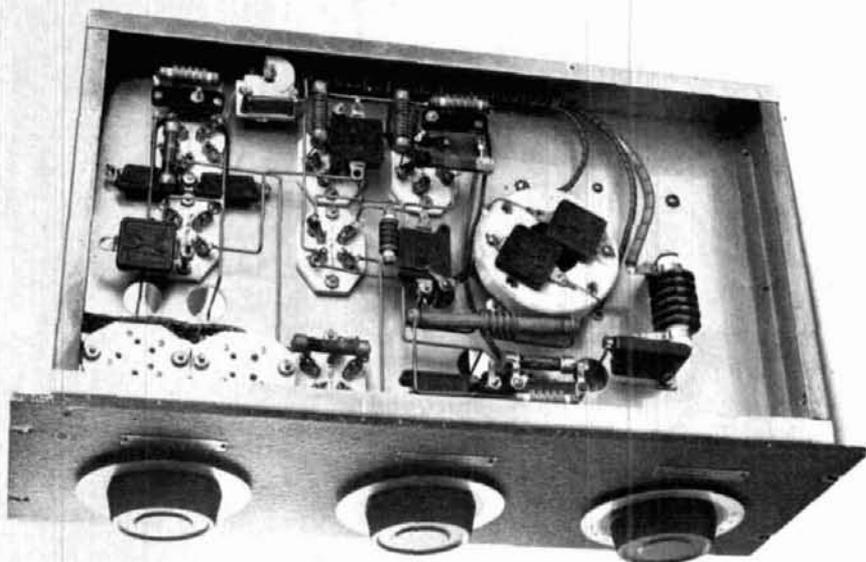


fig. 9. Underview of 150B chassis shows Art Collins's mastery of rf circuitry. Note the small parasitic chokes in the buffer stage circuit and the large parasitic choke mounted parallel to the front panel, near the 50-watt socket. Ample bypassing and use of rf chokes kept the radio energy where it belonged. All connections to the unit were brought out through the two ceramic sockets mounted under the chassis in one corner. All wiring was laced, and rf leads were angled in the approved fashion of the time. All bypass capacitors were encased mica units. (150B chassis from the W6SAI collection.)

scheme is seen in the underchassis view of the rf deck. Today, the presence of a noninductive resistor and choke coil is commonplace in large, tube-type linear amplifiers. But that was a new and novel idea in the 1930s.

The reproducibility and docile tuning of the transmitter were so good that Collins advertised that the transmitter was factory neutralized, and the user wouldn't have to worry about that complicated adjustment! This was a refreshing change for Amateurs and professionals who had spent hours vainly trying to tame a wild and unpredictable amplifier!

Art Collins, now W9CXX, had achieved what others had tried but failed to do. He marketed a shortwave transmitter that could be tuned up by the book — and would work! The price was right. As international shortwave broadcasting became popular, more and more Collins ham transmitters were put to this use. Collins started making commercial versions of the ham transmitters, complete with speech consoles and studio equipment. (In 1934 I visited YV3BC in Caracas, Venezuela, and saw three Collins 150-watt phone transmitters adapted for short-wave broadcast service.)

The big transmitters designed for the Byrd expedition were quickly adapted for broadcast and Amateur use (fig. 10). The company expanded into the broadcast field and, by World War II, was a fixture in the communications world as a reliable manufacturer of communications equipment of all kinds.

From 1932 to 1942, radio was dominated by this small, upstart company that grew from a one-man shop into a giant in communications (fig. 11). World War II brought tremendous expansion to Collins Radio, but I'll leave it to someone else to tell the story of the company from 1942 on.

These stories of "the good old days" were gleaned from Art himself during our occasional meetings over the years. He had many more, but now they'll not be told. Art was a grand person, a good friend of the Radio

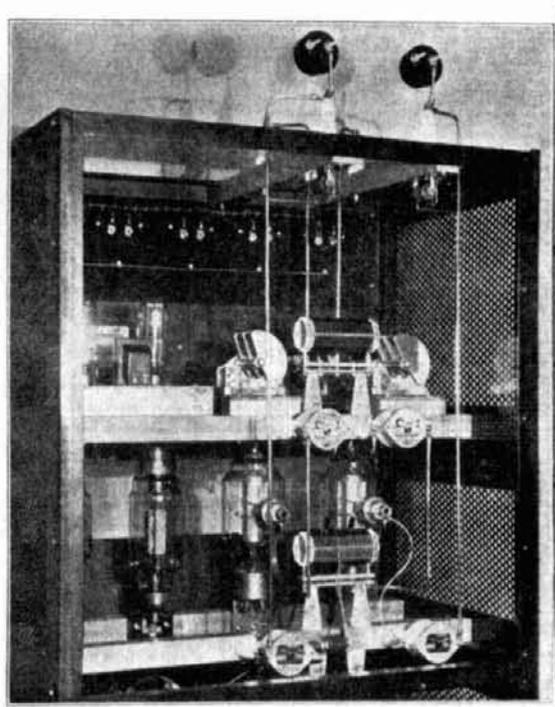
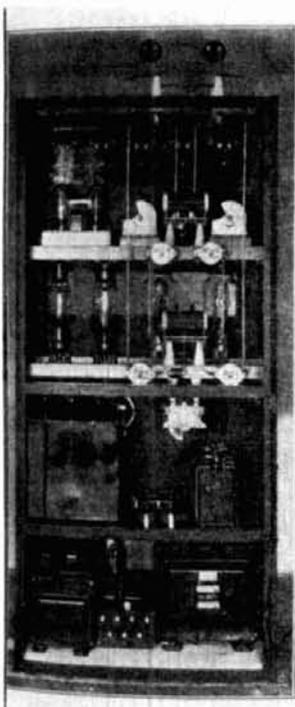


fig. 10. The famous 20B transmitter used by Admiral Byrd at the South Pole. A variation, Model 20C, was sold to Amateurs who could afford the \$2700 price tag! The transmitter weighed well over 1000 pounds. W9BHT, XE1G, and W2BSD owned the first three production models.

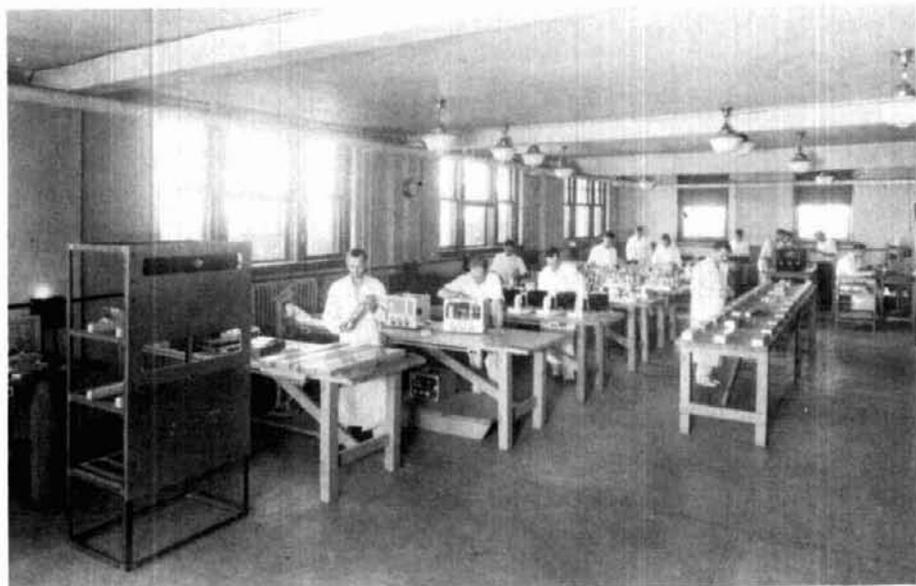


fig. 11. With the 20B transmitter, the Collins Radio Company hit the jackpot. Many of these fine kilowatt phone transmitters were ordered by shortwave broadcasters. Shown in this rare photo is the early Collins production line assembling 20B transmitters. Thirteen workers are visible in this picture; even in the depths of the Great Depression, the company was a success!

Amateur, and a technical wizard. Those of us who knew him miss him very much.

*Art Collins, W9CXX, died on February 25, 1987.*

ham radio

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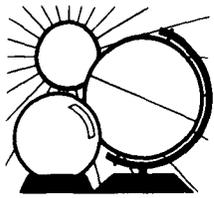
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# DX FORECASTER

Garth Stonehocker, KØRYW

## DXing via the winter anomaly

The increased signal absorption anomaly that results in five- to six-day periods of 20 to 40 dB weaker signals through the mid-to-high latitude propagation paths in winter has been the subject of previous columns.<sup>1,2</sup>

These paths provide our main communication links to European, Asian, and Japanese Amateurs. As discussed in the previous columns, there are exceptions to this anomalous propagation rule; these show up as areas of lower absorption and consequently higher signal strengths. These "windows" can sometimes produce signal levels that exceed those received during the normal (optimum) winter low absorption periods. So to emphasize the positive aspects of wintertime DXing, let me summarize the DXing possibilities inherent in taking advantage of this phenomenon.

Table 1 shows the forecasting sequence of events that precede the good signals, and also when they're likely to be best. Anytime during the months from November through February — and possibly into March — look for the progression indicated in table 1.

The absorption spreads as it rotates to the west, decreasing in latitude at the same time as shown in fig. 1 below. The rotation amounts to 30 degrees (two time zones) per day and decreases in latitude from 65 to 30 degrees in the five days of rotation.

To take advantage of the decreased absorption that provides strong DX signals on east, west, and transpolar paths, one has to access WWV or the bulletin board to keep track of the daily

geomagnetic A value during this winter season (mainly January). Continue keeping track after each A value of 15 or higher until a STRATWARM is given; after that, consult your map or globe to follow the 90-degree position between the location given for the STRATWARM and its 180-degree companion. Coordinate your beam bearings and the DX path control points (1200 miles from the QTHs "on" the great circle) with the areas of lower absorption on both or on at least one end. If the area isn't right for your DX on that particular day, you can forecast — at 30 degrees of longitude

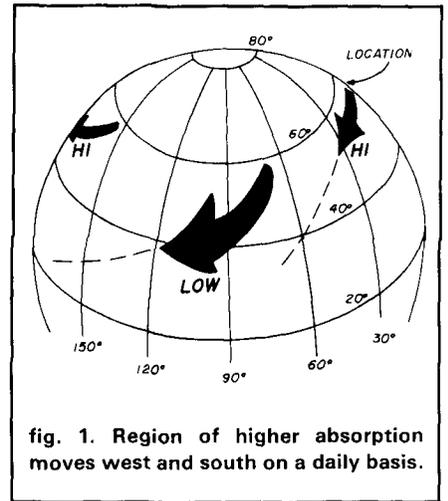


fig. 1. Region of higher absorption moves west and south on a daily basis.

Table 1. Sequence of events preceding best signals.

Day	Condition	Result
0-3	Geomagnetic disturbance, A > 15	(Trigger) Auroral Zone weak signal
3-5	Warm region builds	"STRATWARM EXISTS" (location) on WWV
5-10	Absorption rotates, spreads down	Best signals 90 degrees from location

and lower latitude per day — when you can expect good results during the five to six days to come.

### last-minute-forecast

The higher frequency bands, 10 to 30 meters, are expected to be best the first and last weeks of the month, as well as during half of the preceding and following weeks. Look for good extra-long-skip transequatorial openings to the south during the second week, especially if some days of mild geomagnetic disturbance occur because of the decreasing (relaxing solar pressure) solar flux. The third week of the month — plus a few days on both ends — is expected to be best for daytime short-skip and nighttime DX on the lower bands. Expect other geomagnetic-ionospheric disturbances around the 16th.

The Geminids meteor shower, which will peak on December 13 through 14, will provide the richest and most reliable display of the year, with rates of 60 to 70 per hour. Because optical observations may be difficult or impossi-

ble during periods of poor weather in December, actual numbers must be determined by radio reception. A smaller version of the shower will be noted on December 22. The full moon will occur on the 5th, and lunar perigee will occur on the 22nd. Winter solstice occurs on December 22nd at 0946 UT.

### band-by-band summary

Ten, twelve, fifteen, and twenty meters provide many openings during the daytime. As you go up in frequency (i.e., into the higher bands) the openings will be shorter, centered around noon, and mainly toward southerly directions. Fifteen meters is only a transition band between 12 and 20. Twenty meters, the mainstay daytime band for northerly directions will be useful towards the south in the evenings. Transequatorial openings might occur in evening hours to locations up to 2000 miles away if antenna radiation angles are down to 10 degrees.

Thirty, forty, eighty, and one-sixty meters are all good for nighttime DX.

(continued on page 94)

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		N	NE	E	SE	S	SW	W	NW
0000	4:00	40	40	20	15	15*	12	12	20
0100	5:00	30	40	20	20	15*	12	12	20
0200	6:00	30	40	20	20	15	15	15	20
0300	7:00	40	40	30	20	20	20	15	30
0400	8:00	40	40	30	20	20	20	20	30
0500	9:00	40	40	30	30	20	20	20	40
0600	10:00	40	40	30	30	20	20	20	40
0700	11:00	40	40	30	30	20	30	30	40
0800	12:00	40	40	30	30	30	30	30	40
0900	1:00	40	40	30	30	30	30	30	40
1000	2:00	40	40	30	30	30	30	30	40
1100	3:00	40	40	30	30	30	30	30	40
1200	4:00	40	40	30	30	40	30	30	40
1300	5:00	40	40	20	15	30	30	30	40
1400	6:00	40	30	15	15	30	30	30	40
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1900	11:00	40	40	12	10	15	15	20	40
2000	12:00	40	40	12	10	15	15	20	30
2100	1:00	40	40	15	10	15	12	15	20
2200	2:00	40	40	15	12	15	12	15	20
2300	3:00	40	40	20	12	15	12*	15	20

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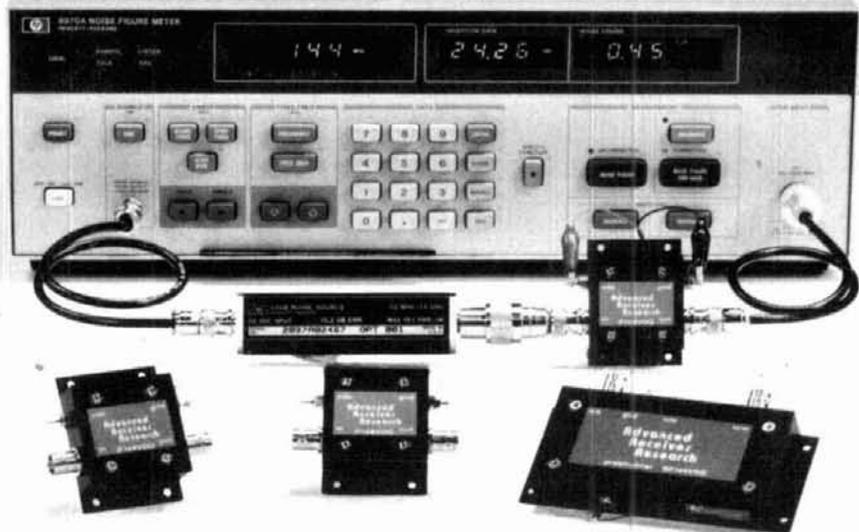
QMT	MST	Directional Indicators							
		N	NE	E	SE	S	SW	W	NW
0000	5:00	40	40	20	20	15*	12	12	40
0100	6:00	40	40	20	20	20	15	15	40
0200	7:00	30	40	30	20	20	20	15	40
0300	8:00	40	40	30	20	20	20	20	40
0400	9:00	40	40	30	30	20	20	20	40
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0600	11:00	40	40	30	30	30	30	30	40
0700	12:00	40	40	30	30	30	30	30	40
0800	1:00	40	40	30	30	30	30	30	40
0900	2:00	40	40	30	30	30	30	30	40
1000	3:00	40	40	30	30	30	30	30	40
1100	4:00	40	30	15	20	30	30	30	40
1200	5:00	40	30	15	15	30	30	30	40
1300	6:00	40	20	12	15	30	30	20	40
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2000	1:00	40	40	12	12	15	12	15	20
2100	2:00	40	40	12	12	15	12	15	20
2200	3:00	40	40	12	12	15	12	15	30
2300	4:00	40	40	20	15	15*	12	15	30

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QMT	EST	Directional Indicators							
		N	NE	E	SE	S	SW	W	NW
0000	7:00	40	40	20	20	20	15	20	40
0100	8:00	40	40	30	20	20	20	20	40
0200	9:00	40	40	30	20	20	20	20	40
0300	10:00	40	40	30	20	20	20	20	40
0400	11:00	40	40	30	20	20	30	30	40
0500	12:00	40	40	30	20	20	30	30	40
0600	1:00	40	40	30	30	30	30	30	40
0700	2:00	40	40	30	30	30	30	30	40
0800	3:00	40	40	30	30	30	30	30	40
0900	4:00	40	40	30	30	30	30	30	40
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1100	6:00	40	30	15	20	30	30	30	40
1200	7:00	30	20	12	15	30	30	30	40
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1600	11:00	40	20	10	12	15	20	20	40
1700	12:00	40	20	12	12	15	20	30	40
1800	1:00	40	30	12	10	15	15	20	40
1900	2:00	40	30	12	10	15	15	20	40
2000	3:00	40	40	15	12	15	15	15	40
2100	4:00	40	40	15	12	15	12	15	40
2200	5:00	40	40	20	12	15*	12	15	20
2300	6:00	40	40	20	15	15*	12	15	30

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 \*Look at next higher band for possible openings.

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## pc-pakratt terminal program for the PK-232

One of the biggest problems many Hams encounter in getting on packet radio is making their home computers "talk" to their TNCs. Despite the claims of software houses ("easy to use," "sets up in minutes!") — don't believe it. Unless you're a computer whiz, it doesn't happen that way . . . or at least it *didn't* happen that way until AEA released its new MS-DOS Packet terminal program for the PK-232. Designed for those of us without EE degrees, PC-PAKRATT allows use of the PK-232 with a minimum of hassle and problems.

PC-PAKRATT will run on all IBM PC-XT or AT machines and most compatibles. You need to be running DOS 2.0 or a later version, have at least 320K internal memory, have a RS-232 serial port, and two 360K floppy drives. If you're using a compatible and it will run one of the flight simulation games, chances are PAKRATT will work OK for you.

PC-PAKRATT requires ROM chips dated 1987 or later to work properly; if you have chips dated October 1986 or earlier, contact AEA for upgrade information.

## installation

Before you begin, you'll want to make a working copy to protect the original from mistakes or other glitches.

Remove the batteries from the internal battery supply. The PC-PAKRATT program will store your callsign and other important information on the program disk. Connect the TNC to your computer, boot your operating system, install the PC-PAKRATT program, and you're just about ready to go.

The first screen you'll see is *Log On*; with this one, you'll be able to choose the most appealing or easy-to-read colors for the screen and text, select communications port 1 or 2, and set the TNC-to-computer baud rate. Hitting the space bar initiates communications between computers; in about 15 seconds you should see the main screen display. If there's a problem, the screen will give you an error message. A quick look in appendix A of the program manual will identify the error and suggest an appropriate fix.

## main screen

Now that the program is up and running and the computers are talking to each other, it's time to learn all the subtle nuances of the program. AEA has tried hard to make the PAKRATT as simple and as easy to use as possible. Commands are straightforward and easy to remember: P = print, R = rename, S = erase, and so on. You can edit and browse using the B com-

mand, and you can set up two user-defined files. Of particular interest, AEA has provided a "soft-key" or user-designed macro that can be used to save time as you enter repetitive commands. You can store as many as 20 different sequences of up to 256 keystrokes.

## mode screens

The packet display is divided into three windows or areas. At the top, the status line lists transmission mode, link status, buffer status, link state, and several other important parameters. The second section, the receive window, displays all the data received by the TNC. The third, the transmit window, the information you're about to transmit.

A number of special keys are provided to help reduce the amount of time needed to make any command changes. F1 brings up the HELP screen; F2 is AUTO CONNECT; F3 is CONNECT; and F4 DISCONNECT, and so on.

The Morse, Baudot, ASCII, AMTOR, and FAX screens are similar in layout and operation. There are divided screens for both receive and transmit as well as plenty of special keys to enhance and speed operation on each mode. These special keys are designed to simplify operation to the point that it's hard to forget how to use the equipment even after a long layoff. You can also use your computer as a dumb terminal to facilitate PK-232 calibration and SIAM operation.

As if that weren't enough, PC-PAKRATT will also emulate MicroPro's WordStar program as a screen editor program. You can create, modify, or examine most files in the system. You can also look at and make changes to the QSO buffer.

## conclusion

All in all, this is a super program. When I first got "digitized," I spent hours setting up my system, then getting the computers to talk to each other. As of now, I've spent three hours trying to get a supposedly easy-to-work dumb terminal to talk to the PK-232; it took about 10 minutes to get PC-PAKRATT to work on my IBM-clone computer.

One distinction needs to be made. PC-PAKRATT doesn't give you hundreds of unique features that aren't found in other communications software packages. PC-PAKRATT does give you, however, everything you need to use the PK-232 to its fullest potential. It also greatly simplifies operation through its carefully structured commands. And, I'm sure that as PAKRATT gets into the hands of more users, it will continue to evolve in ease of operation and overall power.

AEA has just announced the availability of a C-64 program that provides many of the same features as PC-PAKRATT.

You can see PC-PAKRATT in operation at your local AEA dealer or contact the manufacturer (AEA, 2006 196th Street SW, Lynnwood, Washington 98036) for more information.

Circle #301 on Reader Service Card.

— de N1ACH

# 2x4Z BASE REPEATER ANTENNA

THE HIGHEST GAIN DUAL BAND BASE/REPEATER ANTENNA

HIGH POWER 200 WATTS

CENTER FREQUENCY

146.500 MHz

446.500 MHz

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UHF - 11.5dB

VSWR - 1.1-1.2 or less

CONNECTOR:

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LIGHTNING PROTECTION  
GROUNDED DIRECT

LENGTH: 16 FT.

WEIGHT: 5 LBS. 3 OZ.

WIND LOAD: 90 MPH

MOUNTING: UP TO 2 IN.

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CAN SIMULCAST ON

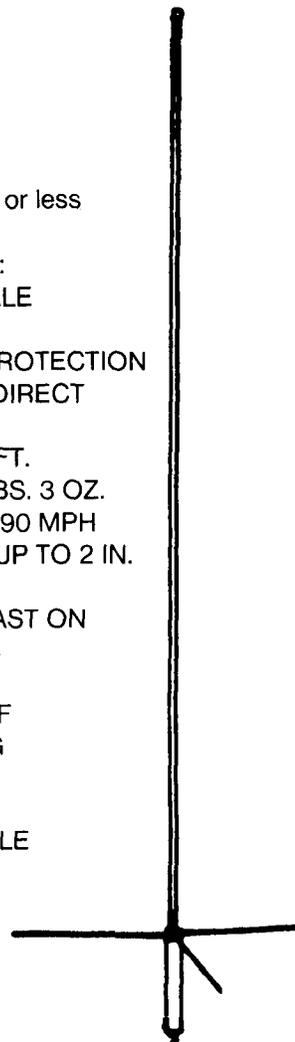
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## NEW products

### new 10- and 6-meter base station transceiver

The new IC-575A is a 10-meter and 6-meter dual-band base station transceiver. This wide-band, all-mode base receives 26 to 54 MHz continuously and has 99 tunable full function memories, passband tuning, a notch filter, noise blanker, built-in SWR bridge, semi- or full CW break-in and a multi-function meter. The IC-575A also has a velvet-smooth tuning knob and easy-to-read amber LCD readout with variable backlight.



Four scanning systems are available: band, programmable, mode and memory scan with selectable lock-out (scans 99 memories in five seconds).

All subaudible tones are built in, and the actual subaudible frequency is displayed. Standard repeater splits are built in and odd splits are programmable.

For packet enthusiasts, the IC-575A incorporates DDS (Direct Digital Synthesizer).

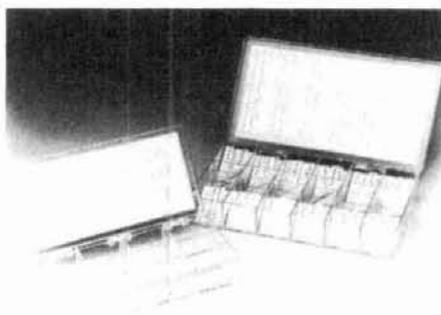
The 10-watt IC-575A is similar in design to ICOM's compact base station line: the IC-735, IC-275A, IC-275H and IC-475A.

Information concerning price and availability can be obtained by contacting ICOM America, Inc., 2380 116 Avenue N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.

Circle #302 on Reader Service Card.

### chip resistor and capacitor kits

Communications Specialists, Inc. has introduced a series of chip resistor and capacitor kits. Intended as prototyping kits for engineers, they may also be used as parts kits for repair technicians and experimenters. Kit CR-1 contains 1540 pieces composed of: 10 chip resistors of



every 5 percent value from 10 ohms to 10 megohm (145 values + 0 ohm jumper), plus a bonus of ten additional resistors in the eight values of 0, 10, 100 ohms; 1, 10, and 100 k, as well as 1 and 10 meg. Resistors are 0.10-watt 0805 size to 3.3 megohms, and 0.125-watt 1206 size above 3.3 megohms. Tolerance for all is 5 percent, and each resistor is marked with its three-digit value.

Kit CC-1 contains 365 pieces composed of five chip capacitors of every 10 percent value from 1 pF to 0.33  $\mu$ F (67 values), plus a bonus of five additional capacitors.

Each kit sells for \$49.95; both are available for immediate delivery from stock. For a free brochure describing both kits, or to order, contact Communications Specialists, Inc., 426 West Taft Avenue, Orange, California 92665.

Circle #303 on Reader Service Card.

### new packet options

A new high-speed pc-board packet modem option for the Kantronics All Mode (KAM) and KPC-4, the 2400 Kantronics Modem™, plugs right in to existing KAM or KPC-4 boards to provide optional 2400-bps packet operation, selected by use of the EXTMODEM command. When installed in the KPC-4 (only), use of the **ONE-RADIO** command permits mixed 1200/2400-bps data rates on a single frequency. The new 2400 Modem retails for \$69.95.

Kantronics is also offering the Version 2.70 feature enhancement update for existing KAM units and KPC packet units. The Version 2.70 update adds the three KISS commands that make the KAM and KPCs TCP/IP networking compatible. Additionally, the update adds the popular Personal Packet Mailbox feature to each unit, allowing you and others to leave and retrieve messages in your packet or All Mode unit. The update is available for the KAM Packet Communicator, KPC 2, KPC 2400, and KPC 4 units for \$15.00, and free to those who purchased lower level units after July 1, 1987 and can show a dated sales receipt.

As of July 31, 1987, Kantronics began providing additional features at no extra charge; all Kantronics KAMs and KPC packet units shipped from the factory included the Personal Packet Mailbox, 32K RAM, and TCP/IP networking

compatibility. Current KAM and KPC owners can add the Personal Packet Mailbox and TCP/IP compatibility to their unit for the special price of just \$15.00; a 32K RAM expansion chip is available for \$15.00.

For more information, contact Kantronics, Inc., 1202 East 23 Street, Lawrence, Kansas 66046.

Circle #304 on Reader Service Card.

### dual-band VHF antenna tuners

MFJ Enterprises, Inc. has introduced two new dual-band VHF antenna tuners that cover both the 144-MHz and the new Novice 220-MHz bands. Both handle 300 watts PEP, match a wide range of impedances for coax-fed antennas, and are built into rugged all-aluminum cabinets painted eggshell white with a black top.

The MFJ-921 has a built-in SWR/Wattmeter, measures 9 x 2 x 3 inches, and retails for \$69.95. The MFJ-920 measures a compact 4-1/2 x 2 x 3 inches and retails for \$49.95.



Both come with a one-year unconditional warranty. If either is ordered directly from MFJ Enterprises, Inc., it can be returned within 30 days for a full refund (less shipping and handling) if you're not satisfied.

For additional information, contact MFJ Enterprises, Inc. at P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #305 on Reader Service Card.

### tool cases, catalog

Two new tool cases are featured in Jensen's new 160 page, full color catalog. Rotationally molded of high density polyethylene, these Rota-Lux and Rota-Tough cases are available options for Jensen's tool kits, including the top of the line JTK-87 Electronic Service Kit for field service engineers.

Rota-Lux and Rota-Tough cases vary slightly in size and styling. All Rota-Lux cases measure 17 3/4 X 12 3/4; Rota-Tough cases measure

17-3/4 X 14-3/4. Five models, differing in depth from 5 inches to 10 inches, are available.

For information and a copy of Jensen's new catalog of electronics tools and test equipment, contact Jensen Tools, Inc., 7815 South 46th Street, Phoenix, Arizona 85044.

Circle #306 on Reader Service Card.

## linear amplifier kit

Heathkit's new SB-1000 linear amplifier provides a full 1000 watts PEP output on SSB or 850 watts output on CW. It provides full HF coverage from 160 to 15 meters, including 80 percent of rated output on the three WARC bands. The SB-1000 Linear Amplifier uses a single 3-500Z tube in a high-efficiency circuit and has a hypersil steel E-I core transformer for high-performance operation. It also features a quiet



computer-style fan, a stiff full wave power supply with computer-grade capacitors, adjustable ALC, and plate and load controls with smooth vernier tuning.

For more information about the SB-1000 Linear Amplifier and Heath's expanding line of Amateur Radio equipment, contact Heath Company, Dept. 150-955, Benton Harbor, Michigan 49022. (In Canada, contact Heath Company, 1020 Islington Avenue, Dept 3100, Toronto, Ontario, M8Z 5Z3.)

Circle #307 on Reader Service Card.

## scanner/computer interface

The Engineering Consulting Model 727S scanner interface for the Yaesu FT 727R and the Commodore 64 computer provides a high quality, feature packed scanner. The entire radio channel memory can be loaded in under 15 seconds at 4800 baud. All parameters are stored and up to ten sets of ten channels can be scanned. Information can be saved to disk, which allows 100 channels per disk. All ten memory groups can be scanned at once or individually. Scan lock-out for individual channels is provided. The scan speed and resume time are

adjustable. All transmit and receive frequencies plus offsets and encode/decode sub-tones can be input and load into radio on command. Return data from the FT 727R provides a full-screen digital S-meter which may be used to stop the scan on preset signal strengths from S-1 to S-9. A comment field is provided for each channel entered and is displayed while scanning the channel. All information for each channel programmed (in groups of 10) is simultaneously displayed on the monitor.

Once the channels are entered via the computer keyboard the information in any of the ten frequency groups may be downloaded to the HT for portable use. All 100 channels may be scanned as one group while under computer control. The model 727S is supplied with hardware and software to operate with the Commodore 64/64C/C128/SX64 series of computers. The hardware interface includes the circuit board, components cables, instructions and connectors necessary (in kit form). Assembly time is approximately 10 minutes, and it makes a great club project.

For further information, contact Engineering Consulting, 583 Candlewood Street, Brea, California 92621.

## antenna rotor

Encomm's new KR 1000SDX azimuth antenna rotor from Kenpro includes features such as 450 degree rotation for easy, speedy antenna pointing; North, South, East, or West-centered readout capability; variable speed rotation control for fast (less than 43 seconds) 360 degree rotation; and preset direction control with automatic movement control. In addition, it features gentle antenna handling, with preset and soft landing automatic slowdown before stop; its weatherproof outside connector resists corrosion and decay of wiring. There's room inside the control box for an optional computer interface board area. Limit switches at 450 degrees are included.

KR1000s (without preset and speed control) are also available. The KR-1000SDX is priced at \$489.00; the KR-1000, \$399.00. For further information, contact Encomm, Inc., 1506 Capital Avenue, Plano, Texas 75074.

Circle #308 on Reader Service Card.

## handheld meter training package

The John Fluke Manufacturing Co., Inc. has announced the availability of a video training package designed to maximize the usefulness and safety of Fluke's 70 Series of handheld digital multimeters.

Titled "70 Series Solutions," the package is intended for industrial or vocational training ap-

plications. In addition to a 15-minute video tape, it includes numerous classroom tools such as overhead transparencies, a 100-page instructors guide, and 25 student workbooks.



The training emphasizes "hands-on" exercises, with only a minimal amount of theory presented. Instead, examples of how to make a wide variety of basic measurements accurately and safely are given by demonstration. Many of the unique features of the 70 Series DMMs are also explained.

For details, contact John Fluke Manufacturing Co., Inc., P.O. Box C9090, Everett, Washington 98206.

Circle #309 on Reader Service Card.

## Bilal relocates

Bilal Company, manufacturer of Isotron antennas for 160 through 10 meters, has moved from Oklahoma to Colorado. Owner Ralph Bilal reports that the new location is great, and that the company has enjoyed a very busy summer season, despite the move.

The new address is: Bilal Company, 137 Manchester Drive, Florissant, Colorado 80816.

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**SAY YOU SAW IT  
IN  
HAM RADIO**

# ham radio

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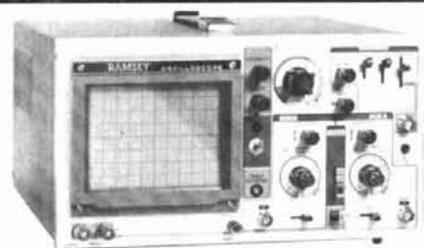
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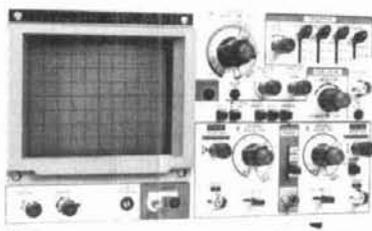
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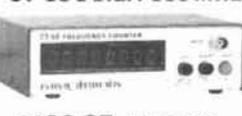
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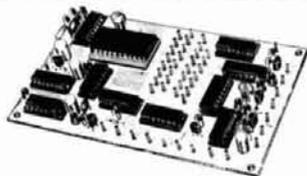
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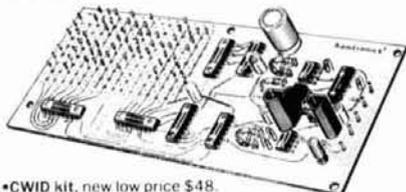
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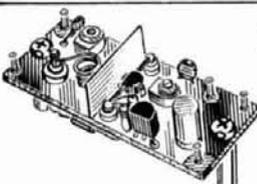
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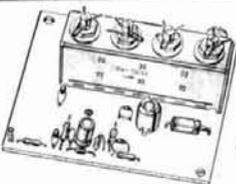
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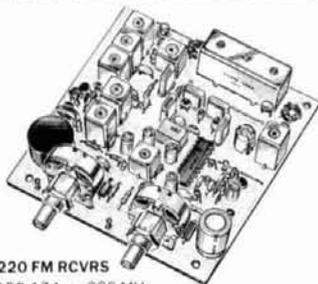
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	144-144.4	27-27.4
	146-148	28-30
	220-222	28-30
	220-224	50-54
	222-224	28-30
	432-434	28-30
	435-437	28-30
	432-436	144-148
	432-436	50-54
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		144-146	50-52
		144-146	28-30
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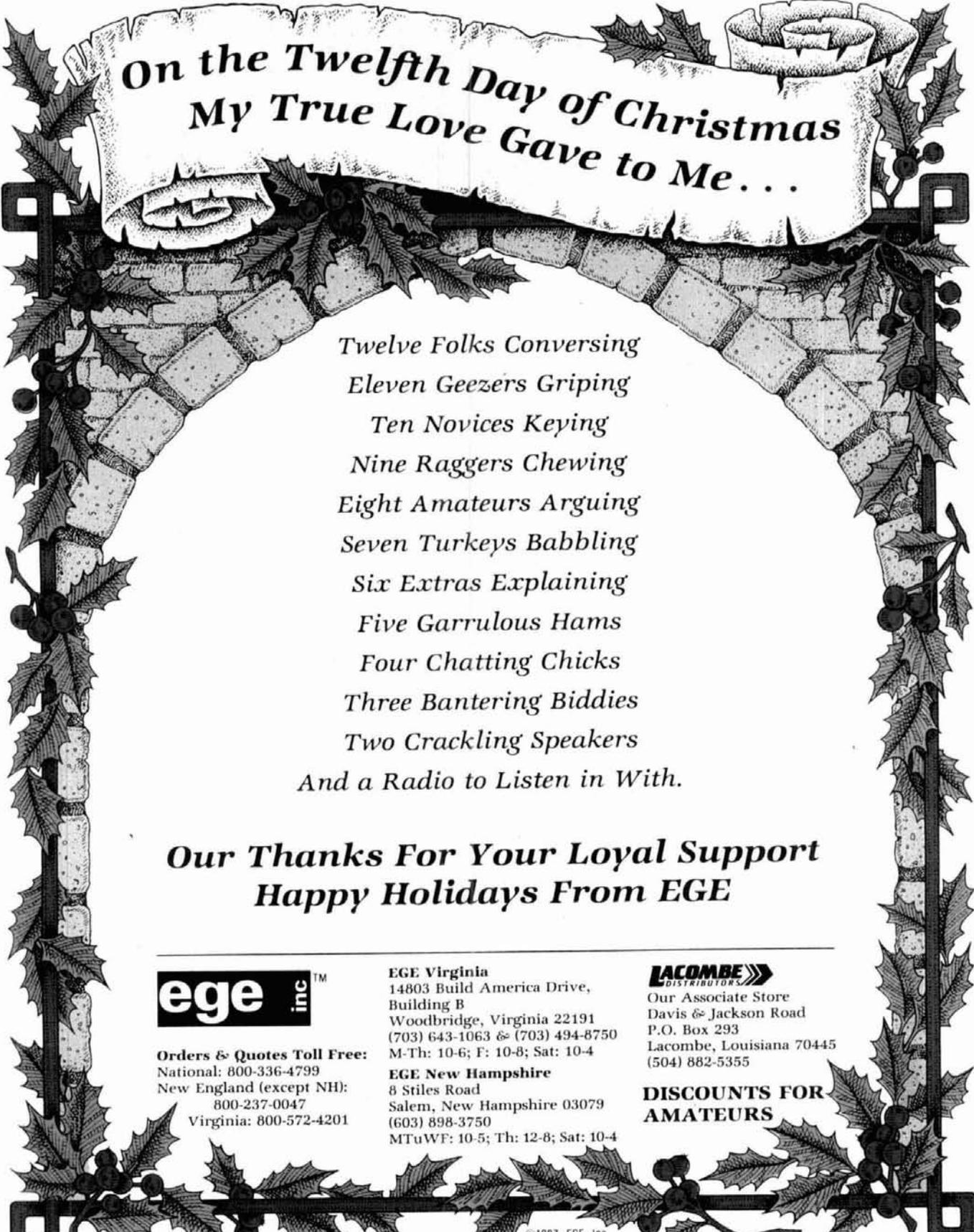
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The idea of handheld DX seems far-fetched, but it's actually very simple. The DX Handy is a battery powered (six penlight AA drycells included) SSB/CW transceiver with two watts output. DX Handy can also use nicad rechargeable batteries, or be powered with 9 VDC.

Two variable crystal oscillators (VXOs), each with 50 KHz range, can be selected with a top panel switch. Crystals for 28.250 to 28.300 and 28.300 to 28.350 Mhz are included, and other crystal ranges for the 10 meter band are also available at a nominal cost.

CW operation can be by either the built-in push button or with an external key or keyer. External speaker and microphone jacks are also provided, and the telescoping antenna is included. The DX Handy also has a top panel S-meter/ output power meter and an effective noise blanker circuit. DX Handy is housed in an attractive gray metal case comparing in size to popular VHF FM handhelds.

Ten meters is coming back strong. With DX Handy all amateurs, novice to extra class, can enjoy the thrill of working handheld DX.

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## Specifications

### General

- Frequency Coverage: Any two 50 KHz segments in the 28.0–29.0 MHz Amateur Band (28.25–28.30 and 28.30–28.35 MHz supplied)
- Frequency Control: VXO provides 50 KHz of continuous tuning with a single crystal
- Frequency Stability: Within  $\pm 500$  Hz from a cold start
- Antenna: 50 Ohms Unbalanced, BNC connector
- Power Requirement: 8.4–9.0 VDC  
(Included): 6-AA Dry Cells (1.5 volt/cell) = 9.0 VDC  
(Optional): 7-AA NiCads (1.2 Volt/cell) = 8.4 VDC
- Current Drain: Receiving - Approx. 70 mA  
Transmitting - Approx. 620 mA
- Dimensions: (W) 66mm  $\times$  (H) 39mm  $\times$  (D) 142mm
- Weight: 710 Grams (1 lb. 9 oz.) with batteries and antenna

### Transmitter

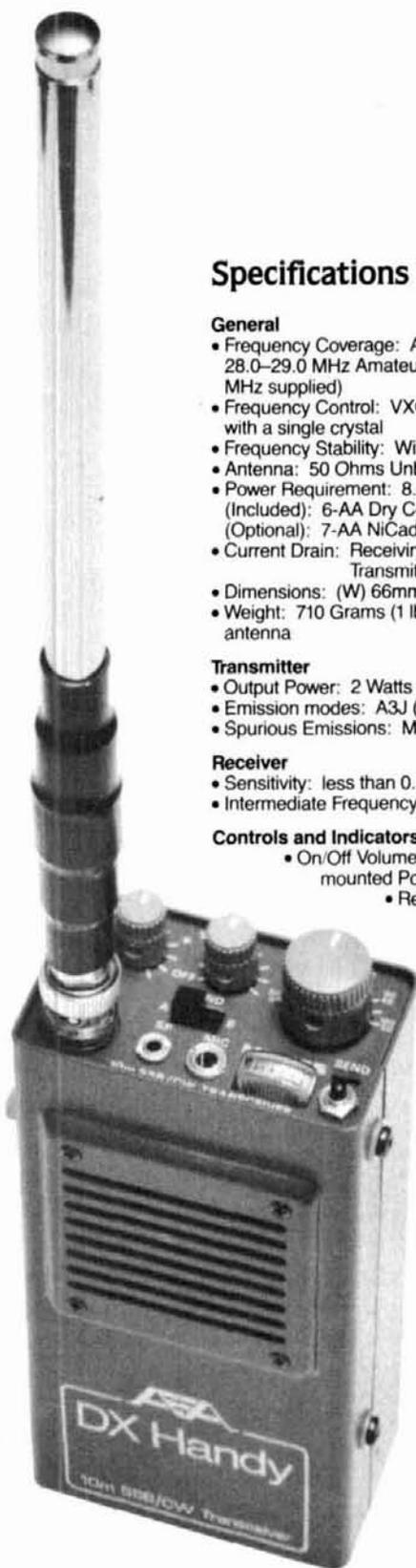
- Output Power: 2 Watts at 9.0 VDC
- Emission modes: A3J (USB) and A1 (CW)
- Spurious Emissions: More than 40 dB down

### Receiver

- Sensitivity: less than 0.5  $\mu$ V for 15 dB S/N
- Intermediate Frequency: 11.2735 MHz

### Controls and Indicators

- On/Off Volume control Top mounted Potentiometer
  - Receiver Incremental Tuning (RIT): Top mounted Potentiometer with center off detent position
- Frequency: Top mounted 50 KHz VXO
- Frequency Range: Top mounted 2-position switch
- Noise Blanker: Top mounted On/Off switch
- S/Rf meter: Top mounted S/Rf meter
- Built in CW key: Top mounted momentary switch
- External Speaker output: Top mounted  $\frac{1}{16}$ " phone jack
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- Antenna Connector: Top mounted Female BNC
- Transmit Indicator: Top mounted Transmit LED
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- External Power: Bottom mounted 2.1 mm coaxial
- External key input: Bottom mounted  $\frac{1}{16}$ " phone jack
- Mode Selector Switch: Bottom mounted 2-position switch
- Charge/External Power: Bottom mounted 2-position switch selecting 12 VDC external power function

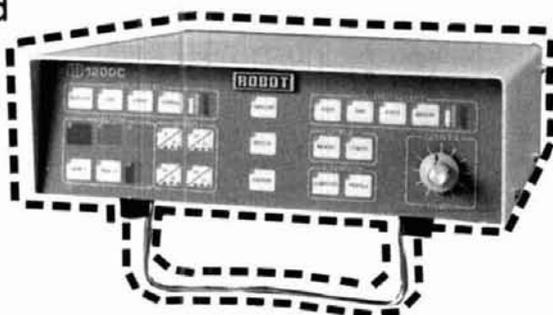


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## CONFERENCE PROCEEDINGS

**21st Central States VHF Society Conference** held in Arlington, Texas, July 23-26, 1987. 28 papers covering everything from use of TVRO dishes for moonbounce to a solid state amplifier for 5.7 GHz. 166 pages.

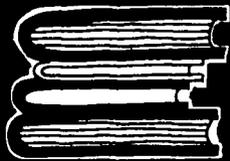
**6th ARRL Computer Networking Conference** held in Redondo Beach, California, August 29, 1987. 29 papers (approximately 150 pages) will appear in the proceedings booklet. Copies will be available at the conference or from ARRL after September 1.

**MICROWAVE UPDATE 1987** held in Estes Park, Colorado, September 10-13, 1987. 15 papers (approximately 100 pages) appear in the proceedings booklet. Copies will be available at the conference or from ARRL after September 14.

Proceedings booklets are \$10.00 each plus \$2.50 per order for postage and handling (\$3.50 for UPS.)

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THE AMERICAN RADIO RELAY LEAGUE  
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# ELMER'S NOTEBOOK

Tom McMullen, W1SL

## the 1200-MHz band

This month I'll explore some of the activities and peculiarities of the 1200-MHz (23 cm) band, and give you a tip on how to become a very popular person with your local UHF crowd.

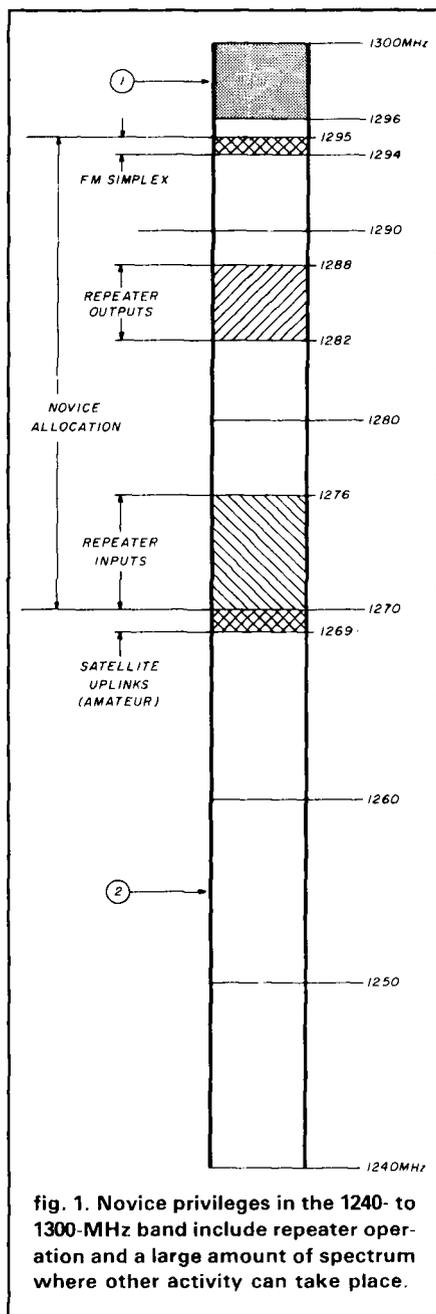
It wasn't too long ago that the 1200-MHz band was a real challenge for technically sharp Amateurs; getting a few milliwatts of stable power was difficult, and getting several watts required a whole bench full of tubes in cavities, heavy power supplies, blowers to keep it all cool, and enough spare surplus triodes to inflate the price of silver beyond reason. How things have changed!

A sketch of the 23-cm band is shown in **fig. 1**; note that the portion in which Novices can operate covers a large chunk of territory — almost half the band.

## what's happening?

This is another band in which Novices can use repeaters, and perhaps one of its most promising activities. The power limitation of 5 watts PEP (peak envelope power) shouldn't create hardship at all. Any decent repeater on this band will have a high-gain, non-directional antenna, and it should be able to hear a 5-watt mobile or hand-held unit for several miles. Since a repeater transmitter can operate with many watts of output, the higher power level plus the antenna gain will assure full-quieting signals into any transceiver it can hear.

Repeater channels for fm on the 1200-MHz band are 25 kHz apart, with inputs starting at 1270.05 and continu-



**fig. 1.** Novice privileges in the 1240- to 1300-MHz band include repeater operation and a large amount of spectrum where other activity can take place.

ing through 1276 MHz. Output frequencies are 12 MHz higher, from 1282 through 1288 MHz. There's room for simplex channels between 1294 and 1295 MHz, again with 25-kHz spacing recommended. There's plenty of room between 1276 and 1282, and between 1288 and 1294 for other modes, which I'll discuss later.

Adopted by the ARRL Board of Directors, this band plan has been widely publicized. Local groups may have different ideas, however, so be sure to check what's available before locking into a range of frequencies.

## equipment

A look through the advertisements in any Amateur magazine shows that there are several choices for Novices to use on 1200 MHz. One notable fm unit is the IC-12AT hand-held unit from ICOM. It has 1-watt output, and has a sensitivity of  $0.32 \mu\text{V}$  for 12-dB SINAD (and that's pretty good, considering that in the "weak-signal" work of only a dozen years ago, anything that could hear  $0.5 \mu\text{V}$  was considered high tech!). One caution, however: current ICOM literature shows the IC-12AT (American version) available with 10, 20, 30, 40, or 50 kHz steps. Their IC-12E (European version) is available with 12.5, 25, 37.5, 50, or 62.5 kHz channel spacing. Be sure the one you get will fit the channel spacing available in your area.

There are a couple of mobile/portable units available: Kenwood's TR-50 (with 1-watt output) and ICOM's IC-120 (also with 1-watt output). Both units can be used mobile, or, given

their relatively low battery-power requirements, portable with a small battery pack.

ICOM also offers a repeater, the IC-RP1210. Novices can't be owners or control operators of repeaters, naturally, but I hope some Elmers or Technicians (who can also be Elmers) will get some ideas. This repeater provides inputs from 1271.02 to 1272.98 MHz, with outputs 20 MHz higher — i.e., 1291.02 to 1292.98 MHz. Output is 10 watts. It will work from either 117V/240V ac, or from 13.8V dc.

Then there's ICOM's IC1271. Again, it has too much power output (10 watts) for the Novice, but it's nice to know about when thinking of upgrading. It's a CW/SSB/fm transceiver, and has all the bells and whistles you'll need for OSCAR, contest, or other weak-signal work. It works from a 13.8-Vdc supply, so it's a good candidate for mobile or home use.

### is fm all there is?

There's plenty of other activity going on in this part of the spectrum, and a look at the VHF/UHF/microwave contest scores in *QST* shows quite a few stations adding to their total by using 1296-MHz equipment. This usually comes under the heading of weak-signal work, and there's equipment available for that, too. Note that although equipment shown in most advertisements is listed as 1296-MHz gear, it works at other frequencies too, and usually won't need any adjustment if you put it to work just below 1295. It will require only minor tweaking if you want to use it between 1288 and 1294 MHz.

Weak-signal modes are CW or SSB, and most stations use their existing hf or VHF gear along with converters or transverters (transmitting/receiving converters) for 1200-MHz work. A popular line of such converters and transverters is produced by Microwave Modules. Among the equipment offered is the MMT 1296/144G — a 2-watt output transverter that uses a 144-MHz transceiver as its transmitting and receiving i-f; the NMK 1296/144 receiving converter that uses your

2-meter receiver tuned to the i-f output; and the MMG 1296 MHz receiving preamplifier to provide more gain and low noise ahead of a converter. Microwave Modules also has other units with more power capability for when you upgrade.

Most of the test equipment available in the usual ham workshop will function just as well at 1290 MHz, with the possible exception of a power/SWR meter. Here, the Bird series of wattmeters with plug-in elements offers an accurate means of checking your transmitter power output and antenna SWR.

Frequency counters, too, have arrived in this part of the spectrum: the Optoelectronics model 1300H works up to 1.3 GHz (1300 MHz), and Ramsey offers the CT125 for this band.

### antennas

Although commercially-made antennas for this band are available, the selection isn't large. There is evidence of improvement, however. Of course, Kenwood and ICOM provide antennas to work with the equipment they sell, and Larsen has a mobile 1200-MHz antenna available. I've also noticed mobile and base-station/repeater antennas made by NCG Company. Some of the NCG units are dual-band, working at both 446 and 1200 MHz.

For weak-signal work, most people roll their own, and considering that the length of a half-wave element at 1290 MHz is approximately 4-3/8 inches, it isn't hard to put together a beam of respectable gain with a few pieces of aluminum.\*

The loop Yagi, which consists of several closed metal hoops mounted on a boom in the same manner that elements are in ordinary Yagi antennas, is a popular item among many enthusiasts. Down East Electronics,

\*A note for those who prefer to work with metric figures: the 1240-1300 MHz band is called the 23-cm band, which is one wavelength in space. A half-wave in space is then 11.5 cm, but the diameter of the metal rod used for an antenna element reduces the resonant length. Using the formula  $L \text{ (mm)} = 142,250/f \text{ (MHz)}$  gives a half-wave element dimension of 110.27 mm, or 11.03 cm, which is a good ball park figure to start with at 1290 MHz.

Spectrum International, and Mirage/KLM offer loop Yagis.

### the television question

Novices are permitted to use all available modes on the 1270-1295 band segment, and that includes television. The obvious precaution, however, is to be sure that television operation doesn't interfere with any repeater operation. A TV signal requires a lot of room — anywhere from 3 to 8 MHz, depending upon the equipment used. There's plenty of space for TV and other modes on the band, but the prudent operator will check to see where others are operating before putting a signal on the air.

The next thought that comes to mind is *How?* I haven't seen any ready-made 1200-MHz television transceivers offered in the Amateur publications. There are, however, 420-MHz television systems and components available. Getting a signal on the air involves applying the video-output signal to an rf amplifier to produce amplitude modulation, then feeding the rf signal through some filters to get rid of one sideband and then to the antenna. Another method is to apply a low-power (i.e., milliwatts) output from a 420-MHz TV generator to a transmitting converter, then mix it with a local oscillator to produce 1200-MHz output. Either way, getting a television station together isn't a terribly difficult procedure, and such a project can easily be explored by the technically adept Novice or Elmer.

### safety precautions

One of the reasons for the 5-watt limit for Novices on 1270 to 1295 MHz is the possibility of tissue damage from rf energy at these frequencies. The problem comes about because unlike 28- or 220-MHz energy, for example, 1200-MHz energy is concentrated in a small area. Look at it this way: if you're operating at 28.1 MHz and using a 1/4-wave whip, the output power is distributed along the length of the whip — approximately eight feet. The portion of it that your hand, arm, or head might intercept is small com-

pared to its total length. At 1200 MHz, however, the antenna length is 4 inches, which means that your hand can intercept most of the energy if you get too close. Even worse, your eye (which is very susceptible to rf damage) is of significant size compared with the energy distribution area, and can be severely damaged by exposure. Microwave ovens operate only 1000 MHz higher, at approximately 2300 MHz, and you know what they do to things in their rf fields.

Allowing newcomers to this part of the spectrum to become familiar with operating procedures and technical requirements at a power level low enough to reduce hazards is a very good move on the part of FCC.

A good precaution is to make sure that antennas are high enough so that they don't present any hazard, from either direct contact with their elements or from the concentrated energy (as in front of a high-gain Yagi) they emit.

## feed line losses

All transmission lines lose some of the energy they're carrying between the transmitter and the antenna, and the higher the operating frequency, the more they lose. At 1290 MHz, RG-8/U or RG-213/U cable loses 11 dB per 100 feet. That means that if you have 5 watts going into the cable at your transmitter, only 1 watt is reaching the antenna in an average run of 60 feet. Obviously, you should use the shortest feedline you can. Don't scrimp on quality. Foam RG-8/U isn't bad (it loses approximately 6 dB/100 feet) and 1/2-inch hardline is even better at approximately 3.5 dB/100 feet. Buy the best you can get, and use good, clean coaxial connectors. The type-N fitting is best, but where space is a problem, the BNC will serve.

As for using RG-58/U cable (with 22-dB loss per 100 feet), and the so-called UHF (SO-239/PL259) fittings, don't even think about it. These connectors do terrible things to the feedline SWR at 1200 MHz, and most are pretty good attenuators, too.

## signal attenuation

Normal atmospheric propagation holds no surprises as far as signal loss is concerned. Buildings will reflect 1200 MHz very well, as will some foliage. By the same token, foliage will absorb the signal, so getting an antenna up in the clear is very important. Mobile flutter (picket-fencing), caused by moving around, will be less noticeable because of the short distance between wavelength peaks and valleys.

One phenomenon that seems to work in a manner opposite from signal attenuation at 1200 MHz is called "ducting." This is caused by layers of air of different densities and moisture content forming channels that reach great distances — sometimes hundreds of miles. These channels seem to behave as waveguides, letting the signal bounce between layers with almost no loss until they pop out at the other end of the pipeline, often with S9+ strengths. Ducting seems to be more prevalent over or near large bodies of water.

Oddly enough, a higher-frequency signal such as 1200 MHz will come through very strong, even though a lower frequency such as 144 MHz won't do well at all. Many UHF enthusiasts have been surprised by scanning a "dead" band, only to have a voice from DX-land come booming out of the speaker.

## how to be a hero

Here's a way to become a very popular person. There are several contests a year involving VHF and UHF operation. Stations operating on the higher bands are always in great demand. For example, in the ARRL UHF Contest (usually in August), each contact on 1290 MHz counts as six points, and the total number of grid squares (see below) on each band becomes the multiplier. You can grab one of the portable rigs described earlier, a couple of spare battery packs or whatever, plus 10 or 12 feet of collapsible mast and a small beam antenna. Get to the highest place you can (a hilltop, a tall



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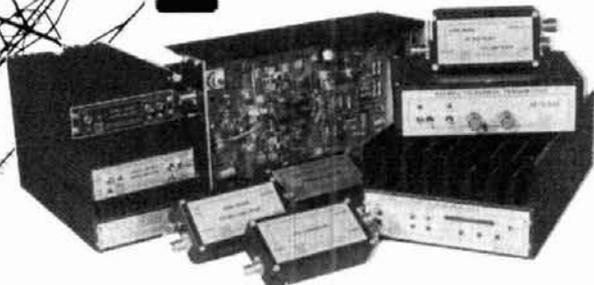


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building) and have a ball racking up the contacts. Many of the stations will be using a frequency very close to 1296.0 MHz, so you'll have to spread the word that you're only a MHz away at 1295, but once they know you're there, you'll have plenty of calls to answer. This contest includes 220 MHz too, so you could easily become a multi-band contest operator.

Another popular activity on UHF is filling in grid (locator) squares to earn points toward a certificate. A simple portable setup, with a medium-sized Yagi, operating from choice locations in some nearby grids will earn you points with the local VHF/UHF group. Get in on the fun yourself — see page 17 of W1JR's column in the July, 1987, issue of *ham radio* for a copy of the ARRL grid locator map, and start earning your own award. You'll need only 25 grid-square contacts to win your first certificate on 1290 MHz.

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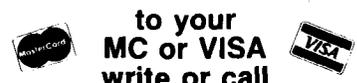
**MICHIGAN:** January 24. The Southfield High School ARC is sponsoring their 20th annual Swap & Shop, Southfield HS, 24657 Lahser, Southfield. Doors open 6 AM for exhibitors, public 8 AM to 3 PM. Admission \$3.00. 8' reserved tables \$20.00 in advance. Additional reserved tables \$10.00 each. All profits go toward Electronic Scholarships and to support Southfield HS ARC. For information, reservations: Robert Younker, Southfield High School, 24675 Lahser, Southfield, MI 48034.

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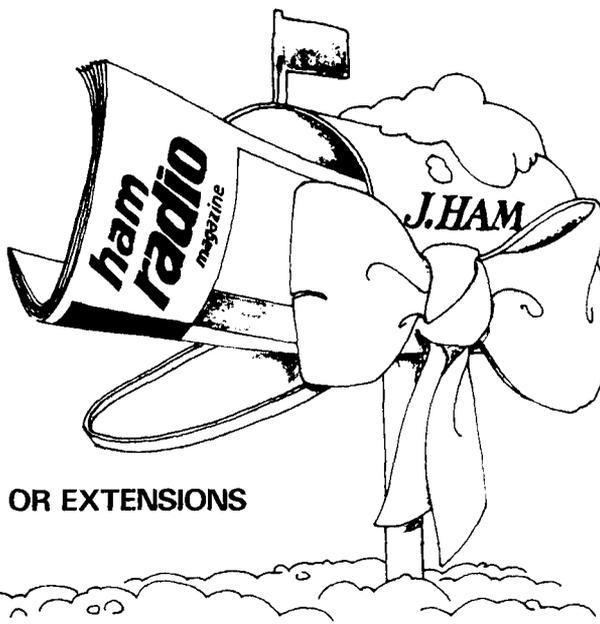
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# 1988 CALLBOOKS



## The "Flying Horse" sets the standards

Continuing a 67 year tradition, we bring you three new Callbooks for 1988.

The North American Callbook lists the calls, names, and address information for 478,000 licensed radio amateurs in all countries of North America, from Canada to Panama including Greenland, Bermuda, and the Caribbean islands plus Hawaii and the U.S. possessions.

The International Callbook lists 481,000 licensed radio amateurs in countries outside North America. Its coverage includes South America, Europe, Africa, Asia, and the Pacific area (exclusive of Hawaii and the U.S. possessions).

The 1988 Callbook Supplement is a new idea in Callbook updates, listing the activity in both the North American and International Callbooks. Published June 1, 1988, this Supplement will include thousands of new licenses, address changes, and call sign changes for the preceding 6 months.

The 1988 Callbooks will be published December 1, 1987. See your dealer or order now directly from the publisher.

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- General Coverage Receiver

## KENWOOD



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- 100% Duty Cycle
  - 100 memories
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  - Optional Built-in AT
- On Sale Now, Call For Price!

## KENWOOD



### TM-3530A

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- 220-225 MHz with 25 Watts
  - 7-Digit Telephone No. Memory
  - Direct Frequency Entry
  - 23-Channel Memory

## KENWOOD



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"FULL FEATURED 2m HT"

- 141-163 MHz Receive
- 144-148 MHz Transmit
- 2.5w Output (5w Optional)
- 10 Memories
- Built-in CTCSS Encoder
- Nine Types of Scanning



## YAESU



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- All Mode Transceiver
  - Dual VFO's
  - Full Break-in CW
  - 100% Duty Cycle
- CALL FOR BEST PRICE!

## YAESU



### FT-767GX HF/VHF/UHF BASE STATION

- Add Optional 6m, 2m & 70cm Modules
- Dual VFO's
- Full CW Break-in
- Lots More Features

## YAESU

### FT23/73R

- Zinc-Aluminum Alloy Case
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- 140-164 MHz, 440-450 MHz
- 600 MAH Standard Opt. 5w New "super handle"



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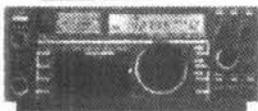


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220 MHz H.T.

- 5 Watts Output
- Battery Saver
- 10 Memories
- Multiple Scanning Routines
- Power Meter

## ICOM



### IC-735 "NEW"

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## ICOM



### IC-751A "NEW"

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- 32 Memories
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## ICOM



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- Full 25W, 5W low
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## ICOM



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### IC-03AT

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& ACCURACY**

**AC-DC • PORTABLE  
OPERATION**



#P-100

#1200H 1.2 GHz



#AC-1200  
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CHARGER

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The size, price and performance of these new instruments make them indispensable for technicians, engineers, schools, Hams, CBers, electronic hobbyists, short wave listeners, law enforcement personnel and many others.

**STOCK NO:**

- #1200HKC Model 1200H in kit form, 1-1200 MHz counter complete including all parts, cabinet, Ni-Cad batteries, AC adapter-battery charger and instructions ..... \$ 99.95
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- #1300HC Model 1300H factory assembled 1-1300 MHz counter, tested and calibrated, complete including Ni-Cad batteries and AC adapter/battery charger ..... \$150.00

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- #P-100 Probe, direct connection 50 ohm, BNC connector ..... \$18.00
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✓ 209

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1.3 GHz  
#1300H

# Decisions, decisions, decisions.

Should you choose one, two, or all three?

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You also get a high/low power switch, power meter, backlit display, 500-mAH battery, wall charger, and soft case. Plus a choice of many interchangeable options, including a VOX headset, fast charger, hard leather case, and plug-in subaudible tone encoder/decoder for controlled-access repeaters.

Let Yaesu's 220-MHz FT-109RH, 2-Meter FT-209RH and 440-MHz FT-709R give you the decided advantage in HT performance and upgrade ability. It may be the most enjoyable HT buying decision you ever make.

## 220 MHz



## 2 Meters



## 440 MHz



# YAESU

208

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...pacesetter in Amateur Radio

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- All modes built-in. LSB, USB, CW, FM and AM.
- Superior receiver dynamic range Kenwood DynaMix™ high sensitivity direct mixing system ensures true 102 dB receiver dynamic range.



- New Feature! Programmable band marker. Useful for staying within the limits of your ham license. For contesters, program in the suggested frequencies to prevent QRM to non-participants.
- Famous Kenwood interference reducing circuits. IF shift, dual noise blankers, RIT, RF attenuator, selectable AGC, and FM squelch.

- M. CH/VFO CH sub-dial. 10 kHz step tuning for quick QSX at VFO mode, and UP/DOWN memory channel for easy operation.
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- 31 memory channels. Store frequency, mode and CW wide/narrow selection. Split frequencies may be stored in 10 channels for repeater operation.
- RF power output control.
- AMTOR/PACKET compatible!
- Built-in VOX circuit.
- MC-43S UP/DOWN mic. included.

#### Optional Accessories:

- AT-130 compact antenna tuner • AT-250 automatic antenna tuner • HS-5/HS-6/HS-7 headphones • IF-232C/IF-10C computer interface
- MA-5/VP-1 HF mobile antenna (5 bands)
- MB-430 mobile bracket • MC-43S extra UP/DOWN hand mic. • MC-55 (8-pin) goose neck mobile mic. • MC-60A/MC-80/MC-85 disk mics.
- PG-2S extra DC cable • PS-430 power supply
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Complete service manuals are available for all Kenwood transceivers and most accessories. Specifications, features, and prices are subject to change without notice or obligation.

# KENWOOD

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