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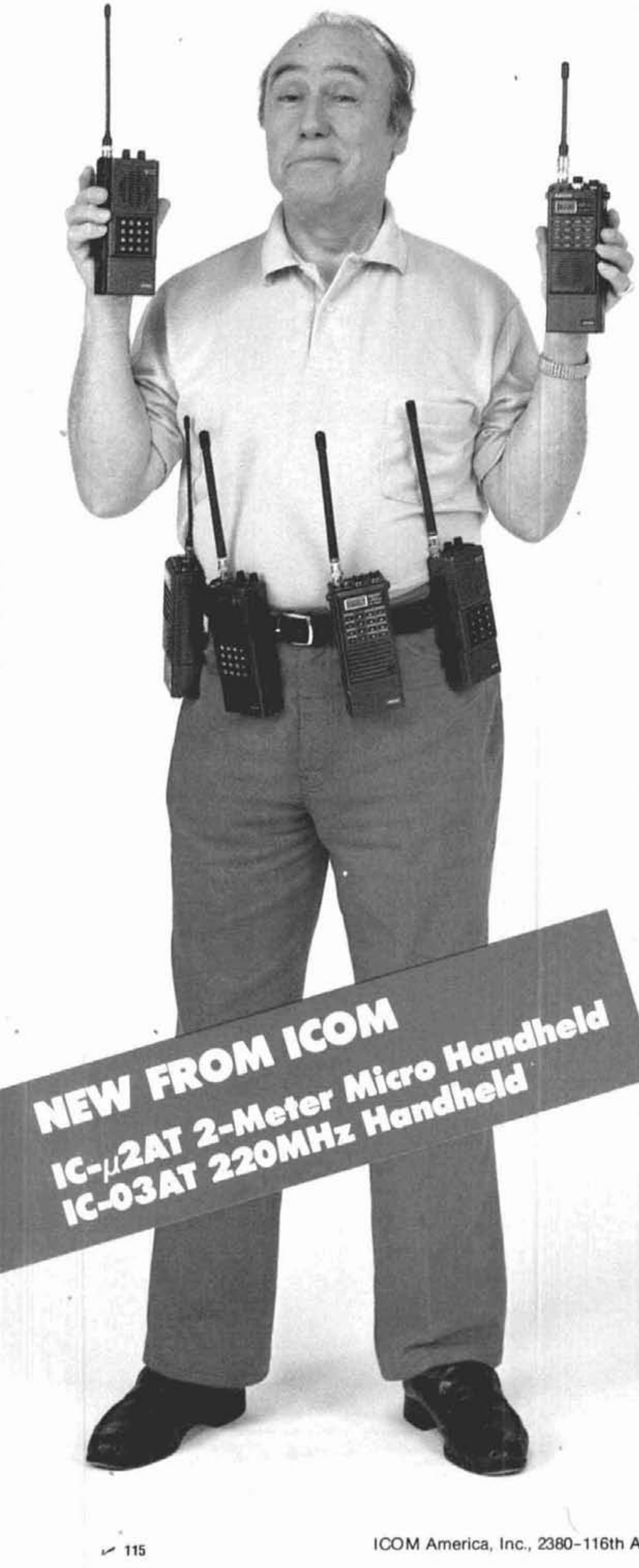
ham radio magazine

hr — focus on communications technology

annual RECEIVER issue



ICOM HAND HELDS

SURROUND YOURSELF WITH THE BEST!

Reliable. ICOM's extensive line of reliable, field-proven handhelds and interchangeable accessories give you the most options for handheld communications. 2-meter, 220MHz, 440MHz or 1.2GHz...ICOM has your frequency covered.

2-Meters. For 2-meter coverage, ICOM offers the IC-02AT and IC-2AT handhelds. The versatile IC-02AT covers 140.000–151.995MHz, the IC-2AT 141.500–149.995MHz...both include frequencies for MARS and CAP operation. The IC-02AT features an LCD readout, 32 PL tones standard, DTMF, direct keyboard entry, three watts output, (optional 5 watts output with IC-BP7 battery pack), 10 memories and three scanning functions. The IC-2AT, the most rugged handheld on the market, has a DTMF pad, 1.5 watts output and thumbwheel frequency selection. The IC-2A is also available and has the same features as the IC-2AT except DTMF.

220MHz. To get away from the crowd, ICOM has the IC-3AT 220.000–224.990MHz handheld with 1.5 watts output, thumbwheel selection and a DTMF pad.

440MHz. For 440MHz operation, ICOM has two handhelds available, the versatile IC-04AT and the IC-4AT. The IC-04AT and IC-4AT offer full coverage from 440.000–449.995MHz. The IC-04AT includes an LCD readout, 32 PL tones standard, DTMF direct keyboard entry, three watts output, (optional 5 watts output with IC-BP7 battery pack), 10 memories and three scanning systems. The IC-4AT has a DTMF pad, thumbwheel selection and 1.5 watts output.

1.2GHz. ICOM announces the IC-12AT 1260.000–1299.990MHz handheld, the first 1.2GHz handheld available. The IC-12AT features 10 memories, an LCD readout, DTMF direct keyboard entry, two scanning systems and one watt output.

Accessories. A variety of interchangeable accessories are available, including the IC-BP8 800mAH long-life battery pack, HS-10 boom headset, CP1 cigarette lighter plug and cord, HM9 speaker mic (for IC-02AT, IC-04AT and IC-12AT), leather cases, and an assortment of battery pack chargers.

ICOM

First in Communications

✓ 115

ICOM America, Inc., 2380–116th Ave NE, Bellevue, WA 98004 **Customer Service Hotline (206) 454-7619**
3150 Premier Drive, Suite 126, Irving, TX 75063
ICOM CANADA, A Division of ICOM America, Inc., 3071 – #5 Road, Unit 9, Richmond, B.C. V6X 2T4 Canada

All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions. HH986

PRICE REDUCED

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

KPC-2

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

Suggested Retail ~~$ 219.00~~ $169

Features

- AX.25 Version 2.0 software
- Supports multiple connects, up to 26
- RS232 or TTL compatible (C-64 too!)
- HF modem included! (both U.S. and European tones)
- Carrier Detect, and software squelch operation
- FCC Part 15 Certified
- Kantronics industry standard extruded aluminum case
- Power supply and cabling included
- All EPROM software is Kantronics sourced and copyrighted
- 128K EPROM, 16K RAM — expandable to 32K, 4K EEPROM.
- Advanced software HDLC routines, eliminating costly out-of-date chips

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- Extensive dealer network
- In-house programmers/engineers
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- Periodic software updates (like 2.0!)

Want more information on Packet?
Contact us about our new **PACKET VIDEO.**
$ 25.00 (shipping included), VHS or BETA format.

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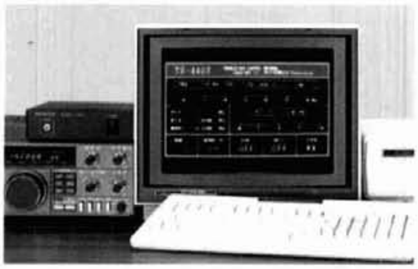
All New Compact HF

"DX-citing!"

TS-440S Compact high performance HF transceiver with general coverage receiver

Kenwood's advanced digital know-how brings Amateurs world-wide "big-rig" performance in a compact package. We call it "Digital DX-citement"—that special feeling you get every time you turn the power on!

- **Covers All Amateur bands**
  General coverage receiver tunes from 100 kHz – 30 MHz. Easily modified for HF MARS operation.
- **Direct keyboard entry of frequency**
- **All modes built-in**
  USB, LSB, CW, AM, FM, and AFSK. Mode selection is verified in Morse Code.
- **Built-in automatic antenna tuner (optional)**
  Covers 80-10 meters.
- **VS-1 voice synthesizer (optional)**
- **Superior receiver dynamic range**
  Kenwood DynaMix™ high sensitivity direct mixing system ensures true 102 dB receiver dynamic range. (500 Hz bandwidth on 20 m)
- **100% duty cycle transmitter**
  Super efficient cooling permits continuous key-down for periods exceeding one hour. RF input power is rated at 200 W PEP on SSB, 200 W DC on CW, AFSK, FM, and 110 W DC AM. (The PS-50 power supply is needed for continuous duty.)
- **Adjustable dial torque**
- **100 memory channels**
  Frequency and mode may be stored in 10 groups of 10 channels each. Split frequencies may be stored in 10 channels for repeater operation.
- **TU-8 CTCSS unit (optional)**
  Subtone is memorized when TU-8 is installed.
- **Superb interference reduction**
  IF shift, tuneable notch filter, noise blanker, all-mode squelch, RF attenuator, RIT/XIT, and optional filters fight QRM.
- **MC-43S UP/DOWN mic. included**
- **Computer interface port**
- **5 IF filter functions**
- **Dual SSB IF filtering**
  A built-in SSB filter is standard. When an optional SSB filter (YK-88S or YK-88SN) is installed, **dual** filtering is provided.
- **VOX, full or semi break-in CW**
- **AMTOR compatible**



Optional accessories:
• AT-440 internal auto. antenna tuner (80 m – 10 m) • AT-250 external auto. tuner (160 m – 10 m) • AT-130 compact mobile antenna tuner (160 m – 10 m) • IF-232C/IC-10 level translator and modem IC kit • PS-50 heavy duty power supply • PS-430/PS-30 DC power supply • SP-430 external speaker • MB-430 mobile mounting bracket • YK-88C/88CN 500 Hz/270 Hz CW filters • YK-88S/88SN 2.4 kHz/1.8 kHz SSB filters • MC-60A/80/85 desk microphones • MC-55 (8P) mobile microphone • HS-5/6/7 headphones • SP-40/50B mobile speakers • MA-5/VP-1 HF 5-band mobile helical antenna and bumper mount • TL-922A 2 kw PEP linear amplifier • SM-220 station monitor • VS-1 voice synthesizer • SW-100A/200A/2000 SWR/power meters • TU-8 CTCSS tone unit • PG-2S extra DC cable.

Kenwood takes you from HF to OSCAR!

KENWOOD

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

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contents

We're sorry to report that pressing international business commitments will make it impossible for W6MGI to continue his monthly column, "The Guerri Report." But we're glad to say that Ernie has promised to take time from his busy schedule to write occasional articles. Watch these pages... Ed.

REFLECTIONS

examining the EPA's rf radiation limit proposals: what do they mean?

The United States Environmental Protection Agency, concerned with the public well-being, recently released a notice that explores options to prevent adverse health effects that may be associated with exposure to rf radiation. Printed in the July 30, 1986 Federal Register, pages 27318-27339 this notice presented an historical overview of previously proposed and/or accepted radiation limitations (for example, the ANSI standards of 1966 and 1982) as well as reports of various studies involving experiments on laboratory animals. Most importantly, it built a case for a new set of levels to be considered for implementation in this country.

There are important reasons for this action at this time. First, several states have independently enacted legislation setting their own limits on what they consider to be acceptable radiation levels. A uniform nationwide standard, especially one that utilizes the considerable facilities and expertise of the responsible federal agencies, would appear to be a better approach. Second, as a result of growth in the communications industries, public exposure to all forms of rf radiation is greater than ever before. (According to the recent EPA notice, there are approximately 4600 a-m stations, 4400 fm stations and 1100 tv stations in the United States.)

But what is an acceptable level? Conversely, what is too high? The question is simple enough, but the answer depends on many variables. One of the first standards (ANSI, 1966) indicated that a power density of 10 milliwatts per square centimeter across the entire rf spectrum was a reasonable limit. In 1982 ANSI released a revised standard that took into account different levels of absorption versus frequency in the human body, which resonates somewhere between 30 and 300 MHz, depending on size, shape factor, and polarization. The revised standard called for a power density level of 1 milliwatt per square centimeter in that particular frequency range.

As a result of continuing research and the need for a nationally-accepted standard, the EPA is calling for comments on the next generation of proposed acceptable levels. This time, a new term has been defined: SAR or Specific Absorption Rate (watts/kilogram). Mathematically a function of tissue conductivity, electric field strength in tissue, and tissue density, it can be related to our old units of measure — for example, power density and electric and magnetic field intensities.

The EPA proposal discusses four options. The first three indicate specific levels of SAR; the fourth basically sets no level but stresses the importance of continued research. The least stringent option, Number 3, calls for a maximum SAR not to exceed 0.4 watts per kilogram of mass. I believe that's roughly equivalent to our old ANSI standard of 10 mw/cm^2. Options Number 2 and 1 are correspondingly more stringent, calling for SARs not to exceed 0.08 and 0.04 watts/kg, respectively.

There is considerable evidence to indicate that above an SAR of 4 watts/kg, the core temperature of the human body increases, leading to health complications. Notice that the EPA's option Number 3 (the least stringent) is one tenth of this amount. However, pre-existing health conditions such as poor circulation and normally elevated body temperatures reduce the level of acceptable SAR.

At this point you're probably wondering, "How does this affect me?" It's a good question, but I'm not sure of the answer. The EPA specifically proposed (on page 27334) to exclude radiation from "consumer electronic products" from the proposed standard. I think that category includes our transmitters, linears, and other equipment. The EPA's primary aim is to protect the public from radiation from high-power rf sources — mainly a-m, fm, and tv stations running many kilowatts. But perhaps this might be added incentive for the few "superpower boys" out there to either cut back or move their families away from the high rf fields.

In this short space it's not possible to cover in detail many of the points brought out in the EPA notice. I highly recommend that interested readers obtain a copy of these 22 pages and specifically review several of the 62 cited references, as well as an excellent article on the subject ("The Microwave Problem," by Kenneth R. Foster and Arthur W. Guy) that appeared in the September, 1986 issue of *Scientific American*.

The conversions from power source to rf radiation levels to SARs are derivable or well-documented. Through its investigations and those of other agencies, the EPA hopes to bridge that last gap in understanding — the one that would relate SARs to health — and thereby provide a nationwide rf radiation standard that we can live with.

— Rich Rosen, K2RR
Editor-in-Chief

KENWOOD

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Good for Satellite Digital QSOs

Matching Pair

Look for FUJI and PHASE III-C

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

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

- **Highly stable dual digital VFOs.** The 10 Hz step, dual digital VFOs offer excellent stability through the use of a TCXO (Temperature Compensated Crystal Oscillator).
- **Large fluorescent multi-function display.** Shows frequency, RIT shift, VFO A/B, SPLIT, ALERT, repeater offset, digital code, and memory channel.
- **40 multi-function memories.** Stores frequency, mode, repeater offset, and CTCSS tone. Memories are backed up with a built-in lithium battery.
- **Versatile scanning functions.** Programmable band and memory scan (with channel lock-out). "Center-stop" tuning on FM. An "alert" function lets you listen for activity on your priority channel while listening on another frequency. **A Kenwood exclusive!**
- **RF power output control.** Continuously adjustable from 2 to 25 watts.
- **Automatic mode selection.** You may select the mode manually using the front panel mode keys. Manual mode selection is verified in International Morse Code.
- **All-mode squelch.**
- **High performance noise blanker.**
- **Speech processor.** For maximum efficiency on SSB and FM.
- **IF shift.**
- **"Quick-Step" tuning.** Vary the tuning characteristics from "conventional VFO feel" to a stepping action.
- **Built-in AC power supply.** Operation on 12 volts DC is also possible.
- **Semi break-in CW, with side tone.**
- **VS-1 voice synthesizer (optional)**

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

Optional accessories.

- IF-10A computer interface
- IF-232C level translator
- CD-10 call sign display
- SP-430 external speaker
- VS-1 voice synthesizer
- TU-5 CTCSS tone unit
- MB-430 mobile mount
- MC-60A, MC-80, MC-85 deluxe desk top microphones
- MC-48B 16-key DTMF, MC-43S UP/DOWN mobile hand microphones
- SW-200A/B SWR/power meters:
  SW-200A 1.8-150 MHz
  SW-200B 140-450 MHz
- SWT-1 2-m antenna tuner
- SWT-2 70-cm antenna tuner
- PG-2U DC power cable

Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.
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presstop de W9JUV

THE "ELECTRONIC COMMUNICATIONS PRIVACY ACT" WAS MOVING RAPIDLY toward Senate approval at presstime and may even have become law by the time this sees print. On September 19 the Senate Judiciary Committee unanimously approved the latest version of S-2575 after only 25 seconds consideration! Fortunately the Senate version, though still objectionable for its basic philosophy that U.S. citizens can't listen to any service or frequency that the government doesn't want them to, has been even more tempered than the version passed by the House in June. The bill now permits monitoring any radio communication "for the use of the general public" as well as cordless phones, marine or aircraft, Amateur, CB, GMRS, government, law enforcement, Civil Defense, private land mobile, or public safety (police and fire) communications which are "readily accessible to the public."

Two Last-Minute Amendments Further Limit The Senate Bill by eliminating criminal penalties for intercepting (without malicious intent) broadcast remote pickup stations and by reducing the penalty for first interception of public land mobile services (cellular, older car phones, and voice paging) to a $500 fine. These worthwhile amendments, proposed by the Association of North American Radio Clubs, were introduced by Senator Paul Simon (D--IL).

If All Goes Smoothly The Bill Could Move Quickly through the Senate Subcommittee on Communications and on to the Senate floor, where it could be voted on before the end of the month. However, columnist Jack Anderson's September 23 syndicated column took a very hard swing at the bill, blasting the cellular telephone industry for having sold both Congress and cellular users a bill of goods on the legislation and "cellular privacy." Its very timely appearance could well induce some Senators to raise enough questions about the bill to slow up, if not derail, its passage. Furthermore, though Senator Goldwater hasn't made his views on the bill public, it's considered unlikely to win his endorsement.

A PRIVATELY ADMINISTERED AMATEUR CALLSIGN PROGRAM is looking more and more likely, with not only ARRL but several other groups interested in taking on the job. The idea has actually been under consideration at the Commission for some time, and FCC officials discussed it at length during the FCC Forum at the recent ARRL National Convention.

Under Its Plan FCC Would Issue Only Basic 2x3 Initial Callsigns to newly licensed Amateurs. An Amateur who upgraded could continue to use that callsign or go to the "Callsign Administrator" who -- for a fee -- would issue a new callsign appropriate to the new license class. The FCC estimates charges for each callsign upgrade would be in the $20-30 range. There would also be an initial "grace period" during which those who wanted to recover a previously held callsign or one formerly held by a deceased family member could request and receive that callsign.

The FCC Is Quite Interested In Moving Forward On The Proposal and could decide to solicit comments on it in a Notice of Inquiry or even "PRB-3" before the year ends.

GEO-SYNCHRONOUS "PHASE 4" AMATEUR SATELLITES are being seriously considered by AMSAT. A just-completed "Phase 4 Technical Study Plan" by AMSAT Engineering VP W3GEY proposes a pair of such birds, positioned above the equator so as to provide a "footprint" reaching from Japan and Australia eastward to most of Europe, Africa and the Middle East.

2-Meter Plus 70, 24 And 13 cm Transponders with a wide variety of capabilities would be carried by the birds, which would be aimed at a much broader segment of Amateur Radio than ever before with a strong "Public Service" orientation. It's possible that even mobile or hand-held radios would be capable of working through the new satellites.

Next Step For The Ambitious Proposal Is A Study And Planning Period of a year or so; launch would be targeted for 1990-91. Preliminary cost estimates are in the million-dollar range, meaning that very broad-based international Amateur support will be required.

NASA's 1995 "Space Station" Plan May Include A Built-In Amateur Station as a result of a recent meeting of NASA, AMSAT, and ARRL representatives. Possibilities look very good, and a working group has been set up to make a formal proposal to NASA next year.

OSCAR 10's Salvage Efforts Continue To Encourage Recovery Workers, though an upcoming solar panel eclipse and resulting battery discharge will soon put it temporarily out of service anyway. When sunlight does return to recharge its batteries, the chances that OSCAR 10 will be able to be brought back to useful life are estimated at no better than 50-50.

AMSAT's Fourth Annual Space Symposium And Annual Meeting will be held at the Dallas/Ft. Worth Hilton November 7-9. Call AMSAT at (301) 589-6062 for details.

FIRST RECIPIENT OF THE "AEA AMATEUR AMBASSADOR AWARD" is Mary Duffield, WA6KFA, who was recognized for her work with the Redwood Youth Foundation, which has introduced hundreds of youngsters to Amateur Radio. The retired telecommunications educator received the honor and an accompanying $1000 cash award at ARRL's San Diego National Convention. Congratulations!

U.S. AMATEUR POPULATION IS STILL GROWING, ALTHOUGH VERY SLOWLY. Most encouraging is the dropout rate, which has decreased steadily from an average of 1478 per month in 1984 to 1210 per month in 1985 and only 910 per month so far this year. At the end of August the total U.S. Amateur population was 421,077.

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NEW!

Ultimate Affordable HT!

TH-205AT

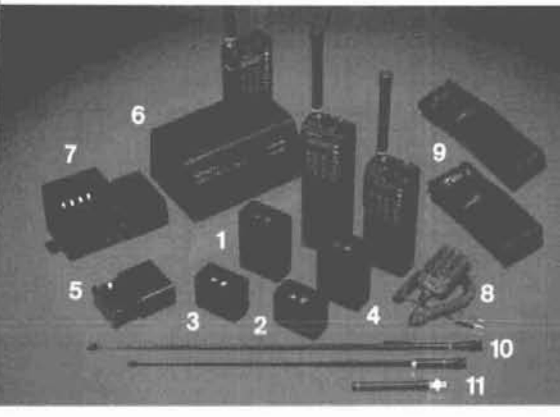
Affordable 5-watt hand-held transceiver. Ultimate Affordability!

It's here now! The affordable, "Kenwood Quality" hand-held transceiver. Standard features include a large, easy-to-read LCD display, wide-range power requirements (operates on 7.2 VDC–16 VDC), 3-channel memory, built-in battery saver circuit, and, when operated on 12 VDC, a robust five watts of power! The die-cast metal rear panel/heat sink assures cool, reliable operation. Receiver frequency coverage from 141–163 MHz is also standard—you can even listen to the "weather channels" at 162.40 or 162.55 MHz!

- Monitor switch—to check frequency when PL encode/decode switch is on.
- Extended frequency coverage for certain MARS and CAP operations.
- 3 memory channels store frequency and offset. And so easy to use! Simply press the memory channel-number to recall your favorite channels!
- Night light, offset/reverse.
- 16-key DTMF pad for repeater autopatch is standard.

- NEW! Twist-Lok Positive-Connect™ battery case. A wide range of quick-change commercial duty battery packs are available.

- 12 VDC input terminal—allows direct mobile or external power supply operation. When 12 VDC is applied, power output increases to **5 watts!**
- Heavy-duty final amplifier and heat sink. The die-cast rear panel assures reliable operation. With the optional 12-volt PB-1 battery pack, the TH-205AT provides 5 W output. The standard 8.4 volt PB-2 provides 2.5 W output. (300 mW low power).
- Large, easy-to-read LCD display. Frequency, offset, memory channel, TX, RX, and battery indicator.
- Frequency UP/DOWN keys. Used to select frequency or scanning direction.
- Scan function key.
- Automatic battery saver circuit extends battery life. No buttons to push!
- Supplied accessories include: Rubber flex antenna, belt hook, 8.4 V, 500 mAH NiCd battery pack, wall charger.



Optional Accessories:

1) PB-1 12 V 800 mAh NiCd batt. pack (5 W output). **2)** PB-2 8.4 V 500 mAh NiCd batt. pack (2.5 W output). **3)** PB-3 7.2 V 800 mAh NiCd batt. pack (1.5 W output). **4)** PB-4 7.2 V 1600 mAh NiCd batt. pack (1.5 W output). **5)** BT-5 AA manganese/alkaline battery case. **6)** BC-7 Rapid charger for PB-1, 2, 3, or 4. **7)** BC-8 Battery charger for PB-1, 3 or 4. **8)** SMC-30 Speaker microphone. **9)** SC-12, SC-13 Soft cases. **10)** RA-3, RA-5 Telescoping antennas. **11)** RA-8B StubbyDuk antenna • TSU-3 CTCSS encode/decode unit • VB-2530 2 m, 25 W RF power booster • LH-4, LH-5 Leather cases • MB-4 Mobile bracket • BH-5 Swivel mount • PG-2V DC cable • PG-3C Filtered cigar lighter cord.

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

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AFFORDABLE PACKET RADIO FROM MFJ

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

MFJ-1270

$129^95

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

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

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

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

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

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

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

SUPER KEYBOARD

MFJ-496

$169.95

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

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

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

TRIPLE OUTPUT LAB POWER SUPPLY MFJ-4002 $149.95

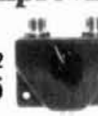
Lab quality power supply gives you plenty of voltage and current for all your analog and digital circuits. **3 completely isolated outputs**: 2 variable 1.5-20 VDC at 0.5 amp and a fixed 5 VDC at 1 amp. Connect in series or parallel for higher voltage and current. It's short circuit protected, has excellent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

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

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

2 KW COAX SWITCHES

MFJ-1702
$19.95



$29.95 MFJ-1701

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

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

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

ANTENNA CURRENT PROBE MFJ-206 $79.95

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

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

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

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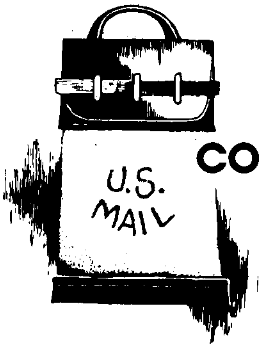


comments

something for everyone

Dear HR:

Credit should be given when it is due. The September issue of *ham radio* is outstanding for my tastes in technical literature. The spread of analog subjects of immediate interest to the dedicated Amateur was just right! Certainly, there should be something for everyone in the September issue.

I was especially attracted to and enlightened by the K1GQ article ("Analyzing 80-meter Delta Loop Arrays," page 10). Having been a loop enthusiast for many years, I found the Myers treatment of the subject to be the most definitive one I have read. His findings confirm many of my intuitive views about the various loop configurations. I am presently using a full-wave rectangular loop for 80 meters, corner-fed and erected vertically. It seems to perform better than the tilted delta loop I used for two years.

The W4UCH article, "Low-cost Spectrum Analyzer with Kilobuck Features" (page 82), was similarly stimulating. I find myself beset with anxiety to build a copy of his unit for use in my lab. The circuit is quite "sanitary" and to the point!

I enjoyed also the neat article by Mike Gruchalla concerning the NE5205 wideband amplifier (page 30). If time permitted such luxury, I would be immersed in component parts and flux fumes for some time, as I built each of the projects that caught my fancy in September *ham radio*. Keep it up, and try to maintain the good mix of topics for those of us who aren't driven by the present-day digital philosophy. The Amateur journals and *rf design* may represent the salvation of the rf/analog technology. The trade journals have surely lost sight of the importance of rf technology!

Doug DeMaw, W1FB/8
Luther, Michigan 49656

safety first

Dear HR:

N1ACH's editorial emphasis on safety is well placed ("Switch to Safety," September, page 4). Every consideration possible should not be overlooked.

As a teenager I experienced the full impact of a misfortune related to this problem. My father was working on a sub-station transformer when a careless operator turned on the main circuit breaker; 13,500 volts of electricity went through his body, resulting in injuries which led to his death. The power company then instituted a procedure of grounding all lines when men were working on them.

Years later, while in the Navy, I almost joined my ancestors by a similar route. I was working on the SJ submarine radar. I had carefully opened the circuit breaker and tagged it with a regulation red warning tag. I also checked for power at the input terminals to the radar. A few minutes later there was a flash of blinding fire and the jaws of my pliers melted. A young, inexperienced officer, in attempting to restore lighting to his room, had closed the circuit breaker. Fortunately, I was wearing thick-soled shoes and never provided a circuit through my body — the old "hand in the pocket" technique.

At our high-power Navy radio stations, we had key switches. When a technician opened the circuit breaker, he locked the switch and took the key with him.

Vigilance is the word. And *never* trust the other guy.

I. L. McNally, K6WX
Sun City, California 92381

price drops on "neat little book"

Dear HR:

As I read my September, 1986, issue of *ham radio* I was pleased to see Cushman Electronics mentioned in "Low-Cost Spectrum Analyzer with Kilobuck Features" by Robert Richardson, W4UCH. Please compliment Mr. Richardson on a very well written technical article.

Incidentally, the "neat little book entitled *Using the Spectrum Monitor*, priced at $7.25 (postpaid)," is now a neat little book priced at $4.95 (postpaid).

Also, our new address is 1525 Atteberry Lane, San Jose, CA 95131.

Ray V. White, KI6DW
President, Cushman Electronics

update on ACSSB level-one adapter

Dear HR:

There have been several small value changes to the Project OSCAR level-one adapter described in the October issue of *ham radio*. We will gladly provide the revisions and pc board information to anyone sending an SASE to Level-One Adapter, 15 Valdez Lane, Watsonville, California 95076.

James Eagleson, WB6JNN
President, Project OSCAR

---

short circuit

program correction

In October's "DX Forecaster," the exponentiation symbol was omitted from lines 100, 200, 280, and 360 of the information provided for adapting the HORANT program for use on the Apple IIe and IIc. The following lines should be substituted for existing lines in the HORANT program shown on page 92:

```
 95  IF 4*H1 < L1 THEN 420
 98  Y = (L1/(4*H1))
100  A1 = ATN (Y/(1-Y^2)^0.5)
198  Y = (3*L1)/(4*H1)
200  A2 = ATN (Y/(1-Y^2)^0.5)
278  Y = (5*L1)/(4*H1)
280  A3 = ATN (Y/(1-Y^2)^0.5)
358  Y = (7*L1)/(4*H1)
360  A4 = ATN (Y/(1-Y^2)^0.5)
```

ham radio

In this edited excerpt from his forthcoming book, Ulrich Rohde, well known to readers for his many articles on receivers and other communication subjects, shares knowledge borrowed from commercial applications to improve noise handling capabilities in Amateur equipment.*

understanding and handling noise

Balancers, limiters, and squelch circuits enhance receiver performance

Pulse interference is often the limiting noise source for communication receivers on our HF and VHF bands. To understand how pulse interference affects performance — and before noise-reducing methods can be developed — it's necessary to understand the sources and types of interfering pulses. Although many solutions have been proposed since the early days of radio[1], a large part of this information is based on recent work.[2,3,4,5]

types of pulse interference

Noise can be viewed in both the time domain, with an oscilloscope, and in the frequency domain, using a spectrum analyzer.

The clicks that appear when a current is switched on or off represent the simplest form of an interference pulse (**fig. 1A**). In this case the energy in the interference spectrum is a function of the amplitude, slew rate, rise time t_r (i.e., the time it takes to build from 10 to 90 percent of final amplitude) and the repetition frequency. For wideband systems with a low-pass characteristic, the approximate formula $t_r = 0.3/\Delta f$ is valid, where Δf is the bandwidth in Hz and t_r is the rise time in seconds.

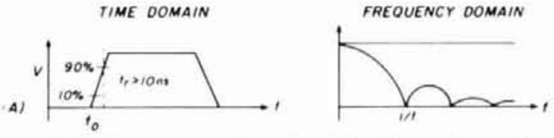
The theoretical vertical step with $t_r = 0$ (infinite rate of rise) has a spectrum that extends to infinity — i.e., the "click" would be heard at all frequencies. For finite pulse duration, t, the amplitude characteristic of the spectrum has a shape described as the sine integral (**fig. 1A**). As t increases, the frequency representation of the noise compresses — i.e., the minima in the spectrum are shifted toward lower frequencies. In actual circuits t_r will be at least 10 nanoseconds because of the presence of some line inductance. This results in the main spectrum components of this form of interference being below 30 MHz. Amplitudes are low and decrease above this frequency.

Commutator sparking is a special case of switching interference, in that a series of individual switching pulses are generated according to the type of machine, the number of poles, and speed (**fig. 1B**). Repetition frequencies up to several kHz can occur. This results in a higher spectral energy density than in the case of the single switch, proportional to this frequency factor. Thus, sometimes the rotating machine noise can be heard up to 30 MHz. The spectral amplitudes can increase by several orders of magnitude when arching occurs between the commutator and brushes. However, this does not occur often, since it would quickly destroy the commutator.

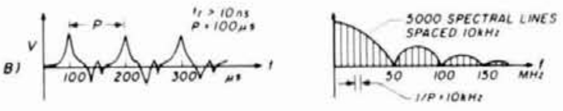
Ignition interference, which results from a high voltage discharge in a pressurized gas, has a repetition frequency of less than 1 kHz and a spectrum as indicated in **fig. 1C**. In the case of conventional circuit-breaker type ignition systems, the voltage amplitude is highest and the rise time shortest at low engine speeds. The breaker points, together with the high-voltage cables connected between the spark plugs and distributor, form resonant circuits which act like the

**HF Communications Receivers: Theory and Design*, by U.L. Rohde, Ph.D., and T.T. Nelson Bucher, Ph.D., to be published by McGraw-Hill Book Company, New York, 1987. Used with permission.

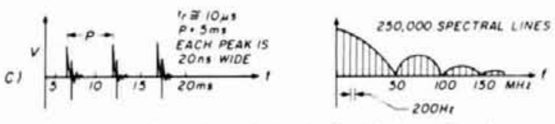
By Ulrich Rohde, DJ2LR, 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458



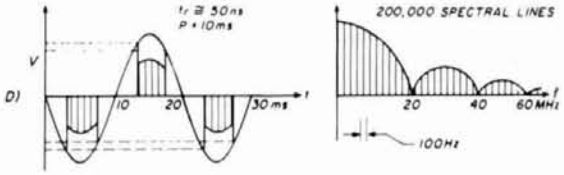
(A) "Click" source generated by simple switching of a power line on and off is seen as a single pulse with a rise time exceeding 10 nanoseconds.



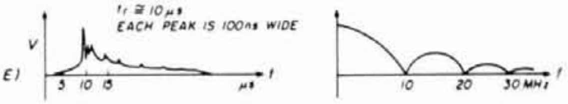
(B) Commutator sparking is represented as a train of complex waveform pulses.



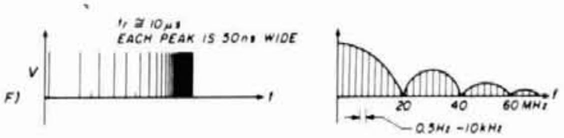
(C) Ignition interference is a periodic train of rapidly damped impulses.



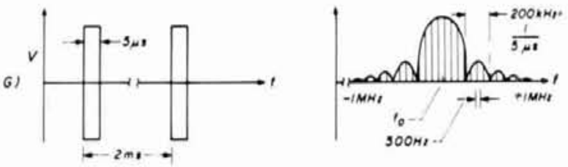
(D) Corona discharge continues until the voltage across an insulator drops below a threshold value determined by physical parameters.



(E) Lightning discharge characteristics are a function of the composition of the return stroke(s).



(F) Raindrop discharge can have frequency components extending in the low VHF bands.



(G) Radar pulses have rise times that can vary from 10 nanoseconds to 1 microsecond.

fig. 1. Time and frequency domain representations of seven different types of "noise" interference. (Courtesy of M. Martin and *VHF Communications*, Spring, 1980.

spark transmitters used in the early days of radio communications. The oscillations decrease in an exponential manner.

Corona discharge occurs across defective insulators on high-voltage ac lines. A discharge can be ignited which, depending on the "quality" of the insulator, starts more or less below peak voltage and lasts until the voltage is reduced below a threshold which is always lower than the starting voltage. This process is repeated during the opposite half waves of the alternating voltage. (See **fig. 1D.**) In the case of a poor three-phase line, or even with a good line in very high humidity (for example, in fog), arcing of all three phases could result in an overlap of the burning times (which occur every 3.33 milliseconds for a 50-Hz line and every 2.78 milliseconds for a 60-Hz line.[6]

Lightning discharges account for what is called "atmospheric noise." In relatively flat terrain, 85 percent of all lightning strokes occur in a downward direction. The cloud involved is negatively charged and a current surge of up to 20 kA passes between it and the earth. Eighty percent of these lightning flashes have maximum currents of 50 kA.[7] It is, however, possible for several clouds to discharge via the same ionized path, in which case currents can exceed more than 200 kA. (See **fig. 1E.**) The duration of a lightning discharge can be between 0.1 milliseconds and 0.5 second, depending on how many subsequent surges are induced by the primary discharge.

Raindrop discharge, also known as precipitation static, results from charges transferred between a grounded antenna and statically charged raindrops. It causes a click-type interference which can be heard as an occasional individual click or a uniform white noise during heavy showers. Because of the very steep slope of this discharge, very high interference amplitudes are generated in the resonant ranges of the antenna. Although the capacitance of a single raindrop is only a few pF and is rapidly discharged, the high potential and large repetition frequency produce a considerable energy density, as indicated in **fig. 1F.** The effect is especially prevalent on the antennas of aircraft flying through cloud formations. A similar effect can be produced by sand or dust storms.

Pulses from radar transmitters that operate in the GHz range (as well as lower frequency over-the-horizon radars) are another source of noise. These transmitters use relatively short pulses (**fig. 1G**) and, depending on the shape of the keying waveform modulation, generate sidebands with various frequency (amplitude) spectra. Similar to the case of baseband pulses, the spectral line spacing of rf pulses is determined by the repetition frequency. Zero spectrum points occur at the reciprocal of the pulse length and its multiples.

effects of pulses on narrow-band systems

A narrow-band system with tuned (resonant circuit) amplifiers only enhances frequency components that fall within its passband. An individual resonant circuit is "shock"-excited to oscillation at its resonant frequency by an impulse slope. The transient duration is dependent on the bandwidth, as determined by the circuit Q. In the case of multistage amplifiers or multipole filters, the output pulse delay is dependent on the circuit group delay, t_g. This increases linearly with the number of resonators and is generally measured from the input impulse time, t_o to the time at which the output signal has risen to 50 percent of its peak amplitude. An approximate formula gives $t_g = 0.35N/\Delta f$, where N is the number of resonant circuits, Δf is the bandwidth (Hz) and $t_r = 1/\Delta f$. If different bandwidth stages are cascaded, rise time is determined mainly by the narrowest filter. The group delay results from the

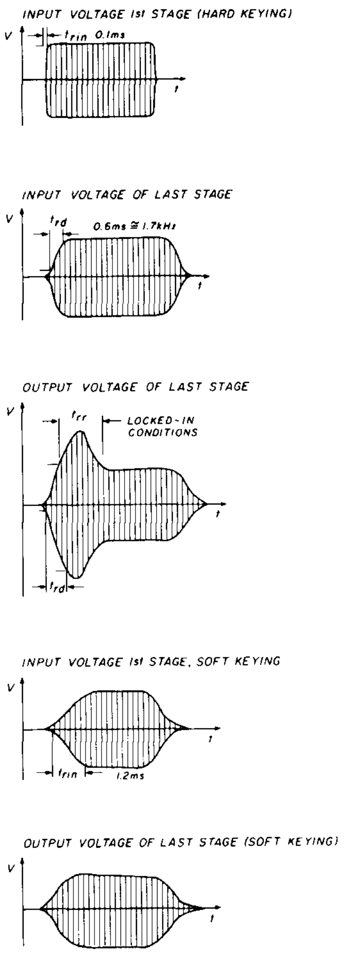


fig. 2. Impulse drive of an rf amplifier with AGC. (Courtesy of M. Martin and *VHF Communications*, Spring, 1980.)

sum of the individual delay times.

If short rise time rf impulses are fed to an amplifier that has a much longer rise time, three different types of responses can occur.[8]

- If the input pulse has duration, t_p, longer than the transient time t_{rv}, the output signal achieves the full amplitude and maintains it for the duration of the drive time less the transient time $t_p - t_{rv}$.
- If t_p is equal to t_{rv}, the output signal achieves full amplitude during time t_{rv}, but then immediately starts to decay to zero in a period, t_{rv}.
- If the pulse is shorter than the circuit transient time, the response is essentially that of the transient, but with an amplitude which only reaches a portion of the pulse; i.e., the shorter the pulse, the smaller the amplitude produced by the amplifier. In other words, a substantial portion of the spectrum of the input pulse is not within the bandwidth of the amplifier, and, therefore, does not contribute to the output amplitude.

In many systems an AGC circuit is provided to ensure that a large range of input signal voltages is brought to the same level at the demodulator output. The AGC control voltage is generated subsequent to the narrow-band i-f filter. This filter might have a bandwidth of from approximately 2 to 12 kHz, corresponding to transient times of about 0.2 to 1 millisecond. Earlier stages have much broader bandwidths. This means that steep input pulses can drive earlier amplifier stages into saturation before a reduction in gain is effected by AGC (whose response time is generally longer than the narrow band filter transient response). This is especially true in superheterodyne receivers, where selectivity is determined in the final i-f, often after substantial amplification of the input signal. Thus, the audible interference amplitudes may be several times stronger than the required signal level after the AGC becomes effective. A long AGC time constant worsens the situation. It is only when the rise time of the input pulse is longer than the AGC response time (e.g., during telegraphy with "soft" keying) that the output amplitude will not overshoot, as shown in **fig. 2.**

An effective method of limiting the maximum demodulator drive, and thus reducing the output pulse peak, is to clip the signal just in front of the demodulator with symmetrically limiting diodes, so that the i-f driver amplifier is not able to provide more than the limited output level — e.g., 0.7 volts peak-to-peak. It is necessary in this case that the AGC detector diode be delayed no more than a fraction of this level (corresponding to 0.4 volts) so that the clipping process does not interfere with AGC voltage generation. Use of a separate AGC amplifier, not affected by the limiter, will also assure this, and can provide an amplified AGC system to produce a flatter AGC curve.

methods for suppressing interfering pulses

Three different methods are used to suppress interfering pulses:[9]

- *Balancers* attempt to reproduce the pulse shape without the signal in a separate channel, and then perform a subtraction from the channel containing both signal and pulse.
- *Limiters* attempt to prevent the pulse level from becoming excessive.
- *Blankers, or silencers,* attempt to detect the onset of a pulse, and reduce to zero the gain of the signal amplifier chain, at an early stage, for the duration of the pulse.

Balancer systems are designed to obtain two signals in which the signal and noise components bear a relatively different relationship to each other. The two signals are connected in opposition so as to eliminate the noise while keeping the signal. The main problems with this type of impulse noise suppression are obtaining suitable channels and exactly balancing out the noise impulse, which is generally many times stronger than the desired signal.

In commercial service, attempts have been made to use different frequency channels with identical bandwidths to get the same impulse shape, but with the signal in only one channel. The difficulties of matching channels and finding interference-free channels makes this approach unsatisfactory in most cases. Other approaches have attempted to slice the center from the pulse (to eliminate the signal) or to use a high-pass filter to pass only the higher frequency components of the pulse for cancellation. While some degree of success can be achieved with such circuits, they generally require very careful balancing and hence are not useful when a variety of impulses and circuit instabilities are encountered.

This type of circuit can be useful where the impulse source is a local one which is physically unchanging. In this case, a separate channel from the normal antenna can be used to pick up the pulse source with negligible signal component, and the gain of the pulse channel can be balanced carefully using stable circuits (and a feedback gain control channel if necessary). It has also been reported that modern adaptive antenna systems with sufficiently short response times can substantially reduce impulse noise coming from directions other than the signal direction.

Since most of the noise terms contain relatively large peaks, limiters have been used, especially in a-m reception (which includes, of course, telegraph through full-carrier voice signals) to clip audio signal peaks which exceed a preset level. **Figure 3** shows a series limiter circuit at the output of an envelope demodulator which has proven effective in reducing

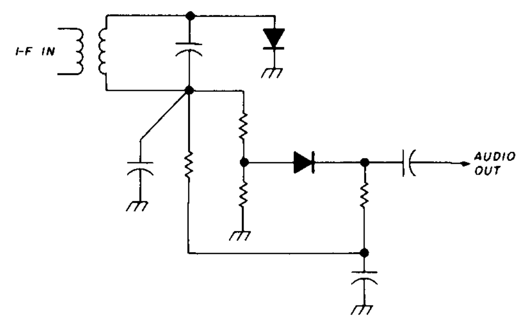


fig. 3. Schematic diagram of automatic series noise limiter circuit.

audio noise caused by impulse interference. This type of circuit makes listening to the signal less tiring, but does not improve intelligibility of the received signal. The limiting level may be set to a selected percentage of modulation by adjusting the tap position of the two resistors feeding the limiter diode's collector. If set below 100 percent, the limiting level also limits peaks of modulation. Since these seldom occur, such a setting is acceptable.

Because the impulse amplitude is higher and the duration shorter in the early stages of a receiver, limiting in such stages reduces the noise energy with less effect upon signal than limiting in later stages. Some fm receivers use i-f stages which are designed to limit individually, while gradually reducing bandwidth by cascading resonant circuits. Such a design eliminates strong short impulses early in the receiver, before they have had a chance to be broadened by the later circuits. Such receivers perform better under impulse noise conditions than those which introduce a multipole filter early in the amplifier chain. However, wideband limiting can reduce performance in the presence of strong adjacent channel signals.

The principles discussed are also applicable to data receivers. While the impulse interference is stronger than the signal, the signal modulation contributes little to the output. Generally, the data symbol duration is longer than the duration of the input impulses. If the impulse can be reduced or eliminated before the establishment of final selectivity, only a small portion of the signal interval is distorted, and a correct decision is much more likely. Consequently, limiters at wide bandwidth locations in the amplifying chain can result in considerable reduction of error rate in a data channel. Again, the possibility of interference from adjacent or other nearby channel receivers must be considered.

Impulse noise blankers are based on the principle of "opposite modulation." In effect, a stage in the signal path is modulated so that the signal path is blanked by an amplitude modulation process for the duration of the interference. It is also possible to use a frequency modulation method in which the signal path is shifted to a different frequency range. This latter procedure[10] uses the attenuation overlap response of i-f filters in a double superheterodyne. The second oscillator is swept several kHz from nominal frequency for the duration of the interference so that the gain is reduced to the value of the ultimate selectivity in accordance with the slope of the filter curves. This method is especially useful since the switching spikes which often accompany on-off modulation should not be noticeable. However, when using an fm modulator having high speed (wide bandwidth), components can appear within the second i-f bandwidth from the modulation. The most stringent limitation of this method is the requirement for two identical narrowband filters at different frequencies along with an intermediate mixer. This technique is limited to a double conversion superheterodyne with variable frequency first (local) oscillator.

When using an amplitude modulation method, two types of processing are possible:

(A)The interference signal is tapped off in parallel at the input of the system and increased to the trigger level of a blanker by an interference channel amplifier having a pass bandwidth which is far different

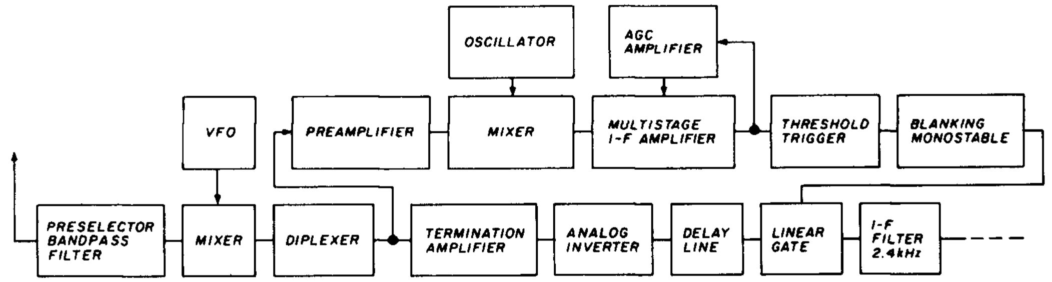


fig. 4. Block diagram of superheterodyne with noise blanker.

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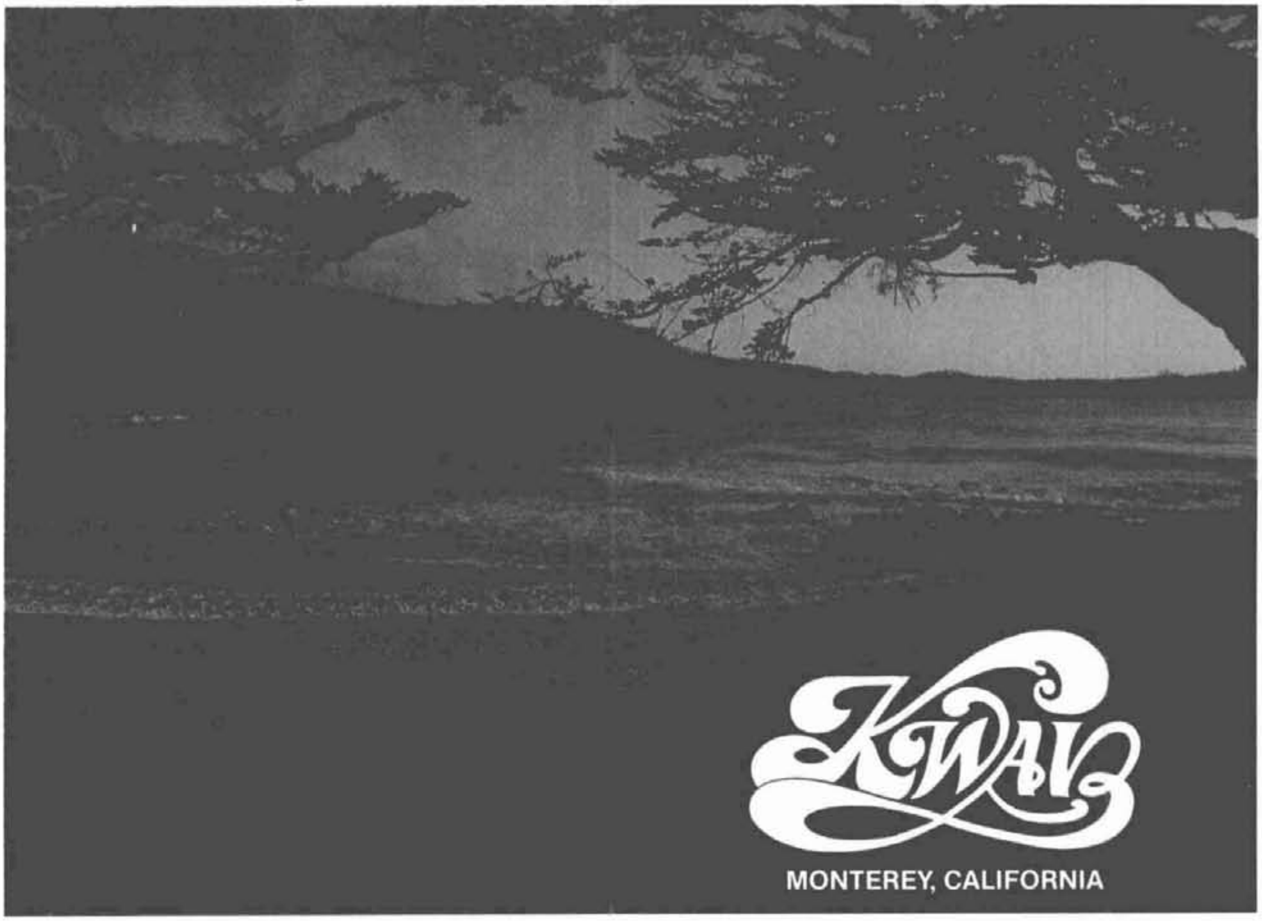

Ken Warren, Chief Engineer at KWAV reports that their 10 kW FM transmitter went on the air in November, 1972, equipped with EIMAC power tubes. The original tubes are still in operation after over 13 years of continuous duty!

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from the signal path. This method is effective only against very wideband interference, since noticeable interference energy components must fall into the passband range to cause triggering. This method will not be effective in the case of narrow-band interference, such as radar pulses, which are within or directly adjacent to the frequency range to be received.

(B)The interfering signal is tapped off from the required signal channel from the mixer and fed to a fixed-frequency, second i-f amplifier, where it is amplified up to the triggering level.[2,3] Since there is danger of crosstalk from the interference channel to the signal amplifier channel, it is advisable to have a frequency converter stage in the interference channel. This would process the interference at a different frequency than the signal i-f. In using this method, make sure that no switching spikes generated during the blanking process are fed back to the interference channel tap-off point. If they are, there will be danger of pulse feedback. The return attenuation must, therefore, exceed the gain in the interference channel between the tapping point and the blanker.

The blanker must be placed ahead of the narrowest i-f filter in the signal path. It must provide blanking action before the larger components of the transient have passed this filter. Therefore, we must assure a small group delay in the interference channel by use of a sufficiently broad bandwidth and a minimum of resonant circuits. It is desirable to insert a delay between the tap-off point and the signal path blanker so that there is sufficient time for processing the interference signal. If this is done, it is not necessary to make the interference channel excessively wide, while still assuring the suppression of the residual peak.

Figure 4 is the block diagram of a superheterodyne that uses this type of impulse noise blanker. **Figure 5** illustrates its operation in the presence of a strong interfering radar pulse. An essential part of the blanker is the use of a gate circuit that can operate linearly over a wide dynamic range. **Figure 6** shows such a gate, using multiple diodes. The circuit is driven by a monostable flip-flop which is triggered by the noise channel. **Figure 7** is a schematic of a noise blanker circuit designed along these lines. When the noise channel is wider than the signal channel, this type of noise reducer can also have problems from interfering signals in the adjacent channels.

squelch circuits

Sensitive receivers produce considerable noise voltage output in the absence of a signal. This condition can occur when tuning between channels or when the station being monitored has intermittent transmissions. At the audio output the noise can be annoying and, if repeated frequently, fatiguing. To reduce this problem, circuits are often provided to reduce the output when a signal is not present. These circuits have been referred to as *squelch*, *muting*, and *quiet AVC (QAVC) systems*. The choice of which circuit to use depends on the received signal characteristics.

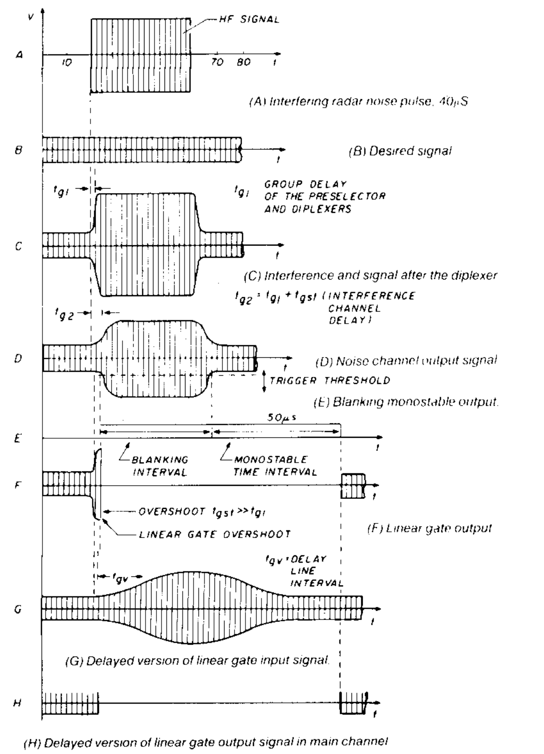

fig. 5. Observed signal waveforms in a superheterodyne receiver that uses an impulse noise blanker.

Squelch circuits for a-m receivers generally operate from the AGC control voltage. When a weak signal or no signal is present, the voltage on the AGC line is at its minimum and receiver gain is maximum. When a usable signal is present, the AGC control voltage rises to reduce the receiver gain. The voltage variation tends to rise approximately logarithmically with increasing signal levels. By using a preset signal level threshold, it is possible to gate off the audio output signal whenever the signal level drops below this point. Such a system can be used to mute the receiver during the tuning process. The threshold may also be set for the level of a particular signal with intermittent transmissions, so that noise or weaker interfering signals are not heard when the desired signal is off. When the transmission medium causes signal fading, as is common at hf, squelch circuits are somewhat less effective for this use because the threshold must be set low enough to avoid squelching the desired signal during its fades. This provides a smaller margin to protect against noise or weaker interfering signals.

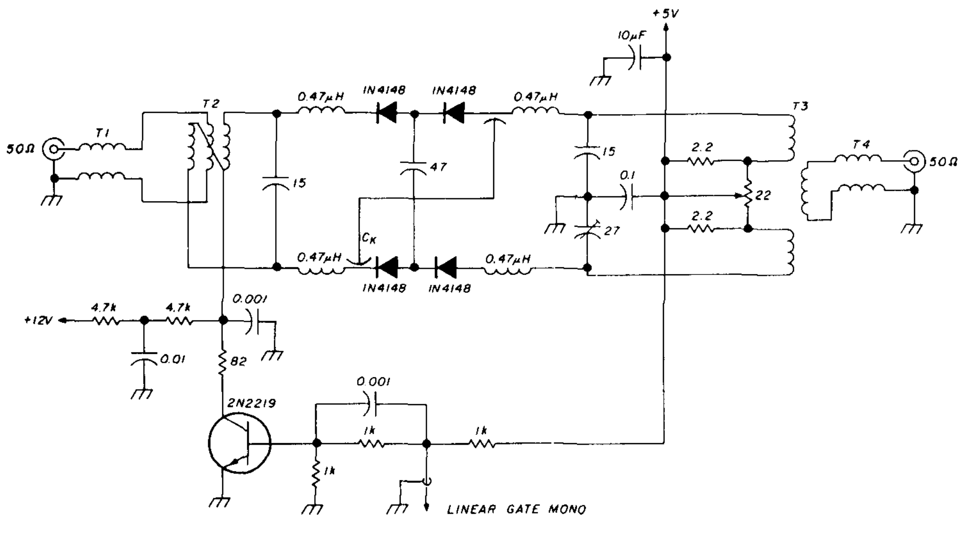

fig. 6. Schematic diagram of blanker gate with high dynamic range.

A typical a-m squelch system is illustrated in **figs. 8** and **9**, where a diode gate is used to reduce the output signal. Many types of switches have been used for this purpose, including biasing the demodulator diode and biasing one element of a multi-element amplifying device. The latter approach was frequently used with receivers that employed multigrid vacuum tube amplifiers. However, it can be applied to multigate FET amplifiers or balanced amplifier ICs with current supplied by a transistor connected to the common base circuit of the amplifying transistor pair. **Figure 10** shows these alternate gating techniques.

Many fm receivers do not use AGC circuits, but depend on circuit limiting to maintain the output level constant from the demodulator. In this case, squelch may be controlled by the variations in voltage or current which occur in the limiter circuits. Such changes occur when single-ended amplifiers are used for limiting, but may not be so readily available in balanced limiter arrangements. Furthermore, the wide range of threshold control provided by AGC systems is generally not available in limiters. This tends to make fm squelch systems, which are dependent on the signal level, more susceptible to aging and power supply instabilities than AGC operated systems. Consequently, two other types of control have evolved for fm use: noise-operated and tone-operated. (The latter could be used for a-m, also.)

Figure 11 is a block diagram of a noise-operated squelch. This system makes use of the fact that output noise characteristics from a frequency demodulator change when no signal is present. At the low output frequencies, when noise alone is present in the fm demodulator, there is a high noise level output, comparable to that at other frequencies in the audio band. As the strength of the (unmodulated) signal rises, the noise at low frequencies decreases, while the noise at higher frequencies decreases much less rapidly.

If in **fig. 11**, the squelch low-pass filter cuts off at, say, 150 Hz, it will be uninfluenced by modulation components. If the gain of the squelch amplifier is set so that the squelch rectifier produces 5 volts when S/N = 0, then a 7-dB signal level will cause this output to drop to about 0.03 volts. A threshold may readily be set to cause the squelch gate to open at any S/N level between −3 dB and 7 dB. Because the control voltage level is dependent on the gain of the rf, i-f, and squelch amplifiers, variations in squelch threshold may occur as a result of gain variation with tuning or because of gain instabilities. If a second filter channel (**fig. 12**) tuned above the baseband is used, the two voltages can be compared to key the gate on. While both are subject to gain variations, their ratio is not. Better threshold stability results. A similar technique has been proposed for SSB voice, where noise density is uniform, but modulation energy is greater below 1 kHz.

With the difference approach, the range of threshold control is, however, limited. A weak interfering signal which would produce negligible interference with the desired signal may still operate the squelch gate. Tone-operated squelch was devised to overcome this problem. A small-deviation, low-frequency tone (lower than the modulation frequencies) is added to the transmitted signal. At the receiver, a narrow-band filter is tuned to the tone, and its output is amplified and rectified to operate a trigger for the squelch gate.

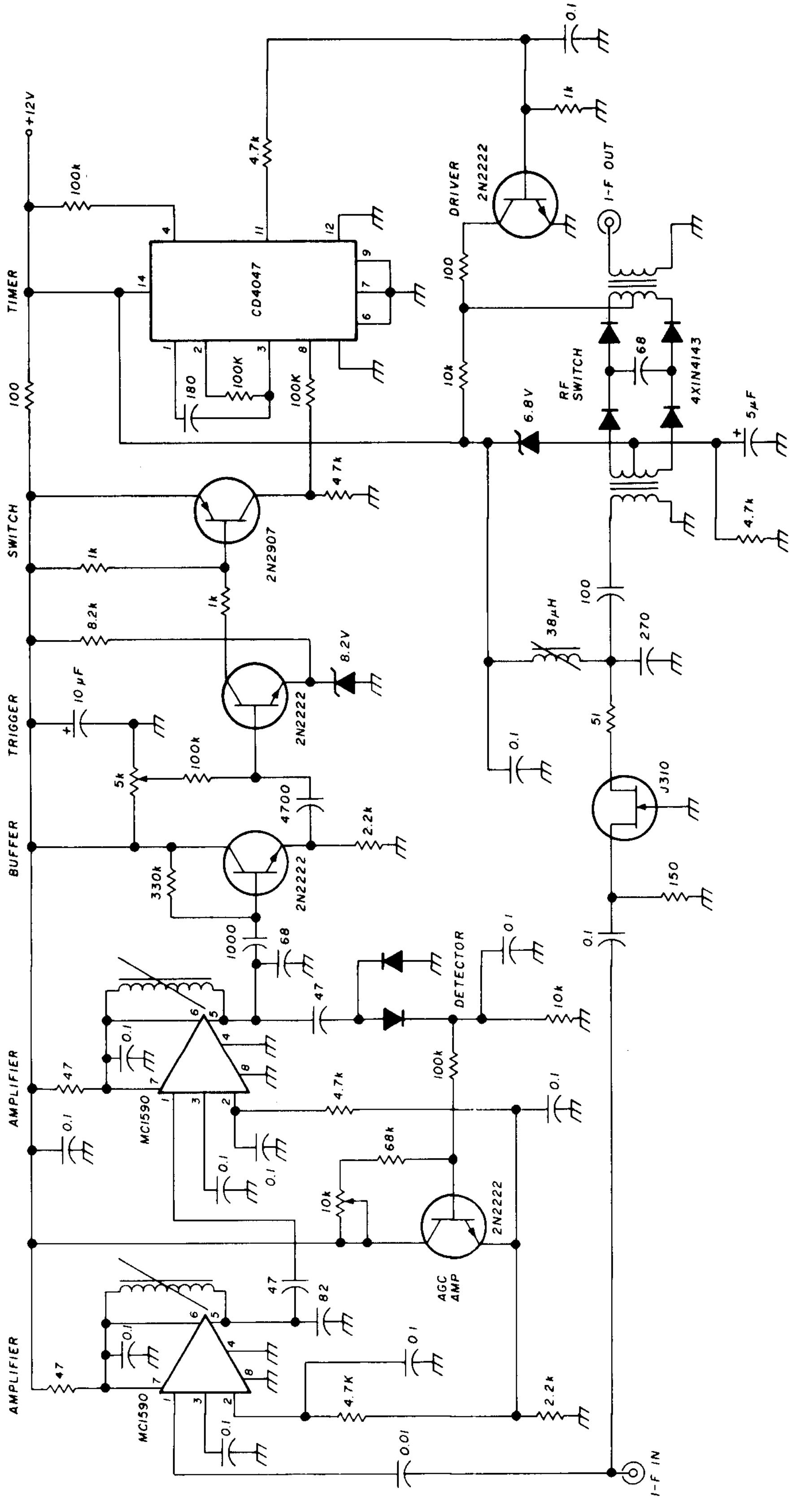

fig. 7. Schematic diagram of noise blanker circuit.

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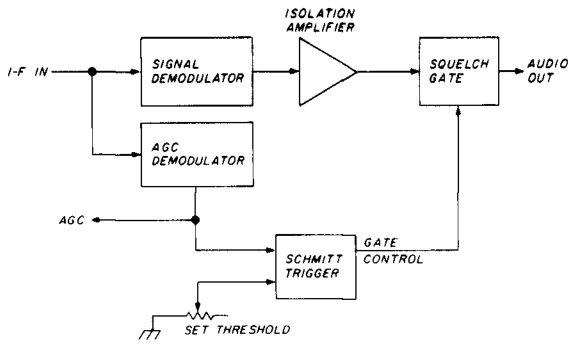

fig. 8. Block diagram of a-m squelch circuit.

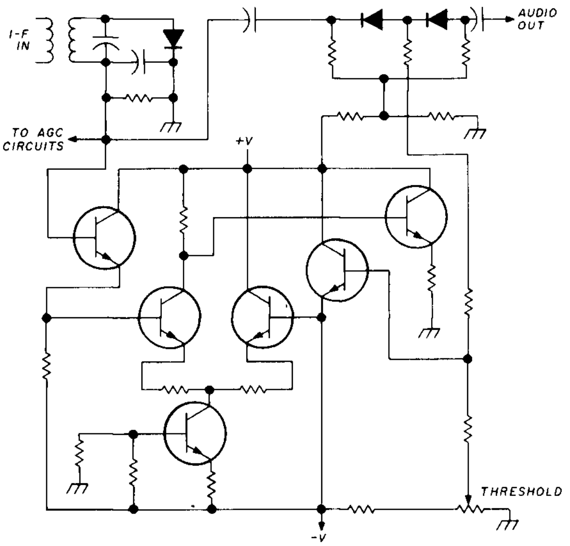

fig. 9. Schematic diagram of a-m squelch circuit.

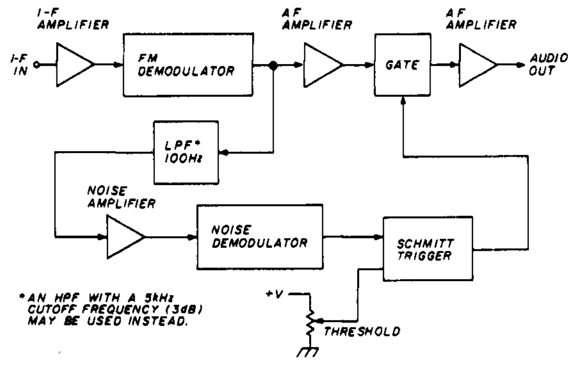

fig. 11. Block diagram of noise-operated squelch circuit for fm receiver.

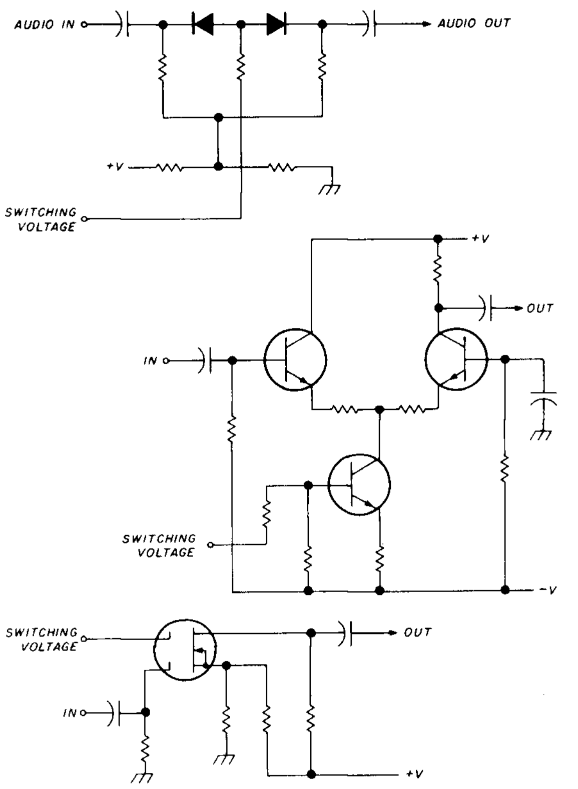

fig. 10. Some gate circuits for squelch application.

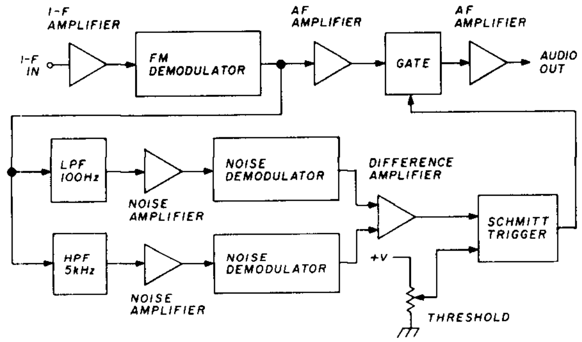

fig. 12. Block diagram of improved noise-operated squelch circuit for fm.

However, in some commercial communication systems, with multi-user net operation on one frequency, a coding scheme known as selective call (SelCall) has been devised so that users need receive only those messages directed toward them. In this type of signaling scheme, the caller sends a multitone or digital code at the beginning of the message to indicate the identity of the called party or parties. Only if the receiver code matches the transmitted code is the output gate enabled to transmit the message to the receiver user. This type of system may be used with both analog and digital modulations, and is independent of the modulation type (a-m, fm, pm) used for transmission. This method is more elaborate than normal squelch systems, but performs an important function in multi-user nets.

conclusion

Several of the basic techniques and their circuits used to handle the introduction of noise in receiving systems have been described. While this discussion is by no means all-inclusive, it is nevertheless indicative of some of the basic approaches taken to solve this problem.

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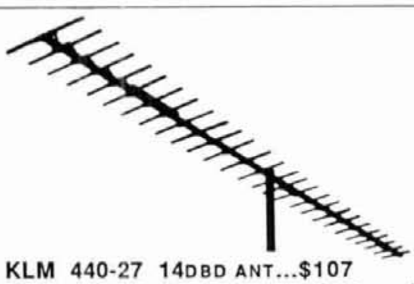

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This tiny set — built around a TV colorburst crystal — pulls in W1AW and fits in the palm of your hand

a simple 80-meter receiver

Back in the good old days when AM reigned over the phone bands, many beginners built simple, one-tube receivers. As AM faded, however, so did the one-tube receiver; the more complex designs required for CW, SSB, and FM were beyond the skills of most beginners. This article describes an easy-to-build receiver for W1AW code practice and bulletins on 3.58 MHz, following a basic approach that minimizes construction difficulties, yet provides the satisfaction of building a useful accessory for even the most experienced Amateur.

Direct conversion receivers have been popular for some time now for CW and SSB. The complexities in the published designs for these units lie mainly in the tuning; the bandspreading and stability necessary to tune in SSB or separate crowded CW signals are difficult to achieve simply. Use of narrowband audio filters puts even tighter constraints on tuning.

Some time ago, I noticed that 3.5795-MHz TV colorburst crystals are in the 80-meter CW band, close to the 3.58-MHz frequency used by W1AW for code practice and bulletins; the difference in frequencies is a usable audio note. A crystal-controlled direct conversion receiver has sufficient stability for CW work, requires no tuning (because only one frequency is desired) or narrow filters (because 3.58 MHz is, relatively speaking, in the "wide open spaces"). The concept seemed useful, since a dedicated W1AW receiver would be a handy accessory as part of any code practice program. For areas where W1AW reception isn't reliable on 80 meters, other 80-meter crystals can be used for reception of other stations. Possibilities include W6OWP code practice on 3.59 MHz, which is heard on the West Coast, and perhaps local slow-speed CW net frequencies.

The receiver RF section fits on a small PC board which, in turn, fits nicely into the case of a small audio amplifier available from Radio Shack. This $12 off-the-shelf amplifier provides the case, more than adequate audio gain, a loudspeaker, earphone jack, volume control, and battery.

Although the receiver is battery-operated and fits easily in the palm of your hand, it does require a full-size antenna. For portable use, a pair of 25-foot long wires connected as a dipole should suffice. For stationary use, an 80-meter dipole (135 feet overall) would be better.

circuit description

The receiver shown in **fig. 1** is a direct conversion type with a preselector, mixer, and local oscillator. The preselector passes 80-meter signals and rejects all others. The mixer combines the received signal with

By Ed Gellender, WB2EAV, 28-37 212 Street, Bayside, New York 11360

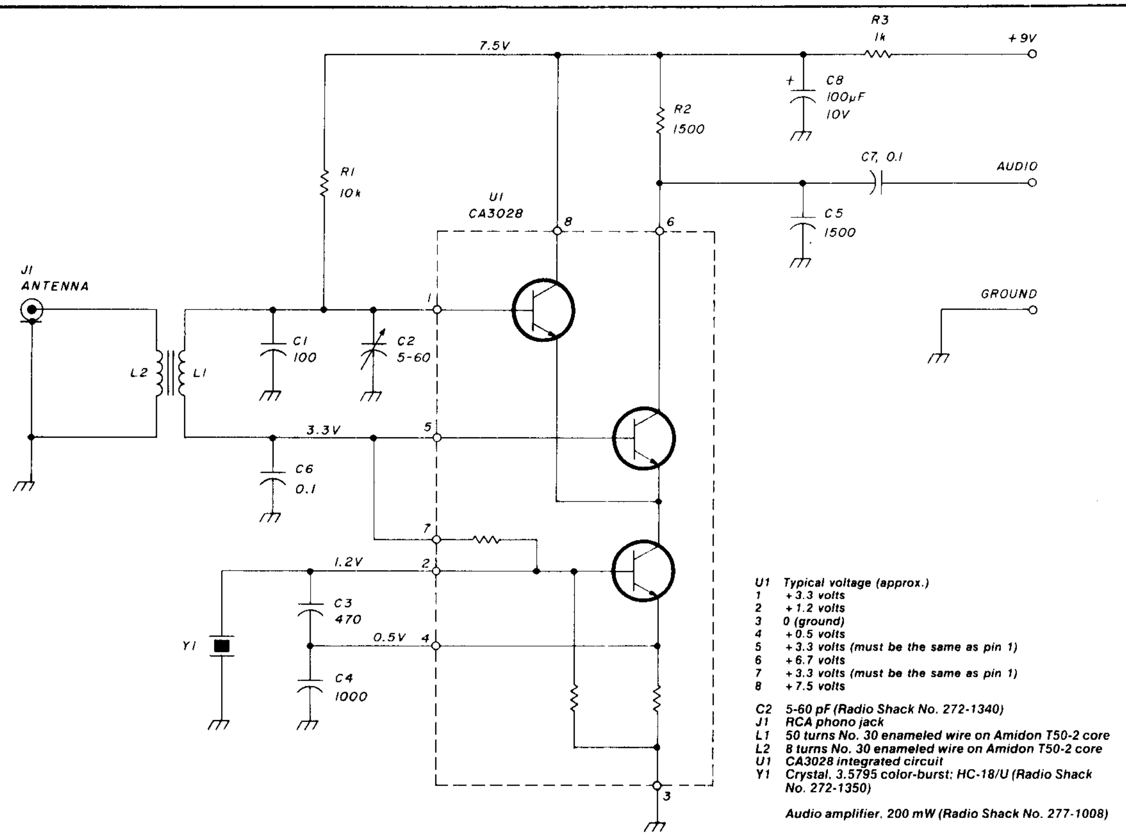

fig. 1. The heart of the simple 80-meter receiver is the CA3028 integrated circuit.

the oscillator output and provides an audible beat note, or difference frequency.

The ARRL Handbook shows several mixer circuits using the RCA CA3028 integrated circuit. The CA3028 consists of a differential amplifier and a common current source. All the published designs use the differential amplifier as a mixer and the current source transistor to buffer the local oscillator. Because we're using a crystal, the stability is good enough so that a buffer isn't needed, and we benefit from the simplification of using the current source transistor as the local oscillator.

The oscillator circuit is the classic Colpitts design, using phase-shift network C3, C4, and Y1 to feed signals from the emitter back to the base of the transistor. For the TV colorburst crystals specified to oscillate reliably, large values of C3 and C4 are required. As a result the crystal will oscillate just slighty above its series resonant frequency. If other crystals are used, their series resonant frequency should be about 1 to 1.5 kHz below the desired reception frequency.

Preselector L1, L2, C1, C2 resonates at 3.58 MHz with a loaded *Q* of approximately 15. C6 is an RF bypass capacitor that maintains U1 pin 5 at RF ground. The differential amplifier is driven by the RF input so that currents into pins 6 and 8 alternate at the input frequency. The total current shared by pins 6 and 8 varies with the local oscillator frequency. Nonlinearities in the base-emitter junctions result in a difference frequency appearing at pin 6. R2 and C5 form a low-pass filter to remove both the input and oscillator frequencies and pass the audio beat note. C7 is a DC blocking capacitor.

The audio is brought to the audio amplifier, which uses a single transistor preamplifier driving an LM386 amplifier IC. According to the amplifier data sheets, the amplifier sensitivity is 1 mv and maximum output is 200 mw. These specifications match the desired performance quite well. Purists might object to buying such a large part of the receiver ready-made, but practical considerations don't permit missing such an opportunity. As purchased, the amplifier's upper frequency response is about 10 kHz — too high for our purposes. But by changing one capacitor, we reduce the audio bandpass to a more usual 3 kHz.

constructing the RF board

The RF board is a 3/4-inch x 2-1/8-inch PC board, although a hand-wired board of those dimensions is suitable. The PC artwork is shown in **fig. 2** and the components layout in **fig. 3**. Be sure to install U1 as

fig. 2. Full-size pc pattern is shown from the DIP side.

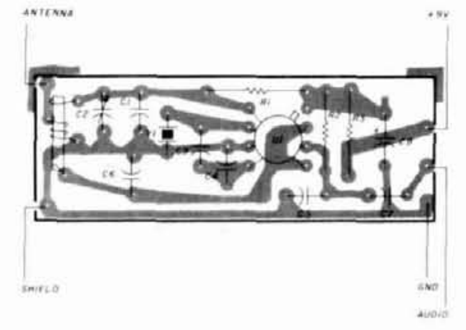

fig. 3. Recommended parts placement (component side).

shown in the parts location diagram. The tab is over pin 8 (pins are numbered clockwise when viewed from the bottom). Bend the leads with a pair of needle-nose pliers to fit the hole pattern.

Coils L1 and L2 are wound on an Amidon Associates T50-2 ferrite toroid (see **fig. 4**). It must be wound as shown to fit the PC board pattern. To wind L1, take a 3-foot length of 30 gauge enameled magnet wire and tightly wind 50 turns. This should occupy about 2/3 of the core and use about 30 inches of wire. Don't forget to leave pigtail leads on each end. Similarly wind L2 in the remaining empty part of the core. Before soldering, scrape the insulation off the wire pigtail leads with a razor blade. A few drops of glue (such as Duco Cement(TM)) can later be used to hold it to the board.

The crystal specified, an HC-18/U type, is soldered to the board. The miniature crystal lends itself well to this construction, but if one wishes to use other crystal types, there's no reason short wires couldn't be used to connect a larger crystal or a crystal socket. If other crystals are used, however, the values of C3 and C4 might have to be changed for the oscillator to start reliably.

If a single small package isn't necessary, or if you want to breadboard the RF board differently, a separate RF breadboard can be used (see **fig. 5**), with the audio output brought to a miniature phone plug that fits into the audio amplifier input jack. If separate 9-volt batteries are used, the audio amplifier used should not be modified (except for adding a recommended 0.01 μF capacitor described below).

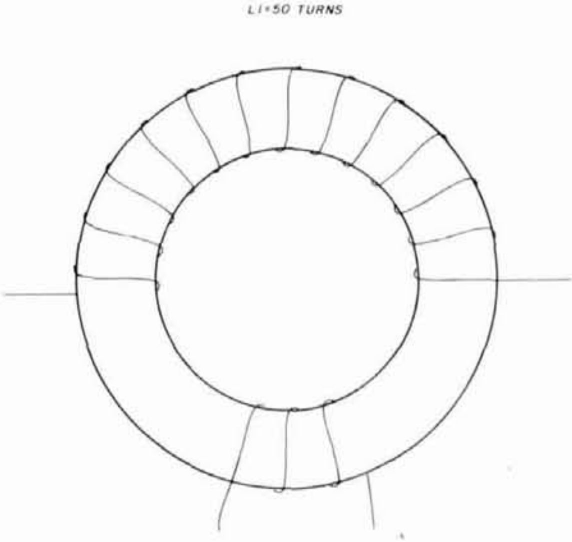

fig. 4. A simplified sketch illustrates the winding procedure for coils L1 and L2 on an Amidon toroidal core.

modifying the amplifier

The Radio Shack Audio Amplifier must be modified slightly before the RF section is added. First, lift the audio amplifier PC board out of the cabinet. To do this, unscrew the two knurled nuts from the outside of the two miniature phone jacks and unscrew the small phillips-head screw at the top of the unit. Then, while applying finger pressure to "belly-out" the plastic case away from the phone jacks, lift the board from the loudspeaker side.

To install the antenna jack, carefully drill a ¼-inch hole through the top center of the cabinet and install J1, an RCA-type phono jack. Be sure to use the ground lug.

The input jack is of the shorting type and must be modified. Unsoldering the jack and removing it is one possibility. Another possibility is to cut the land between the center terminal of the input jack and the volume control. A third possibility, which allows the amplifier to be used for other purposes, is simply to leave an open-circuited miniature phone plug in the input jack. Solder an insulated wire 3 or 4 inches long to the land between the volume control and input jack, on the volume control side of any out lands. This is the audio connection lead and is soldered to the pad on the RF board connected to C7.

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fig. 5. Few leads are needed to interconnect the rf board to the rest of the circuit.

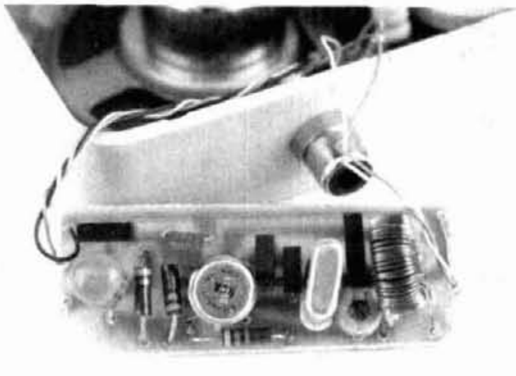

fig. 6. Sufficient space is available in the Radio Shack audio amplifier for mounting the rf board.

One optional but recommended modification is to remove the 0.0033 μF capacitor located in front of the small plastic transistor and replace it with a 0.01 μF ceramic capacitor. This reduces the audio frequency response to about 3 kHz, eliminating much noise.

Now add the remaining wires to the RF board. Connect a ground wire from the large ground plane in the center of the audio board to the ground pad on the RF board near C7. Connect another ground wire from the ground lug on the phono jack at the top of the cabinet to the ground pad at L2. Connect a wire for the switched +9 VDC from the bare jumper between the two phono jacks to the 9-volt pad on the RF board, near C8. Finally, connect a wire from the center conductor of the phono jack on the top of the cabinet to the antenna pad at L2 (**see fig. 6**).

Reinstall the amplifier board in the case (it goes in more easily than it came out). Place the RF board, vertically, in the open space on the other side of the loudspeaker. L1 should be near J1 and C8 near the battery. A grommet or suitable non-conductive spacer placed between the top of U1 and the side of the loudspeaker will hold the RF board in place.

operation

Connect a 9-volt battery to the battery clip in the amplifier. Turn on the amplifier with the volume control. Check the pins of U1 for the DC voltages shown on the voltage chart. The amplifier should output a low hissing noise from the speaker with the volume turned up. If another receiver is available, listen for the oscillator signal at 3.58 MHz.

Connect the receiver to a suitable antenna. The background noise should increase noticeably as the atmospheric noise in the 80-meter band overrides the internal noise. Signals may be heard. Variable capacitor C2 is set for strongest reception of the desired signal. Note that for some antennas, the best adjustment of C2 may cause the mixer stage to oscillate when the antenna is removed, as indicated by a raspy signal. If oscillations occur while the antenna is connected, slightly detuning C2 is all that's necessary.

Private listening is possible, using an earphone with a 1/8-inch phone plug; these are often supplied with broadcast radios, but are also available separately.

performance

The receiver is capable of detecting signals far below the atmospheric noise level in the 80-meter band, so sensitivity is not a problem. With strong signals, room-filling volume is available from the loudspeaker. There are no controls other than the volume control. Because of the lack of tuning and filtering, interference from nearby signals can be a problem. However, in the "wide open spaces" at 3.58 MHz, this won't be encountered often.

ham radio

receiver tuning mechanism selection

What tuning system to use? Read on.

One of the critical steps in designing a communications receiver involves deciding what tuning system will be used. Part of this decision includes determining the tuning rate (kHz covered per turn of tuning knob), band coverage (kHz covered over an entire band), and tuning direction.*

Several related details must also be considered. For example, in selecting the tuning rate, it's also necessary to choose the appropriate knob; a crankshaft knob generally offers smoother tuning than a round knob of the same diameter. Similarly, the band coverage selected will be related to the mechanism reduction ratio and to the tuning rate.

Because most modern receivers have digital readouts, the probability of ending up with opposite-direction dial scales (as a consequence of conversion schemes) is slim, but is something to remember in case analog dial readouts are used.

tuning mechanisms

It's necessary to decide, early in the design stage, whether tuning will be via permeability or capacitance variation.

Permeability tuning offers the advantage of no sliding electrical contacts. It's probably the easiest system to build if you don't have an elaborate workshop. Inductance variation is achieved by moving a ferrite core in and out of a coil of large length-to-diameter ratio, generally 5:1 or more. The best linearity over the frequency range occurs when the core is about 30 to 40 percent inside the coil. Movement consists of the rotation of a threaded shaft, to which one or more springs are attached to eliminate thread backlash and lateral movement. By simply selecting a particular thread pitch and designing the coil winding accordingly, frequency coverage and tuning rate can be designed to meet specific requirements. Very often a combination of series and parallel coils is used to achieve the desired coverage.

Using a 6-32 threaded shaft and a 1/4-inch diameter, 1-inch long coil, one can easily build a VFO into a 1 x 1 x 2-inch box. **Figure 1** shows the basic construction; the VFO printed circuit can be fitted below the coil, fastened to the 1/8-inch aluminum bracket housing the VFO itself.

Construction details for a 5- to 6-MHz permeability tuned VFO is shown in reference 1.

Multicoil setups used in receiver front ends can also be built using the same concept, even though mechanical difficulties tend to increase as the number of coils increases. Regardless of the number of coils, end stops must be used at both coil ends to avoid damaging the mechanism or having the ferrite core fall off the threaded shaft.

An alternative method of permeability tuning (**fig. 2**) is spring-loading the ferrite core against a cam moved by the tuning shaft. In pre-digital days, this technique allowed one to linearize the VFO by filing the cam profile rather than by adjusting the coil winding.

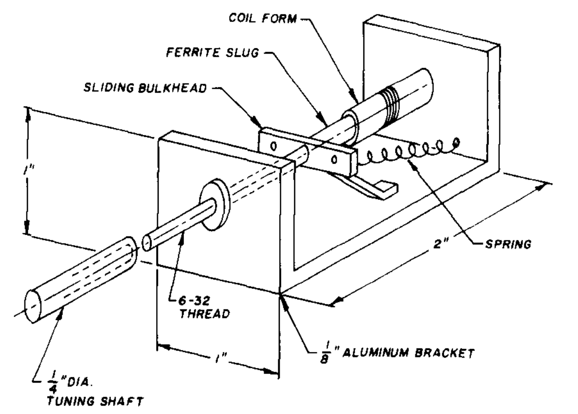

fig. 1. Permeability-tuned VFO (end stops not shown).

*An unwritten convention prevails: clockwise rotation increases frequency. In some British and Japanese sets, however, counterclockwise rotation increases frequency.

By G. "Jack" Perolo, PY2PE1C, P.O. Box 2390, Sao Paulo, Brazil

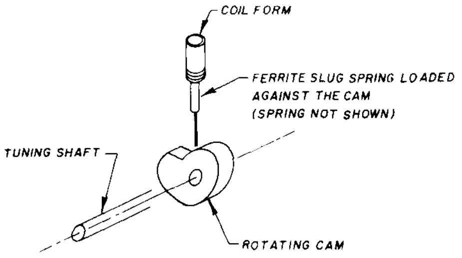

fig. 2. Basic setup of cam permeability-tuned VFO.

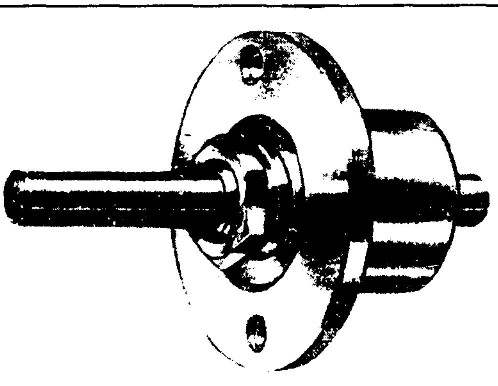

fig. 3. 10:1 ratio heavy-duty ball vernier by Jackson Brothers (UK). This unit has output torque exceeding 30 oz/inch. The front nut fastens a rotary dial.

With digital readout receivers, this method offers no substantial advantage over the standard mechanism shown in **fig. 1**, except for the simplicity inherent in determining the two end stops. Otherwise it's more mechanically complex.

Capacitance variation is possibly the most widely used system for receiver tuning.

The drum and chord is standard in older receivers, and many portable units. Readily-available, low-cost drums and variable capacitors with bearings at both ends make this one of the easiest tuning mechanisms to homebrew. Results are excellent, particularly if stainless steel chord, rather than plastic or synthetics are used. One convenient feature of this system is its ability to slip at both tuning ends, thus providing a built-in safety device to avoid damage to the variable capacitor. One disadvantage of the method, however, is that the reduction ratio is somewhat limited, seldom exceeding 30:1 or 40:1 over 360 degrees.

Many types of *vernier reducers* are available. These are primarily based on a row of steel balls rotating on an inner and outer machined groove. The difference in diameter between the inner and outer ball races provides the reduction effect, which seldom exceeds 10:1. Jackson Brothers, a British manufacturer with distributors in the United States, offers an extensive line of verniers; a good unit to use is their Model 5857, depicted in **fig. 3.**

Some manufacturers build the vernier right into the variable capacitor shaft, making the whole tuning mechanism quite compact, though the reduction ratio is low. In both cases the reduction ratio is generally too small for serious communications work. For instance, if one does not want to cover more than 50 kHz per turn (remember, the full capacitance swing of a variable takes place in about 160 degrees) a vernier with a 10:1 ratio will offer only 160 degrees/360 degrees times 10 turns, or approximately 4.4 turns for the total swing of a standard capacitor, thus limiting the band coverage to 4.4 turns times 50 kHz per turn, or 220 kHz.

Another limitation is aging. With aging, the vernier tends to slip or to develop backlash, especially if the variable capacitor in use requires high torque to rotate.

Gear reduction, widely used in commercial and professional equipment, can be of the parallel or worm

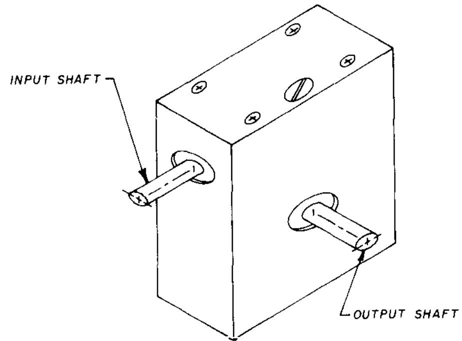

fig. 4A. Typical single worm gear reducer. The input shaft is mounted in precision ball races; the output shaft, in self-lubricating bearings. The final assembly is packed in grease having a temperature range of −34 to +150 C.

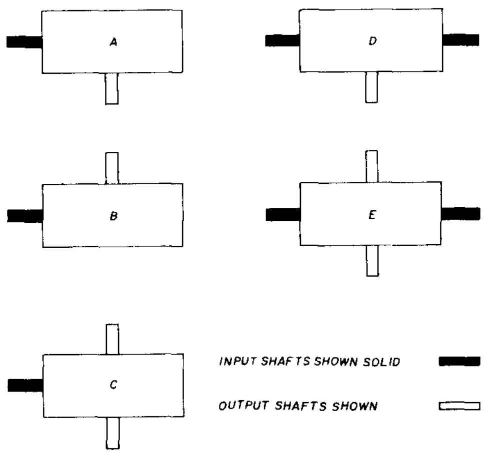

fig. 4B. Shaft arrangements of single worm gear reducers.

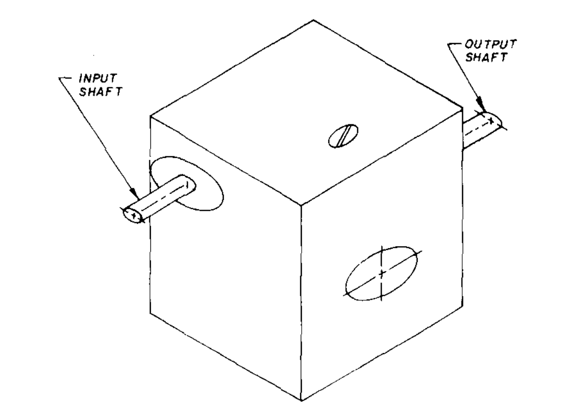

fig. 5. Sealed zero-backlash double worm gear reducer manufactured by Muffett Ltd. (UK).

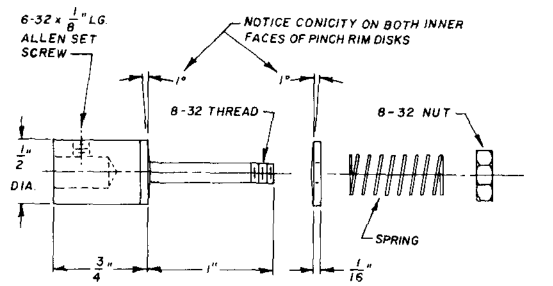

fig. 6. Pinch rim drive can be home-built from aluminum or brass round stock. The spring should be made of spring wire measuring approximately 0.025 inches in diameter and wound in five to eight turns on a 3/16-inch diameter drill.

gear variety. In both cases, the gears must be spring-loaded to eliminate backlash. Both systems can offer any reduction ratio but, for the same reduction ratio, parallel gear reducers tend to be bulkier. From an Amateur standpoint, the availability of parallel gear reducers is more limited, and new reducers tend to be expensive — i.e., in the range of $50 to $80.

A specialized parallel gear reducer is an epicyclic drive, in which the outer (larger) gear is an "internal" gear. (This means that the teeth protrude inward, rather than outward, as on standard gears.) Its most popular form is the unit used in the National HRO series. The epicyclic drive can be home-built or purchased from a manufacturer of precision gears for between $75 and $100.

One limitation of this system is its low reduction ratio, which seldom exceeds 15:1 for 360 degrees rotation. A wide variety of worm gear reducers with ratios in the range 20:1 to 100:1 is available on the surplus market; an entire set can be bought for just $10 or $15. However, because these units are quite old, the tuning mechanism may show some wear and may have developed backlash. Furthermore, by today's standards, these mechanisms are generally heavy and bulky, and will require mechanical adaptation if they're to be used in a modern project.

Used extensively in industrial instrumentation and aerospace applications, new worm gear reducers are available from several suppliers. Versions with ball bearings on both input and output shafts, housed in sealed, lubricated-for-life assemblies, offer a truly superb, "velvet" feeling (**figs. 4A, 4B**). Made by Muffett, Ltd. (UK), they're distributed in the United States by Sterling Instruments of New Hyde Park, New York. The size most compatible with ham gear is No. 2, which is offered in reduction ratios up to 100:1, at about $75.

Another interesting item is a double worm gear reducer, which consists of two reducers cascaded inside the same assembly, thus offering very high reduction ratios (up to 10,000:1) that may be used for specialized applications (**fig. 5**). On all worm gear reducers, because of their high reduction ratio, means must be provided to have end stops at both ends of the variable capacitor excursion to avoid damage.

Pinch-rim drives. In this method, a disc is mounted on the variable shaft and the tuning shaft pinches laterally the periphery of the disc with two spring-loaded discs of much smaller diameter. The system slips automatically at the variable end stops, providing a safety feature at both ends. It can be home-built with limited mechanical means, "turning" it on a hand drill fastened to a bench vise and making the main disc out of thin aluminum sheet or plastic. (See **fig. 6** and reference 2.) As in the case of the ball vernier, however, a limitation is the reduction ratio, which seldom exceeds 10:1 or 15:1 over a 360-degree rotation.

This system is sometimes cascaded with a gear reduction system that provides a clutching (slipping) action at both ends, resulting in "velvet" tuning.

conclusion

Early in the design of any communication gear, the homebuilder must decide on whether the tuning system will be of the variable L or C variety. While variable L is probably easier to build, the system is not as popular as it could be, mainly because even though the mechanical work required is limited, one can find a commercial vernier and variable capacitor rather easily these days. One word of caution: it's practically impossible to build a zero-backlash, high-frequency VFO with variable C unless the capacitor shaft has bearings at both ends. Standard trimmers or transmitting variable capacitors are bushing-mounted and generally show backlash in one of two ways. Either the rotor bushings are quite tight (to avoid the shaft fitting loosely in the bushing), with backlash developing in the tuning system as the torque required to rotate the shaft exceeds the rating of the reducer, or the rotor bushings aren't tight. In the latter case, backlash develops within the variable capacitor itself because of the rotor's wobbling in and out of the stator. I take it as a rule that for decent communications work to be performed, the variable capacitor *must* have bearings at both ends.

references

1. J. Perolo, PY2PE1C, "A Solid State Permeability Tuned VFO with Digital Frequency Read-out," *CQ*, October 1970, page 18.
2. J. Perolo, PY2PE1C, "Portable Short-wave Receiver," *ham radio*, August, 1984, page 67.

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upgrading the Ten-Tec Argosy

This article proves two things: first, that outstanding results can be obtained by choosing inexpensive, well-designed equipment and second, that there's still room for hams to make worthwhile improvements to their transceivers. Owners of the original Ten-Tec Argosy who'd like to hear weak signals in the presence of powerful adjacent signals without "popping" and intermodulation distortion may find it especially useful.

With several thousand in operation around the world, the Argosy is particularly attractive for the CW QRP operator. It can also serve as a low-cost base station transceiver which can drive a high-gain linear amplifier to 1000 watts output on most bands.

Although my Argosy was a good performer in many respects, I decided that it could be improved. For example, with DX propagation only marginal (given the current sunspot cycle), its noise floor was so high that DX signals of S3 (approximately 0.8 μV rms in a 50-ohm system) and below were obscured. In addition, the receiver desensitized 100 kHz away from a signal generated by a station located no more than a mile from my QTH.

The modifications described here will improve the noise floor, compression point, intercept point, and AGC characteristics of the Argosy receiver, as well as the transmitted characteristics of its SSB signal. They will also add digital versatility to the unit by replacing the analog dial with a precise four-digit display capable of reading the transceiver's frequency with an accuracy of ± 10 Hz.

Critical listening and laboratory tests comparing a modified Argosy with an unmodified one have shown that these modifications result in significant improvement (**fig. 1**). The test results (**table 1**) show clear improvement in the areas of minimum discernible signal (MDS); two-tone, spurious-free dynamic range (SFDR); and blocking dynamic range at only 5 kHz from the interfering signal, with the latter showing an impressive 30-dB improvement over the unmodified Argosy. After the modification, on-the-air tests allowed copy of weak CW DX stations of S3 and below as close as 2.5 kHz from WB0NHD, less than a mile from my QTH and running a full kilowatt with his antenna pointed in my direction!

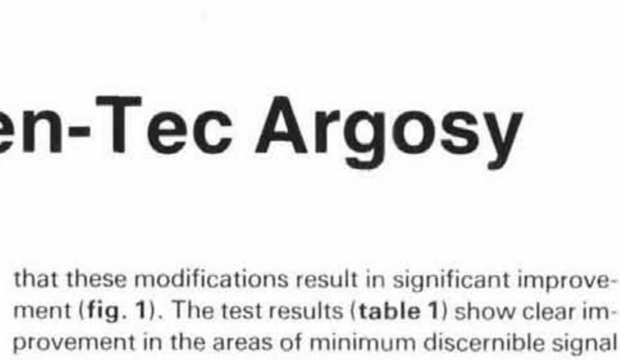


fig. 1. Laboratory setup used for testing the dynamic range of the two Argosys. The tests were performed with two tones at 14.020 and 14.040 MHz. Third-order product was recorded at 14.060 with the help of a true RMS voltmeter.

By Cornell Drentea, WB3JZO, 7140 Colorado Avenue North, Minneapolis, Minnesota 55429.

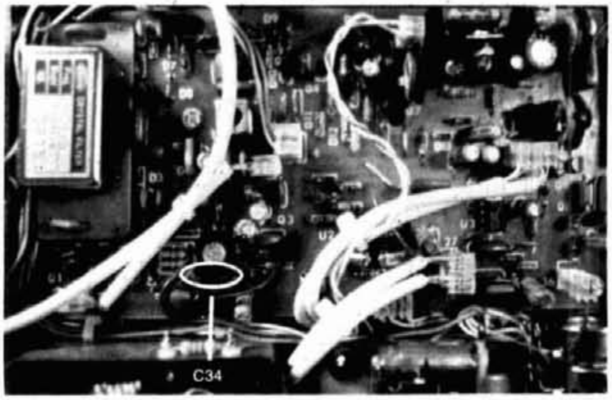


fig. 2. Replacing C34 on the IF/AF board improves the minimum discernible signal (MDS) of the receiver. See text.

While some of these changes were communicated to the manufacturer and reportedly incorporated in the production of the recently-released *Digital Argosy*, owners of this unit may wish to perform those modifications not implemented by the manufacturer.

The changes described in this article are within the reach of any technically inclined Amateur and can be implemented totally or partially as desired. However, I recommend that you have a good understanding of how the Argosy works before proceeding with the modifications. I've tried to describe the modifications in sufficient detail here; because of limited time, neither Ten-Tec nor I will be able to provide additional information. For a better understanding of this article, it would be wise to read the owner's manual as carefully as possible.

improving the noise floor

As previously stated, one of the most annoying problems associated with my Argosy's receiver performance was its high noise floor that obscured weak stations. While this was not apparent on strong signals, the hiss greatly reduced the overall intelligibility of many CW and SSB signals.

Several calls and a face-to-face discussion at the Dayton Hamvention with Ten-Tec engineers offered some possible solutions. After several unsuccessful trials, I proceeded on my own to find out what was wrong with the receiver. A few hours of analysis and careful isolation of stages revealed, much to my surprise, that the problem was caused by a design glitch in a totally different area of the receiver. The audio low-pass filter (R47, C34 following the product detector, Q3, which is located on the i-f/af board 80785) had a corner frequency of 3.28 kHz, which would have been a good choice if attenuation were steep beyond this point. However, this was only a simple first-order low-pass filter with an attenuation slope of 6 dB per octave, which was incapable of preventing BFO noise sidebands of up to 10 kHz from spilling into the high gain audio amplifier of the receiver after being mixed down to audio frequencies in the product detector. This, in turn, superimposed an annoying hiss over all the received signals and obscured signals below S3. Once the problem was found, the fix was simple. Changing C34 from 0.01 to 0.1 started the corner frequency of the low-pass filter at 338 Hz, allowing enough roll-off beyond 3 kHz, cancelling the annoying noise and making a dramatic improvement in the signal-to-noise performance of the receiver. Although one might suspect that the 6-dB roll-off of the new filter with a corner frequency of only 338 Hz might affect the overall audio response of the receiver, this was not the case. The audio frequency response measurements performed after the modification was made showed a flat response over the entire audio range of interest (600 Hz to 2800 Hz).

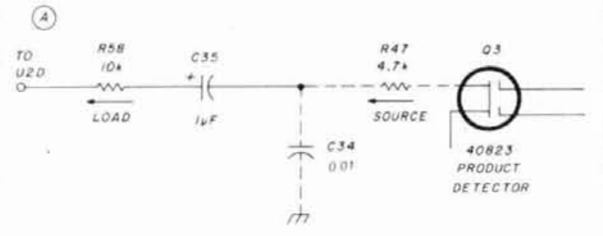
Table 1: Comparative dynamic range tests between an unmodified and a modified Argosy were performed under laboratory conditions. Tests were performed in the 14-MHz CW band with all crystal and audio filters "in", and the noise blanker out of the circuit.

Spec	Unmodified	Modified
MDS	−126 dBm	−138 dBm
Blocking dynamic range, 5 kHz from the interfering carrier	103 dB	133 dB
Spurious-free dynamic range (SFDR) two-tone, third-order 20 kHz spacing	80 dB	98.5 dB

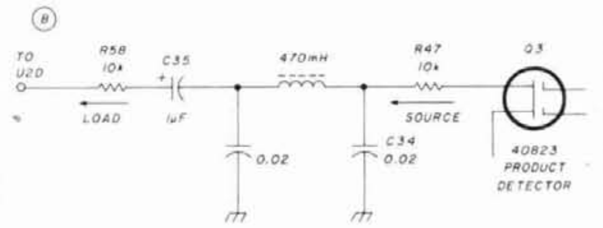
This was due to compensation in the audio gain of the receiver inherent in the original design. With the problem fixed, the rig worked so well that I decided to share the information with Ten-Tec, whose engineers quickly calculated the new corner frequency, tested the change, and concluded that it made a "radical" difference in the noise floor performance of the receiver.

Figure 2 shows the location of C34 in the transceiver. While it's not necessary to completely remove this capacitor (one can parallel the new capacitor on top of the board), doing so involves simply removing the board — just unplug all connectors, remove all metal screws, and replace C34 with a 0.1 μF ceramic capacitor rated at a voltage greater than 25 volts. Slide the board back into place. This modification should take no more than 10 minutes. (Be careful to plug connectors back exactly where they belong.)

Even better performance can be obtained by totally replacing the RC network with a second-order filter with a cutoff frequency of 3 kHz. This involves the use of a high-Q, 470-mH inductor as shown in **fig. 3**. In this modification, the source resistor (4.7 k) has been



Original audio LP filter design (rf/af board 80785) parts to be changed are shown in dotted line



Recommended audio LP filter modification (rf/af board 80785)

fig. 3. Further improvement of the minimum discernible signal (MDS) can be obtained by replacing the first order RC low-pass filter (R47, C34) with a second-order high *Q* inductor type filter with a cutoff frequency of 3 kHz. The 470 mH ferrite inductor is available from the author.

replaced with a 10-k resistor, which was necessary for symmetrical C values in the legs of the filter, as well as to make use of the entire range of the volume control.

reducing ac hum

Although the receiver was now very quiet, it was immediately apparent that the next problem was a 120-Hz hum previously obscured by the noise floor. This hum was caused by the ac switch and power line located in the immediate vicinity of the high-gain audio stages, unshielded audio cables, and front panel controls, all acting as audio pickups for the induced ac field.

I decided that the perfect solution — eliminating the power switch at this location — would not only solve this problem but also allow another modification: the insertion of an rf/af gain, dual potentiometer, which will be described later in this article. Good results can be obtained by shielding both the power line and the sensitive cables as shown in **fig. 4**. Copper foil is recommended; however, aluminum foil should also work. Make sure that the shield is grounded at several points to avoid ground loops.

improving dynamic range

Two additional modifications were effective in increasing the Argosy's dynamic range. While they are specifically intended to improve the intercept point of the receiver, they also improve MDS performance.

The first modification consists of replacing the present mixer diode set (D12, D13, D14, and D15* on the rf/mixer board 80784) with a new set of matched high-voltage Schottky barrier diodes. The part chosen for this application was the Hewlett Packard 5082-2800. The 2800 uses a "guard ring" design, making it ideally suited for handling high-level signals.

The second modification consists of changing the rf switch diodes (D10 and D11) on the same board to high-

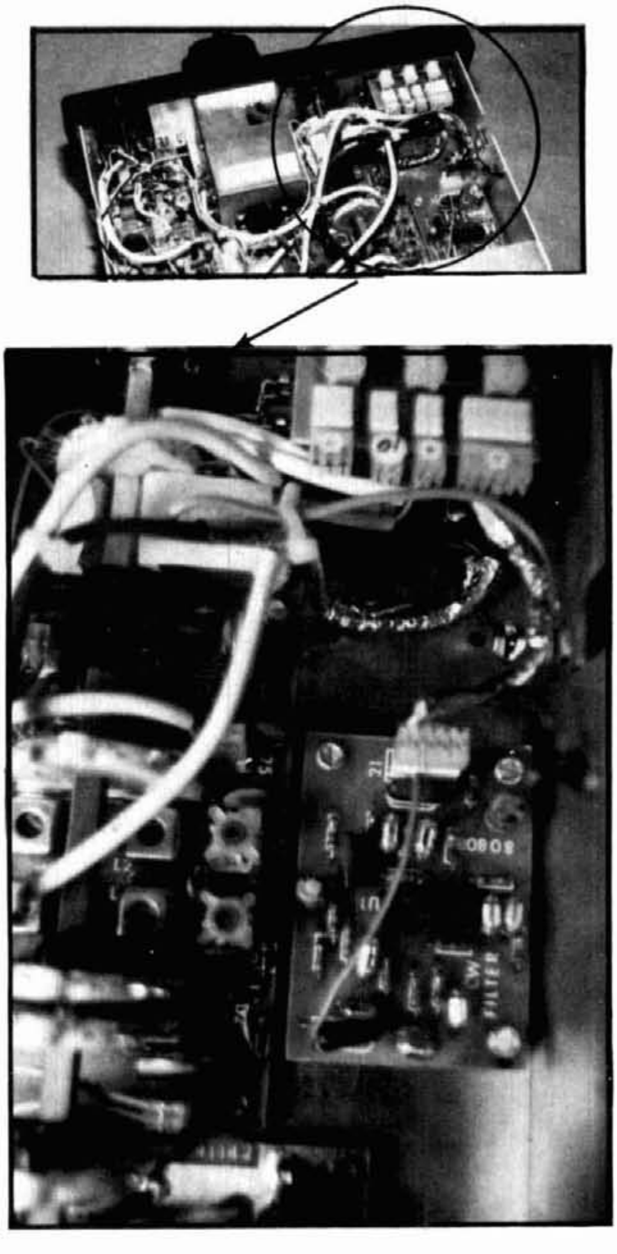


fig. 4. Shielding the power line and sensitive cables in the high gain af section of the Argosy will provide further signal to noise improvements in the receiver. (A) Bottom view of chassis. (B) Expanded view of cable assemblies.

**ham radio* style customarily identifies diodes as "CR." To avoid confusion, however, the "D" nomenclature is used here when referring to Argosy components.

— Ed

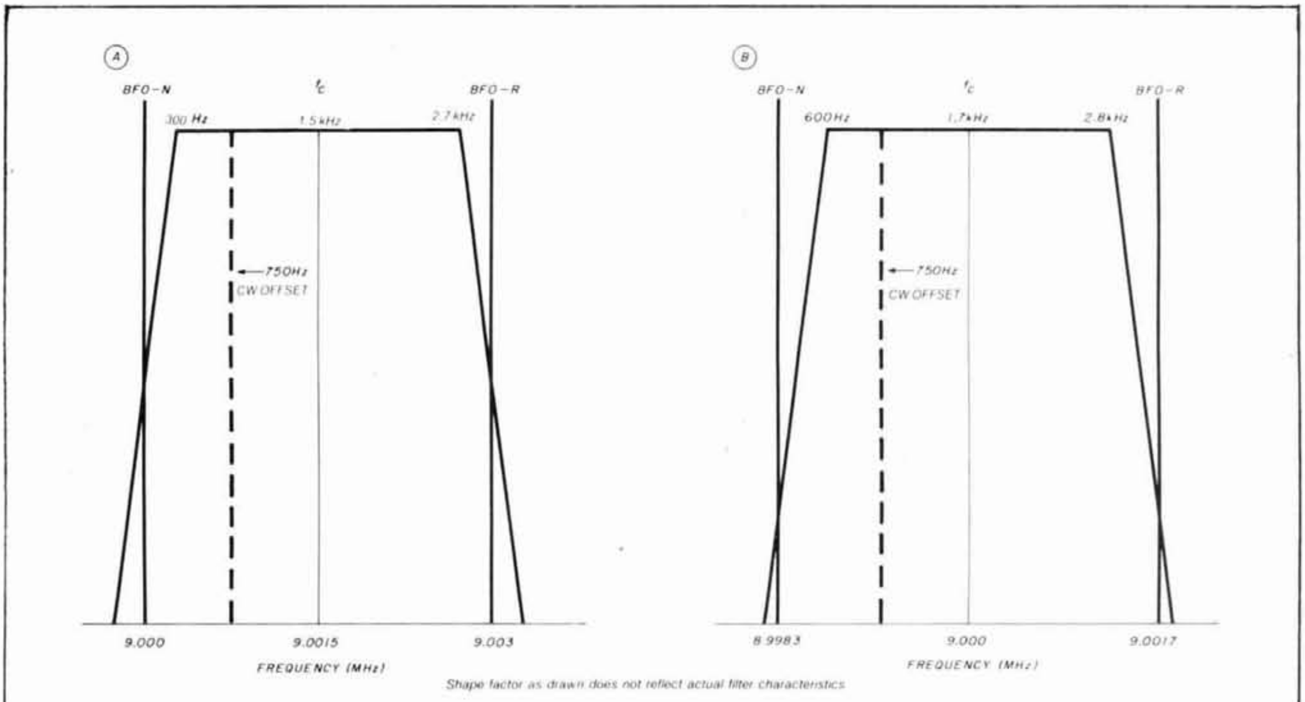
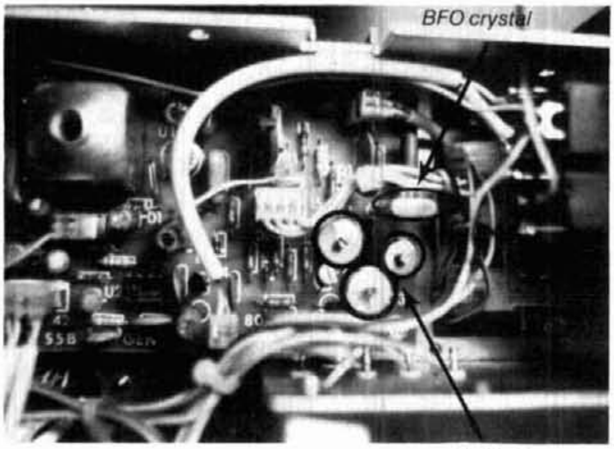


fig. 5. (A) BFO adjustments for the original 9.0015-MHz Argosy filters; (B) BFO adjustments with standard 9.000-MHz filters.

current PIN diodes designed especially for rf switches and attenuators such as the HP 5082-3081. About 75 mA of bias current should be provided to these two diodes for a positive rf turn-on. This is accomplished by replacing the 470-ohm resistor at R4 with a 220-ohm half-watt resistor. Although the 3081 can use more current for better rf switching, this is not recommended in order to protect the drive transistors located on the Control Board 80781. This modification is not recommended for applications requiring thrifty battery use — for example, in portable QRP operation. However, it does further improve the dynamic range of the receiver.

To implement these changes, remove all connectors and metal screws carefully and slide the rf/mixer board out. Remove the old diodes with the help of "Solder Wik" or a similar product and replace them with the new parts, following the diode polarity already marked on the board (the band is the cathode). Reinstall the board, making sure that all metal screws and connectors are back in their proper places. Readjust mixer balance trimmer C2 for minimum received product at 21.320 MHz, as outlined in the manufacturer's manual (pages 3-7). The receiver will now be very quiet and signals will stand out against the background without being disturbed by powerful adjacent stations. The AGC will also be favorably affected since less intermodulation distortion will be present in the i-f passband. Remarkable results have been realized by replacing the original four-pole i-f filter with a better filter, but some problems will occur if you try to use standard 9.000-MHz filters.



C_1, C_2, C_3 settings with new BFO frequencies

fig. 6. New trimmer settings required for the SSB generator Board 89789 when using the recommended 9.000 MHz filters.

using standard 9.000-MHz i-f filters

The Argosy came equipped with a four-pole, 2.4-kHz wide filter which drew some unfavorable audio reports in SSB. In addition, a "wide" transmitted signal was reported on some crowded bands.

A similar problem noted in the receive mode contributed to adjacent signals getting into the i-f passband and consequently activating the AGC. While it's possible to buy optional filters from the manufacturer, this was beyond my financial means at the time. I tried some new 9.000-MHz filters with the proper impedance but found they produced unfavorable results for no apparent reason. A careful analysis of the design showed that the manufacturer's choice of i-f center frequency was 9.0015 MHz instead of the more popular 9.000-MHz approach (this isn't readily apparent from either the manual or the part numbers marked on the filters as used in the transceiver). Because 9.0015-MHz filters were not available to me, some ingenuity was required in order to use the more standard 9.000-MHz filters.

In order to use these filters with the Argosy it was necessary to change the frequency of the BFO crystal and adjust three trimmer capacitors on the SSB Generator Board 80780 for slightly different frequencies.

Let's analyze the way the BFO works from **fig. 5A**. In order to use the 9.0015 center frequency filter, the Argosy designers chose BFO frequencies of 9.000 MHz for "SB-Normal" and 9.003 MHz for "SB-Reverse." These parameters are set by frequency-pulling a crystal oscillator via the triple trimmer setup on the SSB generator board according to a procedure outlined in the owner's manual.

To use 9.000-MHz filters, I replaced the BFO crystal with an 8.9985-MHz crystal (a KVG XF-901) and proceeded to recalibrate the three trimmer capacitors according to the Carrier Oscillator Alignment Procedure explained in the manual and by using the new parameters shown in **fig. 5B**. The new numbers allowed for an audio passband of 600 Hz to 2800 Hz (center frequency, *fc*, is 1700 Hz) when using the filters recommended in this article (see table 2). The 1700-Hz center frequency was selected over the more conventional 1500-Hz unit after a series of intelligibility tests. Many excellent reports were received after the modification.

This audio range lends itself easily to the 750-Hz offset required for the CW mode. The recommended 9.000-MHz filters exhibit superior shape factors over the original four-pole filter (See **table 2**). **Figure 6** shows the approximate position of C1, C2, and C3 trimmer capacitors necessary for this modification as implemented in my transceiver.

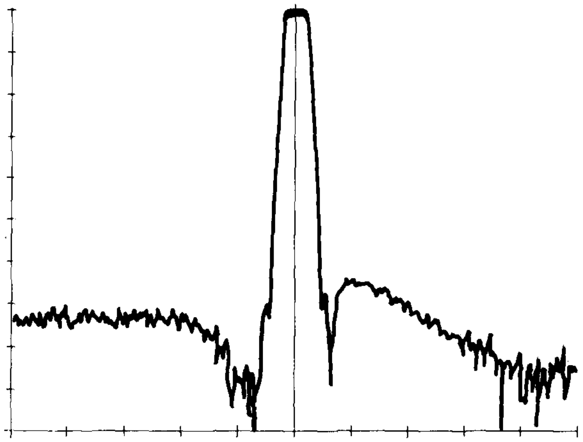
A set of two 9.000-MHz filters can be cascaded (one replacing the four-pole filter on the rf/mixer board 80784 and the other at the optional location of the i-f/af board 80785) with exceptional results in receive or transmit. The combination is the equivalent of a 2.2-kHz wide, 12-pole filter with a shape factor of better than 1.6:1 in the receive mode (only one filter is used in transmit). When combined with the previous changes, this modification produced superlative performance which included improved AGC response in all modes and improved small signal performance in the presence of strong signals.

To make the change, construct the filter connectors by cutting two 2.4 x 1.0-inch pieces of unclad PC board material. Drill four holes to fit four 0.040-inch diameter connector pins snugly. (These pins can be made of discarded TO-5 transistor leads.) The connector pattern can be copied directly from the transceiver PC board layout with a piece of paper and a pencil, using the pencil to punch the existing connector holes and transferring the information to the new PC boards. Drill additional holes for installing the filter assembly on the PC board as required. Then secure the four connecting pins in place at the proper height with blobs of solder on each side of the board, following the dimensions from the original filter assembly. Connect the inputs, outputs, and the grounds of the filters in the same manner as in the original filter. It's important to realize that the cascaded filter on the i-f/af board 80785 will require two dc blocking capacitors if you're using the suggested filters (0.01 μF will do) at the input and output ports because of the diode switching involved there.

After installing the filters and the new BFO crystal, perform the manufacturer's carrier oscillator alignment on the SSB generator board 80780 by using 8.9983 MHz for "SB-Normal" and 9.0017 for the "SB-Reverse" positions. Use **fig. 6** as a guide to begin the setup and fine

Table 2: Specifications of the 9.000-MHz filter used in the modification.

Center frequency	9.000 MHz
Bandwidth at 6 dB points	2.20 kHz
Shape factor, 60-6 dB	1.8
Source impedance	500 ohms
Load impedance	500 ohms
Number of poles	6 crystal poles; 3 LC poles
Insertion loss	Less than 6 dB
USB BFO setting	8998.3 kHz (or 8998.5)
LSB BFO setting	9001.7 kHz (or 9001.5)



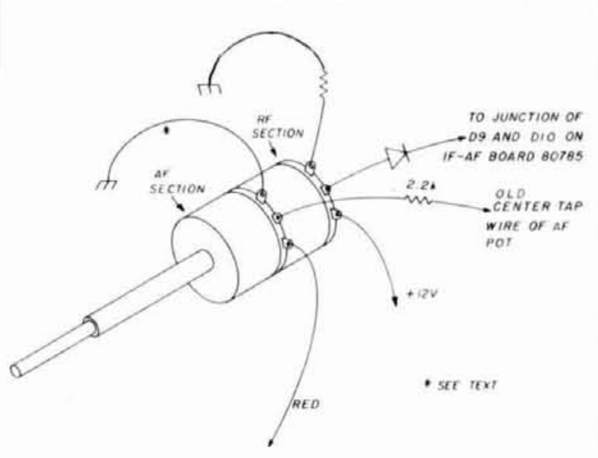


fig. 7. Wiring a dual concentric 10 k potentiometer for rf and af gain controls in the Argosy. The introduction of the rf gain allows control over the AGC when copying weak stations in the presence of strong ones. This modification completely eliminates the popping phenomenon.

tuning of the three capacitors until no error results from the interactive effect (this modification requires a full understanding of how the Argosy BFO works). Adjust the CW offset in step 10 of the procedure to 750 Hz above the "SB-Normal" as required. Although the procedure outlined in the owner's manual is a bit confusing at first because of the interaction between the three capacitors, using a digital counter and a scope should make things easier. No matter how well the settings are performed, the BFO frequency will change value slightly over time because of environmental impact on the trimmer capacitors. Variations of plus or minus several tens of Hz are not unusual for this BFO. These variations can introduce some coloration when you're switching sidebands in either the transmit or receive modes.

To check whether the transceiver needs realignment, follow this procedure. With the receiver on and the antenna disconnected, listen for the "hiss" pitch characteristic in SB-N. If things are "equal" (which they should be), the same pitch characteristic should be heard when switching from SB-N to SB-R. A final test for a different kind of coloration (called *SSB brilliance*) should be performed in the transmit mode with the rf output fed to a dummy load and a microphone connected to the transceiver. To verify that your SSB signal sounds "alive" on the air, use another receiver equipped with a pair of headphones to listen to your own signal. To avoid overload of the receiver, perform the test in the 5-watt QRP transmitter position. If the signal sounds mushy, realign transformer T-1 (the big can) located on the same SSB generator board while pronouncing words containing the letters "S" and "Z" into the microphone.

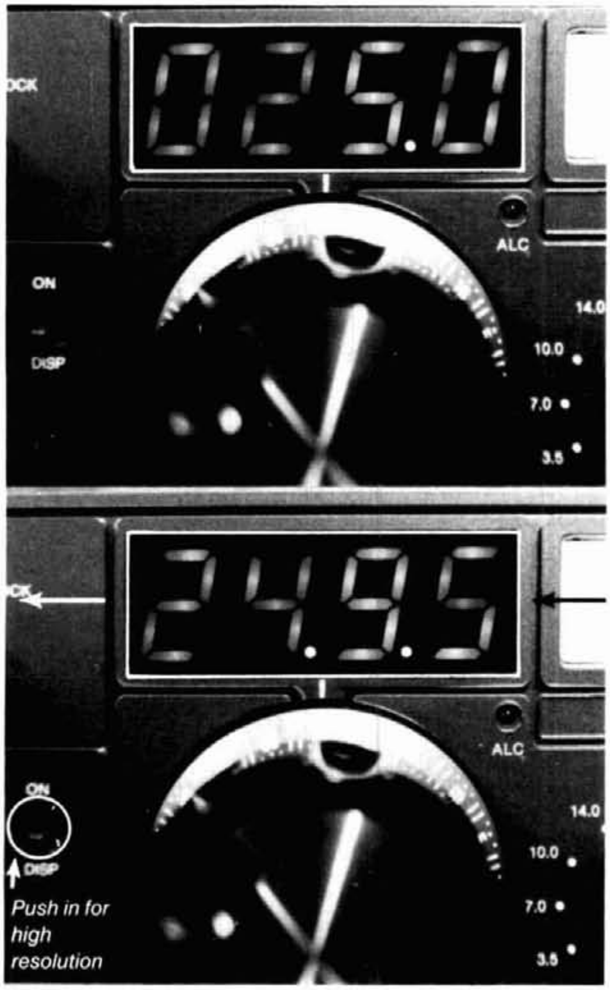


fig. 8. The Argosy frequency can be read to ± 10 Hz (short term stability of the rig is fully compatible with this feature) by pushing in the "CAL" or "DISP" button on the front panel red windows. An additional decimal point will light up in the display (see lower view) indicating that the number has shifted to the left.

Using the plastic tool provided with the transceiver, slightly vary the position of the T-1 core until these letters are heard clearly in the monitoring receiver (the core should be at the bottom of its travel). Repeat this test in the opposite sideband until everything sounds as lifelike as possible. Because the transformer has been adjusted at the factory, this adjustment should be minor. If it hasn't been properly set, this can make a major difference in intelligibility of your SSB signals at the other end. (It has no effect on the receiver itself.) Last, but not least, make sure that carrier balance adjustment, R1, is set for minimum carrier leakage as pointed out in the procedure described in the manual.

improving audio AGC characteristics

One of my biggest complaints was the popping characteristic of the Argosy's audio AGC. While most of the modifications presented so far improve to a great degree the AGC's reaction to unwanted out-of-band signals and in-band background noise, a simple additional modification will virtually eliminate popping. This change consists of replacing C12 on the i-f/af board 80785 with a 22-μF, 35-VDC tantalum capacitor, which exhibits a favorable charging curve that cancels out the annoying "pop," at the same time providing a more suitable response time for the AGC. With this capacitor in place, the attack and release times were measured at 20 milliseconds and 2 seconds, respectively. This constitutes an almost perfect compromise between CW and SSB. (This modification can be incorporated when the other changes are being made to the same board.)

When installing the tantalum capacitor, be sure to observe polarity. After this change, popping was almost completely eliminated with only a hint of it left on signals exceeding 40 dB over S9 in level, and with all filters (including narrow af) inserted. In order to completely eliminate the popping, the addition of the rf gain control is required.

rf gain control

Although the original Argosy didn't include an rf gain control, adding one can further improve the performance and versatility of the rig when attempting to copy weak signals in the presence of strong ones. An additional improvement is the complete elimination of popping. (This simple matter is explained in Ten-Tec's technical note TN2-525.) The modification consists of replacing the single potentiometer used for the audio gain with a dual concentric 10-k potentiometer. To install the new control, the front panel and the old control were removed. I soldered the wires from the old af control in the same locations on the front section of the new dual potentiometer by also inserting a 2.2-k carbon resistor in the center leg (the Argosy has so much gain that only about a third of the old potentiometer range was usable before). Then I connected the rear section as shown in **fig. 7**.

This change eliminated the switch function of the af-Power control. (This can be a good move because you won't need to worry about induced hum into the af sections any more.) The rig may be switched either from the front panel of the power supply or by a miniature switch added to the back panel. If desired, an AGC on/off switch can also be installed by breaking the connection between D9 and Q5 on the i-f/af board 80785 and wiring in another miniature switch. I chose not to implement this modification permanently because it wouldn't add anything to the performance.

Because concentric knobs weren't available, they were fabricated. The af knob was made by cutting off the top of a regular knob with a diameter of 0.8 inch. Additional filing brought the set screw within immediate proximity; little shaft length was available because of the spacer effect of the front panel. The rf knob was fabricated from a smaller diameter knob with the 0.25-inch hole filled with epoxy and redrilled for the inner shaft, which measured 0.125 inch in diameter. The entire modification took half an hour to complete.

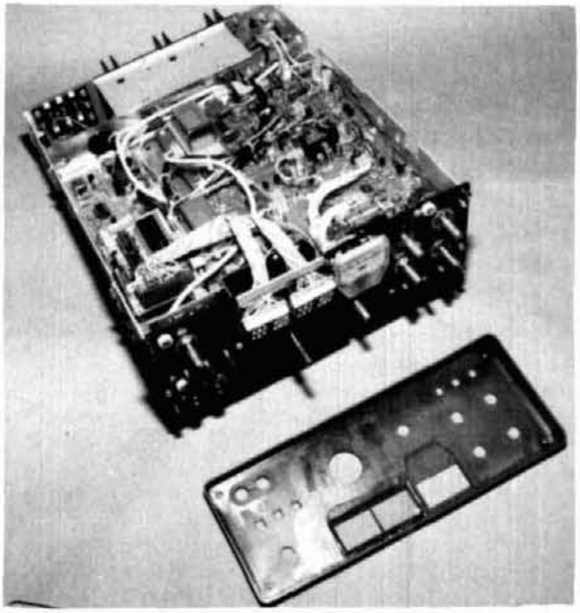


fig. 9. Installation of the digital counter in the Argosy and interconnections with the NSN 784 displays. Also shown is how the red window is secured to the front panel of the Argosy with epoxy through the dial opening.

PTO frequency stability

Another annoying problem related to the Argosy's performance was the frequency instability of the PTO, which caused small, sudden jumps of a few tens of hertz in the received or transmitted signals. This phenomenon seemed to be intermittent and showed up at random times with no apparent remedy. The problem, confirmed by other Argosy owners, may be present in similar rigs.

While the problem appeared mechanical at first, I concluded that it was caused by an intrinsic characteristic of a part in the design of the PTO. I was happy to find that Ten-Tec offers — on an exchange basis and for a reasonable fee of $25 — a new PTO that doesn't exhibit the problem. When a new PTO was obtained and installed, the problem disappeared once and for all.

The installation requires the removal of several wires and PC boards, but shouldn't take more than 15 minutes to complete. The performance of the new PTO is well worth the investment and allows the use of a precision digital counter which displays the transceiver's frequency with a resolution of 10 Hz, a considerable improve-

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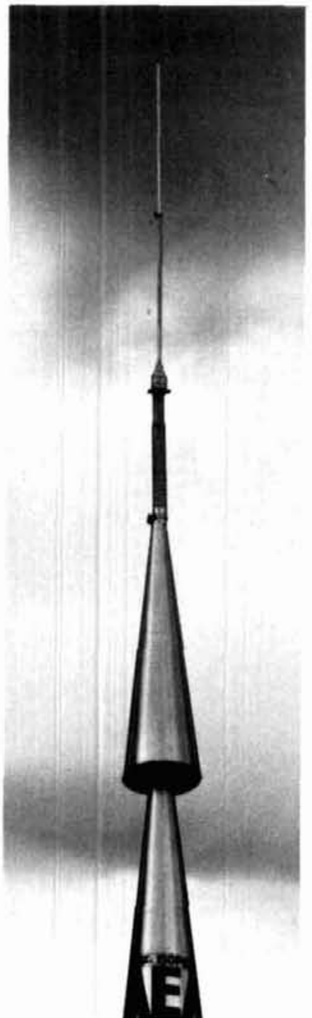
Outstanding mechanical design makes the IsoPole the only logical choice for a VHF base station, especially for Packet operation. All Isopole antennas yield the **maximum gain attainable** for their respective lengths and a maximum signal on the horizon. Exceptional decoupling from the feed line results in simple tuning and a significant reduction in TVI potential. The IsoPole antennas are all impedance matched in the factory so that no field tuning is required. The IsoPoles have the broadest frequency coverage of any comparable VHF base station antenna. This means no loss of power output from one end of the band to the other, when used with SWR protected solid state tranceivers. **Typical SWR is 1.4 to 1 or better across the entire band.**

A standard 50 Ohm SO-239 connector is recessed within the base sleeve (fully weather protected). With the IsoPole you will not experience aggravating deviation in SWR with changes in weather. The impedance matching network is weather sealed and designed for maximum legal power. The aerodynamic cones are the only appreciable wind load and are attached directly to the support (a standard TV mast which is not supplied).



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2.1 VSWR bandwidth	)12Mhz @ 146Mhz	)15Mhz @ 220Mhz	)22Mhz @ 435Mhz
Power Rating	1 kw	1 kw	1 kw
Gain**	3 dbd	3 dbd	3 dbd
Radiating Element Length	125.5" (3.2m)	79.25" (2m)	46" (1.2m)
Amateur Net Price	$49.95	$49.95	$69.95

**dbd — db gain over a dipole in free space

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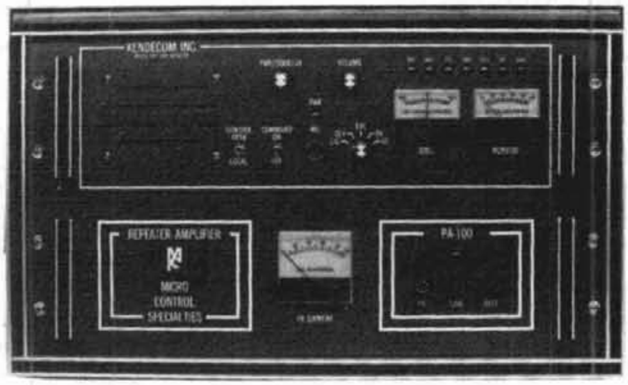

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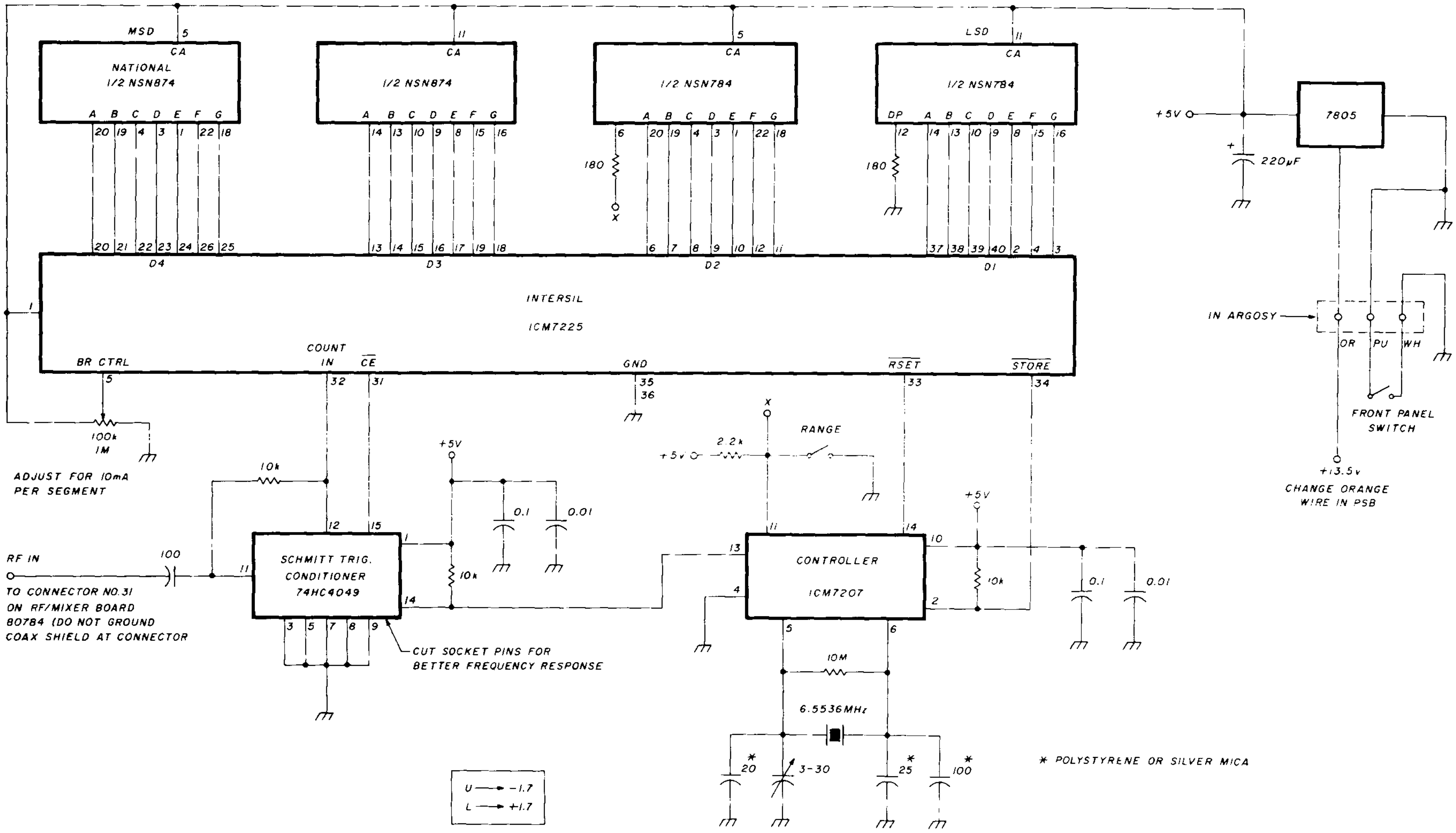


fig. 10. Diagram of the frequency counter as implemented in the author's Argosy. The entire board was wire wrapped in an afternoon on a 2 x 3.3 inch perforated board and installed in place of the calibrator board using its existing three holes.

ment over the ±2-kHz calibration provided by the Argosy's analog dial.

high-resolution digital display

The static digital display design in the modified Argosy uses three ICs and does away with the multiplexer noise so familiar to other designs. It allows the use of the front panel push button previously used to turn on the calibrator to further increase the resolution of the displayed frequency to 10 Hz, a feature I found extremely helpful.

The top-notch performance of the modified Argosy was finally complemented by the installation of a static (non-multiplexed) four-digit counter which displays the frequency of operation by reading the premixed PTO/-crystal oscillator's frequency. Reading the premixed injection presents the advantage of accounting for all possible shifts created in the crystal oscillators, which would have to be accounted for mathematically if reading only the PTO frequency. On the other hand, such a counter must be capable of operating at frequencies better than 20 MHz (as opposed to 5.5 MHz) if measuring the PTO. In addition, by wiring the calibrator push button from the front panel as shown, the four-digit numbers can be shifted to the left, allowing for 10-Hz resolution (an additional decimal point lights up to indicate that the magnifying feature is turned on). See **fig. 8**.

The design of the display was inspired by Intersil application notes. I had initially hoped that an LCD display would fit under the Argosy's front panel, but this was impossible because of the rather small dimension between the top of the bezel and the display opening. In addition, the 16-kHz back plane oscillator called for in this design was out of the question because of rf noise. The resulting design uses a static seven-segment LED design based on the ICM7225 LSIC from the same manufacturer.

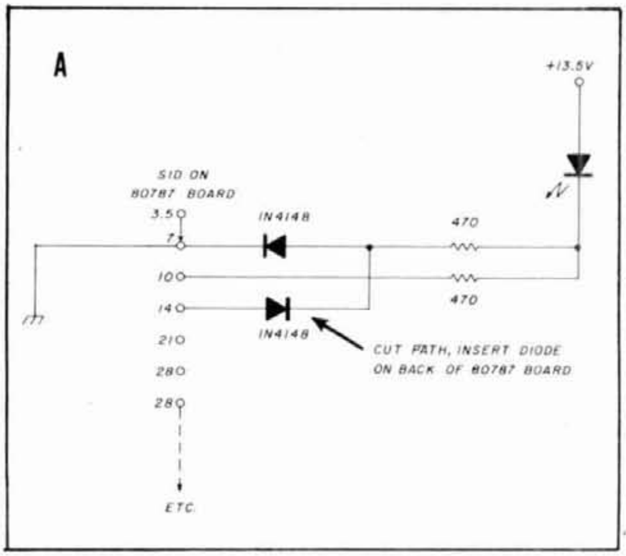
While many seven-segment LED displays were available, I chose the National NSN 784 common anode display because of depth restrictions between the front panel and the sub-panel. The 784 is built without pins and space-consuming extruded parts. Its design is basically a square PC board — with the LEDs fused into the surface of the board, allowing for minimal depth — which fits snugly between the two panels. With this approach, the flat cable used to connect the display with the small digital board located in the transceiver fits nicely through the narrow window previously used for the analog dial as shown in **fig. 9**.

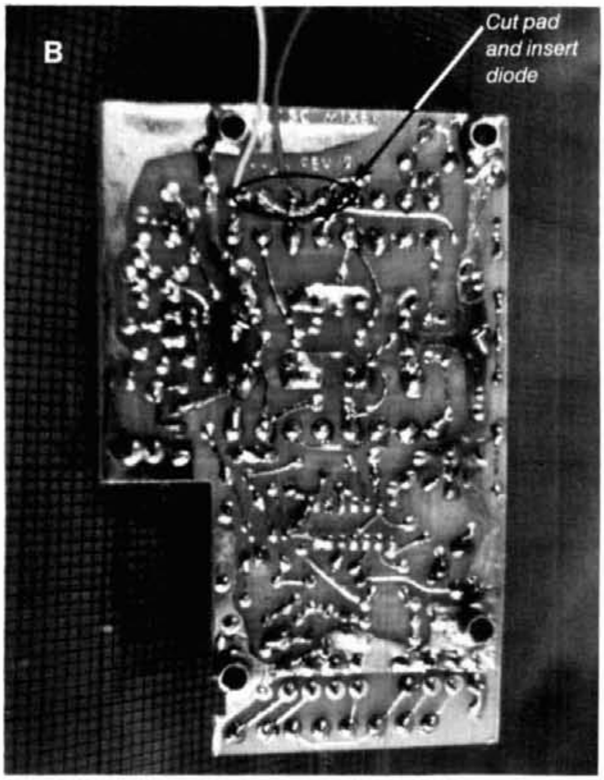
After this wiring was completed, the socket pins from the signal-conditioning IC 74HC4049 and from the controller/oscillator IC ICM7207 were shortened for better frequency response. If not short enough, pins on the 74HC4049 socket will limit the frequency response of the counter on the higher bands. As a matter of choice, the front panel switch (CAL) can be used either for turning on the display or for the magnifying feature. Both choices are shown in the schematic diagram in **fig. 10**. Only one function is possible without the addition of a separate switch.

The rf injection signal is fed to the conditioning IC 74HC4049 via a coaxial cable and a 100-pF capacitor from connector 31 located on the rf/mixer board 80784. When soldering at the connector, make sure not to ground the shield of the coaxial at this point or you'll defeat the turn-on function of the front-panel switch.

Adjusting the display is easy when using a high-resolution counter connected to the same pin on connector 31. Adjust the trimmer capacitor on the ICM7207 for an equal frequency readout between the counters, which should both be set in a high resolution mode. If a counter isn't available, reasonable results can be obtained by tuning to WWV. This counter will read only the center frequency of a station as offset by the BFO modifications performed earlier. If you're using the recommended settings, you'll have to add 1.7 kHz in lower sideband and subtract 1.7 kHz in upper sideband. Because no preset lines are available in this simple design. A feature activated from the band switch can tell the user when to add or subtract the offset number by lighting up either a plus sign or a minus sign inside the last digit of the display. This was accomplished by cutting a pad and installing a diode in its place instead on the S1D switch from board 80787 as shown in **figs. 11A, B,** and **C.**

Installation of the digital display in the Argosy proceeds as follows. Obtain two NSN 784 dual displays and grind off the rivets holding the windows to the back of the PC boards. Carefully remove the windows and plastic inserts so as not to touch the fused LEDs on board, now visible to the eye. Deposit a few drops of "Super Glue" or equivalent on the board in areas outside the segments and LED locations and key back the plastic insert without the window. Squeeze the assembly together until the two parts become a single assembly. This will prevent possible damage to the LEDs. Repeat the operation for the second display. Then solder a 16-wire flat cable to each of the boards as shown in **fig. 10.** Remove the front panel from the Argosy and remove the existing red window as well as all mechanical cables and fixtures associated with the analog display. File out the square opening in the front panel to accommodate the two new windows. Fit the two square windows snugly in the opening until they're flush with the outside surface of the front panel. Then deposit a small amount of epoxy around the perimeter of the two squares inside the front panel. In the process, make sure that the two windows are flush with the outside of the front panel; this is accomplished by laying the entire assembly on a flat surface. Only a small amount of epoxy should be deposited so that the PC board LED assemblies can fit





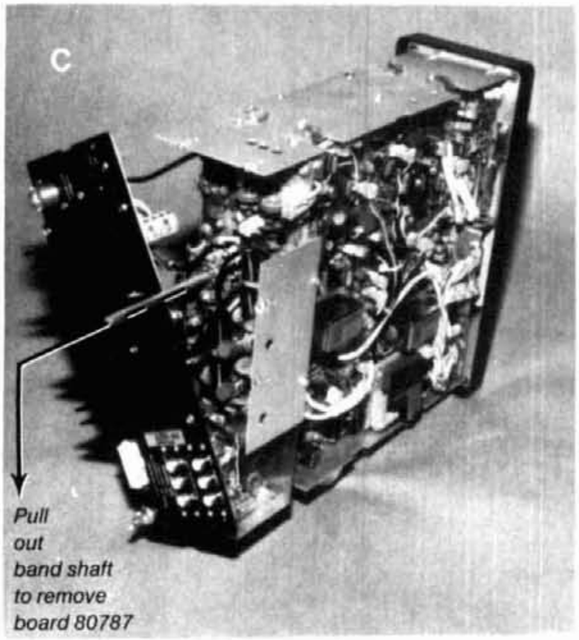


fig. 11. (A) Diagram of a sideband correction indicator (see text). (B) Implementation of the sideband correction mechanism on board 80787 requires cutting a pad and installing a simple silicon diode (1N914) in its place. (C) Removing Board 80787 from the transceiver requires the removal of the bandswitch shaft through the back.

back in their rivets when the job is complete. No epoxy should be allowed in the area under the top of the front panel because the cover must be free to slide back under the bezel.

To complete the job, wrap electrical tape around the metal cutout to prevent possible grounding. Place a weight on top of the front panel assembly and allow it to cure overnight. When curing is complete, reinstall the Argosy's front panel by pulling out the ALC indicator diode assembly and plugging it properly into the red LED from the front panel. Then carefully insert the two seven-segment LED boards in their keys, which are now attached to the front panel. Make sure that the translucent plastic diffuser squares are sandwiched between the red windows and the PC assemblies. Then pull things together until the digits are visible through the front windows. Push back the entire front panel assembly until the ALC LED fits back in its hole and screws can be attached. The flat cables can now be bent and properly wired to the digital board. To complete the job, make a 0.25-inch deep cutout in the top cover for the entire length of the display in order to prevent possible shorts. As an additional precaution, place electrical tape along the cutout.

conclusions

The modified Argosy (**fig. 12**) has been in operation for several months. Its performance has been a pleasure and well worth the efforts described in this article. Other possibilities exist for modifying the Argosy to increase its versatility. These include adding a separate PTO with memories; an rf splitter in the receiver input to allow for a separate receiver to be used in conjunction with the transceiver (this can be done by breaking the coaxial cable from connector 32 and introducing a Mini Circuits PSC2-1 rf splitter in the circuit with one of the outputs wired to one of the empty RCA connectors in

Table 3. Parts available from (A) suppliers and (B) author.

(A) Parts available from suppliers.

6.5536-MHz crystal, available from JAN CRYSTALS, P.O. Box 06017, Fort Myers, Florida 33906-6017 ($7.50 plus shipping).

XF-901 crystal, available from Spectrum International, P.O. Box 1084, Concord, Massachusetts 01742 ($6.25 plus shipping)

ICM7207 (don't order the "A" model), available from Advanced Computer Products, P.O. Box 17329, Irvine, California 92712-7329 ($7.50 plus shipping).

ICM7225 LSIC, available from Intersil authorized distributors nationwide (e.g., Arrow Electronics, Hamilton Avnet, Schweber Electronics, $12.50 plus shipping).

74HC4049, High-speed CMOS, 16-pin hex/buffer/converter (inverting), available from JAMECO Electronics, 1355 Shoreway Road, Belmont, California 94002. Digi-Key, P.O. Box 677, Thief River Falls, Minnesota 56701-9988. ($2.50 plus shipping).

(B) While quantities last, the following hard-to-find parts are available from the author.

Hewlett Packard 5082-2800, set of four matched high-voltage Schottky diodes ($15.50 plus $1.50 shipping).

Hewlett Packard 5082-3081, set of two matched high-current PIN diodes ($8.50 plus $1.00 shipping).

Dual concentric 10-k potentiometer for rf/af gain modification ($12.50 plus $1.50 shipping).

22 μF, 35 VDC Tantalum capacitor for AGC, $2.25 plus $1.00 shipping.

9.000-MHz i-f filter, 2.2 kHz (BW per specification), $45.00 plus $2.00 shipping.

Second 9.000-MHz i-f filter, 2.2 kHz (BW with blocking capacitors), $45.50 plus $2.00 shipping.

470 μH, low-resistance, high-Q inductor for audio LP modification ($6.00 plus $1.00 shipping).

Set of two 0.02-μF capacitors for audio low-pass filter, $0.50 plus $0.50 shipping.

Set of two NSN 784 LED seven-segment displays (four digits), $9.00 plus $1.50 shipping.

If combinations of the above items or the entire kit ($140.00) is required, include $3.00 for shipping (U.S. only, please).

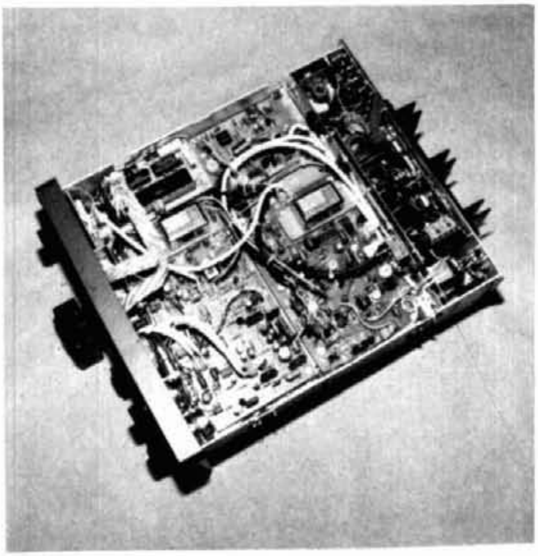


fig. 12. Completed unit.

the back of the transceiver); passband tuning in the i-f, and even a new BFO circuit. A list of parts available from the author and from various suppliers is shown in **table 3**.

acknowledgments

I would like to thank Tom Jorgensen, K0UBF, for donating his unmodified Argosy for the laboratory tests; Marc Denis, KD0QO, for being instrumental in performing them; Ed Wetherhold, W3NQN, for identifying the proper commercially available inductor and capacitor for the low-pass filter design; and Rick Whiting, W0TN, for his suggestions during the writing of this article.

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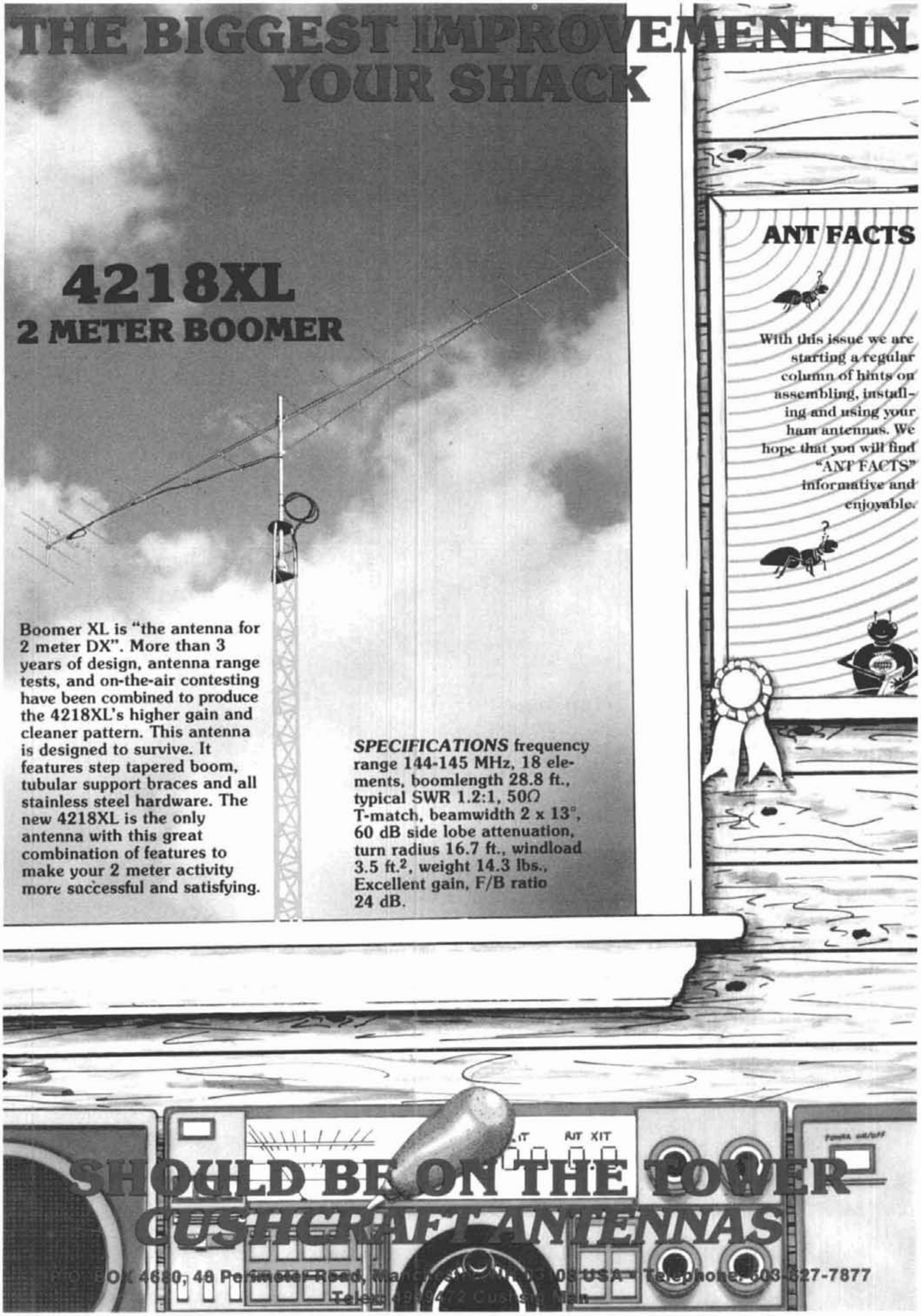

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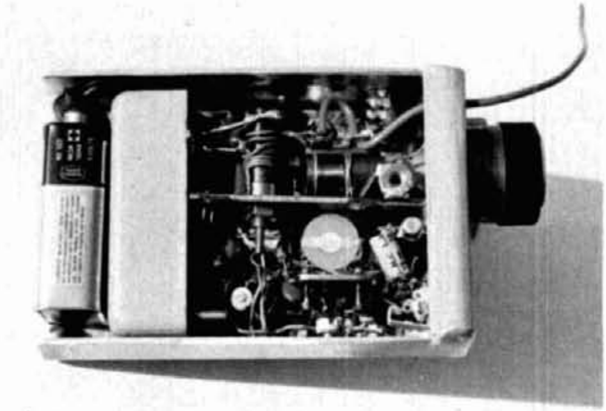

build a pocket-portable SSB receiver

This article describes the design and construction of a very small, portable 20-meter single sideband receiver. Because some of the more demanding performance requirements can be relaxed in favor of small size and reduced component count, the project also represents an interesting design exercise in value engineering.

For example, reference 1 states that performance limitations are the principal drawbacks of integrated circuit mixers. Yet for a portable receiver in use in a remote location — say on a camping trip — small size and high gain may be more important than strong signal performance. Reduced complexity is also attractive to inexperienced builders; using ICs simplifies the design, since they can be considered as building blocks already designed by the manufacturer's specification sheets. The only real work, then, is selecting the best ICs and connecting them together.

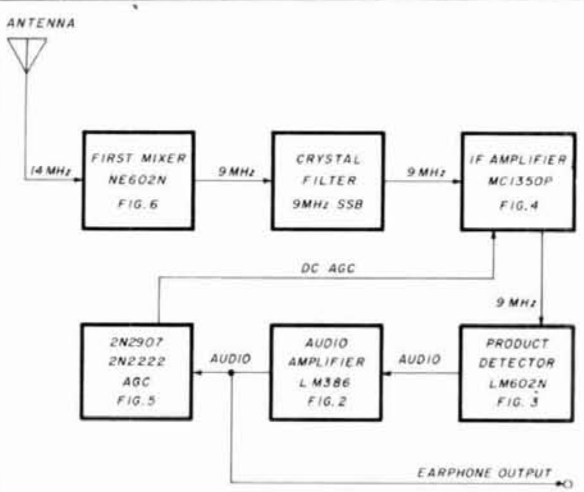

fig. 1. 20-meter receiver block diagram.

circuit description

Figure 1 shows that the receiver is a conventional single conversion superheterodyne design with a 9-MHz i-f. Major circuit blocks are represented by IC part numbers with the exception of the AGC. The following circuit theory of operation is presented in a sequence beginning at the output and proceeding toward the input, which is the recommended sequence for construction. Dividing a large project into several small tasks makes the work seem easier, and the completed output stages can be used as a test aid to align and troubleshoot preceding stages assembled later.

audio amplifier

Figure 2 shows the National Semiconductor LM386 Low-Voltage Audio Power Amplifier, which is used to drive an earphone. The main advantage of this component is low battery drain and operation from a 9-volt

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

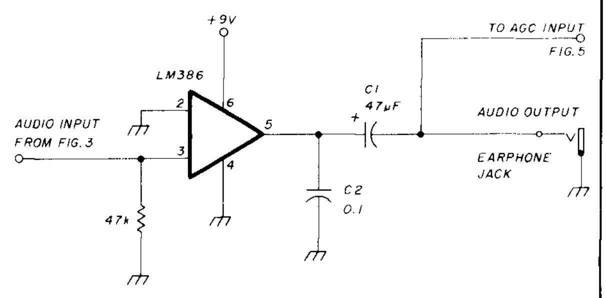

fig. 2. Audio amplifier.

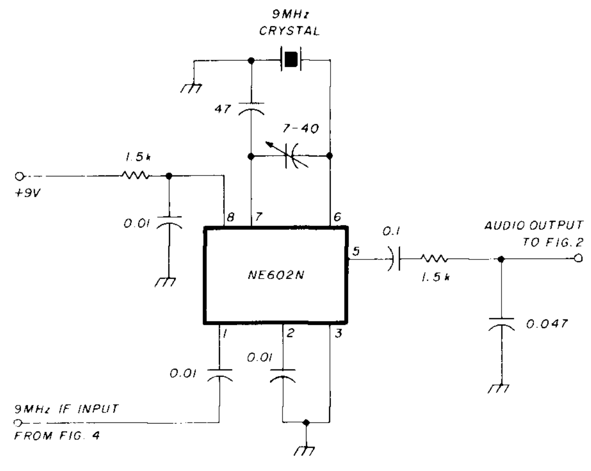

fig. 3. Product detector. Pins 4 and 5 are push-pull outputs, and either may be used.

battery. The 9-volt power source was considered essential for convenience in obtaining batteries while traveling.

Peripheral components increase circuit complexity, but provide an opportunity to shape the receiver audio frequency response. Signal frequencies below a few hundred Hz and above a few kHz should be attenuated by selecting audio coupling and bypass capacitor values carefully. Each capacitor (and associated resistance) provides a 6-dB per octave rolloff beyond the break point. The half-power break frequency is:

$$F = \frac{0.159}{RC}$$

where *F* is in Hz, *R* is in ohms, and *C* is in farads. For example, the output coupling capacitor, C1 of **fig. 2**, gives a low-frequency rolloff frequency calculated as 160 Hz. This is assuming that the LM386 output impedance is very low and the earphone offers the principal resistance in the circuit. I actually measured the earphone impedance to be 21 ohms at 1000 Hz when the calculations gave confusing results. The earphone is presumably 16 ohms, but it could have been 8 ohms. The following data was taken for selected capacitors using one-half voltage for the measurement point, which resulted in slightly lower frequencies (6 dB down):

330 µF 10 Hz
100 µF 70 Hz
47 µF 120 Hz

These results suggest that it may be better to substitute capacitors and sweep the frequencies with an audio oscillator than perform calculations when circuit resistance may be inconvenient to determine. In fact, components were selected experimentally, but the equation is helpful for awareness of circuit operation and to provide a starting point. A bypass capacitor (0.047 µF) in the product detector output provides a similar function for high frequencies, and the equation is the same.

C2, added to cure a high-frequency oscillation, may not be necessary in all cases. A large capacitor bypassing the audio power amplifier wastes power and may cause instability.

Tests showed that a 30-millivolt, 1000-Hz input signal provided a 600-millivolt output for a gain of 20. Current drain was 5 milliamperes at 9 volts.

product detector

The Signetics NE602 shown in **fig. 3** is used for the product detector as well as the first mixer. One of the more popular Gilbert Cell mixers, it also contains a voltage regulator and bias, an oscillator, and an rf amplifier. These features are implemented with an absolute minimum of external components. Pin 7, the oscillator emitter, can be used as a test point for checking oscillator operation. 350 millivolts of 9-MHz sine wave signal is a typical value. The capacitors connected to pin 7 must be adjusted for the correct operating carrier frequency to match the crystal filter. Power voltage for the NE602 is 6 volts, which is supplied to pin 8 through the 1.5k resistor. Application of a 400-microvolt 9-MHz i-f input signal to pin 1 gives a 150-millivolt peak-to-peak earphone output when connected to the audio amplifier **see fig. 2**. The current drain is an economical 2.5 milliamperes. More information on the NE602 is provided in the first mixer circuit description.

The resistor/capacitor network connected to pin 5 shapes the audio frequency response as described in the previous section. The 0.1 µF capacitor provides low frequency rolloff to complement C1 of **fig.1**. The 0.047 µF capacitor bypasses high frequencies.

i-f amplifier

A Motorola MC1350P television i-f amplifier was

MIRAGE/KLM

SPECIFICATIONS

Electrical

- Band Width .... 1260–1300 MHz
- Gain 18.2
- VSWR .... Better than 1.5 to 1
- Feed Imp .... 50 Ohms
- Balun .... 4:1 Rigid Coax

Mechanical

- Beam Length .... 12′ 4″
- Element Length .... 4.5″
- Mast .... 2″ O.D.
- Windload .... 1 sq. ft.

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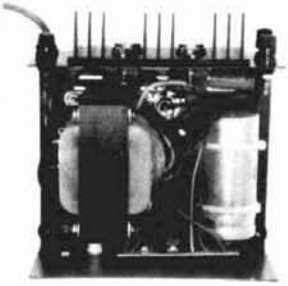
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MODEL VS-50M

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RM-50A	37	50	5¼ × 19 × 12½	50

- Separate Volt and Amp Meters

Model	Continuous Duty (AMPS)	ICS* (AMPS)	Size (IN) HXWXD	Shipping Wt. (lbs.)
RM-35M	25	35	5¼ × 19 × 12½	38
RM-50M	37	50	5¼ × 19 × 12½	50

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RS-7A	5	7	3¾ x 6½ x 9	9
RS-7B	5	7	4 × 7½ × 10¾	10
RS-10A	7.5	10	4 x 7½ x 10¾	11
RS-12A	9	12	4½ x 8 x 9	13
RS-20A	16	20	5 x 9 x 10½	18
RS-35A	25	35	5 x 11 x 11	27
RS-50A	37	50	6 x 13¾ x 11	46

RS-M SERIES


MODEL RS-35M

- Switchable volt and Amp meter

MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H x W x D	Shipping Wt (lbs)
RS-12M	9	12	4½ x 8 x 9	13
RS-20M	16	20	5 x 9 x 10½	18
RS-35M	25	35	5 x 11 x 11	27
RS-50M	37	50	6 x 13¾ x 11	46

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- Current limit adjustable from 1.5 amps to Full Load

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VS-20M	16	9	4	20	5 x 9 x 10½	20
VS-35M	25	15	7	35	5 x 11 x 11	29
VS-50M	37	22	10	50	6 x 13¾ x 11	46

RS-S SERIES


MODEL RS-12S

- Built in speaker

MODEL	Continous Duty (Amps)	ICS* Amps	Size (IN) H x W x D	Shipping Wt (lbs)
RS-7S	5	7	4 x 7½ x 10¾	10
RS-10S	7.5	10	4 x 7½ x 10¾	12
RS-10L(For LTR)	7.5	10	4 × 9 × 13	13
RS-12S	9	12	4½ x 8 x 9	13
RS-20S	16	20	5 x 9 x 10½	18

used for the 9-MHz i-f amplifier **fig. 4**. This popular IC features high gain, excellent stability, and a very handy AGC input terminal. The MC1350P was intended for a 12-volt power supply, but works well on 9 volts with a current drain measured at 12 milliamperes. No particular effort was expended to wind T1 with a 14-turn primary (center tapped) and a 14-turn secondary on an FT 37-61 ferrite toroid core with No. 27 AWG wire. It seemed to resonate with about 15 pF of capacitance provided by a 9- to 20-pF variable, but it also works without the capacitor. Be sure to ground the AGC input, pin 5, for maximum gain while testing. Performance testing now shows that only 0.7 microvolts RMS 9-MHz input is required to produce a 100-millivolt peak-to-peak earphone audio output. The MC1350 gain was 50 dB with a 200 microvolt i-f output for the 0.7 microvolt input. Total receiver current drain at this point was 20 milliamperes.

crystal filter

The crystal filter is the largest and potentially most expensive item. The price of a new crystal filter would make it impractical for so simple a project. I first considered the crystal filter as an optional or less critical item, but the obvious performance improvement made it a necessity. The filter and BFO crystal can be a junk box or surplus item. The 9-MHz filter used for this project was purchased for about $20 from a *ham radio* advertiser a few years ago, but swap meets and hamfests are also good sources. Be sure to get a BFO crystal with the filter, but if several filters are available inexpensively it may be better to break apart a filter to get an oscillator crystal. With luck it may be possible to tune the BFO to the right frequency with the oscillator capacitors and avoid the expense of ordering a crystal. At this point, a substantial effort may be required to sweep the filter with a signal generator while monitoring the receiver audio output and adjusting the BFO frequency for the desired frequency response.

automatic gain control

AGC is a truly optional feature that could be substituted with a potentiometer voltage divider connected to the MC1350 AGC input. Some experience using this method showed that the "two-knob" tuning method required was somewhat inconvenient considering the small controls and lack of panel space. Also, eliminating the manual gain control provided additional space for an AGC circuit.

The AGC characteristics of the MC1350 used were measured and tabulated as follows:

Pin 5 voltage	4.50 volts max gain
	4.77 volts min gain

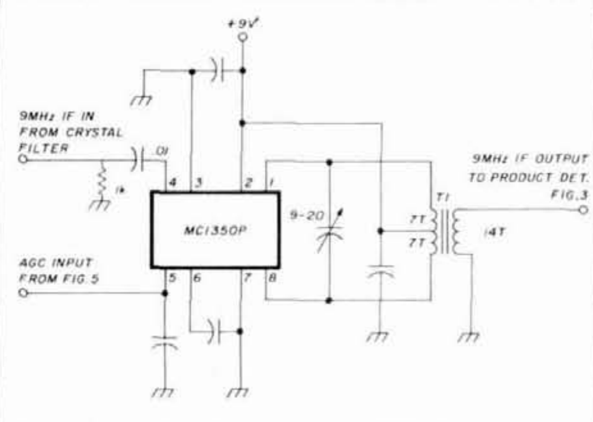

fig. 4. I-f amplifier. All capacitors are 0.01 disc except the 9-20 pF variable.

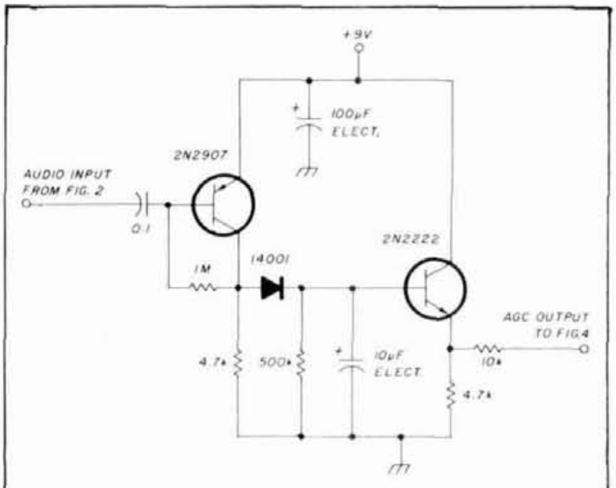

fig. 5. Automatic gain control.

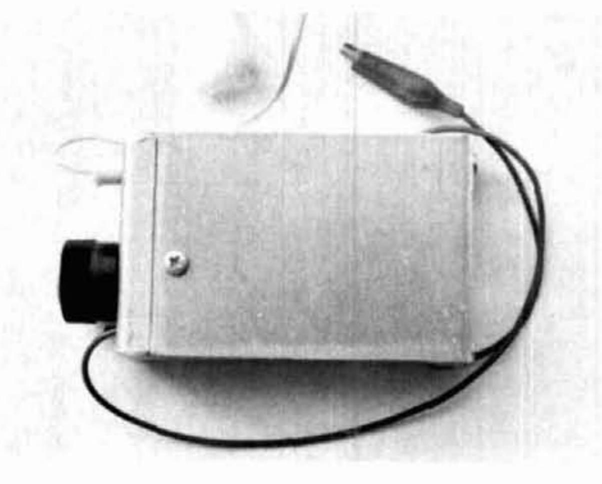

Photo A. The receiver is housed in a sheet aluminum enclosure. The aluminum was bent in a brake and the corners were TIG (Tungsten Inert Gas) welded. The clip lead is the antenna connector.

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Pin 5 with a 10-k series resistor	*4.00 volts max gain*
	6.30 volts min gain

Pin 5 is essentially a current sink. Adding a 10-k resistor in series makes a convenient voltage range for the AGC circuit to drive.

Figure 5 shows the AGC circuit, an unfortunate departure from the use of ICs. The Plessey SL621C would have provided an excellent AGC IC, but I felt that it was too sophisticated (and expensive) for this simple application. The 2N2907 amplifies the earphone audio, which is half-wave rectified by the 1N4001. The time constant circuit uses a 10-μF capacitor and a 500-k resistor. The 2N2222 is a dc amplifier that drives the MC1350. A 100-μF electrolytic capacitor was required to bypass the 9-volt power line to prevent a low-frequency oscillation.

The addition of this AGC circuit holds the earphone audio output to *100 millivolts peak-to-peak* and consumes 2 milliamperes of current drain. Performance could be described as very aggressive but slightly slow on attack time. A slow attack time prevents the receiver from being muted for the RC time constant period when only a brief noise pulse is received. A full wave AGC rectifier would improve attack time but would also add to complexity. The circuit has more gain than is required to keep the audio ouput leveled, but *I prefer this compression effect to eliminate the* need for any other gain control.

mixer

The NE602N is used in the receiver first mixer (**fig. 6**). Two LC-tuned circuits are used in this circuit; L3 tunes the 14-MHz input and L1 is the 5-MHz local oscillator (LO) frequency control. L2 is a small rf choke added to restrict the L1 tuning range to 5.000 to 5.375 MHz. It's difficult to find a small vernier dial and variable capacitor, so a knob was attached to L1 for a tuning control. L1 was a 0.375-inch iron slug-tuned coil wound with 17 turns of No. 27 AWG wire. Many different L and C combinations could probably be used in this oscillator circuit. Pin 7 is the emitter and pin 6 is the base of the oscillator transistor. Reference 2 cautions against using too low a circuit *Q* and suggests connecting a 22-k resistor from pin 7 to ground if the oscillator won't start. Increasing the 300-pF capacitor values in **fig. 6** reduced the oscillator output, which was measured at pin 7 to be about 300 millivolts peak-to-peak. L3 is a 0.250-inch iron slug tuned form with 14 turns of No. 27 AWG wire. The input coupling link used five turns of hook-up wire. Don't try to use capacitor coupling for the NE602N input without a parallel choke or coil winding to ground. Low-frequency noise ("hum") will be coupled to the input amplifier, modulating all signals received.

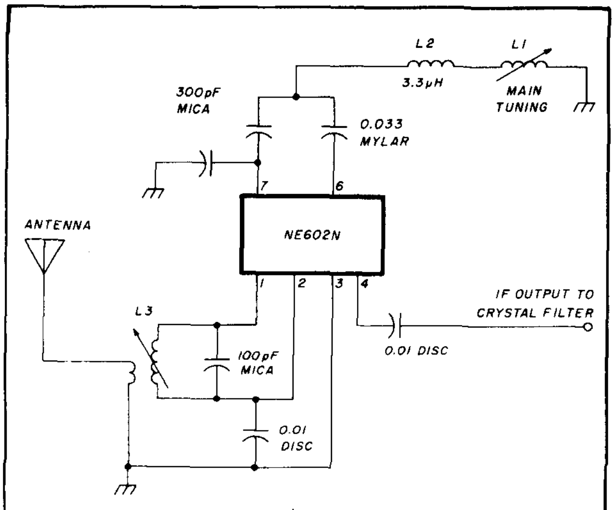

fig. 6. First mixer. The value of the 300-pF capacitors must be adjusted for alignment.

construction notes

I started out soldering components together by their leads as sort of a breadboard without the board to test the circuits. It was soon obvious that the most compact construction technique is to cut the leads as short as possible and solder them together on a double-clad unetched circuit board. The board serves as a ground plane as well as a structural mount. This mounting method is really quite strong, considering the light weight of the parts. A dab of epoxy would really add to strength, but it hasn't been necessary. Most of the parts were junk box selections so only general descriptions of the parts required will be given. This is especially the case for the tuning control, L1. The tuning slug screw must have a friction lock to prevent backlash. Since wear is a problem, select the largest screw size slug available and lubricate it with automotive wheel bearing grease. In this case, I found a short spacer with a tapped hole that fit on the tuning slug screw and locked it with a jam nut the same size. A knob can fit easily over the outside diameter of the spacer. The obvious disadvantage is lack of calibration markings, so it's important to limit the L1 tuning range to reduce confusion.

It may be desirable to enclose L1 and other oscillator components with circuit board since flexing the external cabinet will cause frequency changes. The double-clad printed circuit board is quite rigid when soldered together to make a box. After all the components were assembled and tested on the circuit board, I made a small aluminum box to fit around them. It's probably better to plan ahead and buy a small box, but at the beginning I wasn't sure what the final size or shape would be. (See **Photo A.**)

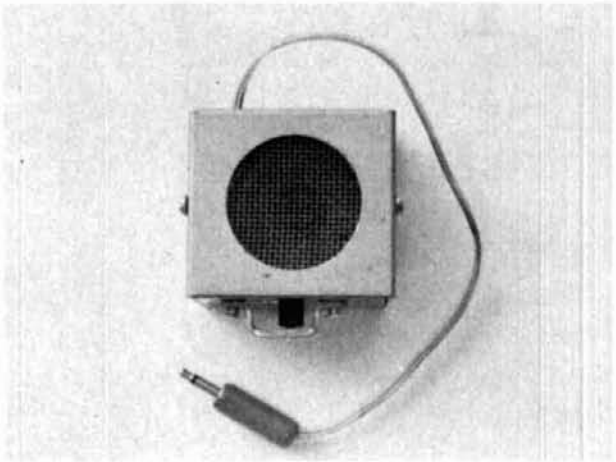

Photo B. This small box contains an amplifier and a speaker. The amplifier is the same as shown in fig. 2. No volume control is required when used with the receiver.

Soldering the components together does pose some problems, however. As can be seen in the photographs, it's very difficult to see some of the components. Repairs seem impossible. Don't solder to the crystal can near any of its solder seals; doing so may cause a vacuum leak, spraying molten solder on the quartz.

The electronic aspects of construction require use of an oscilloscope with a high impedance (x10) probe, an audio oscillator, and an rf signal generator. A frequency counter is handy but not essential. The x10 probe allows monitoring the oscillators with a minimal amount of frequency shift due to loading by the probe. I connect my frequency counter to the oscilloscope channel 1 output for checking the oscillator frequency. This is especially handy for setting up the BFO when the exact frequency is known, but the BFO frequency is subject to adjustment later "by ear" when listening to SSB signals. The first mixer oscillator can be adjusted with a receiver or signal generator, and will also require considerable adjustment to obtain the right frequency range.

conclusion

This receiver has enough gain to be used with almost any metal object as an antenna. I used a clip lead as an antenna connector. It's handy to carry a convenient length of insulated flexible wire for those times when there's a chance to rig a makeshift antenna in a tree or bush. Twenty meters provides good listening most times of the day or night, with some DX in the early morning.

This article presented a few applications of some simple but versatile integrated circuits. My intent was to present a few circuits that might inspire the reader to develop new applications. For example, I mounted an LM386 with a battery and speaker in a small box to carry with the receiver. (See **Photo B**.) Future projects for the NE602 might include a tunable shortwave converter for an a-m car radio, or an aircraft band receiver with an MC1350 i-f amplifier.

references

1. Gary A. Breed, "Mixers: Making the Right Choice," *rf design*, August, 1986.
2. "Applying the Oscillator of the NE602 in Low-Power Mixer Applications," Signetics Applications Note No. AN1982, October, 1985. (Signetics Corporation, 811 East Arques Avenue, Sunnyvale, California 94088-3409.)

ham radio

A simple, low-cost homebrew project

20-meter hf superhet

One of the more diminutive boxing champions of the 1970s was described this way: "pound for pound, the hardest hitter in the world." I like to think that the same can be said of this receiver. Based on ideas put forth by Doug DeMaw and Wes Hayward,[1] it's strictly a lightweight, but it delivers a respectable punch. Its simplicity is accomplished through the use of a single i-f amplifier/detector IC, the Ferranti ZN414.

Because of its sharp selectivity, this superhet (**fig. 1, Photo A**) represents a vast improvement over direct-conversion receivers — though with fewer than 60 parts, it's hardly more complex. I built the prototype to tune about 125 kHz of the 20-meter band, but the receiver can easily be modified to cover 30, 40, or 80 meters.

circuit description

After passing through a fixed-tuned preselector, incoming signals at 14 MHz are admitted directly to gate 1 of the dual-gate MOSFET mixer. Mixer output at the intermediate frequency is passed through a tuned circuit at the primary of T1, a trifilar-wound transformer.* The transformer output supplied to the crystal filter consists of two signals of opposite phase. The effect is that the parallel capacitances within the two crystals are cancelled, leaving an extremely high-*Q* series-resonant circuit. This circuit configuration is known as a half-lattice filter. The shape of the filter's response curve is affected somewhat by terminating resistor R1. R1 is adjusted until the filter response is fairly flat across the top of the curve. The overall width of the curve is determined by the difference in the crystals' frequencies (see **fig. 2**).

Photo A. The receiver cabinet measures 1 $^{15}/_{16}$ x 8 ¼ x 6 ⅛ inch. (49 x 210 x 156mm). Main tuning knob is on the left. Lettering was accomplished with dry label transfers, and the panel was sprayed with clear acrylic.

I used crystals with a frequency separation of about 600 Hz. With different crystal spacing the filter's bandwidth will change. If you wish to use this type of filter you can order two close-tolerance crystals for the desired frequencies. You can also buy three or four inexpensive crystals for about the same price; I used this less expensive approach and obtained three 2-MHz crystals for $2.50 each. When I checked the crystals (this can be done using a breadboarded oscillator with a frequency counter or receiver), I found a pair with spacing that was close enough, but not too close — in other words, just right!

There is an alternative for the experimenter who wants to to simplify this design even further. Acceptable performance can be obtained using only one crystal (**fig. 3**). Trimmer capacitor Cx is adjusted for the sharpest response. This filter has an asymmetrical response curve, with a fairly sharp peak, and one side quite broad. I tried this circuit and found that rejection of the adjacent sideband was fairly good, with only the stronger signals appearing on the wrong side of zero-beat. There's a sharp notch in which the adjacent sideband seems to be totally rejected; it appears that to bring out the best in this simple filter one should include it in a receiver using an audio bandpass filter peaked to the frequency where the image notch appears.**

*To make a trifilar winding, twist three separate pieces of enameled wire approximately 8 turns per inch. Wind the twisted wires through the toroid for 12 turns. I use an ohmmeter to identify the ends.

**If you happen to acquire two crystals of exactly the same frequency, you can use them to construct a ladder filter. I didn't try this approach, but details can be found in Reference 1, pages 217-218.

By Eric Bodner, N3ECZ, 64 South Hazle Street, Hazleton, Pennsylvania 18201

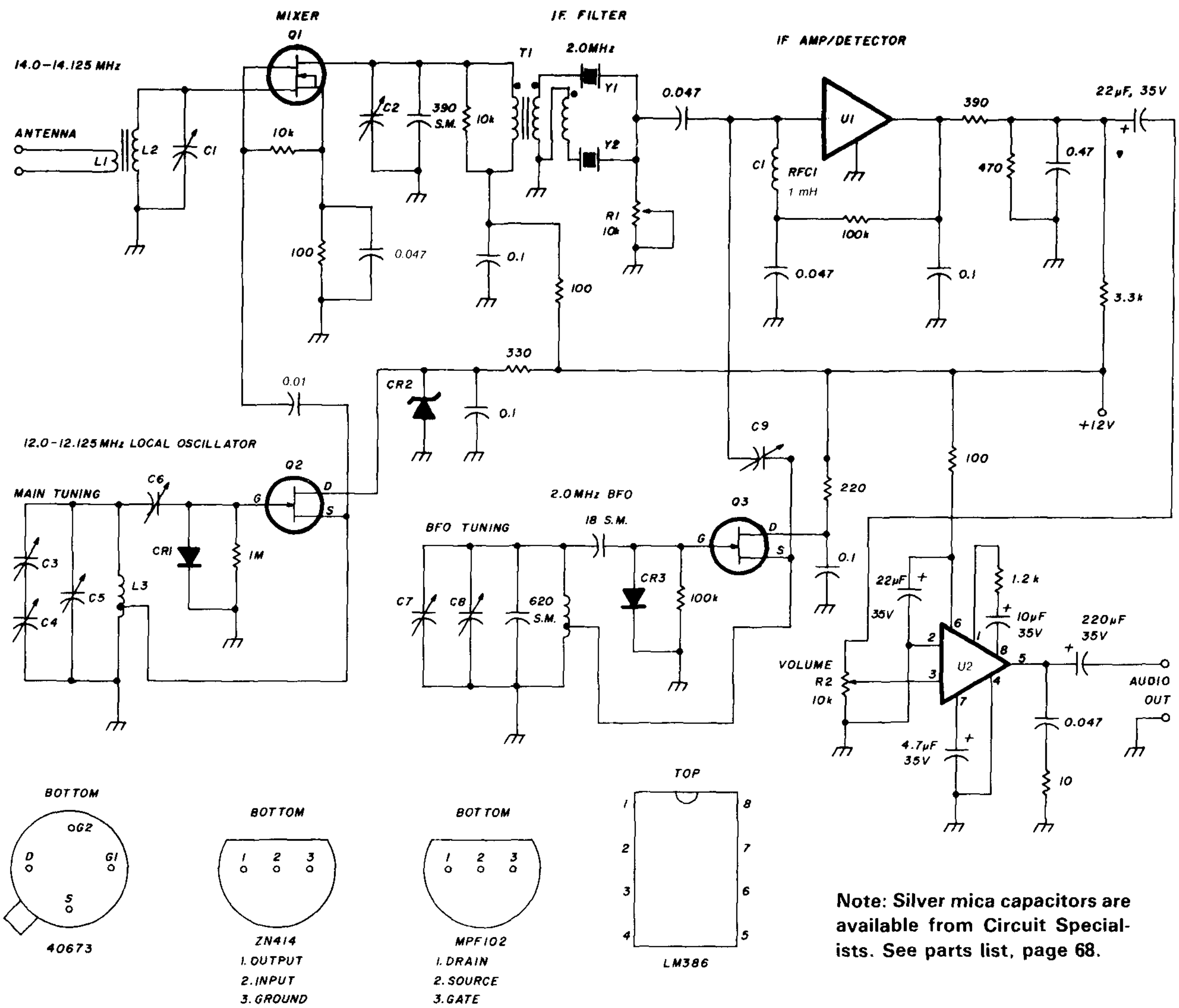

fig. 1. Schematic diagram. Judicious use of discrete devices and hardware results in a miniature receiver that's easy to tame and operate.

The filtered signal at the intermediate frequency is coupled to the input of the ZN414 i-f amplifier. The ZN414 consists of a very high gain rf amplifier followed by an AM detector. The device has three leads and comes in an ordinary TO-18 transistor package. This IC is hot enough to pick up the least bit of stray rf from any nearby (or distant) AM broadcast station, amplify it, detect it, and pass it on loud and clear. In fact, the chip makes a complete TRF receiver for any frequency up to 3 MHz with the addition of only a few external components. However, in the present application the chip should be restricted to amplifying and detecting only a narrow slice of the rf spectrum! Therefore shielded cable is a must for the connections to the ZN414 input from the i-f filter and the BFO.

Audio from the output of the ZN414 is sufficient to drive an LM386 amplifier IC, which in turn provides plenty of volume for headphones or a small speaker.

The local oscillator and BFO are identical except for the tuned circuits. NPO ceramic, polystyrene, or silver mica are the preferred types for the frequency-determining capacitors. C6 is kept at a minimal value to avoid oscillator pulling. Originally a 33 pF fixed-value capacitor was used at C6 and it seemed that every CW station on 20 meters was guilty of sending out a chirpy signal! With the smaller value capacitor in place, loading of the oscillator tank circuit is reduced and no trace of chirp is detectable.

I included a front-panel tuning control for the BFO, but this is optional. If you don't need the versatility

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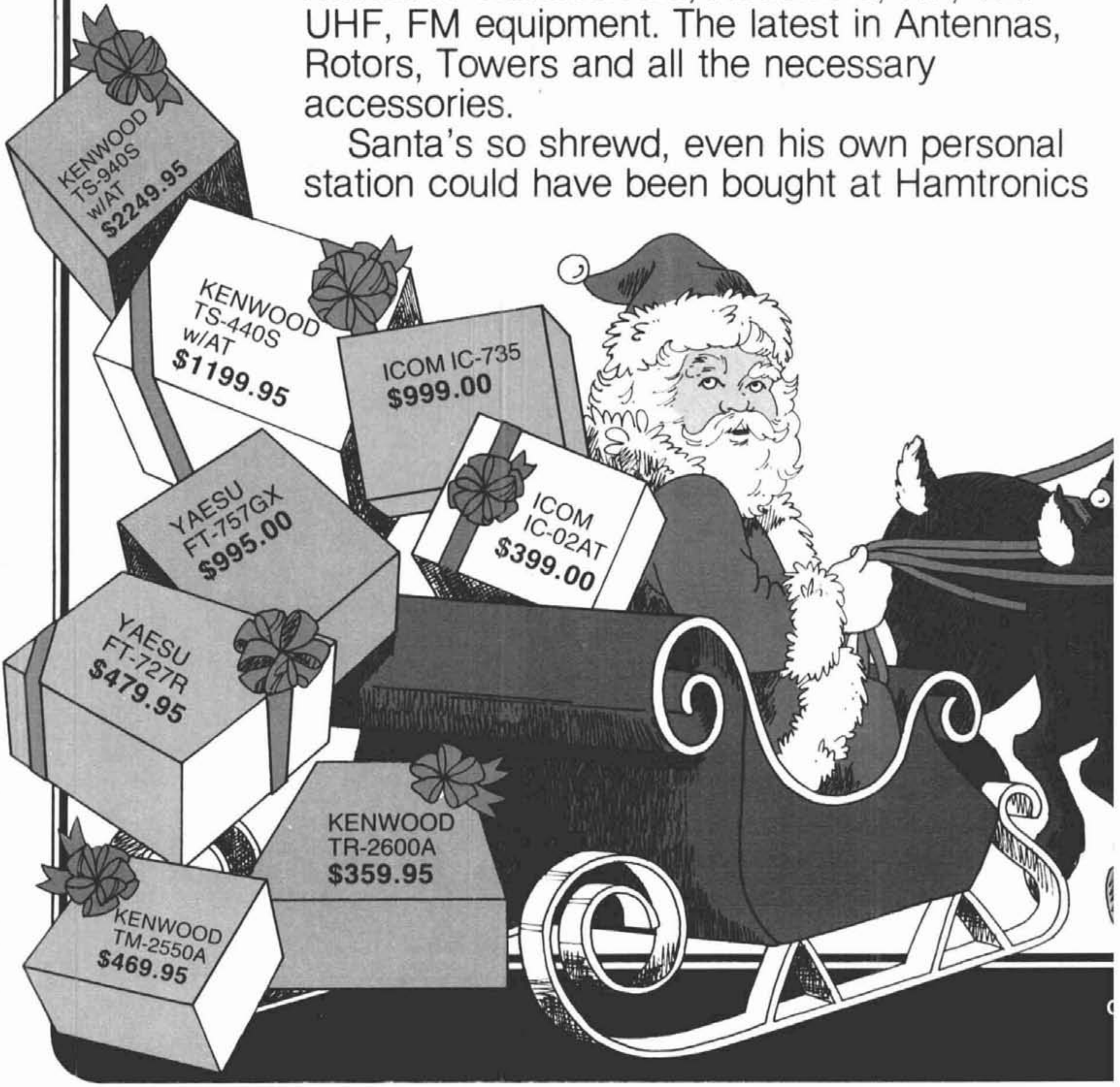

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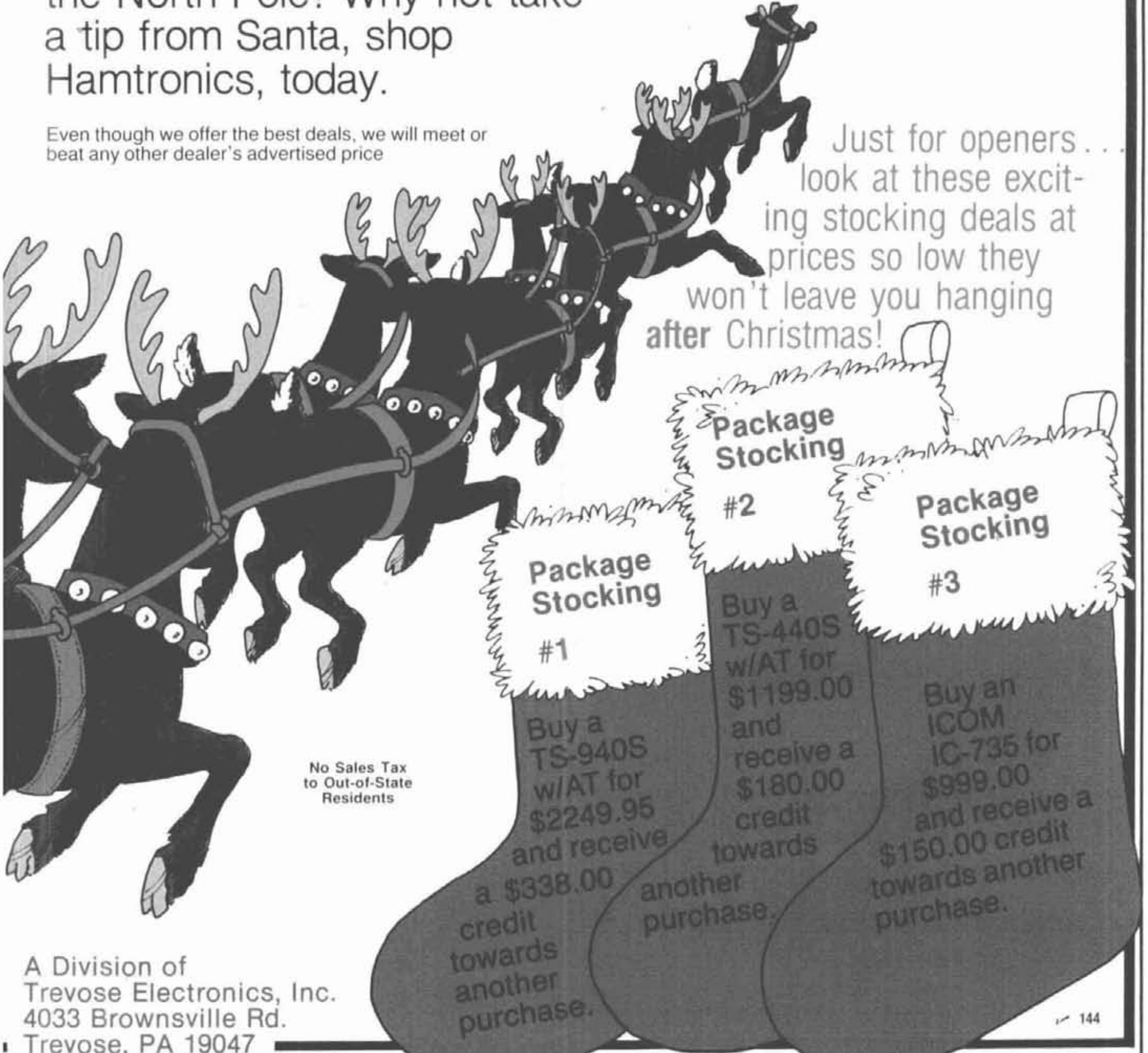

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Parts list, fig. 1:

C1, C2, C5, C8	15-150 pF trimmer capacitor (Radio Shack 272-1339)
C3	15-90 pF air-variable with built-in vernier drive ($2.25 from BCD Electro)
C4	5-60 pF trimmer capacitor (Radio Shack 272-1340)
C6, C9	3-10 pF trimmer capacitor (Radio Shack 272-1338)
C7	1.4-13 pF air-variable ($3.63 from BCD Electro)
CR1, CR2	1N914 (Radio Shack 276-1122)
CR3	6.2-volt Zener (Radio Shack 276-561)
L1	2 turns around ground end of L2
L2	22 turns on a T-50-6 (approximately 1.9 μH)
L3	24 turns on a T-50-6 (approximately 2.3 μH) tap at 6 turns from ground end
L4	40 turns on a T-68-2 (approximately 9.1 μH); tap at 10 turns from ground end tap
Q1	40673 dual-gate MOSFET (available from Circuit Specialists Inc.)
Q2, Q3	MPF102 FET (Radio Shack 276-2062)
R1	10-k trimpot (Radio Shack 271-218)
R2	10-k pot (Radio Shack 271-215)
RFC1	1-mH choke (Circuit Specialists 43LS103)
T1	12 turns trifilar on an FT-37-61 (approximately 8 μH). Note: all toroids available from Circuit Specialists, Inc.
U1	Ferranti ZN414 a-m sub-system IC ($2.00 at Circuit Specialists Inc.) Also available from MHz Electronics, Inc., 3802 North 27th Avenue, Phoenix, Arizona 85017; DC Electronics, P.O. Box 3203, Scottsdale, Arizona 85257; Electronic Emporium, Inc., 4909 East McDowell, Phoenix, Arizona 85008; and Semiconductors Surplus, 2822 North 32nd Street, Unit 1, Phoenix, Arizona 85008.
U2	LM386 audio amp IC (Radio Shack 276-1731)
Y1, Y2	2.0-MHz crystals in HC6/U holder ($2.50 from BCD Electro). Y1 and Y2 can be resonant at any frequency between 1.7 and 2.5 MHz. At an i-f below 1.7 MHz, interference is likely from broadcast stations. Above 2.5 MHz it's likely that the ZN414 IC won't have sufficient gain.

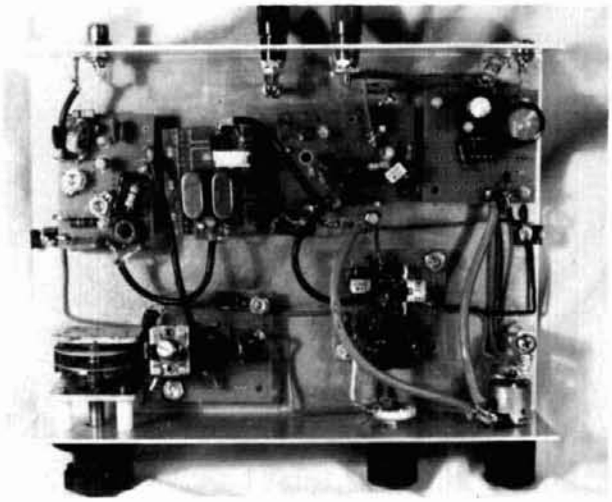

Photo B. Each stage is assembled on a separate board. Layout follows the schematic, with the mixer at the upper left and audio amplifier to the right.

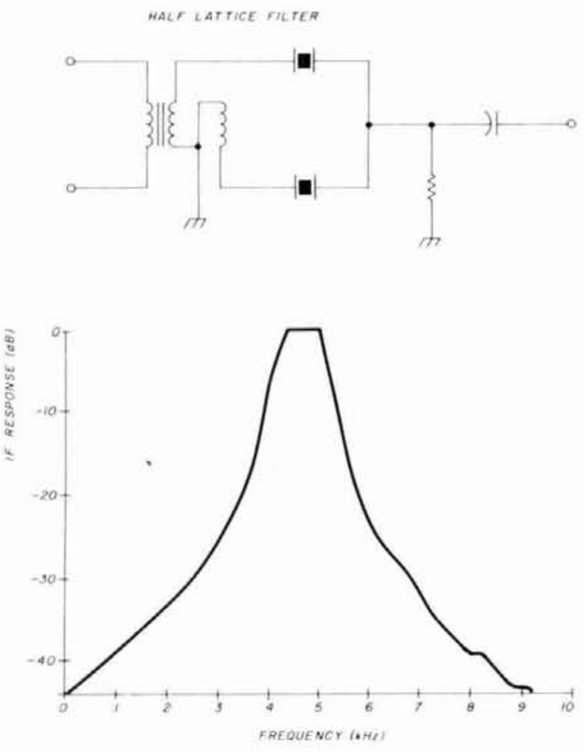

fig. 2. I-f stage response using half-lattice filter.

of a tunable BFO (for tuning either USB or LSB), then a PC-mounted trimmer capacitor may be substituted for the panel-mounted air-variable.

Coupling capacitor C9, which limits the BFO injection, should be adjusted for best results. In this circuit it's necessary to leak only a very low level of BFO energy for CW/SSB detection; the reason is that the BFO carrier is injected before the i-f amplifier. This differs from the usual method in which there is a separate mixer (product detector) and a fairly high-level BFO signal. I can justify the method used in this receiver only by saying that it allows for a substantial reduction in complexity (thanks to the circuitry built into the ZN414) and that I find it works quite well.

construction notes

You can select your own scheme for wiring and assembly, bearing in mind the necessity for shielded cable at the input to the ZN414. The method I prefer involves assembling each stage on a separate circuit board so that construction, testing, and troubleshooting are limited to simple circuits containing about ten components each (see **Photo B**). It's much safer making the journey step-by-step, rather than attempting one giant leap!

Radio Shack circuit boards 276-024 are just the right size; extra holes are drilled through the large copper pads wherever they're needed. A sewing-machine needle makes a satisfactory miniature drill bit.

I've found that push-in terminals are practically indispensable for making external board connections such as ground, +12 volts, input, and output. These are available from Circuit Specialists, Inc. (No. 1495-PK). The circuit boards rest on aluminum spacers (Radio Shack No. 64-3024) and are fastened to the cabinet with machine screws. Solder lugs (Radio Shack No. 64-3029) are grounded to the cabinet in a similar fashion.

Use RG/174-U miniature coax cable for connections on the signal path. This includes the connections between the various stages and the connections from the antenna connector and the volume control. RG/174-U is available from parts stores that serve the TV repair trade.

The crystals can be mounted directly on the circuit board, with the pins used as soldering terminals. Be sure to keep the crystal filter input and output well isolated.

Circuit layout at this frequency is generally noncritical. Still, it's best to position the local oscillator and BFO circuitry close to the front panel, with short runs of stiff wire to the tuning capacitors. Care should be taken in mounting the capacitors and toroids so that they are mechanically rigid.

The Radio Shack 270-272 cabinet made an attractive and sturdy enclosure for this receiver. Mounted on the rear panel are binding posts for power supply connections, a phono jack for the antenna, and a miniature phone jack for headphones or speaker (**Photo C**). The front panel layout includes the tuning knobs for the local oscillator and BFO, as well as the volume control and the on/off switch (Radio Shack 271-215).

access to parts

Radio Shack parts numbers are included for many of the components used in this project. The rest of the parts can be obtained by mail order.[2,3] The tuning capacitor with built-in vernier and dial pointer, available from BCD Electro, rates as a "best buy." Its threaded holes on the front and bottom allow easy mounting. For the prototype of this receiver I used a 30-pF air-variable without a dial pointer but with a built-in reduction drive almost identical to that in the BCD Electro capacitor that had been liberated from a used CB rig. You may choose to forego the use of mechanical bandspread and instead use a small variable in parallel with the main tuning control.

The cost of this receiver is low. Using all new parts the receiver can be built for around $40, but of course with help from a respectable junkbox the cost can easily be reduced to almost zero.

alignment

Before applying power, check the resistance between ground and the +12-volt line; it should be in the vicinity of 200 ohms. With the set turned on and the antenna connected, C4 and C5 should be adjusted for the desired frequency coverage. Tune C8 to place the BFO at the i-f. C1, C2, and C9 are peaked for maximum volume. While a frequency counter and a signal generator would be helpful during the alignment process, perfect results can be obtained with nothing more than a general-coverage receiver and a bit of patience.

Photo C. Rear panel connections include (left to right) the audio output jack, binding posts for the DC supply, and phono jack for antenna input.

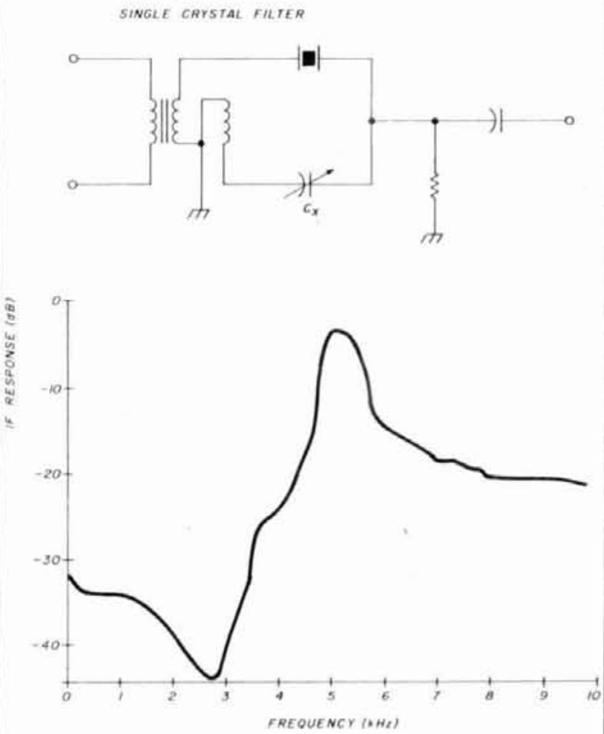

fig. 3. I-f stage response using only one crystal.

performance

Sensitivity was measured using an IFR-1200 Communications Service Monitor and a Motorola R2001-B Communications Systems Analyzer. An input signal of 0.88 microvolts rms was required for a

$$10dB \frac{S+N}{N}$$

A 0.1-microvolt signal was clearly discernible.

The i-f selectivity allows for good copy of both CW and SSB. Naturally the response isn't as sharp as that of a commercial receiver with eight poles of filtering, but for all but the most adverse band conditions, selectivity is more than adequate.

Stability is sufficient for casual CW work, but there's probably too much local oscillator drift for good results on RTTY or computerized CW. This is to be expected with an LC oscillator running as high as 12 MHz. Herein lies a tradeoff between performance and circuit complexity. A more stable (and more complex) local oscillator could be used at 12 MHz. (I've had good results with a series-tuned Colpitts VFO, but it also included buffer and doubler stages.) Alternatively, the simpler oscillator could be used down at 5 MHz for 40-meter reception, and stability would probably be very good. A crystal-controlled converter could then be used for 20-meter coverage.

other bands

I tried the receiver on 30 and 40 meters, with good results. Only one change was necessary. For 30-meter reception I simply retuned preselector C1. If C1 were replaced with a panel-mounted type, a 2-band receiver would result. For 40-meter reception, add a 220-pF capacitor across C1. The local oscillator can be tuned down to 9 MHz.

For operation on 80 meters, replace the antenna tuner and the local oscillator toroids; L1 will now have three turns; L2, 35 turns on a T-68-2 (approximately 7 μH); and L3, 30 turns on a T-68-2 (approximately 5.1 μH). Tapped seven turns from ground. Add a 220-pF capacitor across C1. A panel-mounted capacitor will be needed to peak the antenna preselector. A variation of 15 pF will allow for a preselector tuning range of approximately 100 kHz.

conclusion

The builder who has assembled a few simple projects will find this superhet easy to construct and a pleasure to operate. Perhaps this project will provide a bit of inspiration to some would-be homebrewer who has been discouraged by the supposed difficulty of building a complex receiver.

acknowledgments

Thanks to Tom Krohn, K3IJ, and Jim Debalko, N3BBX, for their advice and encouragement.

references

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2. Circuit Specialists, Inc., P.O. Box 3047, Scottsdale, Arizona 85257.
3. BCD Electro, P.O. Box 830119, Richardson, Texas 75083-0119.

ham radio

ham radio TECHNIQUES

Bill Orr, W6SAI

the super-cathode driven amplifier

Although the cathode-driven (grounded-grid) amplifier looks simple on paper, it is actually complex; what's more, some interesting variations of the basic circuit can provide unusual advantages to the user.

Consider **fig. 1**. This is a simplified grounded-grid amplifier circuit with a tuned cathode input. The drive signal (e_c) is link-coupled to the tuned circuit, but a pi-network or other arrangement could be used as well. The grid of the tube is at RF ground potential and the *exciting signal is applied between cathode and (grid) ground.*

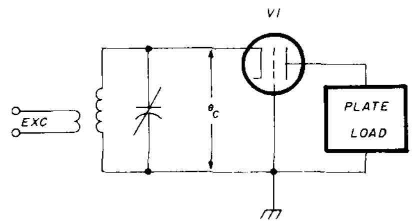

fig. 1. **Simplified cathode driven circuit with driving signal applied between cathode and ground (grid).**

Now look at **fig. 2**. All remains as before, except that the grid of the tube is tapped on the cathode tank so that a portion (e_g) of the total drive signal is applied in-phase to effectively oppose the cathode signal (e_c). This is termed a *super-cathode driven* amplifier. Drive power is thus increased and stage gain is decreased.

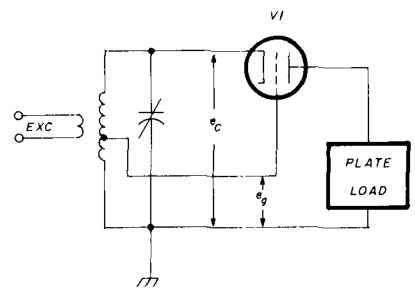

fig. 2. A portion of the drive signal (e_g) is applied in-phase to the tube. This opposed the larger cathode drive voltage, E_c. This is termed a super-cathode driven amplifier.

While it may appear ridiculous to design an amplifier that demands more than the minimum amount of driving power, this circuit may be used to advantage when it's necessary to absorb excess drive power from the exciter. A *case in point: an amplifier is desired to* run 1 kW PEP input and deliver about 650 watts output. It will be driven by the usual RF transceiver, with a power output of slightly over 100 watts. Aha! A single 3-500Z, running at 2500 volts and 400 mA, should do the job. A nice home project for the enthusiastic builder!

Looking at the 3-500Z data sheet shows that the idea is practical except for one fact. The 3-500Z requires only about 46 watts of drive power. What to do with the other 60 watts of drive power available from the exciter?

Some operators who have run into the problem of excess drive try to solve it by merely cranking down the mic gain. This may work if they don't get excited and run the gain up, and if the exciter is capable of proper ALC action at reduced input (many aren't).

Perhaps what's needed is inverse feedback in the amplifier to "soak up" excessive drive. This will help, but only marginally. A T-pad between exciter *and amplifier? Yes, but unless the pad* is switched in and out, it will remain in the circuit during reception . . . not an elegant solution.

super-cathode driving

This is a case where the super-*cathode driven circuit* comes into its own. Excess drive power is converted into "feedthrough" power and stage gain can be tailored to fit the available level of drive.

Hold it! Don't rush out and start converting your 3-500Z amplifier to a super-cathode driven mode. Removing the grid from ground destroys the inherent isolation of the stage and instability is likely to result. What's required is a 3-500Z with an extra grid to be used for RF shielding purposes! Luckily, such a tube has been available for decades: the 4-400A.

The 4-400A super-cathode driven tetrode amplifier

At one time the 4-400A was widely used by Amateurs in grounded-grid amplifier service. Merely tie both grids of the tube to ground and away you go. While the 4-400A wasn't designed for this class of service, it did work, provided the user kept a close eye on grid current . . . it was easy to exceed the No. 1 grid wattage dissipation limit of the 4-400A in classic grounded-grid service (see **table 1**).

The 3000-volt conditions listed in

Table 1. 4-400A (Voice Conditions). Ratings apply to 4-250A, within plate dissipation rating of 4-250A.

DC Plate Voltage	2000	2500	3000	volts
Zero-Signal DC Plate Current*	60	65	70	mA
Single-Tone DC Plate Current	265	270	330	mA
Single-Tone DC Screen Current	55	55	55	mA
Single-Tone DC Grid Current	100	100	100	mA
Single-Tone Driving Power	38	39	40	watts
Driving Impedance	160	150	140	ohms
Load Impedance	3950	4500	5000	ohms
Plate Input Power	530	675	990	watts
Plate Output Power	325	435	600	watts

*Varies from tube to tube

table 1 are interesting. The simplified circuit is shown in **fig. 3**. Grid and screen terminals of the tube are grounded and the drive is applied to the filament circuit in the conventional manner. Power input is 1 kW PEP and drive power is about 40 watts — about the same as a 3-500Z.

But the big advantage of the 4-400A is that it has two grids to play with. Grid No. 1 can be used to vary the power gain of the tube and grid No. 2 provides excellent internal shielding.

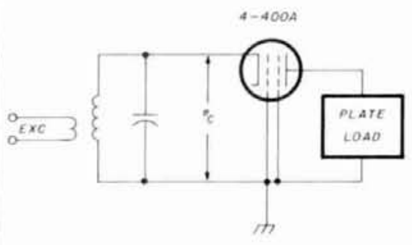

fig. 3. The 4-400A tetrode connected as a high-mu triode for cathode driven (grounded grid) service. Screen-to-cathode voltage (e_{sg}) is equal to e_c.

In passing, it should be noted that when used in a super-cathode driven circuit, the drive signal serves as a screen power source. Screen-to-cathode voltage (e_{sg}) is supplied by the drive signal as shown in **fig. 4**. The control grid of the 4-400A is tapped to a point on the cathode circuit to provide the desired amount of "bucking" voltage (e_b) and the screen element is at RF ground potential. Resting plate current is low because screen voltage is low (zero) with no drive signal. Converted drive power is large, as is total grid drive requirement.

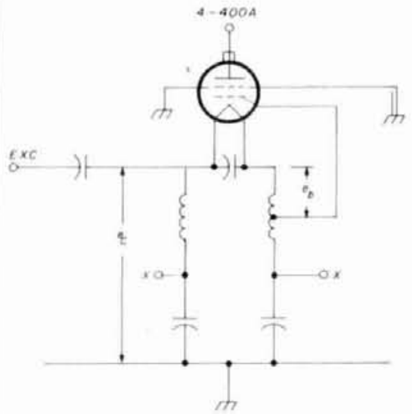

fig. 4. Drive signal (e_c) is developed between cathode and ground. Bucking signal (e_b) is developed between cathode and grid #1.

the K7BYQ-W7EPM tests

In 1959 two EIMAC engineers, K7BYQ and W7EPM, ran extensive tests on a super-cathode driven amplifier using a single 4-400A tube.[1] The results of their tests are listed in **table 2**. They had difficulty getting the test amplifier to work properly on the highest bands (20 and 10 meters) because ferrite-core filament chokes weren't available in those days. But the amplifier worked perfectly on the lower bands, and when a good filament choke was finally designed, performance was duplicated on the higher bands.

However, in 1959, hams weren't troubled by an excess of driving power,

Table 2. 4-400A (voice conditions), super-cathode drive.

DC Plate Voltage	3000 volts
Zero-Signal DC Plate Current*	30 mA
Single-Tone DC Plate Current	330 mA
Single-Tone DC Screen Current	60 mA
Single-Tone DC Grid Current	30 mA
Driving Impedance	250 ohms
Load Impedance	5000 ohms
Plate Input Power	990 watts
Plate Output Power	625 watts
Single-tone Drive Power	115 watts

*varies from tube to tube

the cathode-driven circuit hadn't yet become popular and the whole idea ended up in the dusty pages of history.

Perhaps the super-cathode driven amplifier is today's solution to a 1 kW PEP amplifier driven by a 100-watt exciter. The 1959 experiments showed that the ratio between screen and grid voltages for a 4-400A in this circuit was about 5:1. The peak screen driving signal was about 320 volts. The peak grid signal, then, is about one-fifth of this, or about 64 volts.

How to obtain this voltage ratio between grid and screen voltages? K7BYQ and W7EPM tapped the filament choke (**fig. 5**) directly. One side of the filament was grounded to complete the DC return. Screen current was monitored as shown.

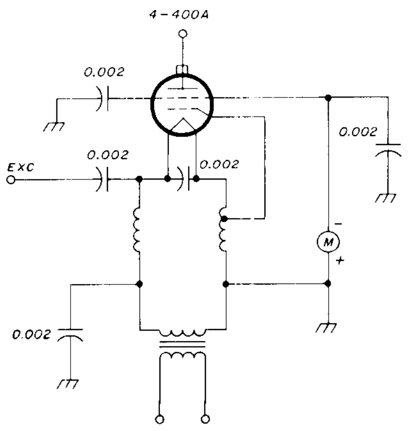

fig. 5. Original K7BYQ-W7EPM super-cathode driven circuit. Grid tap is one-fifth of the way from the filament end of the choke. Note same choke winding is grounded at filament transformer.

Another scheme is to add a third winding, one having one-fifth the number of turns of the bifilar winding, to the choke. Thus, if the choke has 30 bifilar turns, six turns could be added to achieve the 5:1 voltage ratio (**fig. 6**). The ratio can easily be altered by changing the number of additional turns.

If the number of turns between grid No. 1 and the filament (cathode) is too small, the amplifier resembles a straightforward grounded-grid stage. Driving power will be a minimum and grid current will be very high. As the number of turns is increased, grid current drops and grid drive level rises. Too many turns will make the tube very hard to drive.[2]

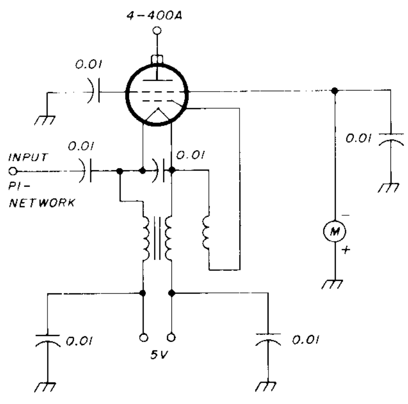

fig. 6. Auxilary winding can be used instead of tap on main choke winding. Meter measures screen grid current.

The data in **table 2** is enough to get started. It will be interesting to see how this circuit works in conjunction with the solid-state exciters in common use today. Experimenters! Here's a chance to try something different.

For a reprint of the article describing K7BYQ's and W7EPM's work with cathode-driven amplifiers, send four first-class stamps or IRCs to me at EIMAC, 301 Industrial Way, San Carlos, California 94070. Request bulletin AS-33.

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ham radio

PRACTICALLY SPEAKING ... Joe Carr K4IPV

from the mailbag

Although I usually devote this entire column to a single topic, I'd like to take this opportunity to respond to some of the questions readers have asked since this column began just over a year ago.*

parts sources

Several readers have asked where they can obtain parts for projects. If they're looking for standard parts, I refer them to ads in the pages of *ham radio* and other magazines. Sometimes parts needed for Amateur Radio projects can be found through local distributors, even though their primary market may be defined as consumer electronics service shops or computer hobbyists. Most semiconductor devices that you'll need are available from sources such as *Jim-Paks* or one of the consumer electronics replacement lines — for example, HEP, ECG, and NTR.

Radiokit** offers a 1500-watt transmatch kit that can be used for a variety of applications besides the stated purpose of antenna matching. Because it contains a 28-μH rotary inductor, turns counting dial parts, and a pair of 208-pF, 3500-volt variable capacitors, it can be adapted for use in homebrewed power amplifiers. Judging from my mail about high-power rf parts, I suspect that the age-old habit of building linear and Class-C power amplifiers is not yet dead — despite the large number of commercial amplifiers on the market.

Obtaining parts for power amplifiers can be aggravating. While every local ham shop used to carry such parts, they are now difficult to obtain. One chap complained bitterly about the difficulty in obtaining the high-voltage plate transformer for a linear project. The parts list called for a commercial transformer, but the manufacturer was used to dealing only with commercial and industrial clients. There was a minimum factory order of $500, and no means for dealing with clients who lacked bank or Dun & Bradstreet references. For high-voltage, high-power parts for dc power supplies, try Peter Dahl Company. They make transformers suitable for amateur projects — and will actually deal with you!

For a one-of-a-kind power amplifier project, of course, you can scour the hamfests and surplus shops. Unfortunately, while such parts were easily obtained from World War II surplus when I was a kid, those sources have since dried up. If you intend to write an article about the project for this or any other Amateur magazine, please don't use a part that was obtained at a hamfest, from a surplus house, or from under a buddy's workbench until you know for sure that the part is still available from other sources. For replication of your project by others, there has to be a reliable source of parts!

There are some novel ways to find high-voltage power supply parts. For example, I needed an oil-filled high-voltage capacitor for a project. Now, if you've watched the right TV shows, you've seen physicians use a clever device called a defibrillator to "jump-start" patients who try to die of certain kinds of heart attacks. The paddle electrodes are placed on the patients's chest, buttons are pressed and *BLAM!* — the patient's body lurches into the air a foot or so.

Because I'd worked as a biomedical engineer in a university hospital, I'd had some experience with defibrillators. The old standard defibrillators generated a damped capacitor discharge waveform from a 16-μF capacitor. Most of them consisted of a 7-kV dc power supply, a 16-μF capacitor, and a dpdt vacuum relay that transferred the capacitor terminals from the dc power supply to the patient electrodes (through a 100-μH choke). Typical defibrillators of a dozen years ago used a 16-μF/7500 wVdc or 16- μF/10,000 wVdc oil-filled capacitor that rarely went bad. Those capacitors make ideal filter capacitors in ham power supplies. The transformers are useless for this application because of their current rating, which is too low.

The vacuum relays (spdt in older machines, dpdt in later models) are useful for rf purposes. I used a relay from a scrap defibrillator to switch coil taps in a loaded vertical antenna many years ago.

OK, so how do you go about locating old defibrillators? They're not just lying around in surplus parts stores, are they? Yes, they are. I also saw one, an old American Optical defibrillator,

*Readers are welcome to contact me at P.O. Box 1099, Falls Church, Virginia 22041.

**Radiokit, P.O. Box 973, Pelham, NH 03076.

at the Gaithersburg Hamfest just a year ago. You might try calling the biomedical engineer at a nearby hospital or checking with firms that deal in used hospital or veterinary equipment. Defibrillators are high-risk items for hospitals; malfunctions cost lives and result in malpractice suits. As a result, outdated equipment is often taken out of service while the relay and capacitor are still useful to hams. Look for models by American Optical (16-μF/7500 wVdc), Hewlett-Packard (16-μF/10,000 wVdc or very old Air-Shields (25 μF/5000 wVdc). Don't pay a lot for these machines. When dickering over the price, remember that they're too risky for the smart hospital engineer to put back into service — and for the same reason, less useful for replacement parts than might be expected. Other sources of parts include rf diathermy equipment, industrial inductive heating equipment, magnetizing equipment, and so forth.

amplifier tuning problem

One reader complained that his commercial linear amplifier worked poorly, resulted in less than encouraging signal reports and (here's the clue) always tuned to the same spot on the loading dial. Furthermore, according to signal reports, the output was horribly distorted on 20 meters. My first thought, confirmed in conversations with two friends who work in radio transmitter repair, was that although something might be wrong with the amplifier, the most likely problem was in the antenna or transmission line.

In my own experience, the only time my transmitter (and later linear) loaded to the same point on the loading control dial was when the antenna (or coax) was either open or shorted. This problem was sometimes masked by the fact that the receiver still worked correctly. The 20-meter distortion was merely more pronounced than distortion on other bands. One explanation of the distortion would be improper impedance matching between the anode of the power tube and the antenna. Another possible explanation — one consistent with my experience — would be that the shield on the coax was open, leaving the reception intact but obliterating the transmitter or linear tuning! If you're experiencing that kind of problem, check out the antenna before messing with the transmitter.

In most commercial equipment, "loading problems" are unlikely if the correct load impedance is presented to the output. Of course, they're possible . . . but they're so unlikely that it's best to look for other causes first. The correct way to diagnose the problem, in my opinion, is to use a low-cost piece of test equipment that every Amateur ought to have: a 50-ohm dummy load. If the amplifier loads into the dummy, then I suspect the antenna.

Of course, it should go without saying that the Amateur should check the antenna, transmission line, couplers, low-pass TVI filters, and switches or relays in the line. In some cases, dc resistance checks of switches and relays is not too useful at rf. While a "bad" reading is to be believed, a "good" reading might be a false indication. If the dc resistance checks reveal no obvious fault, try checking the parts by either substitution or removal. In a future column, we'll deal with antenna instrumentation and troubleshooting.

coax velocity factor

The velocity factor (VF) of a transmission line is a decimal fraction describing the percentage of the speed of light (C) at which signals propagate in the line. For example, when we say that ordinary coaxial cable has a vf of 0.66, we are saying that the signal travels in the line at 66 percent the speed of light. When we want to cut a length of coax to a specific electrical length, we calculate the physical length required for that frequency and then multiply by the VF. A common example is the half-wavelength transmission line. The impedance of a load (such as an antenna) is repeated every half-wavelength back down the line. If we want low-cost antenna measuring instruments to be accurate, then we should use a connecting transmission

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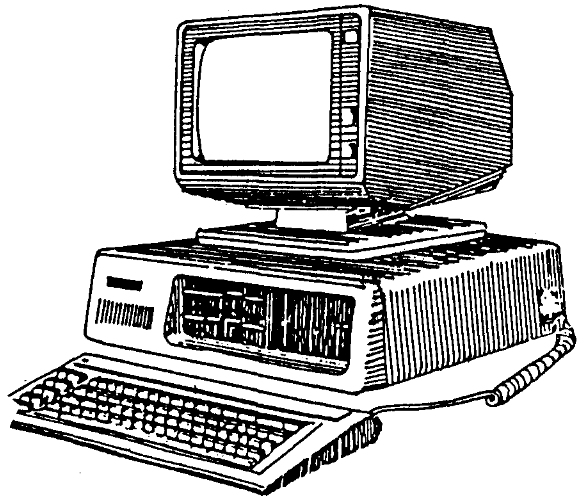

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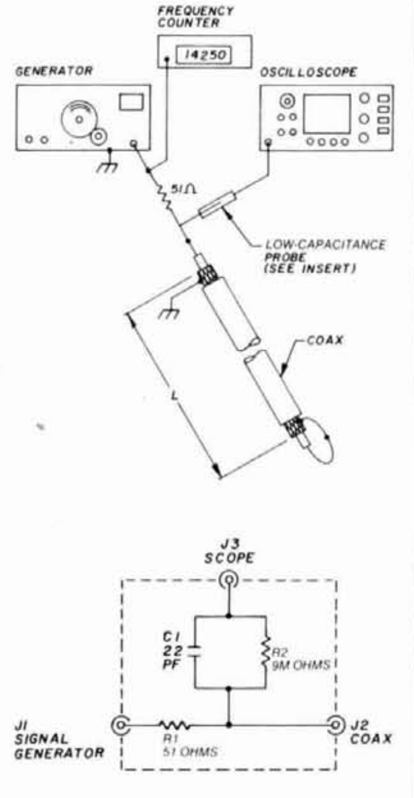

fig. 1. Simple, accurate method of determining velocity factor of coax.

line that is an integer multiple of half-wavelength. To find the correct physical length, we would use the half wavelength formula multiplied by the VF of the coax:

$$L = \frac{492}{f} \times VF$$

where:

L is the length in feet

f is the frequency in megahertz

VF is the coax velocity factor

When we work through an example, we find that a 20-meter half-wavelength (492/14) is 35 feet. If we use regular coax (VF = 0.66), then we find a correct physical length to achieve an electrical half-wavelength is (35 x 0.66), or 23.1 feet.

Standard Amateur literature (including mine) usually cites the following velocity factors for common coax:

Regular Polyethylene: 0.66
Polyfoam: 0.80
Teflon: 0.70

We take these figures as gospel true, only to find problems on the workbench. I discovered this problem years ago in a marine radio shop (the old-fashioned kind, where a "frequency meter" was a war surplus BC-221) where we used coaxial cable as a calibrator for depth sounders. Those devices send an ultrasonic pulse to the bottom and then time the return echo. We used a precisely cut roll of coax to time the signal to exactly 100 feet.

But the physical length I was ordered to cut didn't make sense if the coax VF was 0.80. The shop owner informed me (and he turned out to be right!) that most coax only approximates the specified velocity factor. He showed me a method of measuring VF in any given sample of coax (see **fig. 1**). The procedure is as follows:

1. Cut a convenient length of coax (20 to 100 feet). Measure its physical length as accurately as you can.
2. Connect the coax to a signal generator and either an oscilloscope or rf voltmeter as shown in **fig. 1**. (The junction box shown in the inset is useful.) Short-circuit the distant end of the coax.
3. Calculate the approximate half-wavelength frequency from

$$f = \frac{492 \cdot VF}{L}$$

using the "standard wisdom" velocity factor given above.
4. Adjust the signal generator output to maximum and get a decent deflection on the oscilloscope. Rock the frequency back and forth to find the frequency at which the trace on the oscilloscope drops to its lowest point. This frequency (which can be read on the optional frequency counter) is the electrical half-wavelength frequency. It is nulled because the short circuit at the end is a zero-ohms impedance, and is reflected exactly to the feedpoint at the half-wavelength frequency.
5. Calculate the actual VF from $(f \times L)/492$.

For example, I bought a 50-foot roll of RG-58 coax of unknown ancestry at a hamfest (it measured 51 feet). Because it was foam coax, the standard-wisdom VF was 0.80. Thus, a 51-foot length was an electrical half-wavelength on a frequency of (492 × 0.80)/51 ft), or 7.72 MHz. When I measured it using the method shown in **fig. 1**, the "short-circuit frequency" that indicated half-wavelength was not 7.72 MHz, but 7.13. Thus, the actual VF was

$$\frac{7.13 \cdot 51}{492}, \text{ or } 0.74.$$

While the actual velocity factor isn't terribly important for most Amateur antenna work, it can be important in measurements of antenna parameters, or in cases (like my marine shop employer's) where the coax is used in another measurement system.

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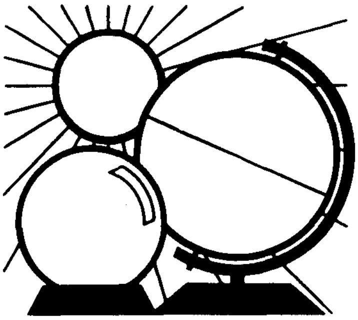

DX FORECASTER

Garth Stonehocker, KØRYW

sunspot minimum update

You can expect current DX propagation conditions to last for about a year after we pass the sunspot number (SSN) minimum; it will take about that long before much change can be noted. But when is the minimum? Have we reached it yet? Let's review the data so far.

Since our last look (in April, 1985) the SSN has shown more flattening, sinking to a value of 16 at the end of 1985. Even the increased solar activity in February and March, 1986 raised the SSN only moderately. In June, a new low in observed sunspots for this 11-year cycle was reached, but more activity occurred in the following months. Was June the minimum? At that point, the present sunspot cycle was ten years old (see "DX Forecaster," October 1985, page 105).

The new cycle (No. 22) region data analysis shows that an active region or two may have been seen for a day or so in April, May, and July of 1985. From September, 1985 on they were more numerous, were seen by more observatories, and lasted long enough for magnetograms to be obtained for polarity determination. In January, 1986, those of reverse polarity were seen. February's flares and mammoth geomagnetic disturbance were caused by a *Cycle 22* sunspot.

The SSN minimum should occur about a year after the first spots of the new cycle are observed. So is that September, 1986, or January, 1987? Your guess is as good as mine.

second corroboration

Now let's look at the solar flux (10.7-cm emissions) data. The solar flux minimum should be near, but probably not coincident with, the SSN minimum; it should occur within approximately one month of the SSN minimum in data corrected for distance. In determining the solar flux minimum (at the sun), scientists correct for the distance, producing a different minimum in their data than solar flux data from WWV.*

Prior cycles solar flux minima were recorded in June, 1954, July, 1964, and June, 1976; notice all were in the summer. There were 10.08 and 10.87 years between these minima, respectively.

In 1986, the solar flux increased in February and March — as did the SSN — then decreased steadily until June. If the solar flux minimum for Cycle 21 occurred in June, 1986, with a monthly average value of 67.5 and seven daily values of 66 in a row from June 24 to 30, the duration of the interval between the 1976 minimum and the 1986 minimum, then, would have been 11.05 years.

One can expect a daily value lower than 66 because the other minimum daily values were 63.0, 64.7, and a 66, which occurred during Cycle 20, lower in maximum amplitude than Cycle 21. Therefore we may expect a lower daily minimum value during the coming months.

Could a lower daily minimum value occur next summer? If it did, this would mean that the duration of the solar flux cycle would be at least 11.93 years. Not likely! Scientists at the Space Environment Center at Boulder have concluded that considering all the variables, the SSN minimum will probably occur during the first half of 1987. This forecast gives a Cycle 21 duration of 10.5 to 11 years, which is a reasonable length. Time will tell how all this analysis of data will turn out.

* A change in the earth-sun distance (e.g., between summer and winter) equates to a change in the included solid angle and consequently the amount of intercepted solar flux. Scientists normalize to one A.U. (astronomical unit — earth-sun distance) and WWV measures the data directly. —Ed.

last-minute forecast

The lower frequency bands, 30 to 160 meters, are expected to be excellent during the first two weeks of November. Summer and fall thunderstorm noise should be behind us, leaving quiet conditions with low QRN and also few geomagnetic disturbances. The maximum usable frequencies are low enough that 80 meters is near optimum for east-west and northern DXing at night. The higher bands may have some good openings during the second and third weeks. Expect some transequatorial openings in the evenings. They could be enhanced by sunspot activity and/or geomagnetic disturbances. There is the possibility of low signal strengths for a few days at a time, during both day and night, over the next few months.

The Taurids meteor showers will occur from October 26 to November 22, with a maximum count of ten per hour from the 3rd through the 10th of November. Lunar perigee is on the 4th, and a full moon appears on the 24th.

band-by-band summary

Ten and twelve meters, the highest day-only DX bands, are nearest the MUF for southern hemisphere paths. They will be open most days when the solar flux is above 75 during the 7- to 10-hour period centered around local

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0000	4:00	30	40	20	12	12	10	10	20
0100	5:00	20	40	20	20*	12	10	10	20
0200	6:00	30	40	20	12	20	12	12	20
0300	7:00	40	40	20	20	15	15	15	30*
0400	8:00	40	40	30	20	20	20	20	40
0500	9:00	40	40	30	20	20	20	20	40
0600	10:00	40	40	30	20	20	20	20	40
0700	11:00	40	40	30	30	20	20	20	40
0800	12:00	40	40	30	30	20	20	30	40
0900	1:00	40	40	30	30	20	30	30	40
1000	2:00	40	40	30	30	30	30	30	40
1100	3:00	40	40	30	30	40	30	30	40
1200	4:00	40	40	30	30	30	30	30	40
1300	5:00	40	30	15	15	30	30	30	40
1400	6:00	40	20	12	12	20	30	30	40
1500	7:00	40	20	12	12	15	20	20	40
1600	8:00	40	20	10	10	15	20	20	40
1700	9:00	40	20	10	10	15	20	30	40
1800	10:00	40	30	10	10	12	15	20	40
1900	11:00	40	40	10	10	12	12	20	40
2000	12:00	40	40	12	10	12	12	15	20
2100	1:00	40	40	12	10	12	12*	15	20
2200	2:00	40	40	15	10	12	10	12	20
2300	3:00	40	40	20	10	12	10	12	20

MID USA

GMT	MST	N (Asia / Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania / Australia)	NW (Japan)	CST
0000	5:00	30	40	20	12	12	10	10	40	6:00
0100	6:00	30	40	20	15	15	12	12	40	7:00
0200	7:00	40	40	30	20	20	15	15	40	8:00
0300	8:00	40	40	30	20	20	20	20	40	9:00
0400	9:00	40	40	30	20	20	20	20	40	10:00
0500	10:00	40	40	30	20	20	20	20	40	11:00
0600	11:00	40	40	30	30	20	20	20	40	12:00
0700	12:00	40	40	30	30	20	30	30	40	1:00
0800	1:00	40	40	30	30	20	30	30	40	2:00
0900	2:00	40	40	30	30	30	30	30	40	3:00
1000	3:00	40	40	30	30	30	30	30	40	4:00
1100	4:00	40	40	15	30	30	30	30	40	5:00
1200	5:00	40	30	12	20	30	30	30	40	6:00
1300	6:00	40	20	12	15	20	20	20	40	7:00
1400	7:00	40	20	10	12	15	20	20	40	8:00
1500	8:00	40	20	10	12	15	20	30	40	9:00
1600	9:00	40	20	10	10	15	20	30	40	10:00
1700	10:00	40	20	10	10	12	15	20	40	11:00
1800	11:00	40	20	10	10	12	15*	20	40	12:00
1900	12:00	40	30	10	10	12	12	15	30	1:00
2000	1:00	40	40	12	10	12	12	15	20	2:00
2100	2:00	40	40	12	10	12	10	12	20	3:00
2200	3:00	40	40	15	12	12	10	12	30	4:00
2300	4:00	40	40	20	12	12	10	10	40	5:00

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0000	7:00	40	40	20	20	15	15	15	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	20	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
1000	5:00	40	30	15	20	30	30	30	40
1100	6:00	30	20	12	20	30	30	30	40
1200	7:00	30	20	10	15	20	20	20	40
1300	8:00	40	20	10	12	20	20	20	40
1400	9:00	40	20	10	12	15	20	20	40
1500	10:00	40	20	10	12	15	20	20	40
1600	11:00	40	20	10	10	12	20	20	40
1700	12:00	40	20	10	10	12	20	20	40
1800	1:00	40	20	10	10	12	15	20	40
1900	2:00	40	30	10	10	12	12	20	40
2000	3:00	40	40	12	10	12	12	15	30
2100	4:00	40	40	15	10	12	12*	12	20
2200	5:00	40	40	20	12	12	10	12	20
2300	6:00	40	40	20	15	12	15	12	30

noon. These bands open on paths toward the east and close toward the west. The paths may be as long as 2400 miles in single-hop length, and occasionally twice as long during evening transequatorial openings.

Fifteen meters, a day-only DX band open most of each day, has lower signal strengths and greater multipath variability than 10 and 12 meters. It will be best when the MUF is just resting above this band, until it drops below it — a transition period that occurs right after sunrise and just before sunset. Transequatorial openings will occur, with distances similar to 10 and 12 meters.

Twenty, thirty, and forty meters are both daytime and nighttime DX bands. Twenty is the maximum usable band for DX in the northern directions during daytime. In combination with 30 meters, it provides nighttime southern paths for the day-only bands. Forty meters becomes the main over-the-pole DX daytime band, with some hours covered by 30 meters.

Eighty and one-sixty meters, the night-only DX bands, exhibit short-skip propagation during daylight hours, then lengthen at dusk. These bands follow the darkness path, opening to the east just before local sunset, swinging more to the north-south near midnight and ending up in the Pacific areas for a few hours before dawn. On some nights 80 meters, with its high signal strengths, will be the best band to use. One-sixty is also expected to provide favorable conditions. Please remember the DX windows of 3790 to 3800 and 1825 to 1830.

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PS-45 Compact 8A power supply	139.00	129.95
UT-16/EX-388 Voice synthesizer	34.99	
SP-10 Slim-line external speaker	35.99	
IC-28A 25W 2m FM, UP/DN mic	429.00	379.95
IC-28H 45W 2m FM, UP/DN mic	459.00	399.95
IC-48A 25W 440-450 FM	459.00	399.95
HM-14 TTP microphone	55.50	
UT-28 Digital code squelch	37.50	
UT-29 Tone squelch decoder	43.00	
HM-16 Speaker/microphone	34.00	
IC-3200A 25W 2m/440 FM w/TTP	599.00	499.95
UT-23 Voice synthesizer	34.99	
AH-32 2m/440 Dual Band antenna	37.00	
AHB-32 Trunk-lip mount	34.00	
Larsen PO-K Roof mount	20.00	
Larsen PO-TLM Trunk-lip mount	20.18	
Larsen PO-MM Magnetic mount	19.63	
RP-3010 440 MHz, 10W FM, xtal cont.	1229.00	1099
IC-120 1W 1.2 GHz FM Mobile	579.00	499.95
ML-12 1.2 GHz 10W amplifier	379.00	339.95
IC-1271A 10W 1.2 GHz SSB/CW Base	1229.00	1079
AG-1200 Mast mounted preamplifier	105.00	
PS-25 Internal power supply	115.00	104.95
EX-310 Voice synthesizer	46.00	
TV-1200 ATV interface unit	129.00	119.95
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RP-1210 1.2 GHz, 10W FM, 99 ch. synth	1479.00	1299

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IC-2AT with TTP	299.00	259.95
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IC-4AT 440 MHz, TTP	339.00	299.95
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BP-8 800mah/8.4V Nicad Pak - use BC-35	74.25
BC-35 Drop in desk charger for all batteries	74.95
BC-16U Wall charger for BP7/BP8	20.25
LC-11 Vinyl case for Dlx using BP-3	20.50
LC-14 Vinyl case for Dlx using BP-7/8	20.50
LC-02AT Leather case for Dlx models w/BP-7/8	54.50
Accessories for both models	**Regular**
BP-2 425mah/7.2V Nicad Pak - use BC35	47.00
BP-3 Extra Std. 250 mah/8.4V Nicad Pak	37.50
BP-4 Alkaline battery case	15.25
BP-5 425mah/10.8V Nicad Pak - use BC35	58.50
CA-5 5/8-wave telescoping 2m antenna	18.00
FA-2 Extra 2m flexible antenna	11.50
CP-1 Cig. lighter plug/cord for BP3 or Dlx	13.00
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VHF/UHF WORLD

Joe Reisert W1JR

broadband amplifiers in receiver design

Electronic technology is roaring forward. Sometimes that's bad, but generally speaking, it's good for Amateur Radio. Prices decrease, devices get smaller, and sometimes, performance improves! However, when technology changes, we often must learn new tricks or change the way we do things if we're to take advantage of the latest developments. This is a small price we pay.

Such is the case of small signal rf amplifiers. Only 20 years ago the Nuvistor was a premium device used in many of the low-noise VHF and UHF converters. Then came the bipolar transistor, which was followed by the JFET, MOSFET, and the GaAs FET. Each one of these devices caused us to change the way we designed our gear. We went from multiple power supplies with hundreds of volts and filament voltages to single low-voltage supplies, often below 5 volts.

At the same time, the circuitry has changed dramatically. Tubes often required large boxes and complex neutralization circuitry. New techniques such as grounded-gate JFETs or dual-gate MOSFETs solved some of the neutralization problems. Special feedback and loading techniques alleviated most of the remaining solid-state stability problems. Finally, broadband, unconditionally stable circuitry arrived. This, too, required a change in thinking because filtering was not contained within the circuit itself.

Traditionally November marks the appearance of the annual *ham radio* issue spotlighting receiver technology. The subject of receivers has been a part of *VHF/UHF World* from the start. Several areas of receiver design — including rf amplifiers, mixers, local oscillators, filtering, and high-dynamic range — have been covered.[1-5] In keeping with that custom, this month's column will be devoted to receiver-type rf amplifiers and more specifically, broadband amplifiers and how they can be applied to new or existing receivers.

rf amplifier design trends

In the past, most Amateur gear used narrowband tuned amplifiers (**fig. 1A**). This was good because the selectivity decreased out-of-band signals as well as the image frequency. These same tuning circuits performed the impedance matching required for the device in use. Dynamic range was usually enhanced, but input circuit losses often increased the noise figure.

Today's design trend is to use "gain blocks" that cover a wide band of frequencies. Usually these broadband circuits are rf amplifiers optimized for similar input/output impedances such as 50 ohms or 75 ohms, with the latter used mostly in the CATV business. Because these amplifiers often cover many octaves of frequency (each octave is a 2:1 frequency range), they require additional external filtering (**fig. 1B**). This often consists of a bandpass filter at the input and possibly one on the output of the amplifier. If desired, these filters may be located external to the amplifier and mounted in a shielded box following modular construction techniques described in reference 1.

The number of broadband small-signal rf amplifiers presently available is large, surely in the hundreds. Each has a unique set of specifications that include rf bandwidth, gain, impedance match, noise figure, and output power handling capability. The principal active devices used are bipolar transistors and GaAs FETs. The most common frequency range is 1 to 500 MHz. Many bipolar broadband amplifiers are specified to work up through 6 GHz. Some GaAs FET devices work well up into the millimeter-wave region.

amplifier evolution

To gain an appreciation for the changes in technology, it may be worthwhile to review some of the techniques used to design these broadband amplifiers. While it is theoretically possible to design broadband compensation networks, they are complex and may be lossy. The principal breakthrough for broadbanding is in the proper application of wideband negative feedback.

The earliest practical broadband circuits that I am aware of used discrete transistors with shunt and series feedback (see **fig. 2A**). The founders of Avantek discovered that a broadband impedance match could be realized if a proper high-frequency transistor was used with certain combinations of shunt R_F and series R_E feedback. The patented equation is as follows:

$$R_O^2 = R_F \cdot R_E$$

where R_O is the input/output impedance, R_F is the shunt and R_E is the series feedback (including the internal impedance of the base-to-emitter junction of the transistor) per **fig. 2A**.

The ratio of these two resistors de-

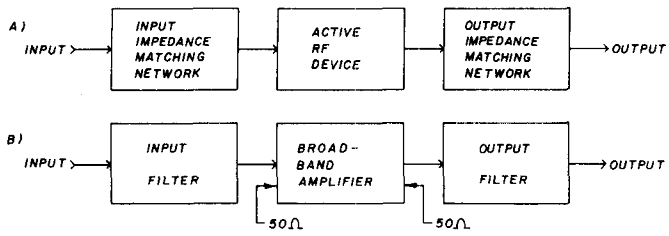

fig. 1. Typical rf amplifier configurations: (A) use of impedance matching transformers in a narrow-band design; (B) use of wideband amplifiers with matched input/output impedances and external filtering.

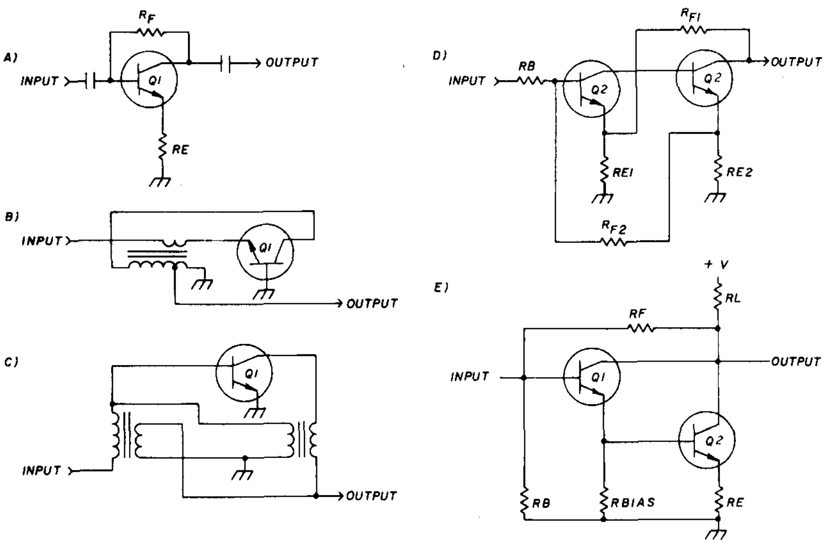

fig. 2. Typical rf representation of various feedback techniques. In some cases the dc portion of the circuit has been deleted for clarity. (A) shows series R_e and shunt R_f negative feedback; (B), lossless feedback employing transformer matching[3]; (C), feedback employing bybrid couplers[7], and (D), two-stage series and shunt feedback.[10] (E) shows Darlington connection, a version of fig. 2A[10,11] R_b and R_{bias} are bias resistors to establish the correct DC circuit parameters.

termines the gain, which can be approximated using the following equation:

$$G = 20\ log\ \frac{R_F - R_E}{R_O + R_E}$$

where G is gain in dB and R_F, R_E and R_O are as described above. For example, if R_F is 500 and R_E is 5 ohms, the amplifier will be impedance matched to R_O, 50 ohms, and will have a gain of approximately 19 dB.

The higher the value of the series feedback resistor, R_E the lower the shunt feedback resistor, R_F must be to maintain the match and vice-versa. Low ratios of R_F/R_E yield lower gain, higher noise figures, and lower output power compression points. High ratios of R_F/R_E yield greater gain, lower noise figures, and higher output power compression points. Although this feedback technique is patented, the patent is near expiration.[6] Reference 2 showed a typical application of this circuit with proper dc biasing.

"Lossless feedback" techniques have also been patented.[7,8] **Figures 2B** and **2C** are some typical rf circuits. The circuit shown in **fig. 2C** is often referred to as *directional coupler feedback*.

The principal advantage of lossless feedback is that there is very little impact on noise figure or output power due to the feedback circuitry. However, these circuits are more difficult to implement over a wide frequency range because of the complexity of the feedback transformer. Reference 2 showed an application of lossless feedback with a typical circuit.

Most of the early broadband rf amplifiers used discrete components and were somewhat limited in performance. In premium designs, "tweaker" inductors and/or capacitors were often added to tune out any circuit or component mismatches. Cost was moderate to high.

In the early 1970s, hybrid techniques using thin or thick film resistors, inductors, and capacitors — as well as chip capacitors and transistors — were popular. These units exhibited improved performance, but were still moderate to high in price.

Meanwhile, integrated circuit manufacturers were also trying to design broadband amplifiers. However, the techniques and materials in the substrates often limited the performance to an upper frequency limit of 100 MHz.

More recently, bipolar IC designs have moved up in frequency. These are referred to as *silicon microwave monolithic ICs* (MMICs). The Signetics NE5202 will operate up to about 600 MHz, while the NEC MM765, MM766, and μPC1656C and their related families will operate to just over 1 GHz.[9] These IC circuits all use a two-stage shunt and series feedback circuit that I found described in reference 10 (see **fig. 2D**).

High-performance, high-frequency (i.e., up through 6 GHz), single-stage, bipolar MMIC designs have now arrived in packages the size of an ordinary microwave transistor![11] The circuitry used is related to that shown in **fig. 2A**, except that some manufacturers use a Darlington connection of two transistors, as in **fig. 2E**. Improved transistors, substrate materials, and photo-lithography now allow very small geometries with greater control of parasitics. This yields more uniform performance and a higher frequency of operation at a much lower cost.

Finally, GaAs FET MMICs are being manufactured that will significantly increase the state-of-the-art frequency limits with lower noise figures than bipolar MMICs. The less expensive lower-gain devices use circuits similar to **fig. 2A**. These GaAs FET amplifiers show great promise, although they are more costly than bipolar devices at the present time.

applications

So where does that leave us? The answer is that if we want to take advantage of the low-cost, small size, and higher performance MMICs, we have to again adapt to the recent changes in technology.

MMICs are going to be a way of life. They're small in size, require only a minimal number of external components, are broadband, easy to bias (most require only a single supply voltage and possibly one external resistor), unconditionally stable, and offer a good impedance match over many octaves of frequency. Furthermore, they're easily replaceable as new and higher performance units become available.

Let's examine some typical applications. MMICs have nominal noise figures of 3 to 7 dB (see **tables 1** and **2**). Therefore, their noise figures are more than adequate for the first stage in moderate performance or low-cost receiver front ends, especially for local contacts. Many of the MMICs available also have moderate output power (10 to 20 milliwatts or +10 to +13 dBm), making them ideal for second-stage or post-amplifiers in receivers or i-fs.

Figure 3A shows a typical hookup for a "generic" MMIC. Some typical circuit board layouts with their amplification characteristics were described in reference 12, so they will not be repeated here.

MMICs are usable for remote or second-stage preamplifiers when tower-mounted gear is used. They're ideal as broadband amplifiers for use ahead of scanners or receivers that cover a wide range of frequencies, especially if they're outside the Amateur bands.

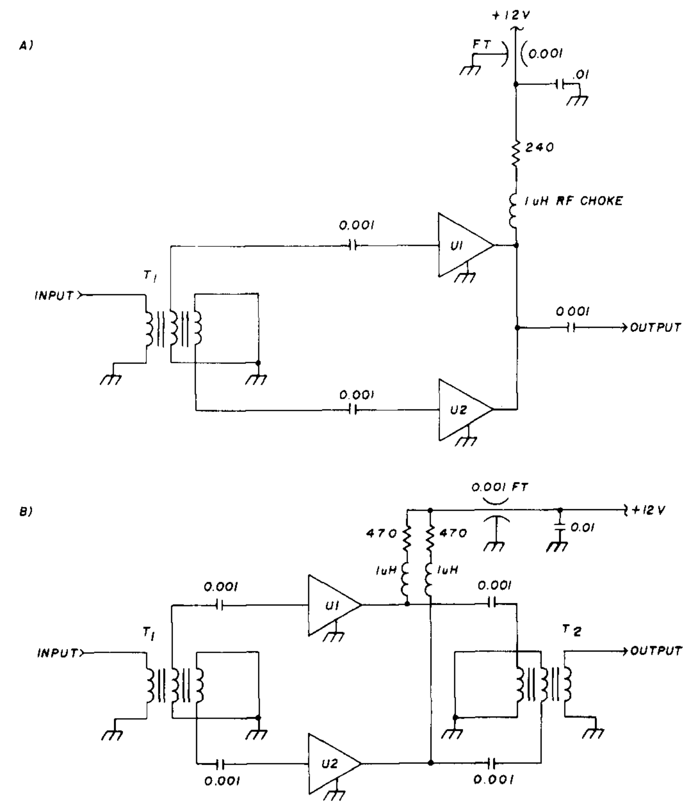

fig. 3. Typical applications using MMICs. (A) is a broadrand amplifier. C1 and C2 are dc blocking capacitors, C_b is a bypass capacitor, FT is a feedthrough capacitor, L is an rf choke and R is the biasing resistor chosen depending on the manufacturers design. Typical values are 100 to 1000 ohms. (B) shows an amplifier with two isolated outputs. Either a hybrid in-phase splitter or a Wilkinson power divider can be used.[5] Each output will be approximately 3 dB below the input. (C) is a typical applications of an LO amplifier with extra filtering.

Many Amateurs are using MMICs for LO (local oscillator) amplifiers, particularly where two outputs are desired for transverter applications, per reference 5 (see **fig. 3B**). A further application in LO service is where there is insufficient power to drive a DBM (double-balanced mixer). This is particularly true above 1 GHz, where some of the multipliers used have low output or low multiplier efficiency (see **fig. 3C**).

In a quick experiment, I hooked up two MMICs in a push-push configuration to see how they would perform as a balanced multiplier. I was quite pleased with the results. **Figure 4A** shows a preliminary circuit which could be further optimized or possibly use higher-power MMICs.

The output of this balanced doubler is free of spurious responses and works well through 500 MHz. This could undoubtedly be extended upwards in frequency with a better transformer design. Gain is moderate, 5 to 8 dB, especially when the input level is below 1 milliwatt. External filtering is desired, but it can be very minimal because the undesired outputs are typically at least 20 to 25 dB below the desired output signal.

If the MMIC outputs are hooked up in push-pull instead of push-push (**fig. 4B**), they should perform as a moderate gain tripler. I haven't tried this configuration, but it should be feasible.

Table 1. Some of these reasonably-priced commercial bipolar MMICs may be of interest to Amateurs.

Part Number	Supplier	Frequency Range GHz	Typical 0.5 GHz gain(dB)	Noise Figure (dB)at 500 MHz	Output Power dBm	Voltage/ current (mA)	Price each $
MAR-1	Minicircuits	DC-1	12	5.5	0	7/20	1.50
MM765	NEC	0.01-1.1	19	5.5	10	10/43	7.20
MM766	NEC	0.01-1.3	18	5.5	5	5/20	7.20
MSA-0104	Avantek	0.05-2.5	17	5	1.5	5/17	2.75
MSA-0204	Avantek	0.05-2.5	12	6	4.0	5/25	2.90
MSA-0304	Avantek	0.05-2.5	12	6	10	5/35	3.00
MSA-0404	Avantek	0.05-3	8	6	12	5/50	3.25
MSA-0185	Avantek	0.05-2.5	17	5	1.5	5/17	3.15
MSA-0285	Avantek	0.05-2.5	12	6	4.0	5/25	3.25
MSA-0385	Avantek	0.05-2.5	12.5	6	10	5/35	3.35
MSA-0485	Avantek	0.05-3.8	8	6	12	5/50	3.55
MSA-0835	Avantek	0.5-6	28	3	12.5	8.5/36	11.25
MWA0204	Motorola	0.01-3	12	6	4	5/25	2.65
NE5205	Signetics	DC-0.5	19	6	4	6/24	2.80
PC1656C	NEC	0.01-0.75	19	5.5	10	10/43	4.15

Table 2. The following reasonably-priced commercial GaAs FET MMICs may be of interest to Amateurs.

Part	CGY-40	NEPA 1001
Supplier	MSC/Siemens	NEC
Frequency range	0.5-4	0.5-3
Typical 0.5 GHz gain (dB)	9	11
Noise figure at 500 MHz	3	4
Output power (dBM)	17	9
Voltage /current (mA)	+5/60	5/60 −5/4
Price	$16.30	$23 @ 5M quantity

However, the harmonic output will require slightly more complex filtering because the number of output frequency components will increase.

suppliers and devices available

So far I've mentioned only general trends in circuit design and capabilities of hybrid circuits and MMICs. There are many suppliers of each. Some of the major suppliers of 50-ohm broadband hybrid rf circuits are Anzac, Avantek, Aydin Microwave, Hewlett Packard, MiniCircuits Labs, Motorola, Optimax Division of Alpha Industries, Q-bit, TRW, and Watkins Johnson. Suppliers of MMICs include Avantek, Minicircuits Labs, Motorola, MSC/Siemens, NEC, and Signetics.

Table 1 is a list of the most common low-cost bipolar MMICs that are available to Amateurs. **Table 2** lists some low-cost GaAs FET MMICs. Just as with transistors and FETs performance, the variations in frequency, gain, noise figure, and other parameters, are many. Hybrids and MMICs are presently available up to several watts of output from dc through the millimeter-wave range!

Probably the biggest thing for us to do as Amateurs is to become familiar with the devices that are available and use them wherever possible. In this regard, the GaAs FET MMICs are the most exciting because they hold the key to lower noise figures, higher frequencies of operation, and higher output power.

summary

Time and space have not permitted a long dissertation on the subject of hybrid and MMIC broadband rf amplifiers. Instead, only an overview has been presented. The references provided and data sheets available from the manufacturers shown will fill in the blank spaces. Some of these devices will be discussed in future columns.

These MMICs are not always the ultimate nor necessarily the desired choice for the front end of a low-noise receiver. However, they are good choices for second stages and input stages where noise figure is not at a premium. They are also recommended in intermediate frequency circuits or where gain is desired over a wide frequency range. Don't overlook their possiblities in transmitters as low-level stages. . . but that's another story!

We've only just scratched the surface. The MMIC manufacturers have already moved one major step forward. Not only are they providing amplifiers, but now whole "subsystems" are appearing — complete with rf amplifiers, mixer, local oscillator, and i-f amplifier, *all built on a single substrate!* Who knows what's in store in the future?

acknowledgments

I'd like to particularly thank Al Ward, WB5LUA, who sent me my first MMIC to "play" with. I have been hooked on them ever since.

new records

Summer is historically the time when VHF/UHF/SHFers go mountain-topping and otherwise take advantage of the improved propagation brought on by more favorable weather. This summer was no exception.

At least three difficult DX records have been recently set in North America. I don't yet have all the details, but here's a preliminary summary.

The 9-cm, 3456-MHz record now belongs to WA5TNY/5 and W7CNK/5 at approximately 222 miles. This was a tropo shot from Oklahoma City, Oklahoma, to Grapevine, Texas. Up in Oregon, WA3RMX and WB7UNU set a new 12-mm, 24.2-GHz line-of-sight record of approximately 115 miles. One

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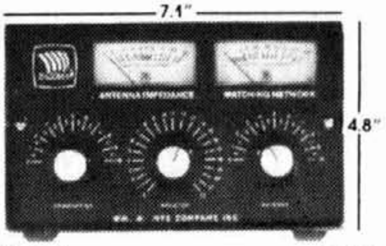

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25 watts	—	25A	25B	25C	25D	25E
50 watts	50H	50A	50B	50C	50D	50E
100 watts	100H	100A	100B	100C	100D	100E
250 watts	250H	250A	250B	250C	250D	250E
500 watts	500H	500A	500B	500C	500D	500E
1000 watts	1000H	1000A	1000B	1000C	1000D	1000E
2500 watts	2500H					
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of the important facts about this record is that it was done with only 20 milliwatts and on two-way SSB!

Reports are circulating that some of the trans-Pacific VHF/UHF DX records may have also fallen in early August, especially on the 23-cm (1296-MHz) band between Hawaii and San Diego, California. I hope to be able to provide more details on these important events next month.

Congratulations to the new record holders!

references

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3. Joe Reisert, W1JR, "VHF/UHF World: Low-Noise GaAs FET Technology," *ham radio*, December, 1984, page 99.
4. Joe Reisert, W1JR, "VHF/UHF World: High Dynamic Range on 2 Meters," *ham radio*, November 1985, page 54.
5. Joe Reisert, W1JR, "VHF/UHF World: 33cm — Our Newest Band," *ham radio*, April, 1986, page 83.
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10. Robert G. Meyer et. al., "A Wide-Band Ultralinear Amplifier from 3 to 300 MHz," *IEEE Journal of Solid-State Circuits*, August, 1974, page 167.
11. Craig Snapp et. al., "Practical Silicon MMICs Challenge Hybrids," *Microwaves and rf*, November, 1982, page 83.
12. Jerry Hinshaw, N6JH, "Monolithic rf Amplifiers," *ham radio*, March, 1986, page 22.

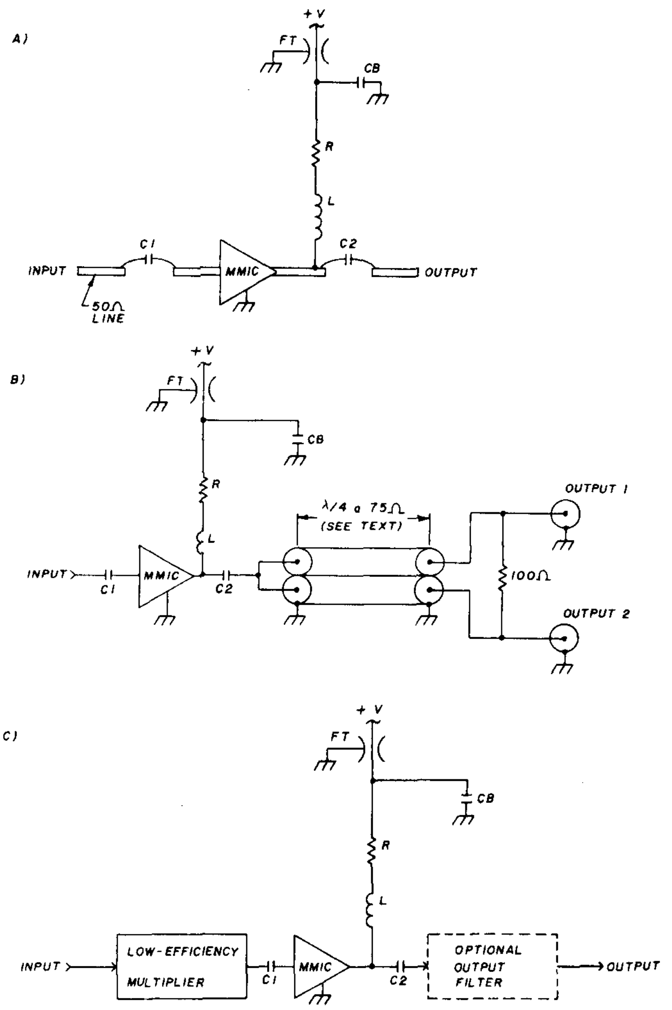

fig. 4. Examples of multipliers using MMICs. (A) is a frequency doubler. U1 and U2 are Avantek MSA0104s or equivalent. T1 is a trifilar wound transformer with three turns of No. 32 AWG per winding on a FairRite type 2843002402 or equivalent binocular core. Frequency range is limited by transformer characteristics. As shown the limit is about 300 MHz on the input. (B) is an example of a proposed tripler using MMICs. T1 and T2 are similar to T1 in *fig. 4A*. See text for further information on both circuits.

important VHF/UHF events:

November 2	*Predicted peak of the Taurids Meteor Shower at 1520 UTC.*
November 3	*Predicted peak of the Casseopids Meteor Shower at 1515 UTC.*
November 4	*EME perigee*
November 17	*Predicted peak of the Leonids Meteor Shower at 0850 UTC.*
November 22/23	*ARRL EME Contest, second weekend.*
December 2	*EME perigee*
December 13	*Predicted peak of the Geminids Meteor Shower at 1250 UTC.*
December 21	*± 1 month. Winter peak of sporadic E propagation.*
December 22	*Predicted peak of the Ursids Meteor Shower at 0400 UTC.*
December 30	*EME perigee.*

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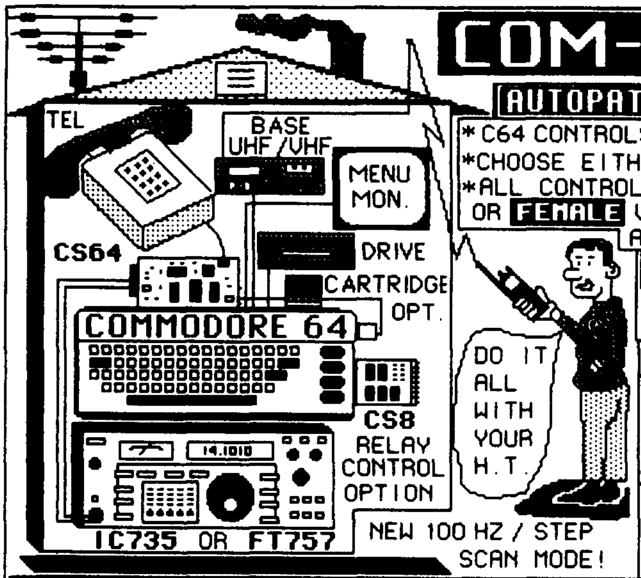

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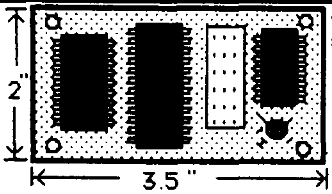

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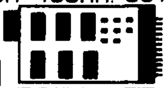

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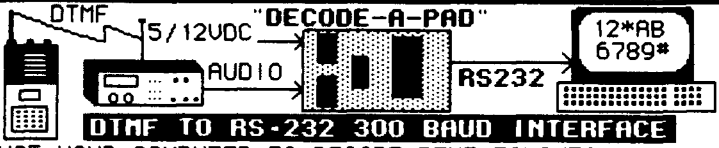

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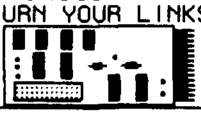

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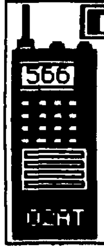

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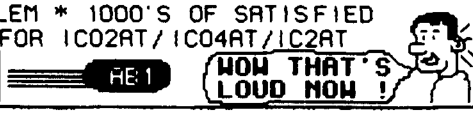

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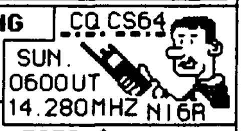

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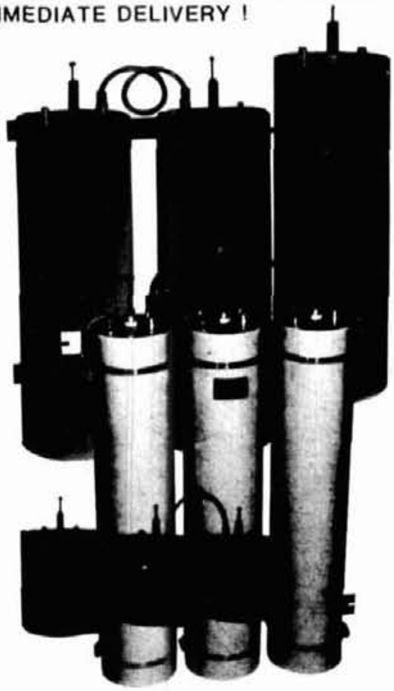

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the ham notebook

waterproofing fittings

Keeping water out of antenna fittings, traps, and other outdoor assemblies can be a tough problem for most hams. Products often recommended in construction articles may be difficult to obtain. They may be expensive. But there is an alternative: Plastic Rubber™*, an inexpensive material that's readily available at most hardware counters and works better than a lot of other products I've heard recommended.

Plastic Rubber can be used freely on such things as coax fittings that will be exposed to the weather and on the seams of mini-boxes or other enclosures that must be kept watertight outdoors.

As it comes from the tube, it's either a gooey white or black liquid that quickly becomes tacky when exposed to air. It dries to the touch in 5 or 10 minutes, but remains soft and "tender" for an hour or two. When it has cured for several hours it dries to a tough, rubbery film a few mils thick. The film never becomes brittle.

I've used Plastic Rubber to seal coax fittings on 2-meter beams that remained in the air for several years of use, then lay on the roof for several more years of disuse after they were replaced by another beam. Even after all this exposure to Florida's summer sun, winter frosts, and plenty of thunderstorms, I found the seals intact. Two pairs of pliers had to be used to unscrew the shells of the PL-259s; the interior threads were as clean and uncorroded as they were when the fittings came from the store. In fact, it was difficult to peel the material from the metal. In many places, I had to scrape off the Plastic Rubber with a knife or file to get to the metal.

I haven't run tests on VHF or UHF losses in the material in those places where it's used as a dielectric, but any losses appear to be within acceptable limits. I can't detect any change in performance after application of the material to the solder connections of some SO-239s used to mount a half-wave balun on the beam.

Plastic Rubber also makes excellent seam-sealer for those leaky tents on a rainy Field Day. Apply it to the tent seams while the material is completely dry and let it cure for a day or two before re-folding the tent to prevent treated seams from adhering to each other. The material never stiffens and repeated folding of the tent doesn't erode the seal.

George L. Thurston, III, W4MLE

*"Plastic Rubber" is a trademark of the Duro Division of the Loctite Corporation of Cleveland, Ohio 44128.

ham radio

NEW products

high-performance receiver

Kenwood's new R-5000 high-performance receiver isn't just another all-band, all-mode receiver. The R-5000 covers 100 kHz-30 MHz in 30 bands, with additional coverage from 108-174 MHz available with installation of the optional VC-20 converter. It offers 100 memory channels, optional computer control, and much more.

Though similar in appearance to the TS-440S, the R-5000 matches the superior performance of the TS-440 receiver section. Its exclusive DynaMix™ direct mixing system ensures an honest 102-dB dynamic range (14 MHz, 500 Hz bandwidth, 50 kHz spacing.)

The R-5000 does not replace the popular high-performance R-2000, which is still available, but instead gives hams two high-performance receivers from which to choose.

For information, contact Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90220.

ACC expands

Advanced Computer Controls, Inc., has moved its offices and manufacturing plant to a new facility in Santa Clara, California. The new building adds space for manufacturing, marketing, and engineering. (Northridge Square in Cupertino remains an acceptable mailing address.) ACC manufactures microcomputer-based control systems for Amateur Radio, commercial, and government radio users.

For more information, contact Advanced Computer Controls, Inc., 2356 Walsh Avenue, Santa Clara, California 95051.

Circle #309 on Reader Service Card.

new antenna from Mirage

The 1.2-44 LBX from Mirage utilizes the latest in ultra-high gain, low sidelobe design. The parasitic elements are pseudo-log tapered in length and spacing to produce wide usable bandwidth with low VSWR.

Because of its light weight, low windload and rugged construction, it's appropriate for use in higher gain multi-antenna arrays. Used alone it still delivers outstanding performance with better than 18.2 dBd gain across the specified bandwidth. This antenna requires no tuning; it's factory assembled and tested to insure that each unit meets or exceeds the advertised specifications.

For information, contact Mirage/KLM Communications Equipment Inc., P.O. Box 1000, Morgan Hill, California 95037.

Circle #301 on Reader Service Card.

two new communications microphones

Shure Brothers Inc., Evanston, Illinois, has added two new, economical models to its line of communications microphones.

The Shure 550L Base Station Microphone, suitable for radio communications, paging, and dispatching system applications, shares many design features with Shure's well-known Model 450k. Its omnidirectional cartridge is specially tailored for voice intelligibility, and its balanced, low-impedance design makes it useful for long cable runs and use under severe hum conditions.

Constructed of strong, corrosion-proof ARMO-DUR™, it features Shure's long-life "Million Cycle" press-to-talk bar switch. User Net Price is $66.25.

The Shure Prologue 6L Handheld Communications Microphone — the lowest-priced handheld communications microphone ever offered by Shure — features a dynamic low-impedance cartridge with tailored response for high intelligibility, a sturdy push-to-talk switch, a durable coiled cable, an extra-strength mounting bracket, a relay closure circuit, and compact, lightweight construction. The Shure Prologue 6L's list price is $41.75.

For further information about the Shure 550L and Prologue 6L, contact Shure Brothers Inc., Customer Services Department, 222 Hartrey Avenue, Evanston, Illinois 6020-3696.

Circle #308 on Reader Service Card.

test monitor

Comtest Systems has introduced the Model 3000B Communications Service Monitor. Said to be the only monitor in its size and price range that gives the kind of testing capability usually available only in larger instruments costing thousands more, this lightweight, versatile instrument provides three different displays — waveform CRT, meter, and digital counter.

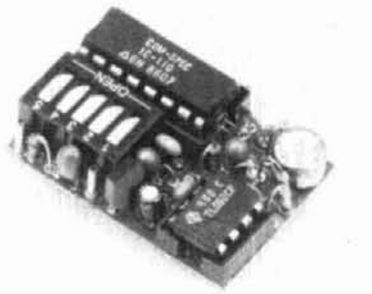
Receive features include a tuneable range of 400 kHz to 1000 MHz, combining high sensitivity with good intermod rejection and wide frequency range for "off the air" monitoring. A high-resolution audio frequency counter LCD display assures versatility and accuracy. The counter also permits the display of CTCSS frequencies directly off the air. The large CRT provides instantaneous information about modulation waveforms and internally generated markers can be displayed at ±5 kHz or ±600 Hz for "at a glance" idenfitication of FM modulation peaks.

For further information, contact Comtest Systems, Inc., P.O. Box 470, Beech Grove, Indiana 46107.

Circle #307 on Reader Service Card.

programmable encoder

Communications Specialists has announced the introduction of its new programmable encoder, Model SS-32P. The SS-32P allows the user to specify the available tones in the memory. Up to 32 tone frequencies are stored in an EPROM memory; these tones may be standard or non-standard, and may be changed. The working tone is retrieved from the memory with a five-position DIP switch mounted on the circuit board.



The SS-32P is available in either CTCSS or burst tone format: Model SS-32PA will operate on any tone from 67.0 to 250.0 Hz; Model SS-32PB will operate between 250.0 and 3000 Hz. Both versions measure 0.9 x 1.3 x 0.4 inches and will operate on voltages as low as 6 VDC for handheld applications and up to 25 VDC for mobile or base station use.

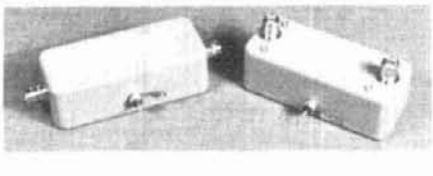
The SS-32P allows the use of non-standard tones for extra flexibility on crowded channels and for added security on tone controlled repeaters. It also simplifies multiple tone switching (up to six tones).

Priced at $28.95, the SS-32P is covered by a one-year warranty and is available for immediate delivery from stock. For information and a free catalog, contact Communictions Specialists, Inc., 426 West Taft Avenue, Orange, California 92665-4296.

Circle #312 on Reader Service Card.

audio/video amplifier

An audio/video amplifier from WI-COMM Electronics, Inc., operates over the frequency range from 300 Hz to over 10 MHz and features multistage design, with gain rated at 32 dB; noise figure, 3 dB; 3rd order intercept point, 33 dBM; power output, 0.10 watt into 200 ohms; input/-



output VSWR 2:1; and reverse isolation, 55 dB. Standard connectors are BNC female, 26 VDC. Reverse polarity protection is included. Possible applications include audio/stereo, SCA, AM stereo, video, digital audio, and LF through HF communication links.

For details, contact WI-COMM Electronics, Inc., P.O. Box 5174, Massena, New York 13662.

Circle #311 on Reader Service Card.

NEW products

new Heath catalog

Heath Company of Benton Harbor, Michigan, has announced the release of its upated fall catalog. With an expanded line of starter kits, computers, weather instruments, and a variety of electronic products, the redesigned Heathkit catalog brings a new, refreshing look to its pages.

Heathkit's expanded computer software/hardware line includes the new HyperACCESS communication software, designed to permit communication with other microcomputers and databases. Also included is the new Teach-N-Tutor Authoring software from Zenith Data Systems, which allows programmers to create tutorials for computer-aided instruction (CAI). New computer hardware includes Epson printers and a 2400-Baud modem from US Robotics.

For a free copy of the catalog, contact Heath Company, Dept. 150-785, Benton Harbor, Michigan 49085. In Canada, contact Heath Company 1020 Islington Avenue, Dept. 3100, Toronto, Ontario M8Z 5Z3.

Circle #310 on Reader Service Card.

New Larsen Antennas

The new YA5 series of Yagi directional antennas includes the YA5-900, designed to operate in the 900-960 MHz range. It features all-weather constuction (i.e., coax termination *inside* the Yagi — away from wind and rain — plus a black weather-resistant coating. Other features include user interface via N-male connections to the N-female cable-mounted connector supplied with the antenna kit. The mounting hardware (double-welded, heavy-duty U-bolts) will fit any pipe from 1-1/8 to 2-1/2 inches in diameter.

Specifications include 10 dBd gain, 45-degree horizontal beamwidth, 55-degree (estimated) vertical beamwidth, and maximum power of 300 watts.

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

Circle #313 on Reader Service Card.

eight-pole crystal filters

Several new eight-pole crystal filters are available from International Radio.

The new Kenwood TS-440 8-pole crystal filter package consists of SSB 2.1-kHz or 1.8-kHz and 400 Hz or 250 Hz filters. An SSB 2.1-kHz matched crystal filter set is also available. The typical response of the matched set is 2.1 kHz at 6 dB and 2.8 kHz or less at 60 dB.

New filters are also available for ICOM units. Stock No. IRI-455H400X is a CW, 400-Hz (eight-pole) that serves as an exact replacement for the FL-52A. It fits the IC-751(A), the IC745, the IC740, etc.

Stock No. IRI-455H1.2X is an eight-pole SSB, 2.4 kHz exact replacement for the FL-44A. It fits the IC730, IC740, IC745, and the R70 and R71.

The typical shape factor for the SSB filters is 1.66 or less; for CW filters, the center frequency is 8.0 or 9.0 MHz = 3.2 or less. The 455 kHz center frequency is 2.0 or less. All International Radio crystal filters are guaranteed to the original purchaser for two years.

Many other ICOM crystal filters available. For details, contact International Radio, Inc., 747 South Macedo Blvd., Port St. Lucie, Florida 33452 (enclose SASE).

Circle #314 on Reader Service Card.

Palomar "Tuner-Tuner"™

Palomar Engineers has announced a new operating aid, the Tuner-Tuner.™ It connects between your transceiver and antenna tuner, and allows you to tune your tuner precisely *without transmitting*. The built-in 50-ohm noise bridge gives an audible null in the receiver when the tuner matches the coax line to 1:1 SWR. Your transmitter never need operate into high SWR, and you need not cause interference on the band while tuning up.

The Model PT-340 Tuner-Tuner is priced at $99.95 plus $4 shipping. For more information, contact Palomar Engineers, Box 455, Escondido California 92025.

Circle #315 on Reader Service Card.

temperature-controlled soldering station

Start Manufacturing has announced the release of a versatile soldering station that permits the interchanging of 30, 48, and 60-watt irons, thus providing the operator with three stations in one. The station also features a unique control that keeps the temperature to within ±8 degrees F of the setting. It also offers direct temperature readout, easy and fast calibration, and a feature that permits the station to be set and locked at a specific temperature. The station comes with a standard 48-watt pencil iron and adjusts over the full temperature range of 200 through 900 degrees F without having to change the tip or heating element.

For information, contact Start Manufacturing, Inc., 15775 North Hillcrest, Suite 508, Dallas, Texas 75248.

Circle #306 on Reader Service Card.

two-band rotary dipole

The CD 78 from Orion Hi-Tech is a 80- and 75- meter rotary dipole. Approximately 40 percent shorter than a full-sized dipole, its unique design results in a less than 2 dB-reduction in radiation efficiency over a full-size antenna.

The CD78 is equipped with a special high-performance matching unit that is used to switch the antenna between the two bands. 2:1 VSWR bandwidth is approximately 50 kHz on both 80 and 75.

Built from high-strength, heavy-duty aluminum, it features a very strong element-to-boom mount. All hardware is hot-dipped galvanized after fabrication. The CD78 will handle full legal power and is rated at 40 m/s wind survival.

For details, contact Orion Hi-Tech, P.O. Box 8771, Calabasas, California 91302.

Circle #316 on Reader Service Card.

free QSL cards!

Varta Batteries, Inc. — one of the world's three largest battery manufacturers and a leading U.S. supplier of batteries for short-wave radio, photography, data processing, and other high-tech applications — is offering a package of 20 QSL cards to Amateur Radio Operators, free upon request.

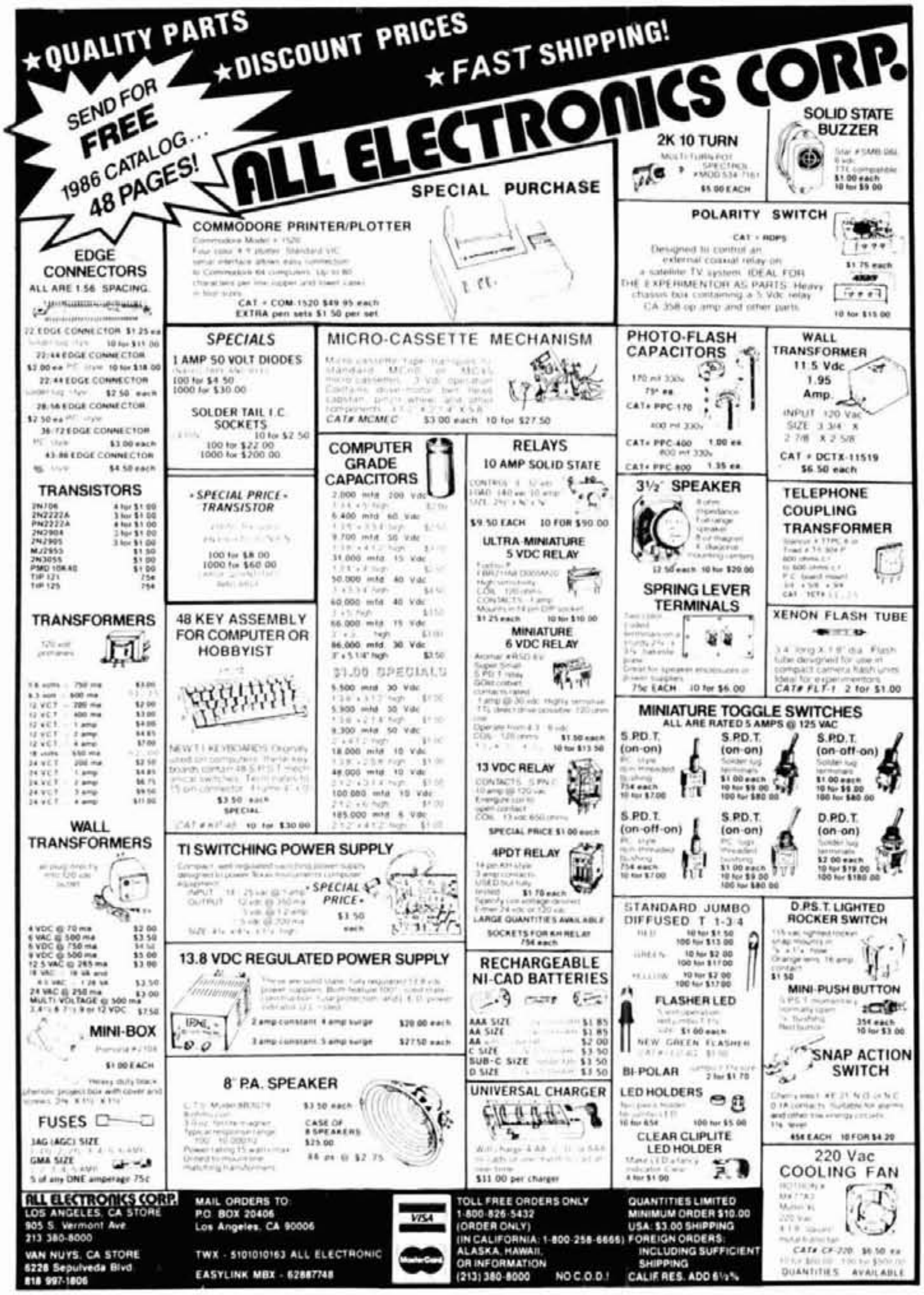
The postcards are printed in full color with an illustration of world map as a background for Varta's wide line of batteries for shortwave Amateurs. The address side of the card follows the typical QSL card form.

Readers who would like to obtain a package of cards should send their name and address to: Paul Silliman, Varta Batteries Inc., 300 Executive Blvd. Elmsford, New York 10523-1202.

Circle #318 on Reader Service Card.

R-2000 repeater controller

Resultant Engineering has introduced the



NEW products

R-2000 repeater controller, which can control a complete repeater system including two remote bases and a control receiver. The fully-programmable, microprocessor-based controller includes many features for today's demanding repeater service. Features include autopatch with memory dialer, ALC and call progress detection, mailbox/bulletin board, and dual RS-232 ports for interfacing to a computer or printer.

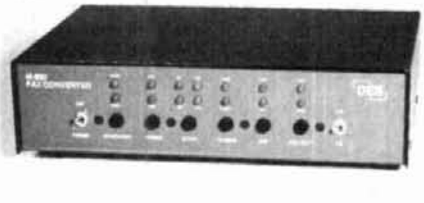
For more information, contact Resultant Engineering, 175 East Homestead, Sunnyvale, California 94087.

Circle #317 on Reader Service Card.

FAX unit prints photos

Universal Shortwave has introduced the microprocessor-controlled DES M-800 FAX Converter, which allows reception and printing of pictures, photos, maps, and marine and National Weather Service information, as well as satellite earth imagery and world meteorological charts transmitted by shortwave and satellites.

The M-800 Facsimile Converter connects to the audio output of any quality communications receiver or satellite receiver (AM or FM). Audio



is converted to graphics data and printed out on most Epson parallel dot-matrix computer printers (FX-85, LQ-800, or equivalent). Print size is 8 inches by length as needed. Aspect ratio is 1:1.

FAX photos are printed on plain paper in 16 levels of gray scale. Weather maps (NWS), charts, and other black-and-white transmissions yield exceptional clarity.

For details, contact Universal Shortwave, 1280 Aida Drive, Reynoldsburg, Ohio 43068.

Circle #320 on Reader Service Card.

D2M2

Known as D2M2™ — *not* DMM — because they offer twice the range and resolution and twice the functions of ordinary DMMs with 2000-count capability, the new 4000-count 4-digit multimeters with 40-segment analog bar graph from North American SOAR are priced to rival ordinary 2000-count DMMs.

All D2M2 range crossover levels are at the 4, 40, 400, and 4000 points to allow measurements of 3.999 or 39.99, etc. Accuracy is better than 0.3 percent for Models 4020, 4030, and 4040, and better than 0.1 percent for Model 4050. All models have been constructed to be shockproof and dustproof for operation in harsh environments.

All models are auto- and manual-ranging with Data Hold Function, Continuity Beeper, Diode Test, and more. Selectable models feature illuminated LCD, Frequency Counter, Relative Set, Memory, Temperature and Min/Max Indication.

Optional adapters expand functions to include Capacitor Test, High AC/DC current, Transistor GAIN and Loss Test, and Temperature. Full overload potection includes two fuses plus transient noise to 6000 volts. 1500-hour battery life is typical with two "AAA" alkaline cells and auto power down. All D2M2 units are supplied with batteries, safety leads, spare fuses and 3 year limited warranty, calibration accuracy guaranteed for 1 year.

Prices for D2M2 Series meters in single-lot quantities are as follows: Model 4020, $99.99; Model 4030, $139.00; Model 4040, $159.00; and Model 4050, $179.00, with delivery from stock. For full specifications or additional information, contact North American Soar Corporation, 1126 Cornell Avenue, Cherry Hill, New Jersey 08002.

Circle #319 on Reader Service Card.

15-channel programmable scanner

Automatic search, scan delay and a priority channel are features that are normally reserved for expensive, top -of-the-line scanners. But one modestly priced programmable scanner, the Regency R1075, is packed with all of these features. Fully programmable, the 15-channel scanner can receive more than 15,000 frequencies from six of the most popular public service bands.

Designed for the beginning scanning enthusiast, as well as the veteran seeking a reliable back-up unit, the scanner can be programmed to search a frequency range for active new frequencies. With its priority channel and scan delay functions, the scanner keeps listeners from missing important transmissions. When activated, the priority channel automatically overrides all other calls so that broadcasts from a favorite channel are never missed. Scan delay puts a 2-second pause at the end of a transmission so that calls and answers can be heard before the scanner resumes its scanning cycle.

Priced at $179.95, the scanner covers six full bands, including VHF-Low (30-50MHz), VHF-Amateur (144-148 MHz), VHF-High (148-174 MHz), UHF Amateur (440-450 MHz), UHF (450-470 MHz), and UHF-T (470-512 MHz).

For information, contact Regency Electronics Inc., 7707 Records Street, Indianapolis, Indiana 46226.

Circle #302 on Reader Service Card.

RFI technical note

Palomar Engineers has published a helpful note titled ""Using Ferrite Beads to Keep rf Out of TV Sites, VCR'S, Burglar Alarms and Other Electronic Equipment." The note explains what kinds of beads and toroids to use and where to put them to suppress most common rf interference problems.

For a free copy, contact Palomar Engineers, Box 455, Escondido, California 92025.

Circle #303 on Reader Service Card.

oscilloscope frequency extenders

Radio Engineers has recently introduced several new products including two models of frequency extenders for the home builder with an oscilloscope that can ""see" only up to 5 MHz. Designated the Type HFX-1 and HFX-2 Oscilloscope Frequency Extenders, these units allow 5 MHz or 10 MHz bandwidth oscilloscopes to see rf signals as high as 55 MHz. Type HFX-1 contains an rf signal source and a broadband mixing circuit that converts the high frequency signal to an intermediate frequency within the oscilloscope's range. Type HFX-2 is designed to be used with an external signal generator but still gives the same frequency coverage. Both units have 50-ohm input impedances and utilize BNC connectors to interface to the circuit under test and the oscilloscope. Also available is Type DBX-30, a fixed 30-dB attenuator that allows the extenders to sample higher power levels. A high-impedance transformer to be used at the input of the oscilloscope extenders is planned for release in the near future.

Data sheets are available on these and other products. For copies, contact Radio Engineers, 3941 Mount Brundage Avenue, San Diego, California 92111.

Circle #304 on Reader Service Card.

turnable preamplifier antenna

Ameco's Model TPA is a dual-function unit that can be used as a preamplifier to improve the gain of a receiver or as an indoor active antenna when an outdoor antenna isn't available. It contains a tuned rf amplifier that covers all frequencies from 0.22 to 30 MHz, including Amateur bands, all foreign broadcast bands, citizen's band and all other services within this range. A dual-gate FET provides an excellent noise figure and over 20 dB gain. The weak-signal performance of most receivers is improved.

Priced at $74.95, Model TPA uses either an internal 9-volt battery or an ac adapter such as Ameco's Model P-9T. As a preamplifier, the input matches most antennas. Long-wire, 300-ohm and random-length antennas can also be used with good results.

For information, contact Ameco Equipment Company, a Division of Ameco Publishing Corporation, 220 East Jericho Turnpike, Mineola, New York 11501.

Circle #322 on Reader Service Card.

1.0 Formula Disk

RF Kit Company has announced a new software disk for the Commodore C-64. This new release includes many formulas such as Ohm's law, inductive and capacitive reactance, resonant frequency, dipole antennas, temperature conversions from C to F and F to C, Great Circle bearings and distances to anywhere, Tower Stress calculations, Noon Meridian passage for

True North antenna adjustments, how to wind coils for a specific inductance, how to make a meter shunt and how to program your own favorite formulas on the disk. The RF Kit 1.0 disk sells for $14.95 plus $1.00 postage and packing.

For information, contact RF Kit Company, P.O. Box 27127, Seattle, Washington 98125.

Circle #321 on Reader Service Card.

Communications Satellites

Now in its expanded second edition, *Communications Satellites* covers spy and surveillance satellites, U.S. and Russian manned space missions, military, tactical and scientific satellites, oceanographic and weather orbiters, deep space probes, navigational and communications satellites, and private and direct broadcast satellites. This directory of space communications includes chapters on channelization band plans, transponder identification, international satellites, and an informative history of earth satellite development.

Priced at $14.95 (plus $3.50 for shipping and handling), the book may be ordered from Ham Radio's Bookstore, Greenville, New Hampshire 03048.

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DYNAMIC COLOR NEWS: Monthly newsletter provides programming instruction for Radio Shack Color Computers. Includes HAM RADIO section. FREE sample. Dynamic Electronics, Box 896, Hartselle, AL 35640. (205) 773-2758.

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CABLE TV CONVERTERS & EQUIPMENT: Plans and parts. Build or buy. SASE for information. C & D Electronics, PO Box 1402, Dept. HR, Hope, AR 71801.

YAESU OWNERS: Hundreds of modifications and improvements for your rig. Select the best from fourteen years of genuine top-rated Fox Tango Newsletters by using our new 32-page Cumulative Index. Only $5 postpaid (cash or check) with $4 Rebate Certificate creditable toward Newsletter purchases. Includes famous Fox Tango Filter and Accessories Lists. Milt Lowens, N4ML (Editor). Box 15944, W. Palm Beach, FL 33416. Telephone (305) 683 9587.

R-390A Receiver: $195 checked; $115 reparable. Parts, tubes, sections. Info SASE. CPRC 26 six meter transceiver (see HR, March 1985) $17.50 apiece, $32.50 pair (add $4.50/unit shipping). Baytronics, Box 591, Sandusky, OH 44870. 419 627 0460 evenings.

MARCO: Medical Amateur Radio Council, Ltd. operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc.) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

IBM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS 232C TU $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

ELECTRONIC ENCLOSURES: Attractive, reasonably priced. Aluminum top and sides. Walnut stained solid wood ends. Variety of sizes and custom sizes available. Sample $5.00 Information free. Energy Engineering, Custom Division, Rt. 4, Box 330, Fayetteville, AR 72701.

NATIONAL RADIO EQUIPMENT manual list or NCL 2000 parts kits. SASE. Maximilian Fuchs, 11 Plymouth Lane, Swampscott, MA 01907.

ATTENTION AMATEURS Send for Free discount catalog. Amateur Communications, 2317 Vance Jackson, San Antonio, TX 78213. (513) 734 7793.

8877 VHF AMP KITS: HV power supplies, CX600N relays, Mu Tek LTD front end boards for IC251/IC271, EME newsletter and QRO parts. SASE for new catalog. KB7Q, "Q" Products, 417 Staudaher Street, Bozeman, MT 59715.

RTTY JOURNAL—Now in our 34th year. Join the circle of RTTY friends from all over the world. Year's subscription to RTTY JOURNAL, $10.00, foreign $15.00. Send to: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 2-3 PM Eastern. Eight hundred Amateurs in 40 countries. Brother Frey, 1 Pryer Manor Road, Larchmont, New York 10538.

RUBBER STAMPS: 3 lines $4.50 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

DISCOUNT CATV CONVERTERS/DECODERS and Video accessories. Send for free information and prices it could save you BIG MONEY on your next purchase of these and other CATV items. Easy View, (HR) PO Box 221K, Arlington Heights, Illinois 60006. (312) 952 8504. Ask for Rudy Valentine.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. Daily Electronics, PO Box 5029, Compton, CA 90224. (213) 774 1255.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. Hein Specialties, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

CABLE TV CONVERTERS/DESCRAMBLERS. Guaranteed lowest prices in US. Jerrold, Hamlin, Zenith - Many others. Lowest dealer prices! Orders shipped within 24 hours! Mastercard, VISA, COD accepted.Free Catalog call (800) 345-8927 only Pacific Cable Co., Inc., 7325-1/2 Reseda Blvd,#1019, Reseda, CA 91335. (818) 716-5914.

WANTED: Heath ET-100. Call 913-898-4695. Mike W0XM. DIRECT AND LONG PATH Headings (degrees). Great Circle Distances (kilometers and statute miles). From your exact QTH to over 400 worldwide locations including 60 within Continental USA. Nine pages. Send $4.50 to W4HET, Engineering Systems, Inc., PO Box 939, Vienna, VA 22180.

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FOR SALE: Collins Equipment: KWM 2 and 30L1 1 KW. Complete with power supply 110V and 220V. SM 2 Fix sta. Dynamic Mic. (voice control carrier). Collins Speaker equip for phone patch. Quad Ant. 80-40-20-10 meters. Carrying Cases: Samsonite for KWM-2 and 30L 1 Amp. Complete with instruction by Collins. Complete with instructions by US Gvt. (FRC 93, TM 11 5820 554). Mobile Mount: MP 1 (new not used). Mobile pwr sup: 35-D2 (new not used). Mobile Dynamic Mic. MM-1 (new not used). The equipment above in excellent condition. Will sell complete for $1,000.00. Contact: William J. Maida, 274 W. Sabal Palm Pl, Longwood, FL 32779 or phone 305-869-6138.

CHASSIS and cabinet kits. SASE K3IWK, 5120 Harmony Grove Road, Dover, PA 17315.

COMING EVENTS

Activities — "Places to go . . ."

CONNECTICUT: November 9. SCARA annual indoor Flea Market, North Haven Park and Recreation Center, North Haven. Sellers 7 AM. Buyers 9 AM to 3 PM. Tables $10.00 advance, $15.00 at the door. Buyers $2.00. For information or table reservations SASE with phone number to SCARA Flea Market, PO Box 81, North Haven, CT 06473. Reservations must be received by November 3, 1986. No reservations taken by phone. For information ONLY contact Brad (203) 265-6478. 7 PM to 10 PM.

MASSACHUSETTS: November 8. New England annual DXCC Banquet. Masonic Lodge Building, Monument Square, in historic Concord Center. Afternoon session 2 PM to 5:30 PM. Banquet 6:30 PM. For further information: Charles Lukas, Jr., W1DOH, RFD 1, 24 Durkee Road, Acton, MA 01720. (617) 263 3743.

MICHIGAN. November 30. The Oak Park High School Electronics Club presents the 17th annual Swap 'N Shop, Thanksgiving Sunday. Oak Park High School, Oak Park, MI. Donation $2.00. 8' tables $8.00.

MICHIGAN: November 2. The Oak Park ARC will hold its largest ever 1986 SWAP N SHOP. New location: City of Southfield Civic Pavilion, Evergreen Road between 10 and 11 Mile Roads, northwest Detroit suburb of Southfield. Ham Radio and Computer activities from 9 AM to 5 PM in the new fully carpeted 30,000 sq. ft. pavilion. The Detroit Area Repeater Team (DART) will provide food and refreshments. Admission $4, under 12 free. VE3's at par. Tables $10.00. Advanced reservations required. Talk in on DART 146.04/.64 and 146.52 simplex. For further information SASE to OPARC Swap N Shop, 303 South Vermont Avenue, Royal Oak, MI 48067. Swap N Shop Hotline (313) 399-3991.

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

MASSACHUSETTS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday, November 19, 7 PM, MIT Room 1-134, 77 Mass Avenue, Cambridge MA. Reservations requested 2 days in advance. Contact Ron Hoffmann (617) 253-0160/646-1641 or Craige Rodgers (617) 494-1986. Exam fee $4.25. Bring copy of current license (if any), two forms of picture ID and completed form 610 available from FCC in Boston (223- 6609)

TEXAS: November 7-9. AMSAT will hold its 4th annual Space Symposium and Annual Meeting, Dallas/Fort Worth Airport Hilton Hotel. Speakers include experts from around the world addressing the latest in OSCAR. Featured speaker Dr. Martin Davidoff, K2UBC. Additional details and registration information available from AMSAT HQ. (301) 589-6062.

MASSACHUSETTS: November 22. The Honeywell 1200 Radio Club, sponsor of 147.72/12 repeater and the Waltham Amateur Radio Association, sponsor of 146.04/64 repeater, will hold their annual Amateur Radio and Electronics auction, Honeywell Plant, 300 Concord Road, Billerica. Doors open 10 AM. Free admission and parking. Snack bar and bargain parts store. Talk in on both repeaters. For more information: Doug Purdy, N1BUB, 3 Visco Road, Burlington, MA 01803.

OHIO: November 16. The Massillon ARC will sponsor "Auctionfest 86", Massillon K of C Hall off Route 21. 8 AM to 5 PM. Sellers setup 7 AM. Admission $3.50 advance; $4.00 at the door. 8' tables $7.00. Free parking. Refreshments available. Auction starts 11 AM. Talk in on W8NP, 147.78/.18. For advance registration and information: MARC, PO Box 73, Massillon, Ohio 44646. Please SASE.

INDIANA: November 9. The allen County Amateur radio Technical Society will prsent the 14th annual Fort Wayne Hamfest. Allen County Memorial Coliseum, Coliseum Blvd, US 30. Doors open 8 AM to 4 PM. General admission $3.50 advance; $4.00 at the door. Children 11 and under free. Tables $10.00 each. AC power extra. Premium tables $25.00 each. Non-ham activities. Banquet Saturday night. Nearby hotels and motels. VE exams Saturday, November 8 by advance registration only. kTalk in on 146.28/.88. Forinformation or reservations: AC-ARTS Hamfest, PO Box 10342, Fort Wayne, IN 46851. For information ONLY Bernie Holm, K9JDF, Hamfest Chairman, (219) 485-0164, 6-10 PM EST.

WISCONSIN: November 15. The Milwaukee Repeater Club is sponsoring the 2nd annual 6.91 FRIENDLY FEST. Eagle's Club, 24th and Wisconsin Avenue. 8 AM TO 1 PM. Sellers 7 AM. Tickets $3.00. 4' tables $4.00. Save $1.00 by sending SASE with payment to Milwaukee Repeater Club, PO Box 2123, Milwaukee, WI 53201 before 11/8/86. Talk in on 146.91 and 146.52.

MINNESOTA: December 6. Annual Handi-Ham Winter Hamfest, The Eagles Club, Faribault. Registration 9 AM. Handi-Ham equipment auction. Dinner at noon followed by a program. For more information contact Don Franz, W0FIT, 1114 Frank Avenue, Albert Lea, MN 56007.

OPERATING EVENTS

"Things to do . . ."

November 9-11: A.F.A.R., the Armored Forces Amateur Radio Net will operate a special event station, 1700 UTC 11/9 to 2400 UTC 11/11. All bands. #10 SASE to WB1DWR, 16 Berkeley Circle, Newington, CT 06111.

December 6: The University of Idaho ARC, W7UQ, will hold its 2nd annual Alumni Reunion on the Air, 2000Z, December 6 to 0400Z December 7. All Amateurs, especially U of I alumni, are invited to participate. Listen for "CQ Reunion". QSL available by sending SASE via callbook address. For more information contact W7UQ.

November 9. In observance of Veteran's week, members of the Hamfesters Radio Club, Chicago, will operate from the Hines VA Hospital's Robert K. "Pappy" Wade, K9CDH Memorial Ham Shack using Hine's club call K9WFN. 1500Z to 0300Z. 40, 20, 2 meters FM and USB. Send QSL, QSO number and 9x12 SASE with 39 cents postage to Hamfesters Radio Club, Inc., Chicago, c/o Robert K. "Pappy" Wade Memorial Ham Shack, Bld 8, Hines Veterans Administration Hospital, Hines, Illinois 60141.

November 15. The Laurel, MD ARC will operate K3LDE from 1300Z to 2300Z for the runing of the Washington International Horse Race. Send QSL, contact number and #10 SASE for certificate to: LARC, 1120-12th Street, Laurel, MD 20707.

W.E.C.A. (Westchester Emergency Communications Association) initiates Equipment/"Elmer" Banks to help new hams get on the air. More information write the club at PO Box 131, North Tarrytown, NY 10591.

AMATEUR RADIO RESOURCES DIRECTORY 1986-87

Have a question that no one can answer????? "Fred" will. The "white" pages list the folks who can answer any Amateur Radio related problems or question you might have: ARRL Directors, Vice Directors, Assistants, Advisory Committee members, Field volunteers, VEC Volunteer examiners, all organized geographically by ARRL Division. The "Blue" pages contain a QST 10 year cumulative index, QEX and Gateway bibliographies, TIS info and more! Every ham should have a copy of this book in their shack. © 1986

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Our 30th Anniversary.

Yaesu USA
17210 Edwards Road, Cerritos, CA 90701
(213) 404-2700
Customer Service: (213) 404-4884
Parts: (213) 404-4847

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

Prices and specifications subject to change without notice.

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NEW

Hear it All!

R-5000

High performance receiver

THE **high performance receiver is here from the leader in communications technology—the Kenwood R-5000. This all-band, all mode receiver has superior interference reduction circuits, and has been designed with the highest performance standards in mind. Listen to foreign music, news, and commentary. Tune in local police, fire, *aircraft, weather, and other public* service channels with the VC-20 VHF converter. All this excitement and more is yours with a Kenwood R-5000 receiver!**

- **Covers 100 kHz-30 MHz in 30 bands, with additional coverage from 108-174 MHz (with VC-20 converter installed).**
- **Superior dynamic range.** Exclusive Kenwood DynaMix™ *system ensures* an honest 102 dB dynamic range. (14 MHz, 500 Hz bandwidth, 50 kHz spacing.)

- **100 memory channels.** Store mode, frequency, antenna selection.
- **Voice synthesizer option.**
- ***Computer control option.***
- **Extremely stable, dual digital VFOs.** Accurate to ±10 ppm over a wide temperature range.
- **Kenwood's superb interference *reduction.*** *Optional filters further* enhance selectivity. Dual noise blankers built-in.
- **Direct keyboard frequency entry.**
- **Versatile programmable scanning, with center-stop tuning.**
- **Choice of either high or low impedance antenna connections.**
- **Kenwood non-volatile operating system.** Lithium battery backs up memories; all functions remain intact even after lithium cell expires.
- **Power supply built-in.** Optional DCK-2 allows DC operation.
- **Selectable AGC, RF attenuator, record and headphone jacks, dual 24-hour clocks with timer, muting terminals, 120/220/240 VAC operation.**

Optional Accessories:

• VC-20 VHF converter for 108-174 MHz operation • YK-88A 1.6 kHz AM filter • *YK-88S 2.4 kHz SSB filter* • YK-88SN 1.8 kHz narrow SSB filter • YK-88C 500 Hz CW filter • YK-88CN 270 Hz narrow filter • DCK-2 DC power cable • HS-5, HS-6, HS-7 headphones • MB-430 mobile bracket • SP-430 external speaker • VS-1 voice synthesizer • *IF-232C/IC-10 computer* interface.

R-2000 150 kHz-30 MHz in 30 bands • All modes • Digital VFOs tune in 50 Hz, 500 Hz, or 5 kHz steps • 10 memory channels • Programmable scanning • Dual 24-hour digital clocks, with timer • 3 built-in IF filters (CW filter optional) • All mode squelch, noise blanker, RF attenuator, AGC switch, S meter • 100/120/220/240 VAC operation • Record, phone jacks • Muting terminals • VC-10 optional VHF converter (108-174 MHz)

More information on the R-5000 and R-2000 is available from Authorized Kenwood Dealers.

KENWOOD

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

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