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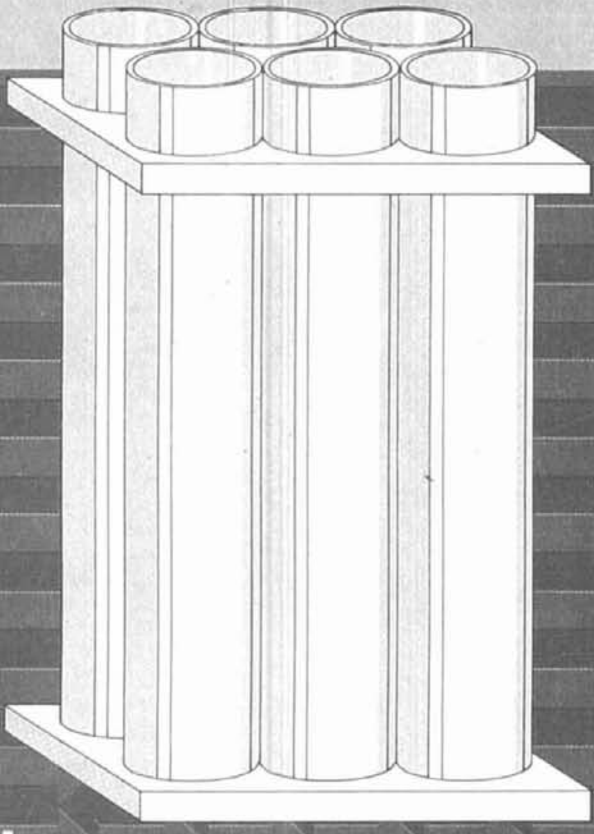
ham radio magazine



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The IC-751 is the most advanced transceiver available today. It's a competition grade ham receiver, a 100KHz to 30MHz continuous tuning general coverage receiver AND a full-featured all mode solid-state ham band transmitter. The IC-751 also covers the new WARC bands, MARS frequencies, and is AMTOR compatible.

Important Standard Features. Compare these important standard features in this "top of the line" base station:

- 100KHz - 30MHz Receiver
- 105dB dynamic range
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- 32 tunable Memories with lithium battery backup
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Options. IC-EX310 speech synthesizer, internal IC-PS35 power supply, external IC-PS15 or IC-PS30 system supply, IC-SM8 two-cable desk mic, IC-SM6 desk mic, RC-10 external controller, and a variety of filters.

FILTER SPECIFICATIONS

Filter	Model	Center Freq. (KHz)	-6dB (KHz) Width
STANDARD FILTERS			
AM Ceramic	CFW 455 IT	455	6.0
SSB (PBT) XTAL	FL-30	9011.5	2.3
FM Filter	9M15A	9011.5	15 (-3dB)
SSB Narrow (Hygrade Crystal)	FL-44A	455	2.4
OPTIONAL FILTERS			
CW Narrow	FL-52A	455	0.500
CW Narrow	FL-53A	455	0.250
SSB Wide	FL-70	9011.5	2.8
CW Narrow	FL-32	9010.6	0.500
CW Narrow	FL-63	9010.6	0.250
AM	FL-33	9010.0	6.0

Operating From 12V, the IC-751 is also available with an optional internal AC power supply, the IC-PS35...for the winning edge in field day competition.

Shown with IC-PS35

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ICOM

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All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions. 7511084

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contents

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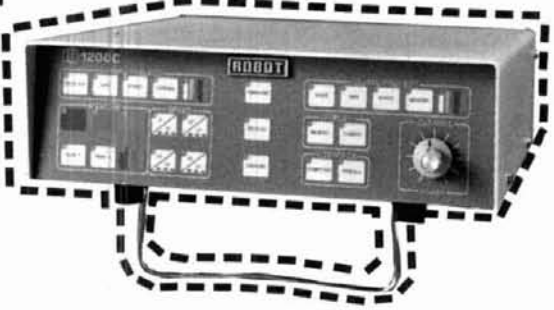

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✓ 175

REFLECTIONS

one million years of experience

If you saw a resume that showed one million years of experience, I'm sure you'd be impressed. One million, after all, is a very large number. But that, roughly, is the amount of experience that we Radio Amateurs have to draw on. In fact, if you add all our years of experience together, it's probably two or three times that number.

More and more often it seems that we're being told that Amateur Radio is dying, that our numbers are diminishing day by day. If you examine the figures — the inanimate statistics — it would, sadly, appear to be so.

The key word here is *inanimate*. Yes, the numbers are inanimate. But we are not. Just thinking of what hams have been able to accomplish, and continue to accomplish, over such a short period of time, is mind-boggling. Perhaps what we need to do is stand back and look at the future of Amateur Radio from a broader perspective.

Please understand that I'm not for one minute discounting the facts or the importance of the statements made by others who share our common interest in the preservation of our hobby. Call me a perennial optimist . . . it's just that when I look at what hams are doing in this country and abroad, I find myself feeling that we do have the capability to bring about the needed changes — but only if we are convinced of the urgency of the situation.

Before putting pen to paper I scratched my head to come up with positive suggestions for actions that would reverse the "doomsday" trend suggested by the declining numbers. ("Surely editors must have greater insight into solving the problems of their own field," I thought. "Given time," I supposed, "I'll contribute a suggestion or two that can be put into action.") But then I thought about you, the half-million hams who have their own opinions about what's happening, and about what can and should be done to strengthen and improve our hobby. What an unbelievable resource!

Maybe *ham radio's* first contribution can be to act as a clearinghouse for information. It would be our pleasure — nay, our responsibility — to help in collecting, sorting, and sharing your written suggestions, ideas, and insights about how to encourage the growth and expansion of Amateur Radio.

Quick! While the thought is still fresh, jot it down on a blank QSL card, post card, or letter addressed to me at *ham radio*, Greenville, New Hampshire 03048. I promise that I'll read each and every one.

Even the whisper of an idea can evolve into a plan and finally into action. "Sure," you can say, "this is all very general, but what can I add?"

That's simple. What are *you* interested in? What aspect of Amateur Radio do you want to preserve and see grow? What do you like about our hobby? Dislike? What would you like to see change? And how would you change it?

Ah, but who has the time? And what good will it do? These days, none of us has the time. We're all so busy, busier than we've ever been. But my answer to this is simply, "Nothing ventured, nothing gained." I'm willing to devote many hours to reading your responses — which may take no more than a minute or two to write.

Make me very popular at the Greenville Post Office. Send those suggestions in today, tomorrow. Keep them coming.

Rich Rosen, K2RR
Editor-in-Chief

presstop de W9JUV

BURBANK, ILLINOIS' ANTENNA ORDINANCE HAS BEEN EFFECTIVELY OVERTURNED under the terms of a Consent Decree entered in U.S. District Court for the Northern District of Illinois on November 30. Burbank's highly restrictive ordinance had put a one-year moratorium on new antennas, which it limited to 35 feet, required insurance plus a $50,000 bond and annual inspection fees, and authorized a fine for interference to home entertainment devices.

The Successful Two-Year Court Fight Was Waged by attorney Jim O'Connell, W9WU, on behalf of WA9EKA and 58 other Burbank Amateur and CB operators. Under the terms of the settlement Burbank agreed to grandfather all existing antennas, promptly issue permits ($15 maximum fee) for new towers up to 65 feet (exclusive of any antenna!), and permit roof mounting up to 12 feet above a building without permit. In addition Burbank is under court order to repeal both the offending antenna ordinance and any other city ordinances or codes in conflict with the terms of agreement. December 19 the Burbank City Council unanimously passed the new ordinance required by the agreement.

Estimated Costs Of This Important Battle Are Over $25,000 for the Amateur community alone, not including the tremendous investment in participants' time. The cost to Burbank taxpayers is not known. Though Burbank does represent an important victory for those Amateurs involved, the fact that it was by Consent Decree (which means in essence Burbank gave up rather than continuing to fight) somewhat diminishes its value as a precedent.

PRB-1, The ARRL's Attempt To Get FCC's "Official Sanction" for Amateur Radio against local restrictions, received strong support from several non-Amateur sources before the Comment period closed in late December. The American Red Cross and a number of communities and county emergency organizations have all joined in supporting the principals of PRB-1. However, it appears unlikely that the League petition will see any Commission response in the near future, quite possibly not until mid-1985.

20 KHZ CHANNELS ON 2 METERS' TOP HALF COMES TO THE MIDWEST, following overwhelming approval of the change by the Michigan Area Repeater Council at its December meeting. The timetable requires their frequency coordinator to come up with a comprehensive plan for changing existing repeaters' frequencies by next June. The actual changeover has been set to take place during May, 1986.

To Accomplish The Switch Will Require Moving All present "split" (15 kHz) systems plus half those in present 30 kHz slots. Unfortunately, 20 kHz channels provide only 99 slots in 2 MHz vs the 132 available in the present scheme. However, 15 kHz spacing has never been entirely satisfactory, while those areas that have already made the change to 20 kHz report they now have few if any problems with adjacent channel interference.

The Shift To 20 kHz Began In The Pacific Northwest, starting with British Columbia and Washington, then Oregon, Idaho, Montana, Utah, Arizona, and now Michigan. In addition, it appears to have been mandated for Mexican Amateurs by their government, and Texas, Louisiana, Kansas, Nebraska, and Oklahoma are all reported seriously considering the change.

The Impact Will Fall Directly On Major Population Centers in adjacent states as well as Canada, so some sort of response to Michigan's action is expected soon. A meeting has been called by ARRL Great Lakes Director W4OYI for January 19 in Ft. Wayne to discuss the situation; how well attended it will be remains to be seen, since it's being held the day before the Midwest's biggest winter hamfest in Arlington Heights, Illinois, 185 miles away.

2240 AMATEUR EXAMINATION ELEMENTS WERE ADMINISTERED IN NOVEMBER by volunteer examiners, with an overall pass rate of 48%. Top Regional VEC was DeVry, whose VEs gave 298 elements wiht a 53% pass rate. Runners-up were GLAARG (Los Angeles), with 225; ARRL 4th District, 212; Central Alabama, 193; and Metroplex, with 185. Nationally ARRL's groups gave a total of 564 elements, and W5YI's 135. DeVry also led in number of exam sessions during the month, with 16. Of the 51 VECs in place, only 55% were active in November.

A Net Devoted To The Volunteer Exam Program Meets Every Sunday morning on 7280 kHz at 1700Z. Net Control is W9JUG, who heads the VEC program at DeVry, and though the net is principally for coordination of the ninth call area VE operations any Amateur who is interested in the volunteer exam program is invited to join in.

A NEW BAND PLAN FOR THE 13 CM BAND, WHICH RECENTLY LOST 80 MHz to telemetry by FCC action, is going to have to be devised by the ARRL's VUAC. The two segments that remain, 2300-2310 and 2390-2450 MHz, will have to be reallocated to accommodate such diverse users as moonbounce, fast scan TV, and the Amateur Satellite Service (which has been authorized, though not exclusively, 2400-2450 MHz by WARC 79). Comments and suggestions should go to VUAC Chairman Dick Jansson, WD4FAB, or to Mark Wilson, AA2Z, at the ARRL.

OSCAR 10 IS ON A REDUCED OPERATING SCHEDULE for at least the next few months, to reduce battery drain during a period of partial eclipse of its solar panels. Check the Tuesday night or Sunday AMSAT nets for current times and modes.

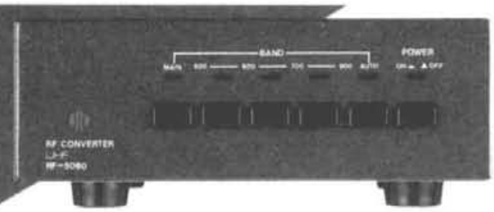
Amateur Satellite Orbital Predictions For 1985 Are Available again from Project OSCAR. Their 1985 orbital calendar covers all four Russian Mode A transponders, RS5, 6, 7, and 8, plus all necessary data to determine the apogee of each OSCAR 10 orbit. Minimum donation for U.S. and Canada users is $10 (it's $12 overseas), to Project OSCAR, Inc., Box 1136, Los Gatos, California 94022. Please include a self addressed mailing label, too.

UNINTERRUPTED FREQUENCY COVERAGE
100 KHz ~ 1.4 GHz with RF CONVERTERS for SX-400 SERIES
SCANNING MONITOR RECEIVER

FIRE · EMERGENCY · MARINE · AIR · SPACE INFORMATION · BUG DETECTOR

RF-8014 DOWN CONVERTER
800 MHz ~ 1.4 GHz RF converter for SX-400

● Bands • MAIN (to cover 26 ~ 520 MHz with SX-400) • 800 MHz ~ 1.0 GHz • 1.0 GHz ~ 1.2 GHz • 1.2 GHz ~ 1.4 GHz • AUTO (Automatic control of RF-8014 with an external computer, etc.) ● Frequencies shown in SX-400 display: 500 MHz lower between 800 MHz ~ 1.0 GHz, 700 MHz lower between 1 ~ 1.2 GHz, 900 MHz lower between 1.2 ~ 1.4 GHz ● Individual Band Switches and LED Indicaters ● Current Drain: 250 mA (approx.) ● Accessories: 1 BNC/M adapter, 1 Cable with BNC terminals ● Dimensions: W 148 × H 51 × D 225 (mm)

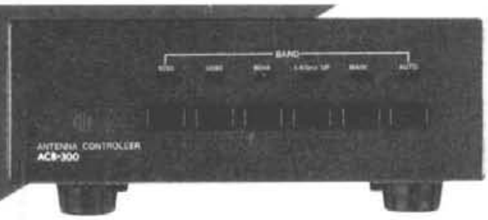


RF-5080 DOWN CONVERTER
500 ~ 800 MHz RF converter for SX-400

● Bands • MAIN (to cover 26-520 MHz with SX-400) • 500 ~ 600 MHz • 600 ~ 700 MHz • 700 ~ 800 MHz • AUTO (Automatic control of RF-5080 with an external computer, etc.) ● Frequencies shown in SX-400 display: 300 MHz lower between 500 ~ 600 MHz, 400 MHz lower between 600 ~ 700 MHz, 500 MHz lower between 700 ~ 800 MHz ● Individual Band Switches and LED Indicaters ● Current Drain: 250 mA (approx.) ● Accessories: 1 BNG/M adapter, 1 Cable with BNC terminals. ● Dimensions: W 148 × H 51 × D 225 (mm)

RF-1030 UP CONVERTER
100 KHz ~ 30 MHz RF converter for SX-400

● Bands: (1) 100 KHz ~ 1 MHz, (2) 1 ~ 2 MHz, (3) 2 ~ 4 MHz, (4) 4 ~ 8 MHz, (5) 8 ~ 17 MHz, (6) 17 ~ 30 MHz • AUTO (Automatic control of 6 bands of RF-1030 with an external computer, etc.) ● Frequencies shown in SX-400 display: 50 MHz higher on all bands than the frequencies received ● Individual Mode Switches and LED Indicaters: AM, USB, LSB, CW, AUTO • CW filter (optional) required for CW reception • AUTO — Automatic Control of modes of RF-1030 with an external computer, etc. ● Band Switch and LED Band Indicaters, Squelch Control, RF Att., AF Gain Control, Delta Tuning, IF ON/OFF Switch, NB (Noise Blanker) Switch ● Current Drain: 1A (approx.) *Power Supply Unit P-1A (optional) required for RF-1030 ● Accessories: 1 BNC-M adapter, 2 Cable with BNC terminals ● Dimensions: W 300 × H 90 × D 233 (mm)



ACB-300 ANTENNA CONTROL BOX
Manual and Automatic antenna control system for SX-400 series RF converters

● Individual Band Switches and LED Indicaters: 1030, 5080, 8014, 1.4 GHz UP (for reception of 1.4 GHz above) AUTO (Automatic control of antennas for RF-1030, RF-5080, RF-8014 and for MAIN scanner) ● Current Drain: 50 mA (approx.) ● Accessories: 1 Cable with BNC terminals ● Dimensions: W 148 × H 51 × D 225 (mm)

SX-400
26 ~ 520 MHz General Coverage Scanner

● Wider Coverage (100 KHz ~ 1.4 GHz or above) with RF converters (optional) ● Computer controlled memory channel expansion (unlimited), High Speed reprogramming, Record of Frequencies and Time, and all functions remote controllable with RC-4000 Interface (optional) ● 20 memory channels, Momentary recall of any memory channel ● Continuous normal and limit search without interruptions by birdies ● Stop Mode Switch for scan or search of modulated signals ● Quick search of the most important frequency with Priority ● Selective FM Narrow/Wide Switch for FM/TV listening ● Variable Delay Control (0 ~ 4 Sec.) ● Current Drain: 1A (approx.) ● Dimensions: W 300 × H 90 × D 233 (mm)

RC-4000 DATA INTERFACE **Control of SX-400 series Scanner and RF Converters through Computer.**
● Direct system for NEC 8801A computer ● High Speed Reprogramming of 20 channels ● Scan of unlimited channels stored in computer ● Record of Frequencies and Time of signals received ● Automatic Control of Bands and Modes of RF converters and ACB-300

P-1A REGULATED POWER SUPPLY UNIT ● 1A ● AC 120V (220V, 240V, 100V available) to DC 13.8V ● Dimensions: W 90 × H 60 × D 135 (mm)

* Design and specifications subject to change without notice.

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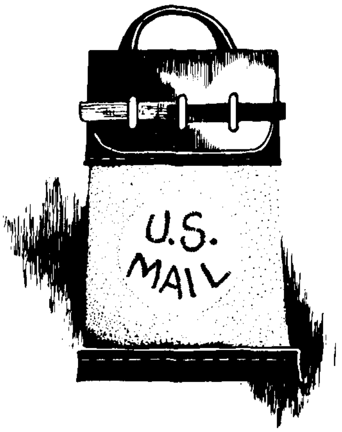


comments

half-wave sloper

Dear HR:

The response to my ham note, "80-meter Half-wave Sloper Uses Reflector," (October, 1984, page 48), has been excellent. One interesting note: *ham radio* arrived at our QTH the Friday before the Boxboro (Massachusetts) hamfest. We spent the weekend at the hamfest. Monday morning I called CQ DX 80 (grayline) and got Graham, ZL3MZ. Into the contact, Jim, KF4HK, broke in, asking for a report from the ZL. (He got 5-9.) He then informed me that he had put up two of my slopers over the weekend, worked a ZS the night before, and wanted to say "Hi." A quick check — with others helping — showed a 3 s-unit (18-dB) front-to-back between his two slopers.

Bruce A. Clark, KO1F
Belfast, Maine

J-pole or Zepp?

Dear HR:

The J-pole antenna described on page 43 of the July issue of *ham radio* (see "All-metal 2-meter J-pole Antenna," by Michael Hood, KD8JB) is not the magical 5/8-wave radiator that the author describes. The radiating portion is only that which extends above the 19-inch 1/4-wave matching transformer. The radiating element is therefore 38 inches, which is a 1/2-wave end-fed "Zepp."

Remember, the 1/4-wave transmission line inverts the high impedance to a low one. A short at one end insures a low impedance.

Slide the feedline away from the shorted end until a match is found.

The reason "convention dictates that the antenna point upward" is so it won't interact with the feedline and distort the radiation pattern.

For more information, check your antenna handbook under the index title "Zepp or End Feed."

Richard Ociepka, K1WWT
Augusta, Maine

The intent of my article was not to design a J-pole antenna, but rather to adapt a number of approaches to building a J-pole antenna for my own use. Along the way, I mentioned why I felt the J-pole antenna was a viable alternative to using a 1/4-wave radiator which had been the main 2-meter antenna at KD8JB to this point. I did not intend for anyone to assume this antenna was a magical 5/8-wave radiator.

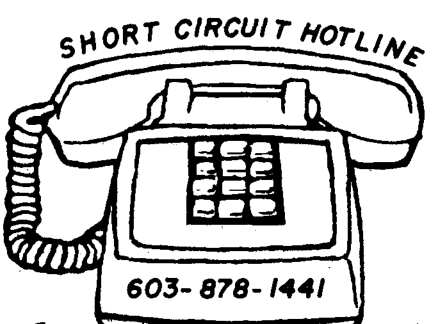
K1WWT is indeed correct in that the J-pole is an end-fed antenna and could be compared to the Zepp, since it is also end-fed, but I wouldn't go so far as to say the J-pole actually is an end-fed two-meter Zepp antenna. While it resembles the Zepp schematically, its appearance does not resemble the Zepp's any more than a Vee, inverted Vee, driven element of a Yagi, or other form of 1/2-wave center-fed radiator resembles the basic dipole. These derive their names from their shapes. If I offended K1WTT by not calling the J-pole an end-fed Zepp, my apologies — but I'm still going to call it a J-pole, because that's what it looks like, which was why someone (not me) selected that name in the first place.

The Zepp is a 3/4-wave antenna in its true form operating against a counterpoise of 1/4-wavelength. The J-pole is tapped by the feedline at roughly the 5/8's point on the radiator — hence my calling it a 5/8-wave antenna. (I'm not the only one calling it a 5/8-wave antenna, either.) We can argue this point forever, but I don't think we'll get any further than we are.

As far as "convention dictating the antenna be mounted upwards," good engineering practice dictates that the feedline of any antenna be brought away from the antenna perpendicularly, or at right angles (your choice — same result) for at least 1/2-wavelength to keep coax/antenna interaction to a minimum. If that is indeed the case, then the installation off the side of the tower as I mentioned in the article is correct, and actually better than if you were to run the cable straight down and away from the antenna, as is most commonly done when a vertical antenna is mounted on top of a tower. I suppose there would be times when interaction would occur regardless of how the antenna was installed, but my experience to date has shown that no adverse effects have manifested themselves by pointing the radiator in the downward direction. It's difficult to argue with success.

While not perfect by any stretch of the imagination, the J-pole as I built it works as I had intended it to work for my purposes. In addition, I felt that hams who put in a 40-hour week do not want to spend their free time with their noses in antenna engineering books trying to build the perfect antenna for their two-meter base stations. They want it quick, and they want it to work. I'd thought I'd covered all those bases.

Michael P. Hood, KD8JB
Grand Rapids, Michigan



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

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

MFJ ACCESSORIES

300 WATT ANTENNA TUNER HAS SWR/WATTMETER, ANTENNA SWITCH, BALUN. MATCHES VIRTUALLY EVERYTHING FROM 1.8 TO 30 MHz.

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NEW FEATURES

MFJ's fastest selling tuner packs in plenty of new features!
- **New Styling!** Brushed aluminum front. All metal cabinet.
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MFJ-1224
$99.95

Free MFJ RTTY/ASCII/CW software on tape and cable for VIC-20 or C-64. Send and receive computerized RTTY/ASCII/CW with nearly any personal computer (VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64, etc.). Use Kantronics or most other RTTY/CW software. Copies both mark and space, any shift (including 170, 425, 850 Hz) and any speed (5-100 WPM RTTY/CW, 300 baud ASCII). Sharp 8 pole active filter for CW and 170 Hz shift. Sends 170, 850 Hz shift. Normal/reverse switch eliminates retuning. Automatic noise limiter. Kantronics compatible socket plus exclusive general purpose socket. 8x1¼x6 in. 12-15 VDC or 110 VAC with adapter, MFJ-1312, $9.95.

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Maximize your antenna performance! **$59.95** MFJ-202B

Tells whether to shorten or lengthen antenna for minimum SWR. Measure resonant frequency, radiation resistance and reactance.

New Features: individually calibrated resistance scale, expanded capacitance range (±150 pf). Built-in range extender for measurements beyond scale readings. 1-100 MHz. Comprehensive manual. Use 9 V battery. 2x4x4 in.

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NEW! IMPROVED! *with higher gain* **"World Grabber" rivals or exceeds reception of outside long wires!** Unique **tuned** Active Antenna minimizes intermode, improves selectivity, reduces noise outside tuned band, even functions as preselector with external antennas. Covers 0.3-30 MHz. Telescoping antenna. Tune, Band, Gain, On-off bypass controls. 6x2x6 in. Uses 9V battery, 9-18 VDC or 110 VAC with adapter, MFJ-1312, $9.95. **MFJ-1020A $79.95**

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Turn your synthesized scanning 2 meter handheld into a hot Police/Fire/Weather band scanner! 144-148 MHz handhelds receive Police/Fire on 154-158 MHz with direct frequency readout. Hear NOAA maritime coastal plus more on 160-164 MHz. Converter mounts between handheld and rubber ducky. Feedthru allows simultaneous scanning of both 2 meters and Police/Fire bands. No missed calls. Crystal controlled. Bypass/Off switch allows transmitting (up to 5 watts). Use AAA battery. 2¼x1½x1½ in. BNC connectors.

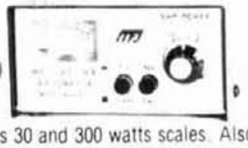
MFJ/BENCHER KEYER COMBO

MFJ-422
$109.95

The best of all CW worlds- a deluxe MFJ Keyer in a compact configuration that fits right on the Bencher iambic paddle! MFJ Keyer - small in size, big in features. Curtis 8044-B IC, adjustable weight and tone, front panel volume and speed controls (8-50 WPM). Built-in dot-dash memories. Speaker, sidetone, and push button selection of semi-automatic/tune or automatic modes. Solid state keying. Bencher paddle is fully adjustable; heavy steel base with non-skid feet. Uses 9 V battery or 110 VAC with optional adapter, MFJ-1305, $9.95.

VHF SWR/WATTMETER

MFJ-812 **$29.95**



Low cost VHF SWR/Wattmeter! Read SWR (14 to 170 MHz) and forward/reflected power at 2 meters. Has 30 and 300 watts scales. Also read relative field strength. 4x2x3 in.

1 KW DUMMY LOAD

MFJ-250 **$39.95**

Tune up fast, extend life of finals, reduce QRM! Rated 1KW CW or 2KW PEP for 10 minutes. Half rating for 20 minutes, continuous at 200 W CW, 400 W PEP. VSWR under 1.2 to 30 MHz, 1.5 to 300 MHz. Oil contains no PCB. 50 ohm non-inductive resistor. Safety vent. Carrying handle. 7½x6¾ in.

24/12 HOUR CLOCK/ ID TIMER

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a home-brewed six-cavity duplexer

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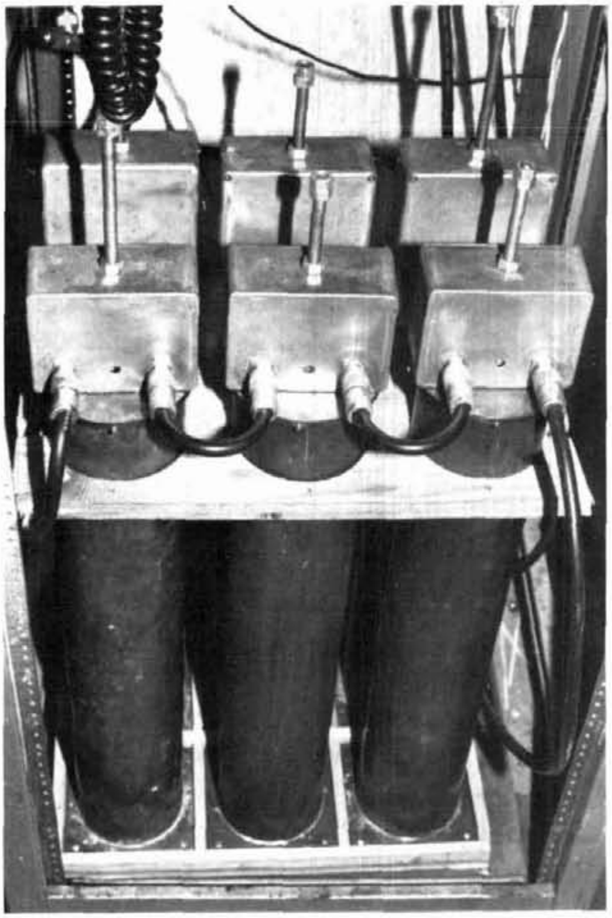


fig. 1. Six-cavity duplexer with a measured notch of 95 dB and an insertion loss of 1.5 dB.

By J.S. Gurske, K9EYY, R.R. 2, Box 178A, Lodi, Wisconsin 53555

After building a repeater, I soon realized that I'd need a duplexer in order to use the same antenna for the repeater, transmitter and receiver. After pondering the situation, I decided to build a six-cavity duplexer similar to the one described in the ARRL *FM Repeater Manual.** This duplexer, while not cheap, still costs much less to build than to buy; the total cost should range from about zero to $250.00, depending on how well your junk box is stocked.

The duplexer I built has a measured 95 dB of isolation and 1.5 dB insertion loss. **Figure 1** shows the completed duplexer in operation on the K9EYY repeater. **Figure 2** shows a completed cavity; **fig. 2A**, a cross-section view (less inductor and capacitor).

construction

The first step in construction is to cut the 4-inch (10-cm) copper pipes to a length of 22.5 inches (56.25 cm). If you are using the thin wall variety of copper pipe, handle it carefully to avoid distortion. Square both ends of all six pieces by using a lathe and a steady rest to support your work.

*Available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 (8.50 postpaid).

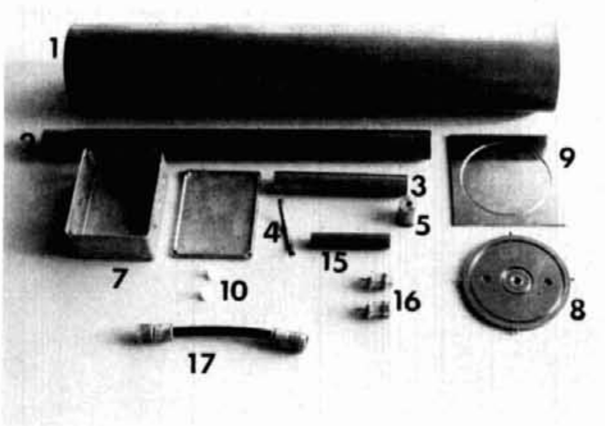
Next cut the 1-3/8 inch (3.44 cm) copper pipes to a length of 18 inches (45 cm). Once again you should square both ends of all six pieces. Cut the 1-inch (2.5-cm) O.D. brass tubing to 6-inch (15-cm) lengths. You will need six of these. Now machine 6 brass plugs from 1-inch (2.5-cm) brass rod stock as shown in **fig. 3**. The center hole in each brass plug is threaded with a 3/8 inch (0.938 cm) × 16 tpi tap.

The teflon insulating bushings are fabricated next. (Refer to **fig. 4**.) Use very sharp cutting tools in the lathe tool holder and rotate the teflon material slowly in the lathe. I used a speed of approximately 35 RPM (I used the back gearing on the lathe) and it cut very easily. You will need two of these bushings for each cavity, for a total of 12 teflon bushings. Be sure to drill a No. 50 hole in each bushing for a No. 16 wire.

Use the lathe to fabricate an aluminum plug (see **fig. 5A**) to be used when silver soldering the threaded rod, the brass plug, and the brass tube. Then fabricate another special aluminum plug to the dimensions shown in **fig. 5B**. This plug will be used to temporarily hold the finger stock inside the 1-3/8 inch (3.5-cm) copper tube while you silver solder the finger stock in place. This plug will prevent the "fingers" from getting too hot and losing their temper. The solder will not adhere to the aluminum.

Thread a nut onto a piece of 3/8 inch (0.938 cm) × 16 threaded rod. Run the nut past the point where you will cut the rod, then cut the rod to a length of 24 inches (60 cm). Then run the nut off the cut end of the threaded rod to chase or clean any threads which may have been damaged when you cut the rod to length. You will need six of these rods (one for each cavity).

Now look at **fig. 6**. Notice that a plastic pipe is slid over the threaded rod and fitted snugly inside the metal box. Check the inside measurement of the metal boxes



Items to be purchased or fabricated for each cavity. The numbers in the photograph correspond to the numbers in table 1.

table 1. Six-cavity duplexer parts list. This is a listing of all the parts you will need to obtain or fabricate to make a six-cavity duplexer. Some of these items are shown in the photograph above.

item number (see photo)	quantity needed	description
1	6	4 × 22-1/2 inch (10 × 56.25 cm) copper tubes
2	6	1-3/8 inch O.D. × 18 inch (3.5 × 45 cm) copper tubes
3	6	1 inch O.D. × 6 inch (2.5 cm × 15.25 cm) brass tubing
4	6	pieces of finger stock to fit inside item 2
5	6	tuning plunger bushing — 1 inch (2.5 cm) diameter brass rod
6	6	tuning rods 3/8 inch (0.95 cm) × 16 threaded rod 24 inches (60 cm) long
7	6	boxes to fit on top of cavities
8	6	top covers for 4 inch (10.5 cm) tubes made of 1/4 inch (0.6 cm) brass plate
9	6	bottom covers for 4 inch (10.5 cm) tubes made of 1/8 inch (0.3 cm) brass plate
10	12	teflon bushings 1/2 × 1/4 inch (1.35 × 0.6 cm)
11	18	nuts 3/8 inch (0.95 cm) × 16 for tuning rods (6 for locking and 12 for tuning)
12	12	coupling loops (made from No. 16 tinned wire)
13	3	inductors (made from No. 16 tinned wire)
14	6	copper straps 1/4 × 1 inch (0.6 × 2.6 cm) No. 0.020 copper
15	6	3/8 inch I.D. × height of mini boxes plastic pipe to keep mini box from compressing
16	12	"N" type chassis coax connectors to couple one cavity to another
17	4	7 inch (17.5 cm) tip to tip RG-192 double-shielded coax to couple the middle cavities to those on each end
18	1	9 inch (22.5 cm) RG-192 double-shielded coax to couple receive cavities to "T" connector
19	1	26 inch (65 cm) RG-192 double-shielded coax to couple transmit cavities to "T" connector
20	3	15 pF small variable capacitor (Johnson 189-5-5)
21	2	lengths of RG-192 to reach from transmitter to transmit cavities and receiver to receive cavities

you will be using and cut six lengths of this 3/8-inch (0.938-cm) I.D. plastic pipe to fit snugly inside the box. This spacer is used to keep the box from changing its shape when you tighten the lock nut after you have adjusted the cavity.

See **fig. 7A**. Make six bottom covers for the six 4-inch (10-cm) tubes by cutting square pieces of 1/8-inch (0.313-cm) brass plate so that they measure 4-1/2 × 4-1/2 inches (11.25 × 11.25 cm). Chuck these pieces of brass in the lathe one at a time and cut a 4-inch (10-cm) slot 1/16 inch (0.175 cm) deep, so that the 4-inch (10-cm) tubing fits snugly into the 1/16 inch (0.175 cm) circle you cut into each 1/8 × 4-1/2 inch (0.313 × 11.25 cm) square piece of brass base. You should have approximately 1/4 inch (0.625 cm) between the circle and the outside edge of these pieces of brass.

Refer to **figs. 7A** and **fig. 7B**. Fabricate six top covers to fit on the 4-inch (10-cm) copper tubes, using 1/4-inch (0.625-cm) brass plate stock. Cut rough 5-inch (12.5-cm) circles from the brass plate stock with a hacksaw. Then insert the rough sawed blank into your lathe chuck. (A 4-jaw chuck might be easier to

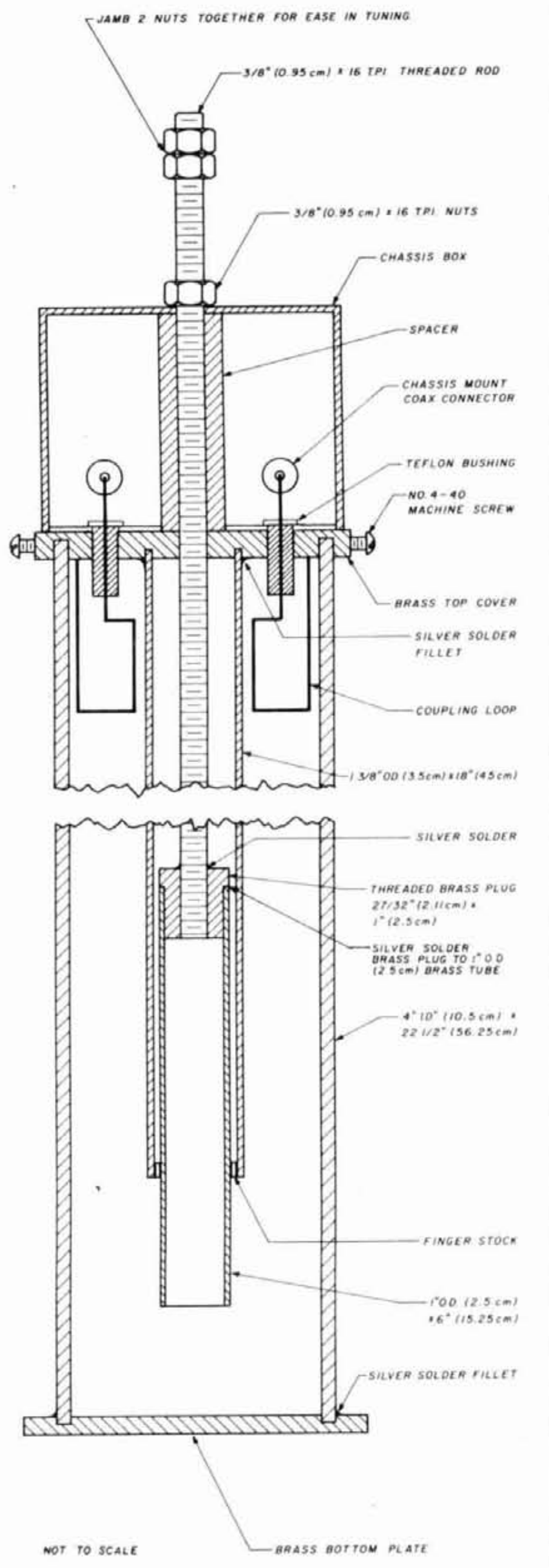


fig. 2A. A cross-sectional view of a single cavity. Neither the inductor nor the capacitor is shown in the metal chassis box.

fig. 2. Completed cavity. Note the locking nut on the threaded rod to hold the tuning adjustment. Also note the metal chassis box, the two "N" type chassis connectors, top and bottom covers.

use at this point.) Cut this blank to 4-1/2 inches (11.25 cm) in diameter and drill a 5/16 inch (0.78 cm) hole in the exact center of this cover plate. Thread this hole with a 3/8 inch (0.94 cm) 16 tap. Cut a circular slot 4 inches (10 cm) in diameter and 0.150 inch (0.375 cm) deep. The width of the slot should equal the thickness of the large 4 inch (10 cm) copper pipe, and the slot large enough so that the cover will fit snugly on the top end of the large copper pipe. Cut another round slot 1-3/8 inch (3.5 cm) in diameter and 1/8 inch (0.31 cm) deep to accommodate snugly the 1-3/8 inch (3.5 cm) O.D. copper pipe. Drill 2 holes 3/8 inch (0.94 cm) in diameter exactly 2-5/8 inches (6.56 cm) apart. The centers of these two holes should be exactly 1-5/16 inch (3.28 cm) from the center of the hole you drilled and threaded. These holes will accommodate the teflon bushings.

Refer to **fig. 7B** and notice the four small screws pointing inward toward the center of the cover. These are used to hold the brass covers on the top of the large copper pipes. Use a No. 43 drill and cutting oil to drill 4 holes as close to the bottom of the cover plate as you can. Tap these holes with a 4-40 tap. (Use a good grade of cutting oil or you will break the tap every time. The broken taps cannot be removed and the exposed edges must be ground off.) Fit 4-40 bolts in each of the tapped holes. If you grind a small point on the end of these bolts, they will hold the cover on the pipe more securely.

Refer again to **fig. 6** and also to **fig. 8**. Try to select a cast mini-box rather than a box made by bending sheet aluminum. The cast box will be more rigid and will keep the cavity tuned. Each box will include:

• input and output coax connectors (chassis mount) located 7/8 inch (2.19 cm) up from the bottom of the box, 1-15/16 inch (3.28 cm) from the center of the box.

• a 7/16 inch (1.09 cm) hole through the top and bottom of the box.

• two 3/8 inch (0.940 cm) holes for mounting the teflon bushings; they must align with the holes in the top cover plate.

• two holes for fastening the box to the top plate of each cavity (6-32 bolts).

• a spacer installed between the top and bottom sides of the box to keep the box from distorting when tuning is completed and the lock nut is tightened. This spacer can be metal or plastic. The inside diameter should allow the 3/8 inch (0.94 cm) threaded rod to slide inside the spacer.

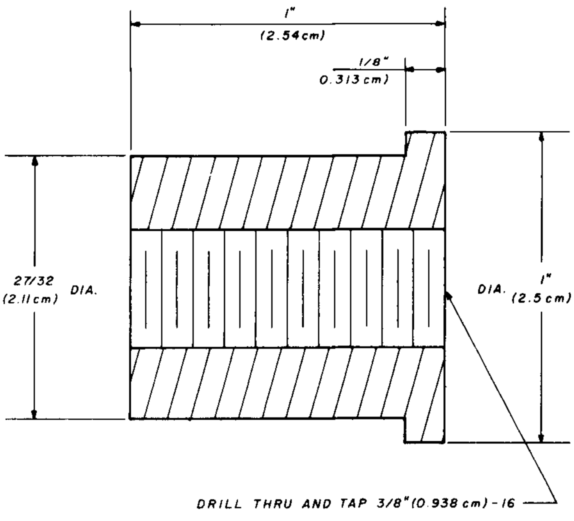


fig. 3. The dimensions of the six threaded brass plugs made from 1 inch (2.5 cm) brass rod.

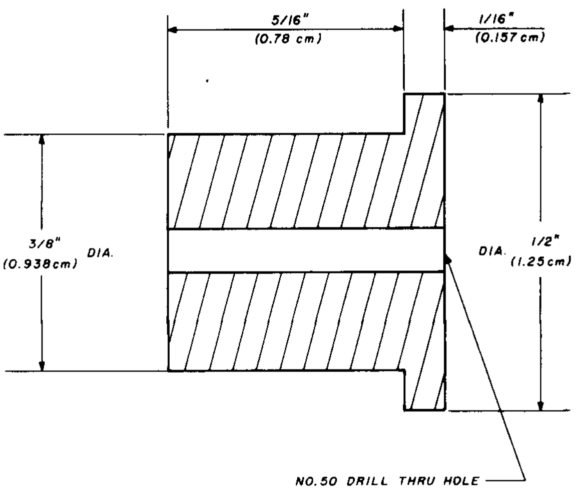


fig. 4. The dimensions of the 12 teflon bushings that allow the coupling loops to pass from the cavities through the top covers and into the chassis boxes. Note the No. 50 drill hole through the center of each bushing.

The boxes I used measured approximately 4-3/4 inches (11.88 cm) wide, 3-1/2 inches (8.75 cm) high and 2-1/4 inches (5.63 cm) deep and were obtained at a surplus outlet.

assembly

Figure 9 shows the main 4-inch (10-cm) diameter copper tube silver-soldered to the brass bottom plate. (Using low-temperature silver solder, we were able to attach the 4 inch (10 cm) tubes to their bases with the heat from only one acetylene torch in spite of the great conductivity of the 4 inch, 10 cm, copper tube.) Place the tube in the slot you machined in each square brass plate, apply flux, and silver solder the base plate to the 4 inch (10 cm) copper tube. Check for trueness before you lay the piece aside.

Next place the 1-3/8 × 18 inch (3.44 × 45 cm) copper tube into the slot previously cut in the round 1/4 inch (0.63 cm) brass top plate. Check for trueness and silver solder in place. See **fig. 10** which shows the tube silver-soldered to the brass top cover plate. It also shows how the finger stock fits inside the other end of this tube. The finger stock should be silver soldered to the inside of 1-3/8 inch (3.44 cm) tubing at the lower end. **Figure 10** shows its location and how it must contact the 1-inch (2.5-cm) tube for adjustment purposes. When silver soldering the finger stock, do not overheat the fingers. The aluminum plug you made earlier will help prevent overheating. I used a propane torch and the low temperature silver solder mentioned above. Obviously, you will not have the 1 inch (2.5 cm) brass tubing inside the finger stock while silver soldering. Instead, use the aluminum plug to hold the finger stock securely inside the 1-3/8 inch (3.44 cm) copper tube while you are soldering. After soldering, slide the 1-inch (2.5-cm) brass tube inside the finger stock. If the finger stock does not make firm contact with the 1-inch (2.5-cm) tube, remove the

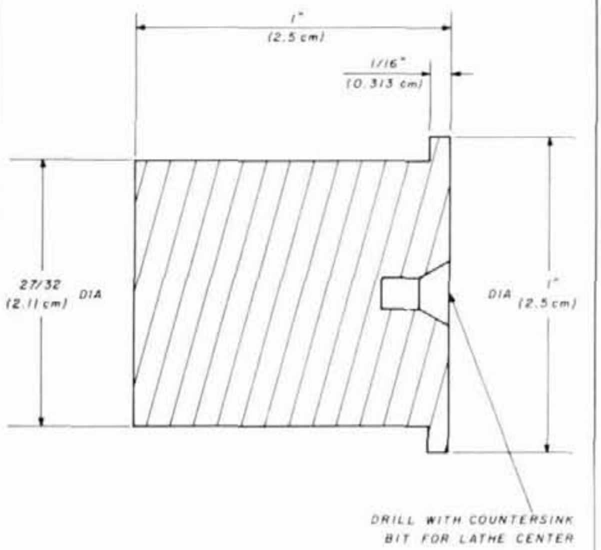


fig. 5A. The dimensions of the single aluminum plug used to fit into the open end of the 1-inch (2.5-cm) tube and supports the open end in the lathe center while the threaded rod, the brass plug detailed in fig. 3, and the brass tube are silver soldered.

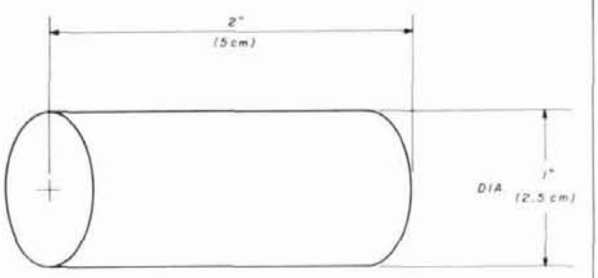


fig. 5B. The dimensions of another aluminum plug to be used when silver soldering the finger stock inside the six 1-3/8-inch (3.44-cm) copper tubes.

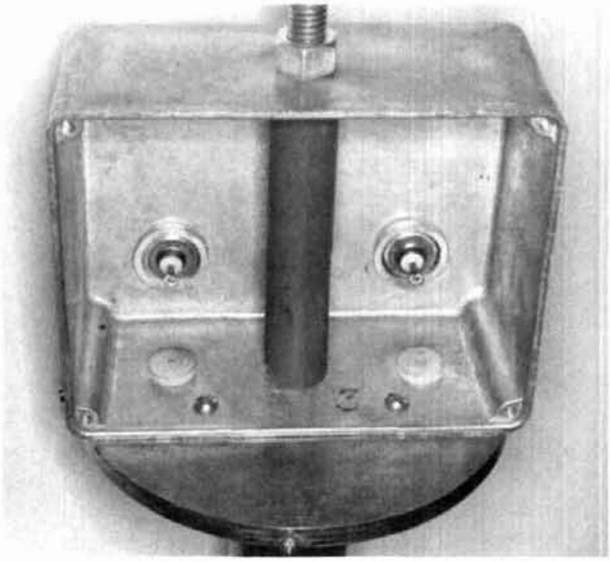


fig. 6. Detail of plastic pipe spacer, threaded rod, locking nut, teflon bushings, coax fittings and how they fit in the box.

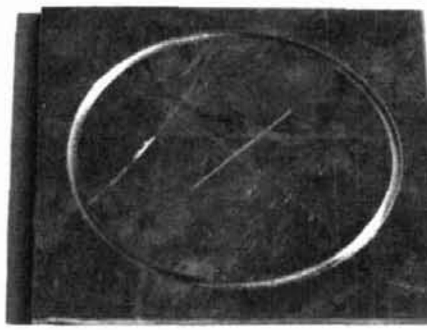


fig. 7A. One of the six bottom covers showing the slot. The large copper pipe will fit in this slot and be silver soldered to the plate.

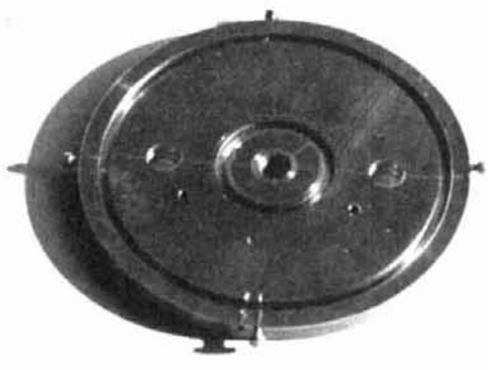


fig. 7B. A completed top cover. Note the center threaded hole, the two holes for the teflon bushings, the two slots for the copper tubes, the 6-32 threaded holes and the four 4-40 bolts in their holes.

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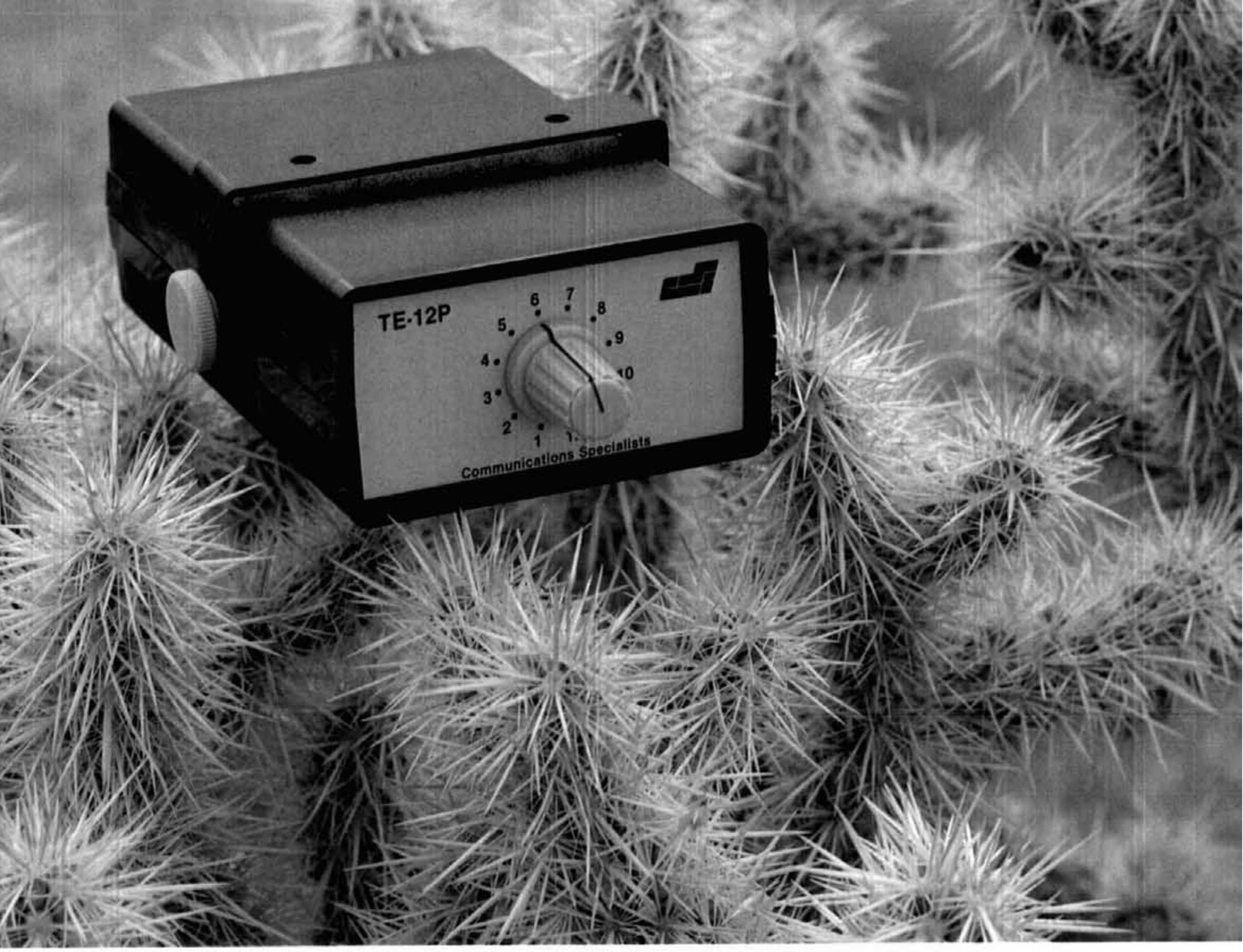

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1-inch (2.5-cm) tube and bend each finger inward so that it does make firm contact.

Examine **fig. 11** for the following details. It is very important that the 1-inch (2.5-cm) brass tube be attached to the 24-inch (60-cm) length of 3/8 inch (0.938 cm) by 16 threaded rod as accurately as possible. In other words, when the 3/8 inch (0.938 cm) by 16 (adjustment) threaded rod is turned, the 1-inch (2.5-cm) brass tubing should not wobble in the finger stock inside the 1-3/8 inch (3.44 cm) copper tubing. An easy way to accomplish this is to put one end of the threaded rod in the lathe chuck and thread the other end into the brass plug you machined earlier. Slide the 1-inch (2.5-cm) brass tube onto this plug. Then put the small aluminum plug (see **fig. 5A**) in the open (other) end of the 1-inch (2.5-cm) brass tube. Support this end by having the live center (or dead center) ride in the countersunk hole drilled in the center of this plug. The other end of the brass tube is held "centered" by supporting it in the steady rest. Lubricate the steady rest jaws and rotate the entire assembly while silver soldering the threaded rod into the threaded brass plug, and the plug to the brass tubing. When the silver soldering is complete, continue to let the piece rotate until it has cooled. **Figure 11** shows the threaded brass plug, the threaded rod, the aluminum plug, and the 1-inch (2.5-cm) brass tube as well as the steady rest as it was set up in my case.

After the assembly cools, thread the rod up through

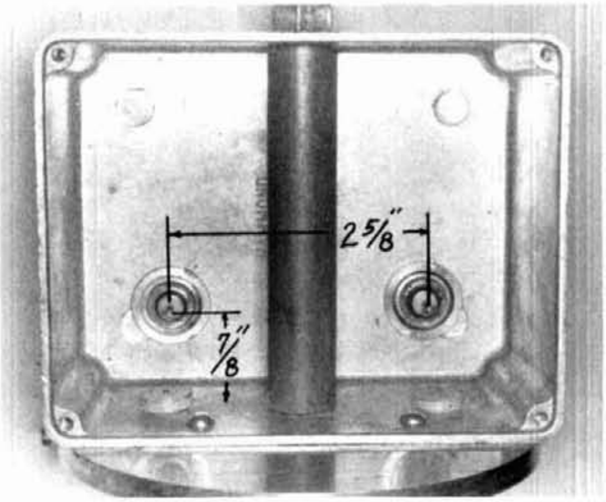

fig. 8. One of the six chassis boxes. These boxes are held to the top cover plates with the two 6-32 bolts in the foreground. Also note the spacer inside the box, the "N" type coax chassis mounts and the teflon bushings.

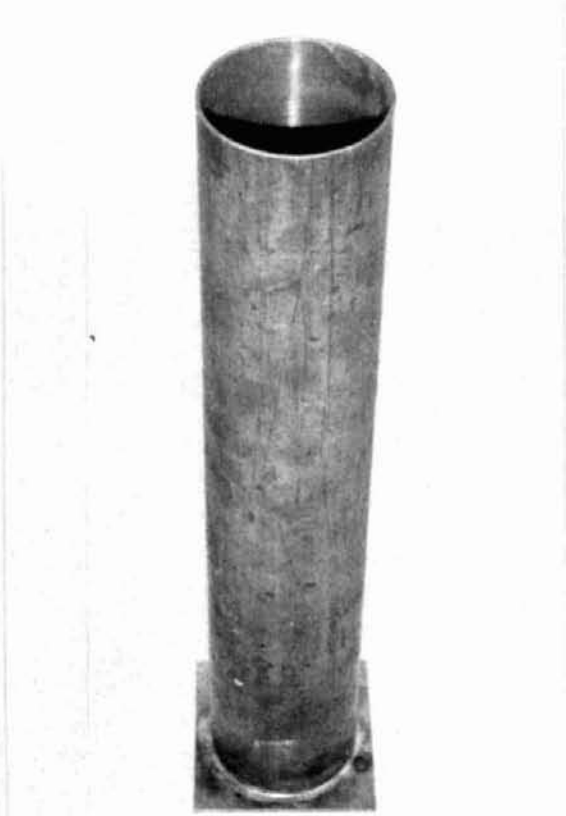

fig. 9. One of the six main copper tubes silver soldered to the bottom cover plate.

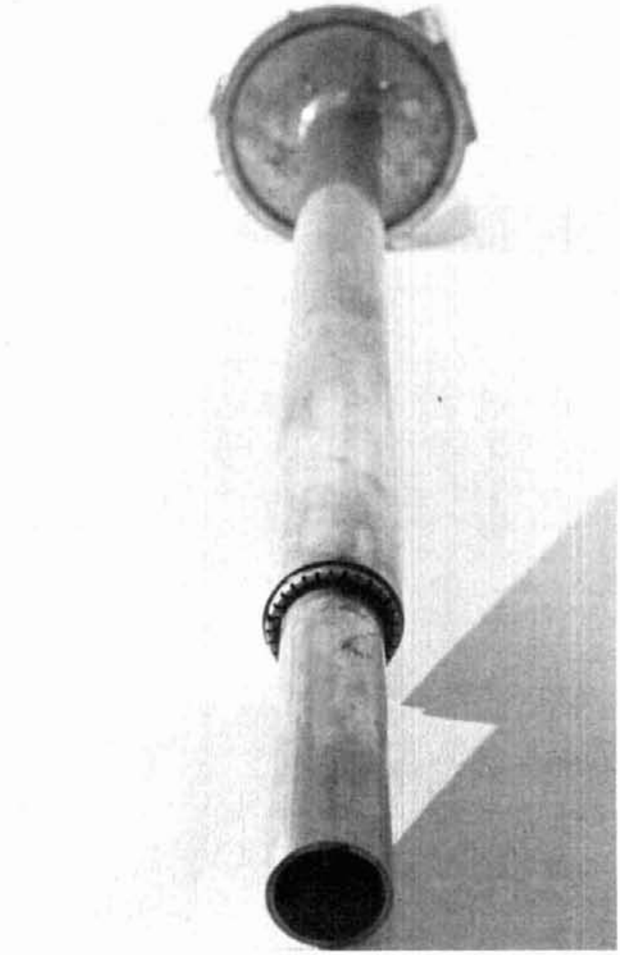

fig. 10. The top plate silver soldered to one end of the 1-3/8 inch (3.44 cm) O.D. copper tube and the finger stock silver soldered to the other end (foreground). Note how the finger stock firmly contacts the inner tube.

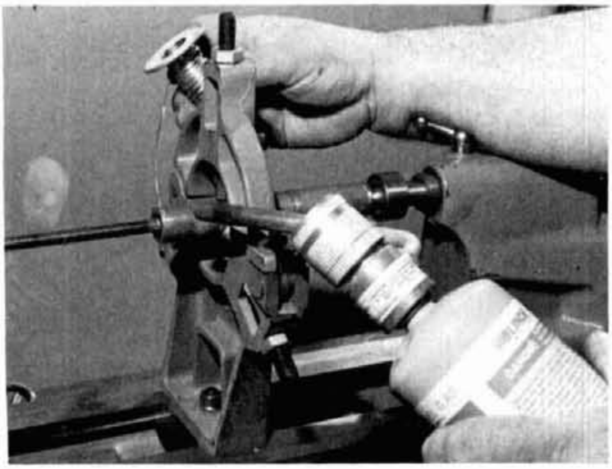

fig. 11. This is how the threaded brass plug is silver soldered to the brass tube and threaded rod while turning in the lathe. Note how the aluminum plug described in *fig. 5A* is used to support the other end of the brass tube in the tail stock live center rest.

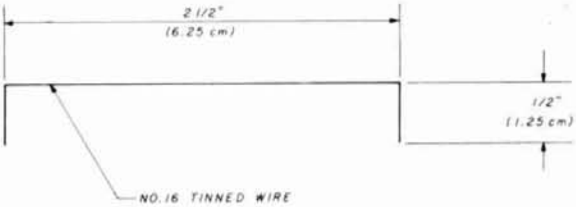

fig. 12. The dimensions and shape of the inductor, which spans the input and output coax chassis connectors inside three of the chassis boxes.

the brass top covers. Make sure the finger stock firmly contacts the 1-inch (2.5-cm) brass tube. (**See fig. 10.**)

coupling energy to the duplexer

Three cavities use short lengths of No. 16 wire while the other three use a small capacitor. The three cavities that have inductors made of No. 16 wire connected from the input to the output coax chassis connectors will go to the receiver and be tuned to provide a notch at the transmitter frequency.

Refer to **figs. 12** and **13**. Bend a length of No. 16 tinned wire to the dimensions and shape shown in **fig. 12**. Temporarily connect all three inductors between the input and output coax chassis connectors. *Do not solder these wires at this time because you will have to remove them for the first step in the tune-up procedure later.*

The other three cavities will each have a small variable capacitor (15 pF) connected between them. These three can then be put in the transmitter line and the notch tuned to the receiver frequency. The capacitors are connected to the input and output coax connectors with copper strips measuring 1/4 × 1 inch (0.625 × 2.5 cm). Refer to **fig. 14** and cut six pieces of copper flashing. Then connect them to the 15 pF

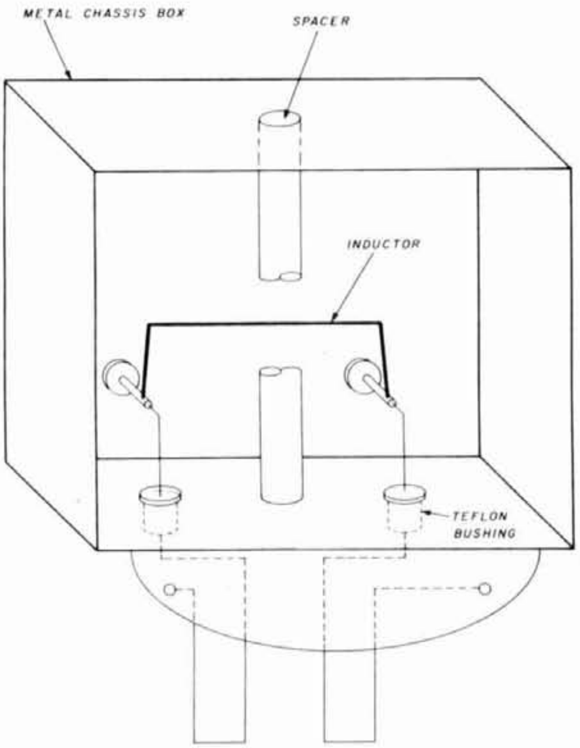

fig. 13. The inductor is connected in three of the cavities.

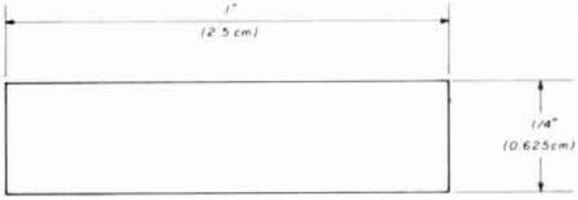

fig. 14. The dimensions of one of the two copper straps that attach to each 15 pF capacitor. Make *six* of these.

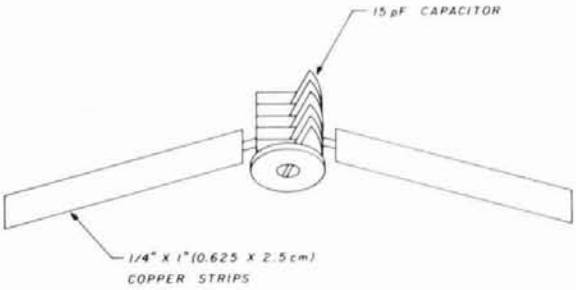

fig. 15. 15 pF capacitors are connected with two copper straps in each of three cavities.

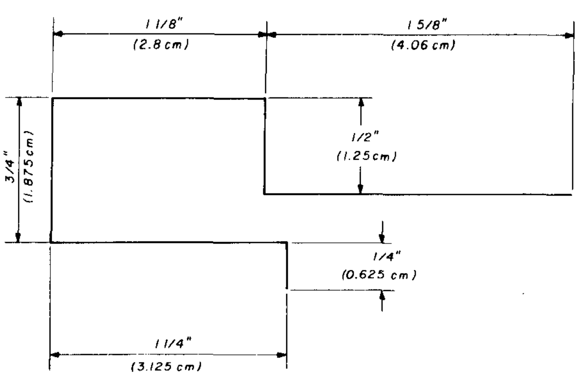

fig. 16. Two of these loops are usd to couple the signal into and out of each cavity. Make 12 out of No. 16 tinned wire. (These measurements are critical, as is the shape of the loops.)

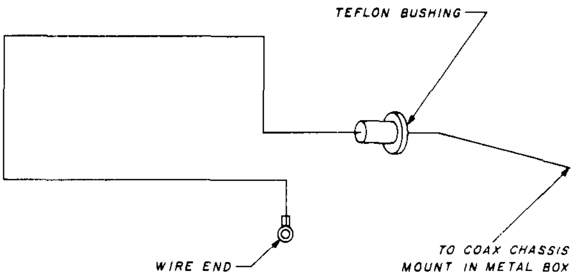

fig. 17. This diagram shows how the wire end is fastened to one end of the loop and how a teflon bushing fits on the wire.

capacitors as shown in **fig. 15** and **fig. 18**. Solder these three capacitors to the copper strips (see **figs. 15** and **18**), but do not solder to the input and output connectors yet.

The loops that couple the energy into each cavity are also made of No. 16 tinned wire. *Their shape and dimensions are critical*: use **figs. 16, 17, 18,** and **19** for the proper configuration and measurements. Connect these loops to each input and output connector and to the bottom side of the top plates. Do not solder the wires yet. Hold the copper strips in place and solder the wire coupling loops and simply tack solder the copper strips to the input and output connectors (**fig. 18**).

One end of these loops is tied to the underside of the top plates. I modified some small wire ends and tapped 4-40 holes. The 4-40 screws through the wire ends provide a mechanically secure and electrically good anchor to the underside of the top plates. (See **fig. 16, 17, 18,** and **19**.) The coax chassis mounts are located 5-5/8 inches (6.56 cm) apart, (or 1-5/16 inches, 3.28 cm, on each side of center) 7/8 inches (2.19 cm) up from the bottom of the mini-box.

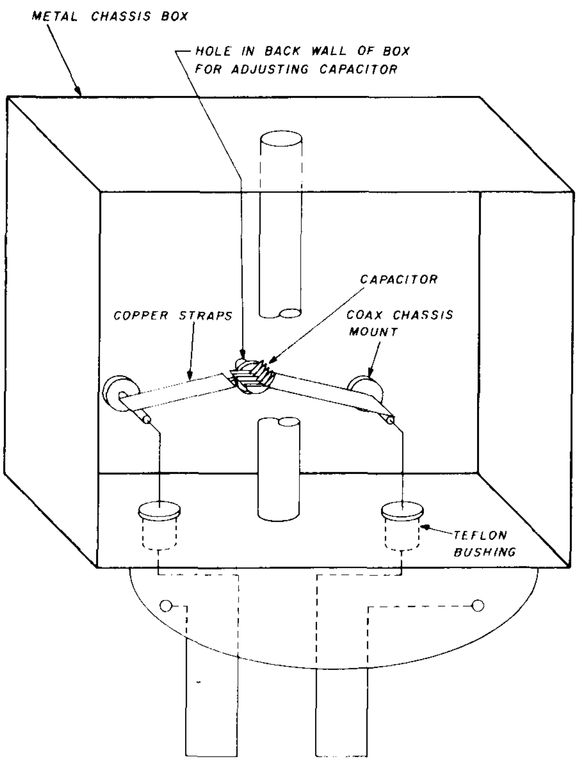

fig. 18. Location of capacitor, copper straps, and coax connectors. Note hole in back wall of box for tuning the capacitor.

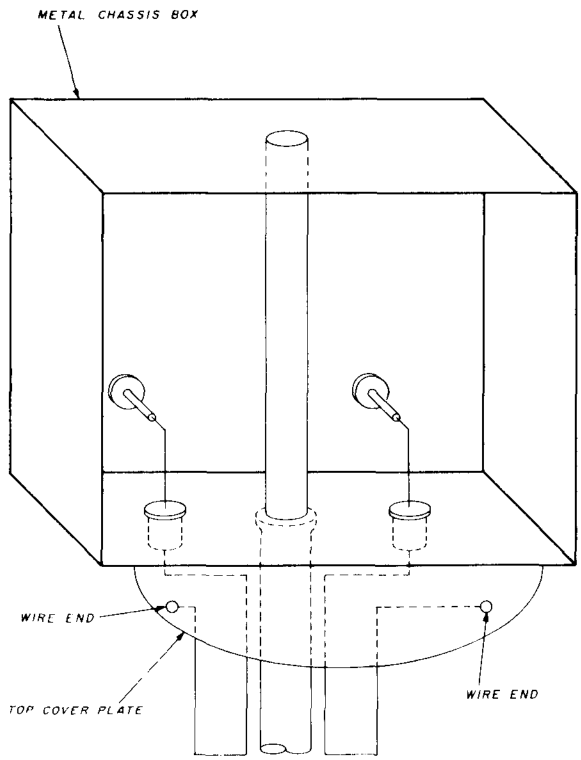

fig. 19. The loops fit on the top covers, pass through the teflon bushings and on to the coax chassis fittings.

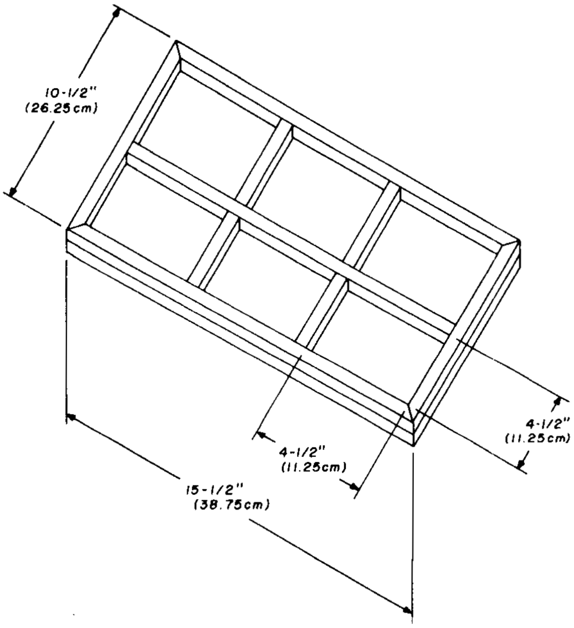

fig. 20. Wooden base holds all six cavities. The base covers fit into the square pockets.

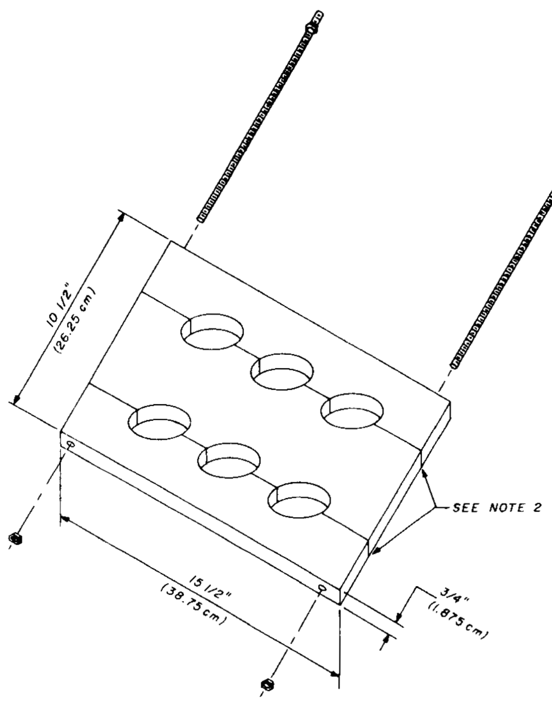

fig. 21. The details of the upper clamp.

building the wooden holder

After all six cavities have been built, mount them together in a holder and tune them to the desired frequencies. (Refer to **figs. 20, 21**, and **22** for construction of the wooden holder clamp assembly.)

The cavities should not be allowed to touch each other as this will tend to detune them. You can build a special holder to prevent them from contacting each other, by following these steps:

Cut a piece of plywood 1/2 inch (1.25 cm) or 3/4 inch (1.875 cm) 10-1/2 × 15-1/2 inches (26.25 × 38.75 cm). Cut 1/2 × 1/2 inch (1.25 × 1.25 cm) wood strips and screw and glue them to the plywood base so that six squares measuring 4-1/2 × 4-1/2 inches (11.25 × 11.25 cm) are formed. This is the base.

Cut a piece of 3/4 inch (1.875 cm) plywood to 10-1/2 × 15-1/2 inches (26.25 × 38.75 cm). Place six marks on one side of this plywood. The six marks should align with the exact center of the six square compartments in the base piece. Using these six marks as the centers of six circles, use a compass to draw 4-inch (10-cm) circles around each of these six points. (See **fig. 21.**)

Mark two straight lines through both groups of three circles. Saw along these lines. You will have three pieces of plywood, each with one-half of three 4-inch (10-cm) circles drawn on the pieces. Using a bandsaw, cut out the 4-inch (10-cm) circle halves. Then drill a hole through the ends of the three pieces of plywood to accommodate a 1/4-inch (0.625-cm) threaded rod. This becomes the upper support. (See **fig. 21.**)

Place a cavity in each base compartment and put at least two wood screws through the brass plate base and into the wood base. Place the upper support around the six cavities and tighten the nuts on the threaded rod.

alignment

We will align the cavities in two stages: stage one for rough tuning each of the six cavities, and stage two for fine tuning the cavities and connecting them all together.

Note that the 3/8-inch (0.94-cm) × 16 threaded rod is for **PASSBAND** tuning. The capacitor, in the case of the transmitting cavities, adjusts the **NOTCH**. (In the case of the receiving cavities, the inductor adjusts the notch.)

In these examples, 147.825 MHz will be used as the repeater transmit frequency and 147.225 MHz as

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Given a cost per unit budget for the CP-1, Al designed as much performance as possible into the Computer Patch, including a unique new tuning indicator, referred to by one of our customers as the "Dead Eye Dick" tuning indicator. This indicator is ideal for RTTY and CW, in that it is both fast to tune and (within 10 Hz) as accurate as scope tuning. It also performs under poor signal to noise conditions in which other indicators provide no useful data.

Al's variable shift tuning was designed to move the space filter center frequency from 2225 Hz to 3125 Hz without changing the bandwidth (by varying the Q of the filter). All this is accomplished using a precision ganged potentiometer to assure proper tracking of the multiple filter stages. We could have used a pot costing a tenth as much by simply using a two-pole filter design, but we feel the advantage of a sharper filter reduces the noise bandwidth significantly and allows the variable shift control to be used like passband tuning for extra elimination of adjacent channel interference.

Some manufacturers are concerned that amateurs might try calibrating their own equipment and, therefore, have used non-adjustable components, which results in sub-optimal performance. Although more costly, trimpots used in AEA equipment allow factory adjustment for performance to design specifications. Competently designed active filter circuits need not be adjusted after leaving the factory; however, for specialized use the owner can easily change filter parameters.

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Central Intelligence Agency

The CIA is an equal opportunity employer the repeater receive frequency. We will adjust the three transmit cavities to pass 146.825 MHz and notch the 147.225 MHz frequencies. The three receive cavities will be tuned to pass 147.225 MHz and notch 147.825 MHz.

stage one: rough tuning

Remove the inductors and capacitors from all cavities. Remove all interconnecting coax cables. (See **fig. 23.**) Connect an RF signal generator (amplitude-modulated for convenience) to one of the cavities (**fig. 26**). If your signal generator output is 50 ohms, you will *not* need to use a 3-dB pad. If the output is not 50 ohms or if it is suspect, then connect a 3-dB pad between the signal generator and the cavity. See **fig. 24** if you do not have a 3 dB pad.

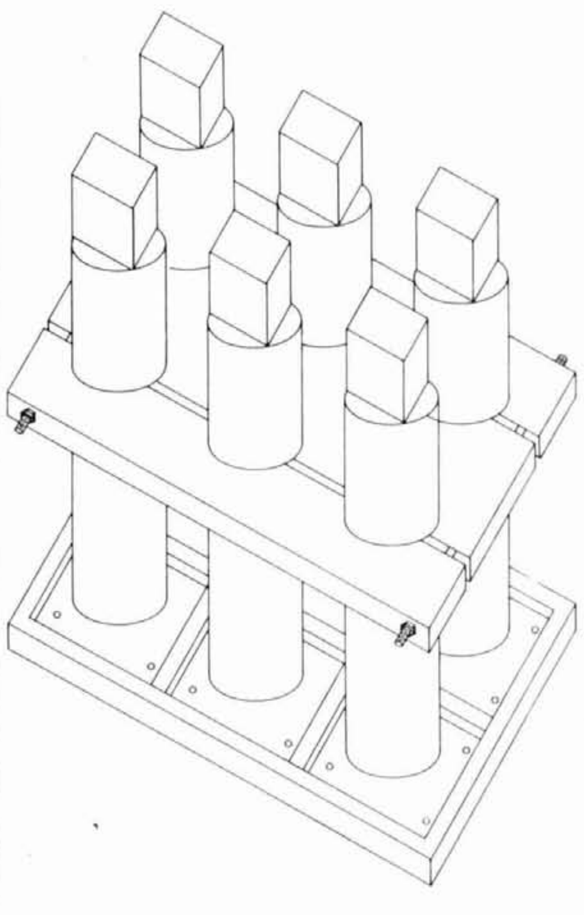


fig. 22. Overview of the wood cavity supporting device.

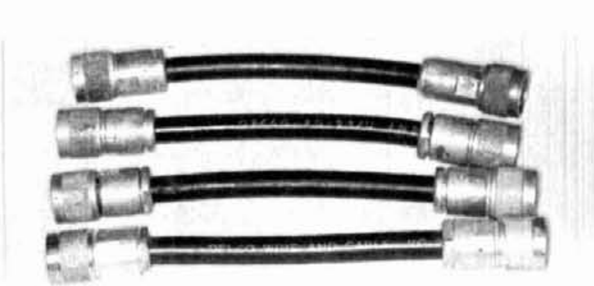


fig. 23. Four cables connect the two middle cavities to the outside ones. Made of double shielded coax, they measure exactly 7 inches (17.5 cm) from tip to tip.

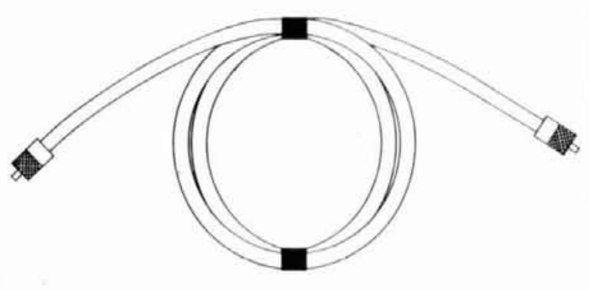


fig. 24. If you do not have access to a 3-dB pad, you can use this device which will be suitable for tuning the cavities. Use RG-58 coax and coil up a 50 to 75 foot (15 to 22.5 meters) length into a neat coil. Put connectors on each end. Tape the coil neatly.

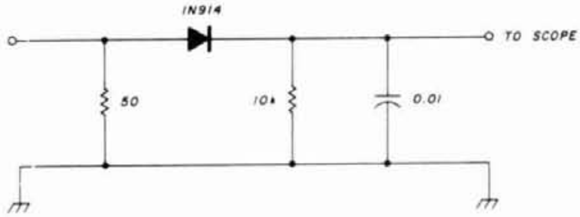


fig. 25. Schematic diagram of a 50-ohm detector suitable for use in this tuneup application. These components should be put in an RF-tight box or enclosure.

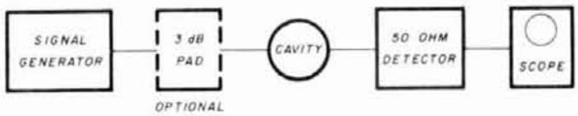


fig. 26. These are the connections for the initial tuning of the six cavities. If you don't have a 3-dB pad, see fig. 24.

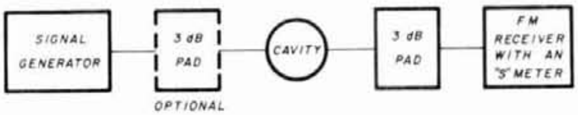


fig. 27. These are the connections to use when setting the notches in the three transmit cavities by adjusting the 15-pF capacitors, and the inductor when adjusting the three receive cavities.

Next connect a 50-ohm detector between the other cavity terminal and an oscilloscope. If you do not have a 50-ohm detector, you can construct one as shown in **fig. 25**.

For the three transmit cavities (the ones which will have the capacitors connected later), adjust the signal generator to within ±100 kHz of 147.825 MHz (**fig. 26**). Then adjust the center threaded rod (passband) until the scope shows maximum energy transfer. You will need to reduce the level of the signal generator as well as the scope gain as tuning progresses.

Adjust all three cavities. From this point on, *leave the threaded rods alone*. Connect the variable capacitors across the input and output connectors of all three transmit cavities.

Connect the signal generator through a 3-dB pad to one of the transmit cavities — now roughly adjusted — then through another 3-dB pad to an FM transceiver which has an "S" meter as shown in **fig. 27**. *(If you do not have a 3-dB pad, refer to* **fig. 24**.) Adjust the signal generator (CW mode) to exactly 147.225 MHz and an S6 reading on the receiver, which is also tuned to 147.225 MHz. Adjust the capacitor (which you just connected in the cavity) for the lowest S-meter reading possible. You may have to increase the output of the signal generator to maintain a visible S-meter indication. When you have obtained the lowest S-meter reading — i.e., the deepest notch — go on to the next cavity.

After all three transmit cavities have been adjusted,

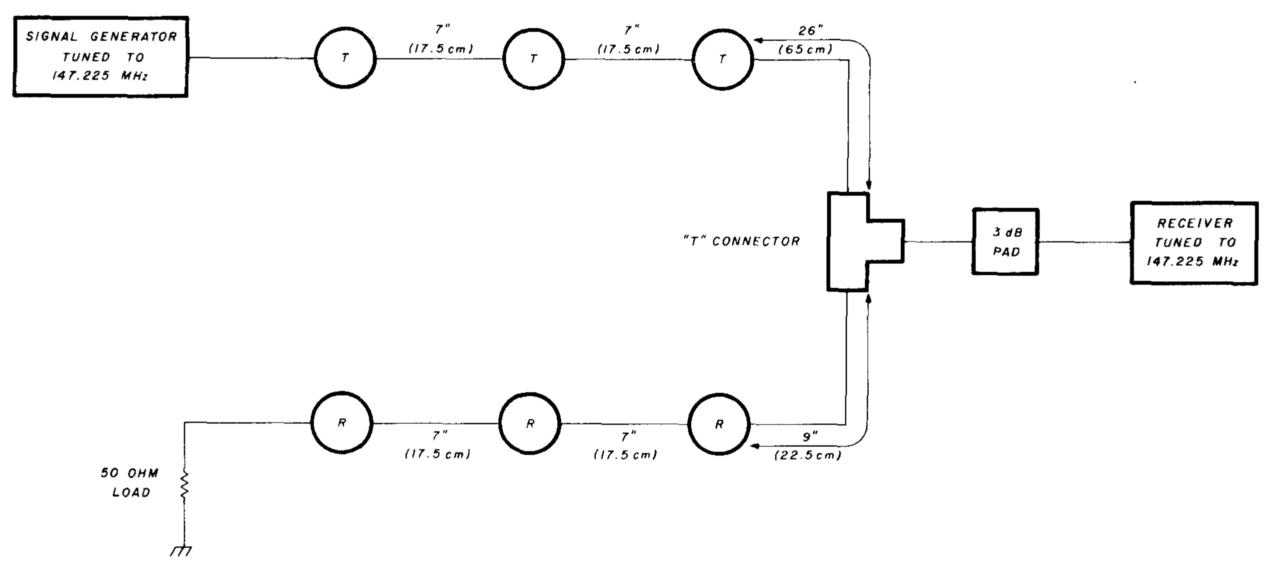


fig. 28. These connections are made for the final adjustment of the duplexer transmit cavities.

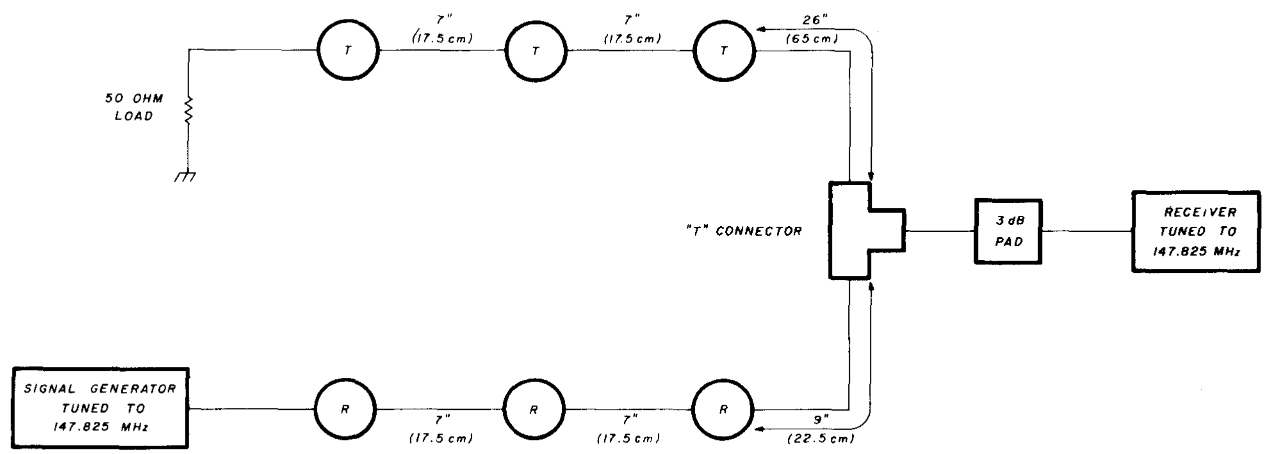


fig. 29. These connections are made for the final adjustments of the duplexer receive cavities.

go back to the beginning of this section and perform the same steps for the three *receive* cavities. Note that you will now be dealing with the inductors you made from the No. 16 tinned wire instead of the capacitors. Adjust the No. 16 wire inductors to deepen the notch. Remember that the frequency to be passed is now 147.225 MHz and the notch frequency is 147.825 MHz.

The inductor dimensions given should be all right, but if the notch is not good enough, try using larger or smaller wire, or even a copper strap if necessary.

stage two: fine tuning

Connect cavities according to **fig. 28**. Tweek the center-threaded rods on the *transmit* cavities only for minimum signal at the receiver (maximum notch). These adjustments interact somewhat. Keep increasing the signal generator output as the S-meter reading decreases. Reconnect according to **fig. 29**. Tweek the center threaded rods on the RECEIVE cavities only for minimum signal (maximum notch). Repeat these steps several times. You may be amazed (as I was) to see the notch get deeper and deeper with each repetition of these steps. You will also notice that bringing objects into the near vicinity tends to detune the cavities slightly as you approach the −100 dB point.

Lock the threaded rods by tightening a 3/8 inch (0.94 cm) × 16 nut against the mini-box as you finish the last adjustment on each cavity.

acknowledgements

Naturally when one becomes involved in a project of this magnitude, friends often prove helpful. In this regard, I would especially like to thank Ted Gisske, K9IMM, and Chuck Forster, WA9ACI, for their technical help over many months, and Mel Seamans, WB9PKH, for helping with coax when my budget was really strained. I would also like to thank Jim Osborn and Sherm Fusch for their photographic efforts and advice. Joe Androfski, K9OMF, provided constant encouragement, and hands-on help over many hours during the construction and tune-up phases.

I will try to answer readers' questions; please enclose an SASE with any correspondence.

obtaining the parts

Because some of the materials needed are rather unusual, they may not be available at your local hardware store. Others will have to be machined.

The two most unusual items are the pieces of 4-inch (10-cm) diameter **copper drain pipe** and the **brass plate**. The copper pipe can often be found at a large plumbing wholesale supply house, often buried under some other pipe. Try looking under "Brass" in the business section of any large city telephone book; you may find the names of outlets for brass plate listed there. If the ones you call don't stock it, ask for the names of other companies. I found my brass plate through just such a referral. I had to drive about 200 miles, but I got it from Howard Brass and Copper in Milwaukee. (Ask for "tag ends" — they're cheaper.)

Finger stock can be constructed, but the commercial material is much better. I got mine (Stock No. 134B) from Tech-Etch Inc., 45 Aldrin Road, Plymouth, Massachusetts 02360.

The best choice of **solder** for this project is silver solder with a low melting point — i.e., 400 degrees (204 degrees centigrade). Ordinary silver solder, with its higher melting point, is more difficult to work with, and regular hard solder will cause problems if you should decide to silver-plate your project later (see "Safe, Sensible Silverplating," page 29). Silver plate will adhere to silver solder, but is likely to flake off of hard solder. My 1/16-inch (0.16-cm) diameter silver solder (manufactured by the J.W. Harris Co., Inc., 10930 Deerfield Road, Cincinnati, Ohio 45242) came from a local rock shop. Do purchase **paste or liquid flux** to use with your silver solder.

The 3/8-inch (0.94-cm) × 16 threaded steel rod can be obtained at almost any large hardware store.

The **teflon** can be found in some hardware stores or plastic stores. I got mine from a friend in the paper business. When large piles of paper stock are cut, a guillotine type of cutter is used. The blade comes to rest against a square piece of telfon. From time to time the teflon is rotated to expose a new unused surface. After the four sides have been used, the strip is replaced with a new one. The used strip has plenty of stock left to make the feed-through bushings.

The **No. 16 tinned wire** is a standard item available at hardware stores and ham swapfests. The small copper strap can be made from a piece of **copper flashing**. Get a scrap from a roofer or builder. All 12 "N" type **chassis mounts and connectors** were purchased at flea markets or swapfests. **RG-192 coax** can be found at dealers or hamfests, as can **Tee connectors**.

ham radio

✓ 104

safe, sensible silverplating

Stake your claim
to recycled silver
lost in photoprocessing

Have you ever completed a ham radio project and wished to improve its appearance or performance with silverplating? When I finished the duplexer described in the previous article, I wanted to silverplate it. But my previous experiences with electroplating were not encouraging. I knew I'd have to work with silver cyanide, a highly poisonous solution that emits cyanide gas, which can cause illness and even death. I would also have to obtain an expensive silver rod to use as an anode.

To devise a safe, economical alternative, I turned to black-and-white photography, which employs vast amounts of silver in the manufacture of film and printing papers. Even though much of the silver freed in processing is more often discarded with the spent solutions than recycled, it can be reclaimed. I reasoned that if it were possible to recover the silver from spent solutions, namely fixer, or "hypo" — then it should also be possible to capture that silver on a copper tube.

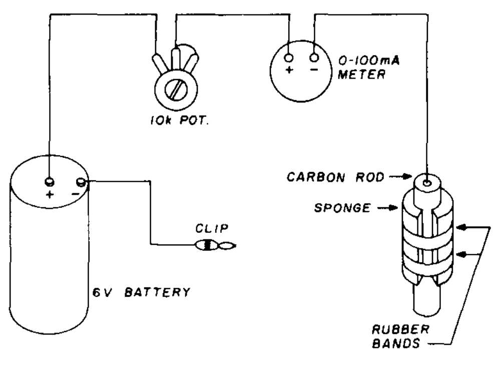


fig. 1. Basic connections for silverplating with photographic fixer.

getting started

The first step in silverplating with reclaimed silver is obtaining an ample supply of exhausted fixer. Sources include photography labs or stores, graphic arts firms that make blueprints or photographic enlargements and reductions, printers with graphic arts departments, and the photography departments of schools and colleges. Friends who process their own film and print their own black-and-white pictures are also good sources.

The best fixer (for your purposes) is that which has been well used; used fixer carries a greater amount of silver than fixer used only slightly. Consequently, *your best source of spent fixer may be the least fastidious photographer.*

Once you've acquired your solution, obtain a simple dry cell. (I used a 7-year old 6-volt lantern battery.) You'll also need a 10k potentiometer, a 100 mA movement meter, and a carbon rod. (My carbon rod, salvaged from a discarded No. 6 dry cell, measured about 0.75 inches — 20 mm — by about 5 inches — 137.5 mm.)

Wrap the carbon rod in an ordinary kitchen sponge. Secure the sponge with rubber bands. You are now ready to silverplate.

silverplating your project

1. Connect the battery, potentiometer, carbon rod, and meter as shown in **fig. 1**.

2. Carefully clean the items to be plated. You will probably want to use fine steel wool and trisodium phosphate. Both of these materials are available in the paint

By J.S. Gurske, K9EYY, RR2, Box 178A, Lodi, Wisconsin 53555

section of large hardware stores or in a paint store.

Once the item is clean, *do not touch it with your fingers*. The oils on your skin can contaminate the surface, ruining an otherwise effective cleaning job.

3. Connect the minus clip to the item to be plated and the plus clip to the sponge-wrapped carbon rod. (See **fig. 2.**)

4. Pour some fixer into a glass or plastic bowl. *Do not use a metal container.*

5. Dip the sponge-wrapped carbon rod into the bowl *of used fixer and rub the sponge-covered rod along* the surface of the item to be plated as shown in **fig. 3**. At the same time adjust the pot for a reading of from 50 to 100 mA. (50 mA *is a good choice.*) As *you* rub the sponge-covered rod along the surface of the item to be plated, you will see the silver begin to collect on the item you are plating.

6. With a little practice, you'll soon be able to evaluate the uniformity and thickness of the silver plate. When you are satisfied, go on to the next piece to be plated.

7. Should you want to plate a large, long tube, simply put the sponge on a long stick and slide it inside the tube. (This is simpler and safer than filling the tube with cyanide solution and then inserting a long silver anode into the tube [**fig. 4**]).

At this point I want to caution you about "flash" plating, which can occur if you don't actively guard against it. "Flash" plating occurs when metals that are

fig. 3. Silver plating the tuning rod of a cavity.

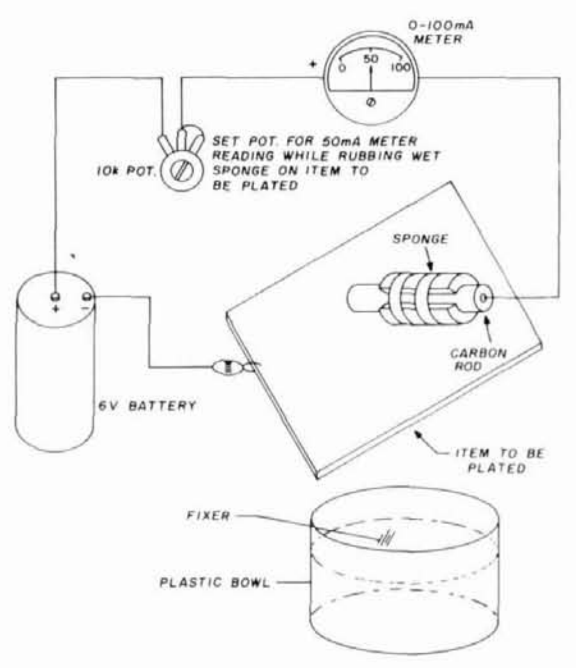


fig. 2. Silver plating with photographic fixer. Note basic connections and how the fixer-soaked, sponge-covered carbon rod is rubbed along the surface of the item to be plated.

fig. 4. Silver plating the inside of the main tubing of a cavity.

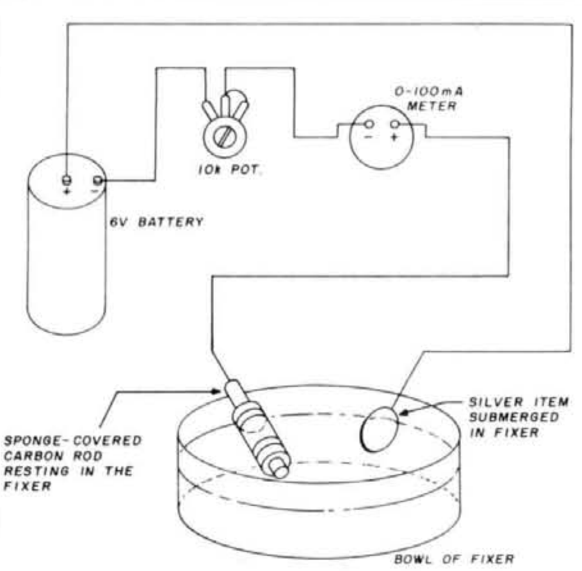


fig. 5. Rejuvenating the depleted fixer: set the potentiometer for a meter reading of approximately 75 mA and wait for about 15 minutes.

high on the activity scale (silver and copper, or silver and brass, for example) come in contact with each other *in the absence of a flow of current*. "Flash" plating looks good but is not permanent. You can prevent it by making sure that the battery is connected every time the item to be plated comes in contact with the fixer-soaked sponge. This is the purpose of connecting the battery (as shown in **step 3** above) *before* you poured the fixer into the bowl.

If your fixer begins to weaken before you've completed the job, but you don't have any more fixer on hand, try this method of rejuvenating the solution. Find an unwanted silver item such as an old vase or piece of discarded flatware. (I used an old silver coin which had been in a fire and was all bent out of shape.) Connect the unwanted silver item to be plated and *reverse* the battery connections. (The meter will read backward unless you reverse its lead. See **fig. 5.**) Place both the silver item and the carbon rod in the fixer solution. Then adjust the potentiometer for a 75 mA reading on the meter. The silver will turn black. After about 10 or 15 minutes, you can resume silverplating for a while longer but *don't forget to reverse the battery and mA meter leads*. I don't know how long or how many times you can go through this rejuvenation cycle. I did it about six times and it seemed to work fine.

I'm sure you'll obtain good results if you follow these suggestions. My cavities looked 100 percent better after they were plated and I know they work better, too. So, go ahead and silverplate your next *ham radio* project.

ham radio

the
weekender

programmable call sign identifier

This programmable identifier — originally conceived by Don Henry, W3FE — can be used in a number of applications including home station or repeater ID and remote link identification. When Don suggested that a 64-bit shift register could be used to store a call sign, I proceeded to develop a circuit that would accomplish this task, be easy to program, and contain few IC's.

construction

The circuit contains four CMOS IC chips (**fig. 1**). CMOS technology is well suited to this application because of its extremely low quiescent current requirements, thus making an on/off switch unnecessary. Because the circuit is powered all the time, backup power for the programmed data is unnecessary.

Circuit layout is not critical; whatever is convenient should work. I used a 4-1/2 inch (11.5 cm) by 4-1/2 inch (11.5 cm) piece of Vector Board with 0.1 inch (2.5 mm) hole spacing for holding the components. The resistors and capacitors associated with U4 (4093) should be kept as physically close to the IC as possible. I recommend sockets for holding the ICs. Wire wrappng works well; point-to-point wiring could also be used to make the connections. The power supply requirements are simple; a single 9 volt alkaline Duracell (or equivalent) battery will do.

programming

The programmable identifier has two modes of operation controlled by the DPDT switch. One mode is *Recirculate* or playback and the other is *Program*. The programming sequence is as follows:

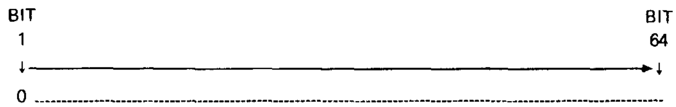
- Set the DPDT mode switch to the Program position.
- Push the reset switch.

By Donald G. Varner, WB3CEH, 214 Bryant Street, Vandergrift, Pennsylvania 15690

table 1. Programming data chart.

character	bit pattern	number of bits
A	1 0 1 1 1	5
B	1 1 1 0 1 0 1 0 1	9
C	1 1 1 0 1 0 1 1 1 0 1	11
D	1 1 1 0 1 0 1	7
E	1	1
F	1 0 1 0 1 1 1 0 1	9
G	1 1 1 0 1 1 1 0 1	9
H	1 0 1 0 1 0 1	7
I	1 0 1	3
J	1 0 1 1 1 0 1 1 1 0 1 1 1	13
K	1 1 1 0 1 0 1 1 1	9
L	1 0 1 1 1 0 1 0 1	9
M	1 1 1 0 1 1 1	7
N	1 1 1 0 1	5
O	1 1 1 0 1 1 1 0 1 1 1	11
P	1 0 1 1 1 0 1 1 1 0 1	11
Q	1 1 1 0 1 1 1 0 1 0 1 1 1	13
R	1 0 1 1 1 0 1	7
S	1 0 1 0 1	5
T	1 1 1	3
U	1 0 1 0 1 1 1	7
V	1 0 1 0 1 0 1 1 1	9
W	1 0 1 1 1 0 1 1 1	9
X	1 1 1 0 1 0 1 0 1 1 1	11
Y	1 1 1 0 1 0 1 1 1 0 1 1 1	13
Z	1 1 1 0 1 1 1 0 1 0 1	11
0	1 1 1 0 1 1 1 0 1 1 1 0 1 1 1 0 1 1 1	19
1	1 0 1 1 1 0 1 1 1 0 1 1 1 0 1 1 1	17
2	1 0 1 0 1 1 1 0 1 1 1 0 1 1 1	15
3	1 0 1 0 1 0 1 1 1 0 1 1 1	13
4	1 0 1 0 1 0 1 0 1 1 1	11
5	1 0 1 0 1 0 1 0 1	9
6	1 1 1 0 1 0 1 0 1 0 1	11
7	1 1 1 0 1 1 1 0 1 0 1 0 1	13
8	1 1 1 0 1 1 1 0 1 1 1 0 1 0 1	15
9	1 1 1 0 1 1 1 0 1 1 1 0 1 1 1 0 1	17

Note: The first bit is always a 0. Insert 0 0 0 (3 bits) between characters.



- Set the programming data select switch to the "0" position.
- Push the programming clock switch once — Bit 1 is not programmed (note: Bit 1 must always be a "0".)
- Set the programming data select switch to the appropriate "0" or "1" position.
- Push the programming clock switch once.
- Repeat previous two steps until all 64 bit positions are programmed.

After the 64th bit is programmed, set the mode switch to the Recirculate (or playback) position. Push the start ID switch and the programmed data will be played back.

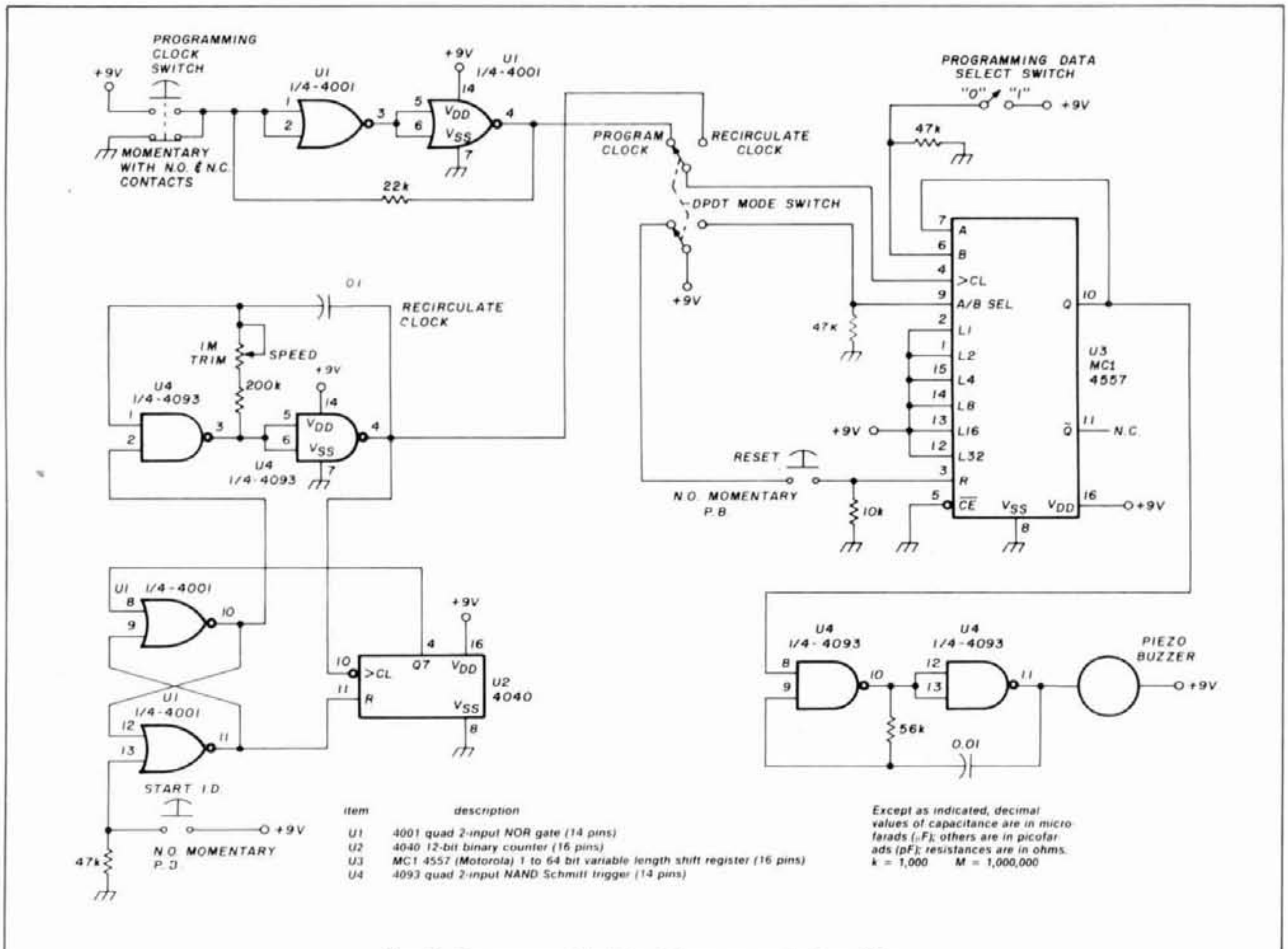


fig. 1. Programmable identifier uses only four ICs.

To program your call, follow the Programming Data Charts (**table 1**) to get the correct data bit sequence for each letter and number. Be sure to program 0 0 0 (3 bits) between each character to allow spacing between them.,Keep count of the number of bits programmed. If your call does not require all 64 bits, insert zeros for the remaining bits up to and including the 64th bit.

If you want to use the programmable IDer with other equipment, a few points need to be mentioned. To start the IDer a positive-going pulse ⎍ on U1 pin 13 of the 4001 will accomplish this. The Morse output can be taken from the Q output of U3 pin 10, the MC1 4557. The 1 megohm trimpot is used to adjust the recirculate (playback) speed.

ham radio

VHF/UHF WORLD

Joe Reisert W1JR

high power amplifiers: part 2

In last month's column, I discussed the design of high power VHF/UHF tube amplifiers with emphasis on the effects of the new FCC Amateur power regulations.[1] This month's column will continue in the same vein, but focus instead on the construction and practical application of VHF/UHF amplifier designs.

DC circuitry

In designing and building high power VHF/UHF power amplifiers, most Amateurs concentrate their efforts only on the RF portion of the design. This is unfortunate because power supply voltages and currents — as well as DC circuitry — are often just as important for successful amplifier RF performance.

Sometimes Amateurs will pay hundreds of dollars for a high power transmitting tube and then neglect to review the manufacturer's specification sheet before firing up the new bottle in the amplifier. Instead, they'll ask "Joe Blow" what voltages he uses on the same tube and follow his advice. Ironically, these Amateurs wouldn't purchase used gear if the instruction manual weren't part of the deal.

Suppliers of high power tubes — such as Amperex, Varian/EIMAC, General Electric, and RCA — all provide comprehensive data sheets with their products. Usually 4 to 12 pages long, these data sheets list mechanical dimensions and RF/DC characteristics. They also specify recommended bias and operating parameters so that the user can obtain the maximum performance and lifetime possible from the tube. Some manufacturers also offer, at a nominal price, abbreviated specification books listing many different tube types.[2,3] The ARRL *Handbook* also includes tube tables.[4]

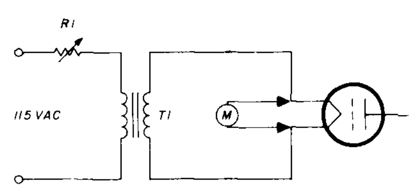


fig. 1. Recommended filament voltage circuit for high power transmitters. The voltage at the tube pins is set by placing an adjustable wirewound resistor, R1, in series with the primary winding. If the dropping resistor is not used, the transformer, T1, must have a current limit close to that required by the tube. Note that the voltmeter, M, is connected directly to the tube socket pins. See text for other precautions and recommendations.

Some of the more significant low-frequency or DC parameters for high power tubes are the maximum, minimum and recommended operating voltages and currents, warm-up time, and grid (and screen grid if a tetrode is used) supply impedance and plate dissipation.

filaments

Filament voltage in the newer tubes is, unlike the old receiving type tubes, far from standard. Because of the high power involved, the filament current required is often quite high. As a result, tubes may have a significantly shorter lifetime if the filament voltage is not kept within the manufacturer's recommended ±5 percent values.

Let's take a few examples. The popular 4CX250B has a filament rating of 6.0 ±0.3 (±5 percent) volts at 2.6 amperes. *Filament voltage must be measured at the tube socket pins with an accurate (within 1 to 2 percent) AC voltmeter with the tube inserted and drawing filament current!* 6.3 volts AC is a common transformer (voltage) used on receiving tubes. Such transformers are often used on transmitting tubes (for example the 4CX250B), but they usually have some means of lowering the voltage. This is most commonly done with an adjustable wire-wound resistor placed in series with the primary of the filament transformer.

Now, let's examine the higher power 8877, which requires a filament voltage of 5.0 ±0.25 volts (±5 percent) at nominally 10 amperes. Since 5.0 volt transformers are quite common, they are usually used *but rarely with any series resistor in the primary since it looks like one isn't needed!*

When a high power tube is first turned on, the filament resistance is always quite low. Initially, a high input current surge occurs; this can significantly shorten tube life. In the case of the 4CX250B, the resistor (which is typically used in the transformer primary) will serve to limit the turn-on current surge. However, in the case of the 8877, if no such primary resistor is used, the surge current will increase in a manner limited only by the resistance of the transformer secondary winding. Furthermore, no adjustments (in primary resistance) would be possible if the line voltage were already lower than nominal.

Therefore, when selecting a filament transformer it's best to use one that is slightly higher in voltage than required so that an adjustable power resistor can be placed in series with the primary winding (**fig. 1**). Another alternative is to place a Variac™ on the primary side of the filament transformer and then increase the voltage slowly on each initial turn-on while monitoring the voltage directly at the tube socket. Many commercial trans-

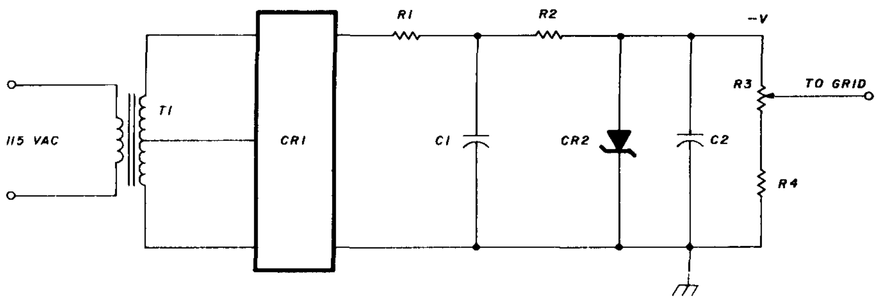


fig. 2. Recommended control grid supply for high-power amplifiers. T1 is chosen to supply the required voltage. CR1 may be a full wave or bridge rectifier. R1, C1, and C2 are filter components. CR2 is a zener diode or VR tube whose current is set by R2. R3 is a 1000-ohm wirewound potentiometer. R4 can be eliminated if the regulated voltage is low (less than 50 volts) or 500-1000 ohms if the voltage is greater than 50 volts. See text for further description.

mitters have a built-in filament voltage regulators to compensate for power line variations.

If you do not use a primary limiting resistor, be certain to always use a filament transformer with a current capability close to but not much higher than the filament current rating of the transmitting tube, selected to enhance current limiting. This may explain why some Amateurs when using filament transformers with higher current ratings than required, have experienced premature filament burnout of high-power transmitting tubes.

Each tube has a minimum warm-up time before any cathode current should be drawn. This can vary from as short as 30 seconds to as much as five minutes for the indirectly heated high-power transmitting tubes! Some manufacturers specify a lower standby filament voltage (for example, − 10 percent) that can be instantly brought up to specification during transmit times, thereby extending tube life. This can be easily accomplished with an inexpensive relay activated by the station send/receive control line. More information on such operation can be found on the manufacturer's comprehensive data sheets, so consult them before you begin operation. Use of a time delay relay is also recommended in the high voltage supply.

Another VHF/UHF phenomenon, especially in grounded grid amplifiers or those where the cathode is hot, is RF on the filament of the tube. This can cause RF current to flow between the cathode and the filament, resulting in increased input drive requirements, additional filament heating, and possibly reduced tube life. To prevent this, the filaments should be bypassed to the cathode and connected to the filament transformer through a bifilar choke.

At VHF and especially UHF, a problem called transit time heating often occurs because of the finite time required for the electrons to move from the cathode through the grid to the plate, where some electrons may be repelled. This problem can usually be controlled by decreasing filament voltage at higher operating frequencies. Recommended filament voltages at various frequencies are provided on the manufacturer's data sheets. Additional information on this subject is contained in reference 5.

grid bias

In the past, triodes were usually biased by grounding the cathode and applying a negative bias voltage to the grid. The new high-μ triodes are usually easier to bias. Often the grid is directly grounded and a large high-power zener diode, rated at the required bias voltage, is placed in series with the cathode circuit. However, many VHF/UHFers use only simple grid supplies often consisting of just a rectifier diode and filter capacitor on a reverse connected filament transformer. The problem with this approach is that if there is any grid current, the grid voltage will fluctuate directly as a function of the impedance of the bias supply.

Good design practice requires the grid supply to be regulated. In addition, the voltage should be adjustable and have a maximum DC output impedance between 1 and 2 kilohms! This can be done with either a shunt type transistor (or tube) regulator or a wirewound potentiometer directly across the output of a regulated grid supply, as shown in **fig. 2**. The main advantages of a low impedance grid bias supply are decreased grid drive and improved IMD.

screen supply

The majority of tetrode amplifier configurations require a screen voltage supply. Over the years I've seen dozens of complex schemes with separate regulated supplies, current protection relays, and surge voltage protectors. Most of these techniques are unnecessary. Screen grid burnout can occur if the screen voltage is not decreased rapidly when plate voltage is removed. Furthermore, negative screen current can occur in a properly operated tetrode amplifier. I believe that the most foolproof screen supply voltage circuit is a shunt regulator consisting of a dropping resistor and appropriate voltage regulators shunted to ground and supplied from the tube's plate supply voltage. Furthermore, I highly recommend the use of VR (voltage regulator) tubes rather than power zeners. VR tubes are low in cost (especially at flea markets), easy to use, offer long life and don't require heatsinking and insulated washers such as required by power zeners. VR tubes are less likely to be damaged by current surges from arcs caused by "barnacling" (more on this shortly).

The reverse screen grid current problem on tetrodes is often ignored by Amateurs. It is specifically noted on the manufacturer's data sheets and can be easily handled by placing a properly selected resistor from the screen grid to ground. In most cases 20-25 kilohms (per tube) is optimum. Don't forget to include this current when selecting the dropping resistor value in the regulator circuit just recommended. The final recommended circuit is shown in **fig. 3**. The circuit is simple and should be all that is required to properly supply voltage to the screen grid in a high power amplifier. In addition, if the series dropping resistor value is properly selected, the tube's screen dissipation can be limited to the specified value.

plate supply voltage

Finally, we must supply the tube plate(s) from a high voltage supply. (This is always the user's choice.) First a transformer must be selected. When running over 500 watts, I highly recommend use of 230 volt primaries since there will be improved regulation without blinking the house lights off and on!

The choice of the rectifier circuitry, either a full wave, full wave bridge, or full wave voltage doubler (all these are acceptable), is a personal choice based on the transformer chosen and its voltage ratings. A common practice is to use a set of high voltage solid-state rectifiers, often feeding just a bank of high voltage capacitors. One should carefully choose the amount of capacitance required before completing the design or use the alternative choke input filter.[6]

Regardless of the configuration chosen, there are several other considerations. The primary of the high-voltage transformer should be adequately fused. An adequate bleeder should be placed across the high voltage output to not only discharge the supply when turned off but to also improve regulation. This is especially important with a choke input filter. Recently there has been a tendency to place a high power, high value resistor in the cathode of transmitting tubes when in the standby mode. *I do not recommend this practice but instead prefer to entirely disconnect the high voltage from the final when not in the transmit mode.* This not only prevents inadvertent shocks but also eliminates any noise or self oscillations that may be possibly generated by the final or feedthrough from the earlier stages. This is easily accomplished by using a vacuum relay in the high voltage output lines as shown in **fig. 4**. These relays are often available at flea markets or surplus stores at reasonable cost.

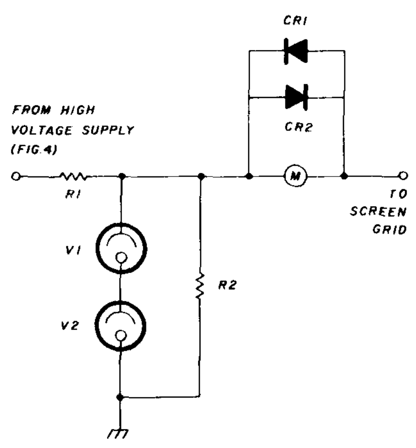


fig. 3. Recommended screen grid supply. The quantity and voltage of the VR tubes, V1 etc. is determined by the tube specifications. R1 should be a high power (200 watts typical) wirewound resistor whose value is selected to provide adequate current to the VR tubes (30 mA typical) as well as R2. R2 should be typically 20-25,000 ohms per tube (see text). CR1 and CR2 are meter protection diodes.

Sometimes there is an advantage to connecting the screen grid directly to ground to stabilize high power UHF amplifiers. This technique requires a slightly different power supply topology as shown in **fig. 5**. If this configuration is chosen, the screen supply *must also be able to handle the full current required by the plate.* However, the total voltage required from the plate high: voltage supply is reduced since it is in series with the screen supply.

Sometimes a small impurity becomes lodged between the grid or screen grid and plate of a high-power tube, causing a short circuit. This phenomenon is called "barnacling." A limiting resistor should be placed in the high-voltage line so that the peak current does not exceed 50 to 100 amperes and destroy the tube. This is accomplished by placing a 25 to 50-ohm resistor in the plate voltage line. The power rating of the resistor is determined by the plate current of the tube in use. If a barnacling condition occurs, this series resistor will limit the plate current and possibly disintegrate, but the tube will survive and will usually return to normal operation after the initial surge. Remember, if a shunt regulator is used on the screen, put this limiting resistor on the supply side as shown in **fig. 4**. In this way, if the resistor blows open, the screen voltage will also be removed.

A high-voltage in-line fuse should also be used. Low-voltage glass or ceramic fuses are not recommended because they are slow acting, can explode, and can arc, possibly causing damage to meters! A short length of a small gauge wire (No. 40 preferred) can be used as a fast acting, low cost high voltage fuse.[7]

amplifier bypassing

It is sound engineering practice to use an extra pair of coaxial relays so that high power amplifiers may be bypassed when not in operation or when the final is warming up (**fig. 6**). The input relay can be a low power type but the output relay must be capable of handling the full output power of the transmitter.

Amplifier bypass relays should never be (hot) switched when RF power is present since this will severely limit relay contact lifetime not to mention generation of spurious pulse noise. Isolation of each bypass relay doesn't have to be as high as with a typical T/R relay, with 30 dB per relay more than adequate. *Furthermore, particularly in grounded grid amplifiers, RF should never be applied to the amplifier input unless the proper voltages are already applied.*

plate dissipation

This parameter is often overlooked. The plate dissipation is approximately

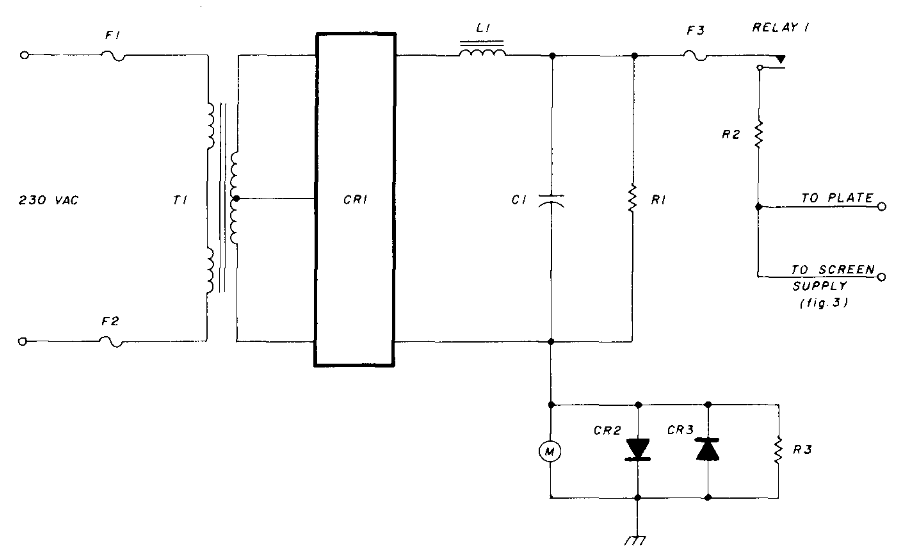


fig. 4. Recommended high voltage supply for a high power amplifier. F1 and F2 are line fuses. F3 is a fine wire described in text. C1, CR1, L1, R1, and T1 are described in text. CR2 and CR3 are meter protection diodes. R2 is described in the text (25-50 ohms typical). R3 is a meter protection resistor (50 ohms 10 watts typical). RL1 is a vacuum relay described in text.

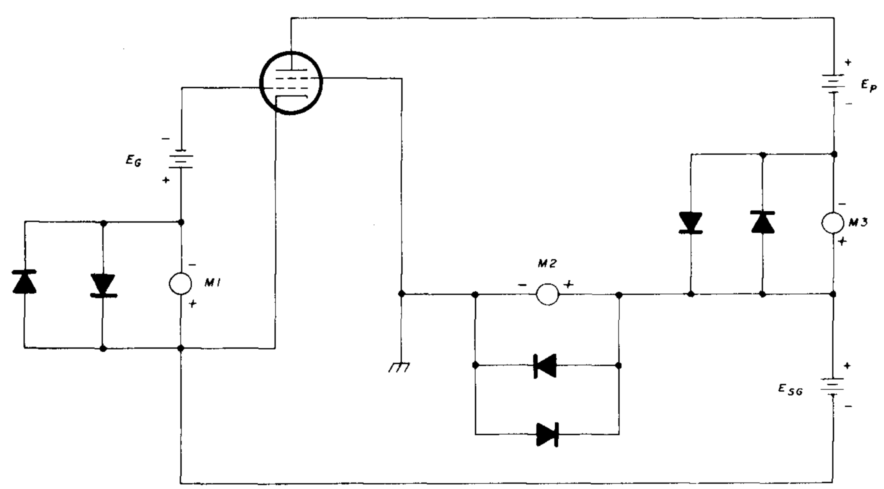


fig. 5. Power supply configuration used with DC grounded screen grids. Power supplies are represented as batteries. M1 is grid current, M2 is screen current, and M3 is plate current. The meters are protected by back-to-back diodes.

the plate power input less the power output of the amplifier (other circuit losses being low). For example, if the plate input power is 2500 watts and the amplifier output is 1500 watts, the plate dissipation is approximately 1000 watts. The plate dissipation ratings of many of the more common tubes is shown in **table 1** of reference 1. (The subject is further discussed in the "cooling" section of this article.)

cooling considerations

Amateurs are notorious for abusing high power transmitting tubes. One of the most misunderstood transmitting tube parameters is the plate dissipation rating. *The manufacturer's specification applies only if there is adequate cooling, by either air or water, to the tube.*

Herein lies a problem. Each air-cooled tube has a different cooling specification, clearly spelled out on the manufacturer's data sheet, based on the *amount of air circulation (in cubic feet per minute) through the plate fins or around internal anode tubes as well as a specified back pressure (usually measured in inches of water).* Therefore an exchange of tubes based primarily on a higher plate dissipation rating, may often require a greater air flow rate — for example, as in the case of swapping the 4CX250B and 8930 in the K2RIW 70-cm amplifier.[8]

External anode tubes are best cooled using air system sockets so that air is circulated over the grid and cathode seals as well as through the plate fins. Since these tubes generally have a high resistance to air flow, especially when compared to internal anode tubes, chimneys are a must to force the air through, rather than around, the plate fins. A large blower, preferably one operating at 3600 RPM, is usually required to keep plate dissipation within the tube ratings and overcome the high back pressure developed by the tube. (Don't forget to occasionally remove external anode tubes from service and clean out any accumulated dirt or dust that becomes lodged in the heat sink fins.)

Gary Madison, WA2NKL, has developed an approximate formula to compare the back pressure of different blowers as shown in **eq. 1**:

$$P_B = 8 \times 10^{-9} d_W^2 V_W^2 \quad (1)$$

where P_B is the blocked-off back pressure in inches of water
d_W is the wheel diameter in inches
V_W is the speed of the blower in revolutions per minute

For example, a 2-inch wheel diameter 3600 RPM blower will have a back pressure of approximately 0.415 inches of water while an 1800 RPM blower of the same size would develop only 0.104 inches in water. This formula *dramatically illustrates how a small increase in wheel diameter or speed will increase the back pressure.*

A recent trend is to use water cooling on the plates of transmitting tubes, especially at UHF. For over 10 years I have been using such a technique on a 4CW800B type water-cooled tetrode. My 2-gallon water supply is housed in a small waste paper container; the pumping pressure is provided by a fish tank pump. Although distilled water is preferred, I find that water collected from a de-humidifier is adequate. Each summer I store the required 10-12 gallons needed for a year of operation. Replacement water-cooled plate radiators are now commercially available for the 2C39/7289 family of tubes.

This technique is very good, but not without its limitations. Often the tube's grid and cathode seals are overloaded. *They also require cooling.* In grounded grid configurations the grid, if attached directly to the chassis, may be sufficiently cooled by conduction, but the cathode is usually overlooked. Therefore, if the plate is water cooled, a reasonable amount of air should also be circulated through the cathode/grid compartment.

Often when the proper amount of air is used, there may be an objectionable blower noise in the shack. Some Amateurs have attempted to lower the noise by locating the blower elsewhere and directing the air through a hose. This method requires special attention, since the hose chosen will have resistance, which will decrease air flow. Therefore, if a blower is remotely located, its output may have to be raised accordingly.

There are two main problems of insufficient air flow. The first one is obvious: tube life is shortened. The other may also be obvious but is seldom mentioned: if plate dissipation is too high, the extra heat is often dissipated in the tank circuit, especially when metal tubing type plate lines are used. The net result is that the tank circuit tuning drifts especially during long transmissions such as on EME.

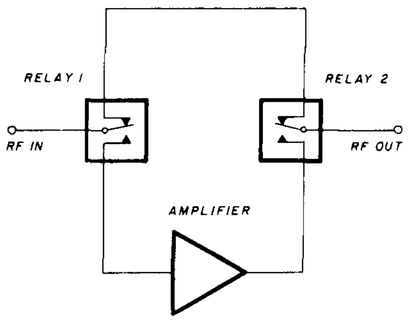


fig. 6. Relay bypassing scheme for protecting a high-power amplifier during warmup. See text for relay description.

Always try to provide a good safety margin (2:1 is recommended) of cooling, whether with air or water. Also verify that there is sufficient pressure differential across the tube, especially for external anode tubes. Also, in the case of air or water supply failure, provide a blower or water flow cutoff switch in the power supply (more on this later). A convenient method of measuring flow and back pressure is described in reference 9.

construction techniques

Many good construction tips are buried in the various articles on high power finals and some of these references will be cited later in this article. Do read as many of the references as possible.

One of the most important design considerations centers on the circuit chosen.[1] The next consideration is the choice of tube type. Choosing a larger tube than required may be wise because the actual plate dissipation will be a smaller percentage of the tubes ratings. However, all is for naught if the mechanical integrity of the amplifier is not given proper attention. All components and mechanical parts should be sturdy and properly secured to the chassis because any changes in temperature or duty cycle will cause detuning affects. Also, the components used in a high performance transmitting amplifier should be first quality. If not, there may be unnecessary down-time, as well as the possibility of destruction to the other components in the amplifier such as the tube! It is not a good practice to *economize here.*

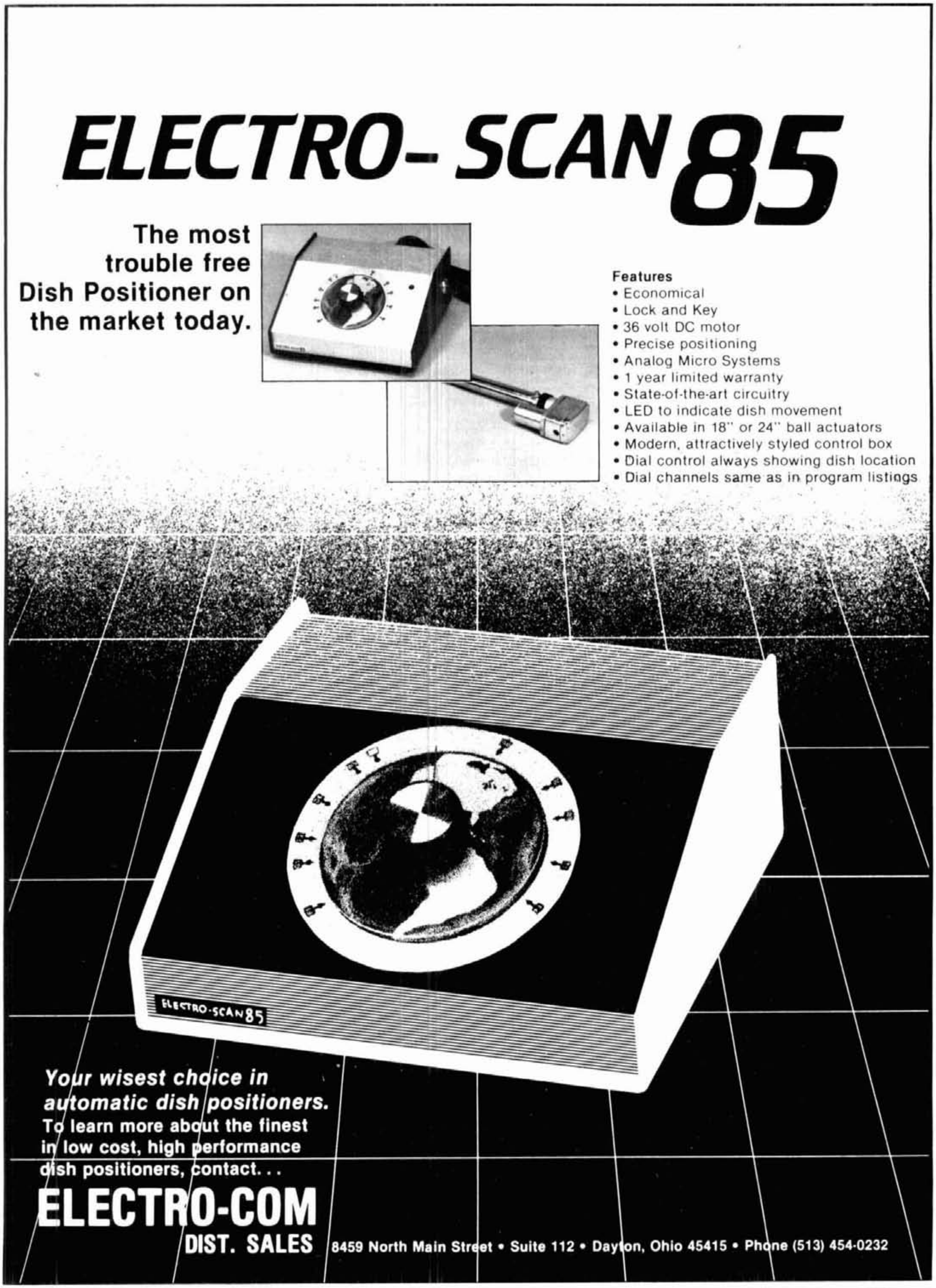
In a high performance, high power amplifier, it is essential that all RF components be placed within shielded boxes (more on this later). It is also wise to locate all other components *outside* the RF enclosures. This is particularly true of the plate compartment. The only items that should be present in the output circuitry are the tube, tank circuit components, RF choke and the high voltage bypass capacitor. Likewise, the input compartment *should not contain components such* as meters or filament transformers.

The method employed to physically tune the plate circuit is very important for stable, trouble-free operation. No matter what you do there will always be some heat dissipated in the tank circuit. Therefore, it is wise to locate the tuning capacitor where thermal detuning effects are minimal.

A typical example of how to and how not to tune a final is shown in **fig. 7**. Note that in **fig. 7A**, any expansion or contraction of the tank due to heating or cooling causes the capacitance to increase or decrease and therefore detunes the tank circuit. However, if the tuning method of **fig. 7B** is used, the tank circuit will only move back and forth past the tuning capacitor and cause a much smaller change in amplifier tuning.

The tuning capacitors must be carefully designed. A disc soldered on the end of a brass screw is a very lossy tuning method which may cause erratic tuning. I prefer a push mechanism in which there are no moving metal-to-metal contacts. For instance, a beryllium copper flapper can make an excellent tuning capacitor by pushing against it with a non-metallic object such as a threaded teflon rod. W2GN has suggested the use of a metallic rod if an insulator such as a teflon button is placed at the contact point to the capacitor (see **fig. 8**).

Another item to note is that when a transmitting tube has a plate contact ring, *the tank circuit should preferably* be attached to it rather than to the out-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side of the plate cooling fins. The circulating RF currents in a typical Amateur high power transmitting amplifier can easily reach 10 to 50 amperes!

Finally, there is often a need to provide air inputs and exits. These can best be made using a waveguide beyond cutoff configuration. It is well known that if the diameter of a hole is small with respect to the frequency (much less than 1/4 wavelength) and the hole has depth (such as tubing), RF will be attenuated approximately 30-33 dB per unit length. For example, if a 1 inch (2.54 cm) diameter tube is 1 inch long, it will attenuate VHF signals approximately 30 to 33 dB. If the same tube is extended to 3 inches (7.62 cm), the attenuation will be approximately 90 to 99 dB, usually more than sufficient. This attenuation principle is applied to the air inlet by using either a long large diameter tube, or several smaller diameter shorter tubes placed in a circle for air inlets and exits. Recently a honeycomb type of material has become available and it is easier to use than bundling up tubing, a technique now in wide use.

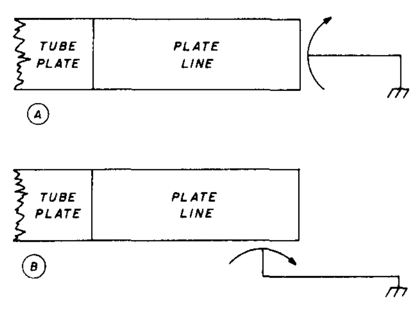

fig. 7. Two methods to tune a plate tank are shown. The method in fig. 7A is not recommended for reasons described in the text.

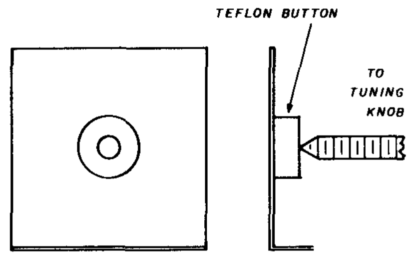

fig. 8. A recommended tuning method for a flapper type of plate tuning capacitor without metal-to-metal contact (see text).

tube selection

So far I have covered many of the different aspects of high power RF amplifier design but haven't said too much about the actual tube selection. **Table 1** in reference 1 shows some of the more popular tube types. Now that the FCC power regulations have been changed to apply to output power there are really many choices.

However, high power transmitting tubes should never be operated above their maximum frequency of operation *unless the voltages and currents are reduced accordingly*. Furthermore, the efficiency usually drops past the rated frequency and hence there may be severe over-dissipation not only in the plate but also in the control grid elements. Unfortunately, at VHF and UHF frequencies, control grid dissipation may increase but will not necessarily show up on the grid current meter as it does at HF. *Failure to observe the tube's ratings can severely decrease efficiency and the life of the tube!*

As I mentioned before, the use of parallel tubes should be a last resort. Using tubes above their rated frequency is also not recommended. If you require only moderate output power (500 watts or less), there are lots of single-tube amplifier choices such as the 4CX250B, 4CX300A, 8930, 8874, or the new 3CX800A7.

There is an alternative to the parallel tube approach. If additional power is required, identical amplifiers can be summed using hybrid power splitters and combiners. However, this technique is tricky and is recommended only for the more experienced VHF/UHFers.

The 4CX350A is not recommended above 135 cm (220 MHz) since it is primarily an HF tube and will exhibit low efficiency at 70 cm. Furthermore, its operating voltages must be lowered above 30 MHz. If you look carefully at the specification sheet you will see that the plate radiator is similar to the 4CX250B but the required air and back pressure have been increased to obtain the 350 watts of dissipation, a technique I mentioned earlier in this article.

For the full legal power limit, the new high-μ triodes such as the 8877 and 8938 are great but costly. Despite rumors to the contrary, the 8938 is not the 8877 with a different base! The 8938 cathode lead inductance has been lowered and the transit time loading has been improved, extending full power efficient operation up to approximately 500 MHz. The 8877 should not be used at full ratings above the 135 centimeter band.

The 4CX1000 series of tubes is often available on the surplus market at affordable prices. However, if stable operation on 2 meters or above is planned, the 4CX1000K is recommended since it has improved input-to-output isolation. The 7213/7214 and 7650/7651 tubes, also often found on the surplus market, will work well through about 1000 MHz, but, despite the data sheet, are not recommended for the 23-cm band since gain and efficiency will be so poor (33 percent if you are lucky!) that the useful output power will be low at maximum ratings. High power on 23 cm and up is still a problem, and no moderately priced single tube that can generate over 500 watts of output power is yet available to the Amateur service.

component selection

The type of RF coupling capacitors chosen is very important. The so-called TV doorknob types are not recommended because they cannot handle the typical RF current in a high-power VHF/UHF amplifier. The Centralab 850 or 857 series or the ITT 50 or 58 series transmitting doorknob type of capacitor (or equivalent) is strongly recommended even though they cost more (available from Radio Kit, Box 411H, Greenville, New Hampshire 03048).

HV feedthrough capacitors are also required. The Murata/Erie model

2498/001-XUO-102M 1000 pF at 4000 volts, is relatively expensive but highly recommended since it will handle the typical high voltages required as well as act as an RF low-pass filter. Some designers have "rolled their own" bypasses by placing a slab of copper or brass against a chassis wall insulated by a thin (0.005-0.010 inch or 0.13-0.25 mm) dielectric insulator.[10]

High voltage connectors are a must especially for safety. The typical "BNC" or "N" types have identical breakdown voltages which are too low for most amplifiers and are not recommended for carrying high voltage. However, the "MHV" (high voltage BNC) connector is highly recommended. Because its end is insulated, making it difficult to touch the tip — a useful feature should a high voltage line be accidentally touched when energized. This feature has saved my life more than once!

Chassis and enclosures are becoming difficult to obtain. Byers Chassis-Kit (K3IWK) has a large selection of chassis kits and will make up special enclosures to order.

When dielectric materials are used at VHF/UHF frequencies, careful selection is important for low loss. I don't recommend nylon or bakelite because they're lossy materials. Some of the recommended materials are Kapton, Isomica, mylar, and teflon. The first two are often difficult to obtain and may be expensive. Mylar, a low-loss dielectric, especially above 300 MHz, is often overlooked. In plentiful supply, it is often used for taping printed wiring circuitry and has a high breakdown voltage (5000 volts/mil) and a dielectric constant of approximately 3.

Teflon is recommended. It has a dielectric constant of only 2.1 and a voltage breakdown of only 1000 volts/mil. It also is porous. Hence for best breakdown it should be rubbed with a silicon grease (e.g. Dow Corning DC-4) or used in dual sheets.[10]

operating considerations

Under the new FCC power measuring regulations it makes sense to design VHF/UHF power amplifiers for linear service right from the start. A linear amplifier is more versatile and does not necessarily require bias adjustments when changing operating modes, thus simplifying switching circuitry. However, ALC circuitry should also be considered to improve linearity. Also the high voltage supply regulation usually improves since the transmitter current excursion is reduced.

I'll say it again! Before operating any tube, consult the manufacturer's data sheets! Excessive voltages can cause arcing and tube destruction. Excessive currents, especially in the cathode, can significantly reduce tube life. Many Amateurs tune their amplifiers for maximum smoke, then get indignant when the amplifier or tube goes up in smoke! Always pay particular attention to the cooling and backpressure. It's better to have too much air flow than not enough.

Also, determine the minimum required filament warm-up time before any cathode current is drawn. Properly built and operated power amplifiers don't require frequent tuning adjustments.

When a power amplifier is working properly, it should generate maximum output power when you are tuned to resonance (a point just above the dip in the plate current). On tetrode amplifiers the same should be true and the screen current should peak (even though it may be negative at the time) at the same point. It is highly recommended that a dedicated screen grid current meter be provided because the screen current is a very sensitive indicator of tuning and loading.

safety considerations

Whenever you are working on a high-power amplifier, safety should be your first concern. Safety applies in both the DC and RF area. *High voltage can kill.* All amplifiers should be adequately shielded to prevent inadvertent contact with the high voltage supply lines as well as the RF circuitry. High voltage primary interlocks, bleeder resistors in the supply, and high voltage discharge mechanisms are a must. Use of a relay in series with the high voltage (as previously recommended) is one additional way to lessen the chance of high voltage shocks, but even a relay's contacts can stick – so don't leave anything to chance. Meters, especially those connected directly in the high voltage line, are particularly dangerous. High voltage may be very close to the glass and a source of arcing. If a meter is placed in the high voltage line, it should be adequately insulated from ground and placed behind a protective panel. Bypass meters with back-to-back diodes as shown in **figs. 3** and **4**, to lessen the chance of meter destruction at high currents.

The loss of cooling air or water to the tube can also present a safety hazard. Besides endangering the tube, loss of cooling increases the chance of fire or explosion should the plate overdissipate. An air or water flow high voltage cutoff switch is recommended in case of failure.

Finally, we must respect RF and microwave radiation. In recent years it has become increasingly obvious that Amateur transmitters, especially those operating at 500 watts and above, have sufficient RF power to be hazardous, especially to the eyes and brain. Power densities of 10 milliwatts/cm^2 were formerly the American National Standards Institute (ANSI) C95.1-1974 limit.[11] This limit has now been superseded. The new ANSI C95-1-1982 limits are 1 milliwatt per square centimeter from 30-300 MHz, following the curve f(MHz)/300 milliwatts per square centimeter from 300-1500 MHz, and 5 milliwatt per square centimeter above 1500 MHz. *This limit can be easily exceeded within 1 meter of a high power VHF/UHF transmitter with the plate compartment shield removed.* Blackwell and White have described a simple probe to measure RF power density.[12] *A power amplifier should never be operated with the shielding removed, especially on 2 meters and above!*

warranty considerations

Most manufacturers will not replace a defective tube, even under warranty, unless certain parameters have been monitored. These include, but are not limited to, filament voltage, hours of operation (as indicated on a built-in elapsed meter), circuitry and operating voltages. These requirements are usually spelled out on a warranty sheet in the original packing container. It's well worth checking into these requirements before placing a tube in service.

recommended designs

Finally we come to the question of what are the most popular and recommened designs. The following table includes many recommended references or designs, listed by frequency band:

band	see reference
6 meters	13-20
2 meters	19-35
135 cm	36-41
70 cm	10,42-48
33 cm	49

23 cm and up is still a difficult area; it will be covered in a forthcoming column, but reference 50 is recommended for a medium power (100-150 watts) 23 cm-amplifier.

This list should cover most of the tubes and circuits presently in wide use. The selection of amplifier and tube is left to the individual.

The AM-6155, a moderately priced ($150) surplus linear amplifier, has recently become available from Fair Radio Sales.[51,52,53] It comes complete with a self-contained power supply and uses a single 8930 tetrode. Properly modified, this amplifier can operate on either 2 meters, 135, or 70 centimeters. With 10 watts of drive, 400 to 600 watts of output have been reported.

summary

Properly operated tubes used in a good circuit with appropriate attention given to component selection will have a long lifetime and provide many hours of satisfactory operation.

I highly recommend that you obtain a copy of reference 5 for your library. This reference is very complete and will provide amplification on many of the items discussed in this article. Let me know if I have left out any major points. They can be covered in a subsequent column.

acknowledgements

This month's column would not have been possible without the efforts of many other individuals. In particular I want to thank Lewis Collins, W1GXT, and Gary Madison, WA2NKL, who helped a great deal by reviewing this month's manuscript and providing many valuable suggestions.

I would also like to thank Bob Sutherland, W6PO, for all the valuable information and guidance he has provided over the last 15 years. Finally, I want to also thank Ray Rinaudo, W6ZO; Bill Orr, W6SAI; Fred Merry, W2GN; and all the other VHFers who have, over the years, helped me and others to understand how to properly design and build a high power VHF or UHF amplifier.

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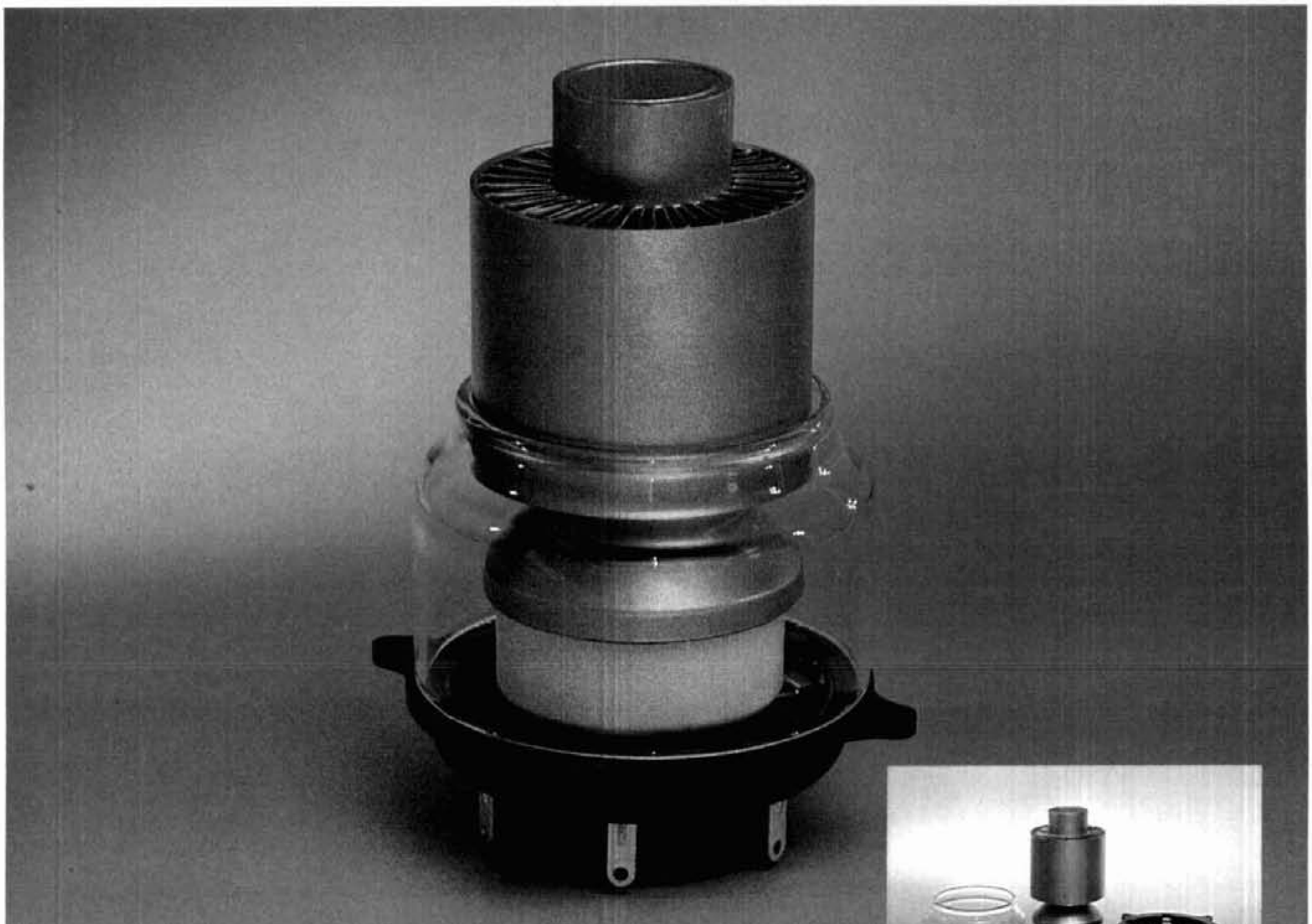
important VHF/UHF events in February, 1985

February, 8: ***EME perigee***

Note: If you know of any important VHF/UHF events, please let me know well ahead of time so that they can be listed in this column.

ham radio



defining the decibel

Why bother? Because in electronics — as in any science — definitions *do* make a difference.

The unit of the decibel, or dB, is used quite widely in electronics to express everything from amplifier gains to bandwidth ratios (is that 10 log or 20 log for bandwidths?). Often the question, "Is that dB-voltage or dB-power?" is heard. The answer to that question is an unequivocal "yes." The short article that follows reiterates the apparently long-forgotten history of the decibel and discusses both its proper application and a few of its common misapplications as well.

The decibel is, roughly, the smallest change in acoustic power that the ear can detect.[1] It's one tenth of a bel, a unit named for Alexander Graham Bell, whose original research revealed the logarithmic amplitude response of the human ear;[2] not surprisingly, the concept of the bel was originally used in the field of telephony. But the unit was found to be too large for practical application, and the decibel was soon found to be more convenient.

In the original acoustic terms, the decibel was defined as 10 log to the base of 10 of the ratio of two acoustic intensities (powers). (A similar but much less frequently used unit is the *Neper* — from Napier — which is given as 1 log to the base e of a *voltage* ratio.[2] Yes, the multiplier is 1, not 10.) In modern electronics, however, the decibel is *defined* as 10 log of a power ratio in which the two powers ratioed are measured at a particular point in a system — at the output of an amplifier, for example. *This is the only definition. Other descriptions of the decibel, such as 20 log of a voltage ratio, are derivations of this definition, often with some critical information omitted.*

The decibel is really just a type of mathematical shorthand. It is more convenient, for example, to express the power gain of an amplifier as 80 dB than as 100,000,000 watts/watt. One variation to this basic definition has been a generalization to allow the two powers ratioed to be at *different* points in a system that have equal impedances — for example, the power gain of an amplifier in a constant 50-ohm system expressed in dB as 10 log of the ratio of the output power to the input power. Such a generalization, however, is still consistent with the original definition. Consider a 50-ohm amplifier in a 50-ohm system. Its input and output impedances must both be 50 ohms to be consistent with the 50-ohm system. Therefore, the source driving the amplifier will deliver the same power to a 50-ohm termination as it delivers to the amplifier input. Let us choose the 50-ohm input to a power meter as the point of measurement of the original definition above. First apply the source directly to the power meter input and record the source power. Then, remove the source from the measurement node (power meter input), apply it to the amplifier input, and apply the amplifier output to the power meter. Measure the new power at the point of measurement. The amplifier gain in dB is then 10 log of the ratio of the second measurement, the output power, to the first measurement, the power applied to the input. This measurement technique is a direct application of the definition of the decibel.

Alternately, we could, by some means, measure the input and output powers of the amplifier with it attached to the source and 50-ohm load (computed from measured input and output potentials perhaps) and compute the gain in a similar manner as above. There is a subtle difference between this second measurement technique and the first. In the first, a single point of measurement, the input to the power meter, was used to measure the two powers for the ratio; in the second, two different points in the system were observed — the input and output ports of the amplifier.

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Since the system was defined to be a 50-ohm system throughout, both techniques will yield the same results. However, if the impedances in the system are not the same throughout, the results will *not* be the same. (This will be demonstrated later.) So, the ratio of two powers, P_2 and P_1, in a constant impedance system expressed in dB, is given by **eq. 1**, where the term "D" is simply a general notation and the form "dB" is used to show the units of the result.

$$D = 10 \log (P_2/P_1) \ [dB] \qquad (1)$$

In many cases the power, P_1, is chosen as some convenient reference power such as one milliwatt. The value of D is then given in dB referred to a milliwatt, abbreviated dBm. This is still consistent with the basic definition of the dB since D is then a representation of the actual power at a point in a system compared to the chosen reference power at that same point.

Now, we will expand **eq. 1**. However, since this is not a lesson in arithmetic, the impedances will be defined as being real with no imaginary part, which will simplify the math considerably. Each of the powers in **eq. 1** may be expressed in terms of the potentials and corresponding impedances, or resistances for the case of impedances with only a real component, at the power measurement points. Expanding **eq. 1**:

$$D = 10 \log [(E_2^2/R_2)/(E_1^2/R_1)] \qquad (2)$$

$$= 10 \log (E_2^2/E_1^2) - 10 \log (R_2/R_1) \qquad (3)$$

$$= 20 \log (E_2/E_1) - 10 \log (R_2/R_1) \ [dB] \qquad (4)$$

This is an interesting result. We can now see where the 20 log of a voltage ratio expression originated in the widely used dB expressions. But what about the second term in **eq. 4**? Well, in the case of a constant impedance system, the two resistances are the same value, resulting in a second term of 10 log(1), which is of course zero. As a result, D is correctly expressed in dB as 20 log of the ratio of two voltage measurements, which is the expression so familiar to many of us. So we'll make a note of it here:

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$$D = 20 \log (E_2/E_1) \ [dB] \qquad (5)$$

This would be a good point to digress a moment and examine the question, "Is it dB-voltage or dB-power?" Consider a 50-ohm amplifier in a constant 50-ohm system. If we applied an input signal of one microwatt (−30 dBm right?) to this amplifier and measured an output power of one milliwatt (0 dBm?), what would be the gain of that device in dB? Letting that power ratio be represented by "G" and applying the basic definition of the dB given in **eq. 1**:

$$G = 10 \log (P_o/P_{in}) \ [dB]$$

$$G = 10 \log (1 \ milliwatt/1 \ microwatt) \qquad (6)$$

$$= 10 \log (1000) = 30 \ dB$$

We could have easily found this result by *subtracting* the −30 dBm input level from the 0 dBm output — 0 dBm − (−30 dBm) = +30 dB. To show this mathematically, consider the following:

$$G \ [dB] = 10 \log (P_o/P_{in})$$

$$= 10 \log (P_o/P_{in}) + 10 \log (1 \ mW/1 \ mW)$$

$$[add \ 10 \log (1 \ mW/1 \ mW) \ which = 0]$$

$$= 10 \log (P_o/1 \ mW) - 10 \log (P_{in}/1 \ mW)$$

$$= P_o \ [dBm] - P_{in} \ [dBm]$$

Now we will try it from a voltage point of view. First we must compute what input and output voltages we would measure with the corresponding powers given. We all know that the power dissipated in a resistor with a potential E applied across it is given by:

$$P_R = E^2/R \ [watts]$$

Solving for E in terms of P and R:

$$E = (P \cdot R)^{1/2} \ [Volts, \ RMS]$$

For the one microwatt input (remember, we said we had a 50-ohm system):

$$E \ (1 \mu W) = (1 \cdot 10^{-6} \ watts \cdot 50 \ ohms)^{1/2}$$
$$= 7.07 \ millivolts \ RMS$$

And for the one milliwatt output:

$$E \ (1 mW) = (1 \cdot 10^{-3} \ watts \cdot 50 \ millivolts)^{1/2}$$

$$= 223.6 \ millivolts \ RMS$$

Now, applying **eq. 4**:

$$G = 20 \log (E_2/E_1) - 10 \log (R_2/R_1) \ [dB] \qquad (7)$$

$$G = 20 \log (223.6 \ mV/7.07 \ mV) - 10 \log (50 \ ohms/50 \ ohms)$$

$$= 20 \log (31.63) - 0 = +30 \ dB$$

Look carefully at the two results in **eqs. 6** and **7**. If you were told that the gain of this 50-ohm amplifier was 30 dB, would you have to ask "dB-voltage or dB-power?" (I hope not.) As shown in this example, computing the gain by either 10 log of the power ratio or 20 log of the voltage ratio yields exactly the same result in a constant impedance system. So you can see that the all-too-often-asked question has little meaning when the concept of the decibel is properly used.

We will now see how the concept came to be misapplied. Look back at **eq. 4**. This is an exact expression of the decibel and, as explained, reduces to **eq.**

5 in systems of constant impedance. In the early applications of the decibel, power measurements were made in waveguide and coaxial RF systems using various instruments for direct power measurement. The use of these instruments required the signal of interest to be applied directly to the measurement instrument input as is required by the definition of the decibel. Therefore, ratios of measured powers expressed in dB were consistent with the original definition. Then something terrible happened: the performance of electronic instruments improved dramatically. RF voltmeters could now be used to measure actual RMS potentials in systems, rather than only power. Oscilloscopes could provide direct viewing of the voltage waveforms from which RMS values could be computed. And worse yet, these instruments were of such a nature that these potential measurements could be made quite accurately in systems of almost any impedance without the need to break the circuit for direct application of the measured signal to the measuring instrument. In fact, the impedance did not even have to be known to accurately measure potentials, although circuit loading did have to be considered. Well, many of the first applications of these instruments were still in the area of constant impedance systems and it was well known that **eq. 5** applied, and **why**. As several generations of engineers and technicians used these new and ever-improving instruments, the use of **eq. 5** became second nature and its origin (and limitations) slowly became lost and forgotten. Then another terrible thing happened . . . the operational amplifier appeared. These were marvelous devices with staggeringly high voltage gains — perhaps as high as 1,000,000 or even higher! Using such large terms in everyday communication presented a bit of an inconvenience. Then someone, remembering **eq. 5** (at least most of it), said "Wow, we can express this gain in dB as 20 log of the voltage gain." What was omitted was that **eq. 5** applies only in constant impedance systems. Operational amplifiers typically exhibit very high input and very low output impedances. So was yet another misapplication of the decibel born.

To demonstrate the problem associated with this misapplication of the concept, we will examine a few examples. Consider an operational amplifier configured for a voltage gain of unity. Let the amplifier have a 1 Megohm input resistance and a very low output resistance (much smaller than 50 ohms). Also, consider a source with a 50-ohm impedance. Finally, let the load be 50 ohms. If we apply an input signal and measure the input and output voltages we will naturally find them to be the same since the amplifier is configured for a gain of one. Using **eq. 5** and rather ignoring the impedance requirement, we would find the amplifier gain to be 0 dB. Now let's compute the gain in dB as 10 log of the output to input power ratio. The input power is simply the input RMS voltage squared, divided by the input resistance. The output power is given as the output RMS voltage squared divided by the load resistance. However, since the voltage gain is unity, the input and output voltages are equal. Let that voltage be E. Computing the gain from the power ratio:

$$\begin{aligned} G &= 10 \log [(E^2/R_L)/(E^2/R_{in})] \\ &= 10 \log (R_{in}/R_L) \\ &= 10 \log (1 \cdot 10^6 \text{ ohms}/50 \text{ ohms}) \\ &= 10 \log (2 \cdot 10^4) = 43 \text{ dB} \end{aligned}$$

Well, that presents a bit of a problem. Is the actual gain 0 dB or 43 dB? Let's try still a different measurement by trying to apply the single-point measurement approach of the original definition. Let the 50-ohm load be the input resistance of a 50-ohm power meter. Applying the source to the power meter input, a power, P, is observed. Now, move the power meter to the amplifier output and apply the source to the amplifier input. Since the source is not loaded by the amplifier input (1 megohm $>>$ 50 ohms), the voltage at the amplifier input is twice that measured when the source was terminated with the 50 ohms of the power meter. (This can easily be shown with some simple circuit analysis, but since that's not our purpose here, you'll have to either accept it as true, or prove it for yourself.) The amplifier output voltage is also twice the loaded value of the source, since the amplifier voltage gain is unity and the low output resistance of the amplifier prevents loading by the power meter. Power varies as the square of voltage, so the doubling of the voltage at the power meter input results in an increase in power by a factor of 4. The power reading of the power meter will then be 4P. Applying **eq. 1**:

$$\begin{aligned} G &= 10 \log (P_o/P_{in}) \\ &= 10 \log (4P/P) = 6 \text{ dB} \end{aligned}$$

This gives us still another choice as to what the gain in dB is for an operational amplifier configured for unity gain. It is either 0 dB, 43 dB, or 6 dB, depending how one makes the measurement.

Now, let's modify the unity gain amplifier circuit configuration slightly by the addition of an input transformer. Let that input transformer match the 1 megohm amplifier input resistance to the 50-ohm source resistance, a turns ratio of 1:141 (remember, transformer impedances vary as the square of the turns ratios). The transformer/amplifier combination now satisfies the constant impedance requirement of the definition of the decibel — the input and output resistance is 50 ohms in a 50-ohm system. The 50-ohm input of the transformer presents the same load as the power meter of the original measurement of the source power. The source power will produce some input voltage. Let that voltage be E. Since the transformer has a 1:141 turns ratio, the input potential to the amplifier is 141E and since the amplifier has unity gain, the output potential is 141E. Since this is a constant impedance system, we may compute the power gain either from the power ratio or the voltage ratio. Therefore, since we have the input and output voltages (in terms of E) we will apply **eq. 5**.

$$G = 20 \log (E_2/E_1)$$
$$= 20 \log (141E/E) = 43 \ dB$$

Now, isn't that an interesting result? This is the same value that was found for the original configuration in the second calculation, which was based on the actual input and output powers. This can somewhat be understood since the transformer can have no power gain. The transformer does provide a proper impedance match to the source so that for any given source potential the maximum amount of power will be coupled, but it does not provide any power gain. The optimum matching simply implies that this is the configuration in which the *available* source power is most effectively coupled. Thus, for some desired output power, this configuration will require the least input voltage, and least available input power. The first unity gain configuration and the transformer/amplifier configuration both have a power gain of 20,000. However, in the first, the voltage gain is unity, so if an output potential of V volts RMS is needed for some desired output power, the input potential must also be V volts. In the transformer/amplifier configuration, the voltage gain is 141, so for an output of V volts an input of V/141 volts is needed. Since each of these configurations is delivering the same power to the load and they have the same power gain, the second makes the more efficient use of the source signal.

Since the gain of this final configuration to which the concept of the decibel may be properly applied is the same as that of the simple unity gain amplifier expressed in dB as 10 log of the actual output to input power ratio, perhaps the gain in dB of the unity voltage gain amplifier should be 43 dB? One can easily see the confusion that can result. This is particularly true since all four of these results could be considered correct depending upon how one chooses to use the concept of the decibel. Considering the first two cases it might have some meaning to use the expressions dB-voltage and dB-power to distinguish between the two measurement techniques. But what do we do with the third measurement? It was also a power measurement and actually more consistent with the actual definition of the dB. Perhaps this value could be called "dB-power-almost-consistent-with-the-definition-of-the-decibel," or dB-PACWTDOTD for short. Certainly that would be a bit ridiculous — but would it be any more absurd than dB-voltage and dB-power? Then there's the modified configuration, to which the concept of the decibel may be properly applied, which yields a power gain that is the same as that of the second calculation. However, this is a different configuration, and its relation to the problem is not immediately obvious. Perhaps the best way to avoid this dilemma is to stick to the actual definition of the decibel. Nevertheless, widespread use of the expression of voltage gain in dB as 20 log of the ratio of the output to input voltages has resulted in this expression becoming a type of alternate definition of the decibel.

One popular use of this expression is the specification of the open loop voltage gain of operational amplifiers. There seems to be a slight trend away from this erroneous specification, however, in favor of the correct units of volts per millivolt, volts per microvolt, etc. Look through some data books with specifications on operational amplifiers and see if you can find these different open loop gain units.

noise analysis — yet another creative misapplication

The use of the decibel to express the voltage gain of an amplifier in a system of non-constant impedances is by far the most common misapplication of the decibel that you're likely to encounter. Yet there's another interesting misapplication that's also quite creative; this is found in the area of noise analysis. The noise power available in a system is directly a function of the system noise bandwidth. Without going into detail, the available noise power, P_n, in a noise bandwidth, BW_n, and absolute temperature, T_O, is given by **eq. 8**.

$$P_n = k \cdot T_O \cdot BW_n \ (watts) \tag{8}$$
$$k = \text{Boltzmann's constant}$$
$$= 1.38 \cdot 10^{-23} \ \text{Joules/degrees Kelvin}$$

Now suppose we have two different noise bandwidths and want to know how much noisier, in dB, the larger is than the smaller. Consider an amplifier system of power gain G with a variable bandpass filter and a suitable power meter tied to the amplifier output. With the bandpass filter set for a narrow bandpass, BW_{n1}, let the power reading be P_{n1}. Then let the filter be adjusted to a wider bandpass, BW_{n2}, with a corresponding power reading of P_{n2}. The relative increase in power with the increased bandwidth expressed in dB is then given as $10 \log (P_{n2}/P_{n1})$, and this expression is an exact application of the definition of the dB. Let this quantity be defined as D. The two powers may be expressed in the form of **eq. 8** above. Then, expanding the expression for D:

$$
\begin{aligned}
D &= 10 \log (P_{n2}/P_{n1}) \\
&= 10 \log (k \cdot T_o \cdot BW_{n2} \cdot G/k \cdot T_o \cdot BW_{n1} \cdot G) \quad \textbf{(9)} \\
&= 10 \log (BW_{n2}/BW_{n1}) \; (dB)
\end{aligned}
$$

Well, there you have it — the ratio of two bandwidths expressed in dB is given as 10 log of the bandwidth ratios. Just what does it mean? That's right, *nothing* . . . unless, of course, you know that you're really talking about ratios of noise powers and not simply bandwidths. Feel free to consider some of the possibilities for this misapplication — but please don't take them seriously. Why, one could use **eq. 9** (without considering its origin) to express the peaking properties of a bandpass filter in dB as 10 log of the output bandwidth to input bandwidth! Of course in this case we'd most likely want to invert the ratio (i.e., 10 log of the input to output bandwidths) so that we would always have positive values to work with. We could even express quality factor, Q, in dB if we are a little creative. Quality factor of various systems is often expressed as the ratio of the center frequency to the bandwidth. Well, the center frequency could be considered as a bandwidth with the lower frequency of 0 Hz. Then Q would be nothing more than a ratio of two bandwidths and misusing **eq. 9**, we could express Q in dB (again, we would wish to invert the ratio to have positive dB values of Q since negative values might be confusing).

If these suggestions seem quite outrageous, perhaps it's because they haven't been seen before. These are actually as correct as expressing the open loop voltage gain of an operational amplifier in dB, but we've come to know *that* expression because of its widespread use, and so as a result, it doesn't look particularly strange. But this doesn't make it inevitably correct. There is some obvious confusion because in the absence of uncertainty, the voltage/power question would need never be asked. If you stick to using the concept of the decibel only where it applies, you'll have no problem. In cases where you must work from someone else's error, you'll just have to try to figure out what was meant. This does not mean that we would specify the gain of the unity gain amplifier in the example above as 43 dB. That voltage gain is 1 volt/volt or simply a voltage gain of 1. The power gain of that configuration is 20,000. That is where we arrived at the 43 dB figure; but as pointed out, the concept of the decibel does not apply because the system is not of constant impedance. The power gain would simply be stated as 20,000 watts/watt, 20 watts/milliwatt, or simply a power gain of 20,000.

As the examples above have shown, misapplication of the concept of the decibel has led to considerable confusion as to what is actually implied by the expression of a quantity in dB. Hopefully this article has served to clarify your understanding of the concept, and you can now correctly apply the concept. Furthermore, when you see quantities expressed in dB, you'll be able to tell whether or not they're proper expressions. In cases where they're not, you should have a better understanding of the concept to aid you in trying to comprehend the original intention. In any event, if you keep the definition of the decibel clearly in mind and always apply it properly, then your expressions, at least should always be correct and should be understood by anyone who shares your understanding of the decibel. When you're asked, "Is that dB-voltage or dB-power?", you'll not only be able to show why that question has little meaning, but also silently revel in your mastery of the concept. Always return to the basic definition of a notation or concept and apply it accordingly. Also, look those basic definitions up in the literature. Don't simply take some *expert's* opinion as being correct. Perhaps you should apply that advice to the information in this article!

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ham radio

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ham radio TECHNIQUES

Bill Orr, W6SAI

the G5RV explained

While it may be premature to speculate, Spring can't be far away. Now's the time to think about that new antenna you're going to put up as soon as milder weather rolls around.

Some Amateurs in the United States have been bemused, even confused, by the short, cryptic description of an antenna used by many European Amateurs. Described as simply a "G5RV," the antenna must work, judging from some of the powerful signals that come "across the pond" from stations using this sky-wire.

The antenna design is named after its designer, Louis Varney, G5RV, an old-timer — (licensed as 2ARU in 1928, and as G5RV in 1929) — still very active on the bands. Louis has used the antenna from many of his overseas DX locations over the past few decades. It enjoys worldwide popularity because it's a good, inexpensive multiband antenna that works very well.[1]

The grandfather of the G5RV was an "all-band" antenna first described in Amateur literature by Arthur Collins, WØCXX, then President of Collins Radio Company. Sold as a kit in 1933, it never attained widespread popularity because it was both expensive and difficult to install.

The Collins antenna consisted of a 3/2-wavelength long 20-meter, center-fed wire with an impedance transformer that provided a satisfactory match to the open-wire line and tuned tank circuit rigs of the pre-war period. The transformer was a linear affair made of copper tubing that was difficult to suspend from the center of the antenna. Art's transformer was quickly forgotten, but the idea of the inexpensive, effective 3/2-wave antenna remained (**fig. 1**). As shown in **fig. 2**, it has an interesting field pattern and a radiation resistance value of about 95 ohms at the center feedpoint. Its power gain over a dipole is about 1 dB.

Antenna dimensions for the higher frequency bands are shown in **table 1**. The antenna can be easily matched to 50-ohm coaxial line by means of a quarter-wave section of 75-ohm coaxial line. Sufficient line isolation can be obtained by wrapping a portion of the 75-ohm line into a simple four-turn RF choke coil directly beneath the antenna feedpoint.

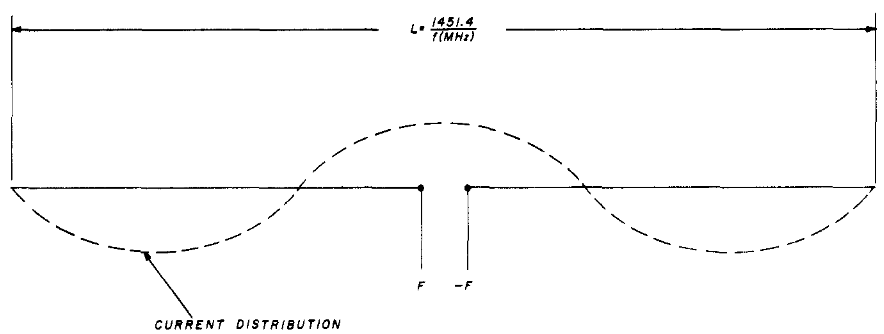

fig. 1. The 3/2-wave center-fed antenna. Feedpoint resistance at resonance is about 95 ohms.

This simple antenna is recommended as a general coverage, single-band antenna for the Amateur bands between 10 and 30 MHz.

a practical G5RV multiband antenna

Louis Varney, G5RV, devised a 1/2-wave matching section that functions as a 1:1 transformer for a 14-MHz 3/2-wave dipole, enabling the coaxial line to "see" a close match on this band (**fig. 3**). On other high frequency Amateur bands, the transformer section acts as a portion of the antenna, folded back upon itself, to provide a reasonable value of feedpoint impedance on all bands between 3.5 and 29.7 MHz. Even though the antenna termination may be reactive, a good antenna tuning unit will match the system to a 50-ohm transmitter. This scheme will satisfy the rather stringent load conditions required by many of the solid-state transceivers employing a "fail-safe" ALC circuit that senses the SWR on the transmission line and reduces amplifier input to protect the output transistors of the transceiver from damage.

It is tempting to substitute a balun for the antenna tuner to make a "no adjustment," multiband antenna. This is an unsatisfactory solution. Ferrite-core baluns are not effective with reactive loads or loads presenting a high value of SWR, and cannot compensate for the reactive load presented by the G5RV antenna on most Amateur bands. The tuners listed in references 2 and 3, however, will do the job properly.

the linear transformer for the G5RV

The heart of the G5RV antenna is

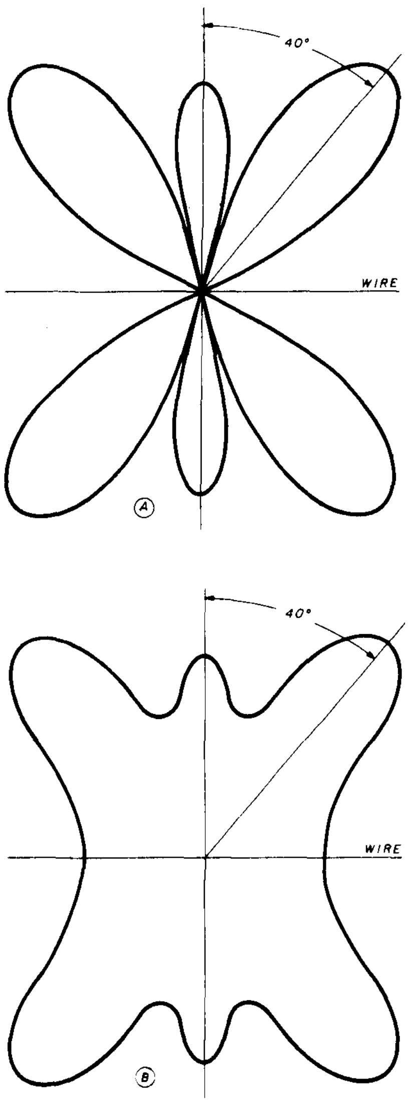

fig. 2. Horizontal field pattern for 3/2-wave antenna: (A) ideal pattern; (B) over imperfect ground.

table 1. Dimensions of flat-top and coaxial transformer for 3/2-wavelength, center-fed antenna.

		L = *		1/4-wave transformer (RG-11/U or RG-59/U	
band	f(MHz)	feet	(meters)	feet	(meters)
30	10.12	143.40	(43.70)	16.04	(4.89)
20	14.15	102.60	(31.30)	11.46	(3.49)
17	18.11	80.14	(24.43)	8.97	(2.73)
15	21.22	68.40	(20.85)	7.66	(2.33)
12	24.94	58.20	(17.74)	6.51	(1.98)
10	28.60	50.75	(15.47)	5.68	(1.73)

$$*L = \frac{1451.4}{f(MHz)}$$

the 14-MHz 1/2-wave transformer placed at the feedpoint of the antenna. Line impedance is not important. Ideally, an open-wire line is best, but is difficult to build and spacers are hard to come by. A good substitute is TV-type "ladder line" that will function with power levels up to 250 watts or so. On occasion, transmitting-type ladder line that will work very well can be found.

Alternatively, 300-ohm line having "windows" punched in the dielectric can be used, but this material is not difficult to obtain. While 300-ohm TV ribbon line will work, the transformer section can be detuned by rain or snow, making antenna tuning erratic in wet weather.

Regardless of construction, the transformer section should drop down vertically beneath the antenna for 20 feet (6 meters) or so before it is brought away at an angle. This will keep undesired coupling between line and antenna at a minimum.

The G5RV can be installed as an inverted-V antenna and still perform successfully.

the 160-meter compact dipole

Have you heard the DX coming through on the 160-meter band? Would you like to work some of it? A great idea, but a lot of would-be "top band" DXers pause when they consider that a 1/2-wave dipole antenna is about 246 feet (75 meters) long when cut for the midpoint of the band. And while a vertical antenna would be appropriate, it requires a good ground connection and a system of buried radials.

An effective alternative is a short, coil-loaded dipole antenna. By reducing the dipole to half size, about 130 feet (40 meters), the antenna becomes more feasible for the ham who lives on a medium-sized lot. A loaded antenna can be just about any length, however, if a compromise between length, efficiency and bandwidth can be accepted. Bandwidth and efficiency drop sharply when the loaded dipole is much less than 1/4-wavelength long.

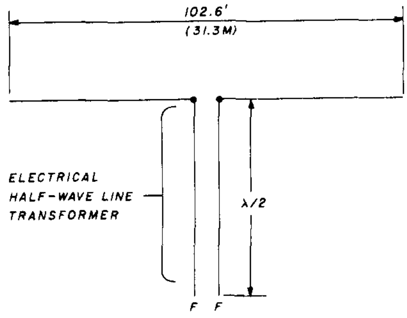

fig. 3. The G5RV antenna for 14 MHz. A parallel-wire transformer 1/2-wavelength long acts as a 1:1 matching device on 14 MHz and as a folded portion of the antenna on other bands. A tuner is required at F-F to match the system to a coaxial feedline. The velocity factor of the line must be used to determine physical line length. On 80 meters the antenna is a foreshortened dipole. On 40 meters the antenna is a folded "two 1/2-waves in phase." On 18, 24 and 28 MHz the antenna functions as a long wire, center-fed.

The bandwidth of a full-size 160-meter dipole mounted close to the ground (40 to 60 feet — or 12 to 18 meters — high) is quite narrow — only about 150 kHz between the 2:1 SWR points on the passband. Shortening the dipole and loading it to resonance sharpens the passband. The antenna design shown in **fig. 4** has a passband of about 50 kHz between the 2:1 SWR points. That's the penalty you pay to get a compact antenna on 160

table 2. Coverage of the entire 160-meter band requires changing dimensions and component values.

design frequency (MHz)	overall length (S) feet	(meters)	length center-to-coil (D) feet	(meters)	loading coil (L_1) μH	turns (L_1)	matching coil (L_2) μH	turns (L_2)
1.80	130.0	(39.6)	32.5	(9.9)	91.9	38.9	3.9	11.6
1.85	126.5	(38.6)	31.6	(9.6)	89.2	38.0	3.8	11.3
1.90	123.2	(37.6)	30.8	(9.3)	86.5	37.2	3.7	11.1
1.95	120.0	(36.6)	30.0	(9.1)	84.0	36.4	3.6	11.0
2.00	117.0	(35.66)	29.3	(8.9)	81.6	35.7	3.5	10.8

Notes:

Dimensions rounded to nearest tenth, metric dimensions in ( )
Coil L_1 diameter = 3 inches (7.6 cm) use No. 14 wire, close-spaced
Coil L_1 length = approximately 2.5 inches (6.3 cm)
Coil L_2 diameter = 1 inch (2.54 cm), use No. 18 wire, close-spaced
Operating bandwidth = 50 kHz between 2:1 SWR points
Adjust tip sections for antenna resonance
Adjust coil L_2 for best match at resonant frequency

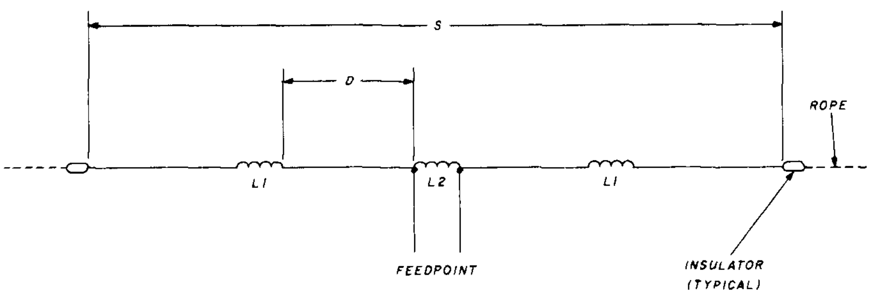

fig. 4. The 160-meter compact dipole (see table 2).

meters! You can make the dipole shorter with larger loading coils, but your operating passband will shrink until it becomes impractically narrow.

simplifying the design

The chart shown in **table 2** reveals a number of interesting points. Overall antenna length varies from 130 feet (39.6 meters) at the low end of the band to 117 feet (35.6 meters) at the top end. That's a difference of 13 feet (4 meters). The length of the center-to-coil distance also changes appreciably (from 32.5 feet to 29.3 feet). The loading coil (L1) inductances change only slightly, as the number of turns changes only from 38.9 to 35.7. And the matching coil at the center of the antenna changes hardly at all.

It seems to me that things could be simplified by using the center-band design (1.90 MHz) and then varying the resonant frequency of the whole antenna by merely changing the length of the tip sections. Leave all the other dimensions alone. Fold-back tip sections can be wrapped around the antenna wire and then unwrapped and left to hang down when operation is desired over a lower frequency range.

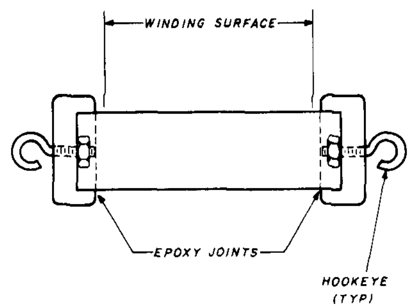

fig. 5. Loading coil can be made up of PVC-type plastic pipe and end caps. Hookeyes permit connection to the antenna wire.

adjusting the antenna

Accepting the 1.90 MHz dimensions as par, then, what's to be done? The antenna is built, erected in place, and lowered so that a dip-meter can be coupled to the matching coil, L2. The end sections of the antenna are trimmed equally until resonance is established at 1.90 MHz, or at any other point you decide is your "pet" operating frequency. (The feedline is removed for this test.)

Once antenna resonance is determined, matching coil L2 is adjusted, a quarter-turn at a time, for the lowest SWR indication on the feedline at the frequency of antenna resonance. The antenna must be in the final operating position when this is done.

building the antenna

The loading and matching coils can be easily made up using PVC tubing, as shown in **fig. 5**. If the coils are given a good coat of acrylic spray, they'll be weatherproof. Some detuning may be noticed in damp or wet weather, or if snow clings to the coils.

An alternative for Amateurs living in mild climates is to make the coils of prefabricated coil stock. The latest Barker & Williamson catalog lists show both "Airdux" and "Miniductor" coils.* I understand the "Airdux" coils can be specially ordered with LEXAN® insulation, which is impervious to ultra-violet rays. This means that the coil support strips will not disintegrate after being exposed to sunlight over a period of time.

the easy way out

If you don't want to build the compact 160-meter dipole yourself, you can purchase either the loading coils (Model LC-1) or the complete antenna (Model AES-160) from Barker & Williamson. Keep in mind, however, that this antenna is shorter than the one described earlier in this article, and while it works just as well, it may have a smaller passband because of its shorter 96-foot length. Take your choice.

heavy-duty equipment

Do you need mica transmitting-type capacitors? One possible source is Milton Levy, W5QJT, Apartment 303, 350 North Resler Drive, El Paso, Texas 79912. Milt has a large collection of capacitors and vintage radio tubes for sale at modest prices. (By the way, have you priced receiving tubes lately? The new Newark Electronics catalog lists a 6SJ7 at $29.46 and a 6SN7 at $16.82.)†

lightning protection

Many VHF/UHF repeater antennas are mounted to the side of a metal tower and grounded to it. Even so, the antenna and equipment can be damaged by the electric field of a nearby lightning stroke. A simple and effective way to protect the side-mounted antenna is shown in **fig. 6**. A "lightning rod" is mounted to the tower just above the repeater antenna. The horizontal metal rod, a few inches longer than the spacing between the antenna and tower, is placed 6 inches or more above the tip of the antenna. The lightning rod will not affect antenna performance, but it will help to protect the antenna and the equipment attached to it during a nearby storm.

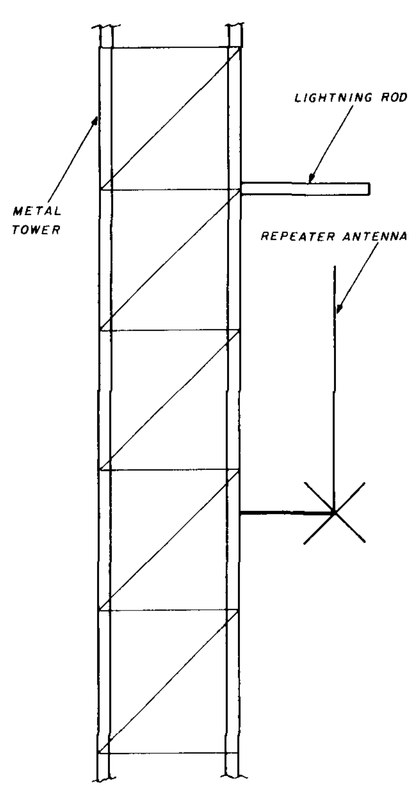

fig. 6. Lightning rod will protect repeater antenna mounted on side of metal, grounded tower.

reprint available

I have a limited number of reprints of the article "A High Power 2-Meter Amplifier Using the New 3CX800A7" from the April, 1984, issue of *QST*. Address your request to me, c/o EIMAC, 301 Industrial Way, San Carlos, California 94070. (Include two first-class stamps or two IRCs.)

Thanks to the American Radio Relay League for permission to reprint.

*Barker & Williamson, 10 Canal Street, Bristol, Pennsylvania 19007.

†Newark Electronics, 500 North Pulaski Road, Chicago, Illinois 60624.

references

1. Louis Varney, G5RV, "G5RV Multiband Antenna . . . Up-to-date," *Radio Communications*, July, 1984, page 572.
2. "Band Switched Link Coupler," *The ARRL Antenna Book*, 14th edition, 1982, page 4-4 and 4-5.
3. William I. Orr, W6SAI, "Antenna Tuner for Center-Fed Antenna," *Radio Handbook*, 22nd edition, 1981, page 27.23.

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B108	2M	Yes	10W	80W	10A	$159
B1016	2M	Yes	10W	160W	20A	$249
B3016	2M	Yes	30W	160W	17A	$199
C22	220	No	2W	20W	5A	$ 79
C106	220	Yes	10W	60W	10A	$179
C1012	220	Yes	10W	120W	20A	$259
D24	440	No	2W	40W	8A	$179
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RS20M	16	20	109
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RS35M	25	35	149
RS50A	37	50	199
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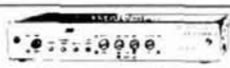

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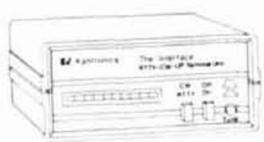

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✓ 163

Build a compact, powerful, portable unit for under $300

mobile solid-state kilowatt HF linear amplifier

Not too long ago my mobile kilowatt linear amplifier barely fit inside the trunk of my car and raised havoc with the electrical system each time a heavy load was applied. Because the efficiency of the old tube-type linears was low, the current drawn from the battery was high. Sometimes it even caused the car to stall. But progress in transistor technology has brought the mobile HF linear within reach of most Amateurs. If you're handy with a drill, a screwdriver, and a soldering iron, you're an ideal candidate for this project. No special skills are required beyond the desire to own a high-power mobile linear and the willingness to do some assembly work.

The efficiency of the amplifier is as high as 70 percent, depending on the condition of your battery and the accuracy of your antenna match. With a DC input of 830 watts, output power on 75 meters is as high as 580 watts. The total cost for the entire circuit — assuming a good supply of junk box parts is available — should be under $300. If you can get the transistors for free, the amplifier shouldn't cost you more than $150.

table 1. Test data on amplifiers matched for low end of HF band (2-7 MHz)

band (meters)	input drive (watts)	VSWR in	CW power out (watts)
160	35	1.2:1	500
75	30	1.2:1	500
40	45	1.5:1	450
20	50	2.0:1	450
15	50	2.5:1	350

amplifier circuit description

The linear amplifier consists of four amplifier modules capable of PEP power output levels in excess of 150 watts each (see **fig. 1**). Each module uses a pair of 75 watt RF transistors in a push-pull configuration for maximum efficiency and lowest possible distortion (see **fig. 2**). Both input and output impedances of each transistor module are preset at 200 ohms, which makes combining relatively easy. The input and output divider/combiner provides an ideal match with very low loss from the modules to the input/output connectors (see **fig. 3**).

A drive requirement of 50 watts was selected to allow the amplifier to be used with the standard exciters at reduced output. The actual gain of the amplifier depends on the frequency used and the transistors selected for the project. I had good results with the TRW PT9784 type. The transistors are slightly forward biased for good linear performance and maximum efficiency. No fancy biasing circuits are needed; just a few inexpensive resistors and a diode are sufficient. I found that temperature stability was not

By Frank Kalmus, WA7SPR, 7016 NE 138th Street, Kirkland, Washington 98034

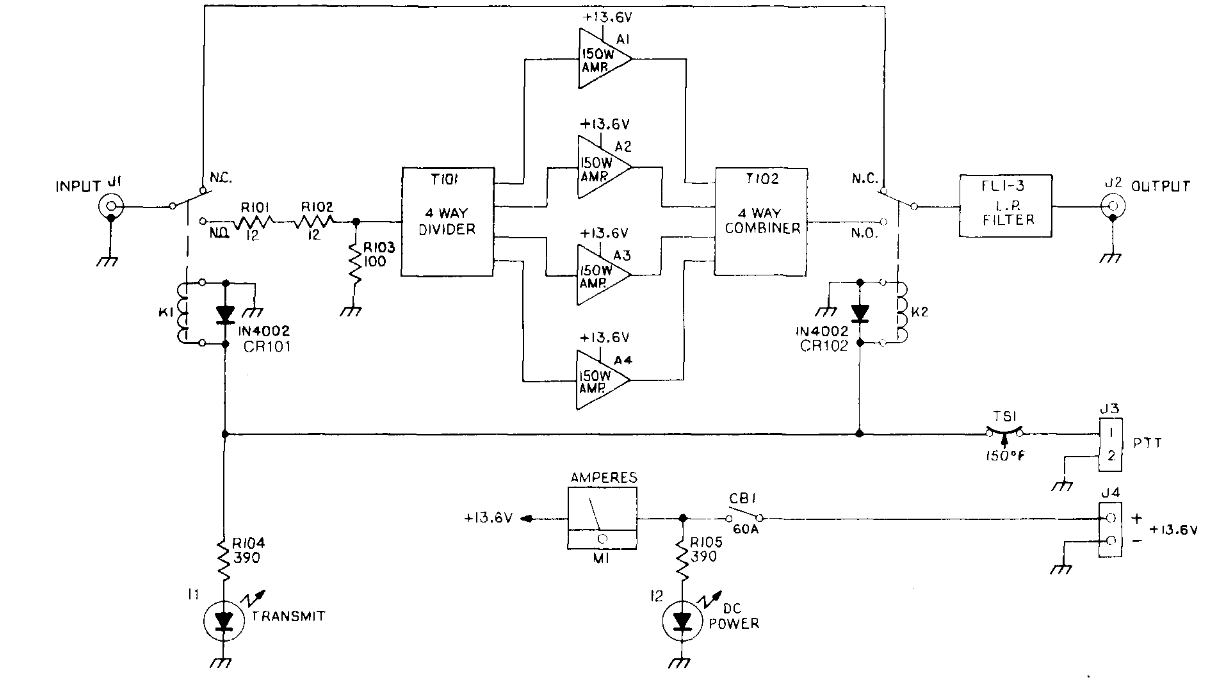
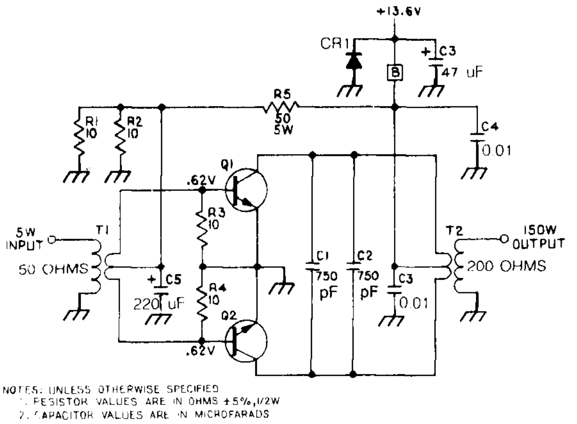


fig. 1. Mobile kilowatt block diagram.

a problem even when the unit was operated on CW for long periods of time. The two relays that form the



T1 input transformer

quantity	description
2	ferrite bead, 2643006301
2	PC board ends
2	brass rod, 3/4 inch (small rod)

T2 output transformer

quantity	description
2	ferrite bead, Stackpole No. 57-2857
2	PC board ends
2	brass rod, 1-7/16 inch (large rod)

fig. 2A. Schematic of basic building block: the 150-watt amplifier.

item	description	quantity
B	bead, shield	3
C1,C2	capacitor, SM 750 pF	2
C3	capacitor, 0.01 μF, 50 V	1
C4	capacitor, 47 μF, 35 V	1
C5	capacitor, 220 μF, 35 V	1
C6	capacitor, 0.01 μF, 1 kV	1
CR1	diode, MR500	1
Q1,Q2	transistor, RF, 75 watts TRW PT9784 or Motorola MRF454 and MRF412, MRF458	2
R1-R4	resistor, 10 ohm, 1/2 watt	4
R5	resistor, 50 ohm, 5 watts	1
	PC board	1
T1	transformer, input	1
T2	transformer, output	1

fig. 2B. Parts list for 150-watt RF amplifier (four required).

T/R switching are keyed by the PTT line, which is wired for 12 volts input from the transceiver in transmit mode. If your exciter doesn't provide you with 12 VDC when keying the microphone, you can rewire the PTT relay circuit so it will key when a ground is provided from the exciter.

The *T/R switch* provides automatic switching between the receiver and the amplifier during transmit and receive modes as well as during exciter "barefoot" operation (see **fig. 4**). When the circuit breaker is switched off, the amplifier is bypassed. With the DC power breaker in the ON position, the linear is switched on every time you key the microphone; you are then transmitting at a kilowatt without having to worry about high voltages or battery drain.

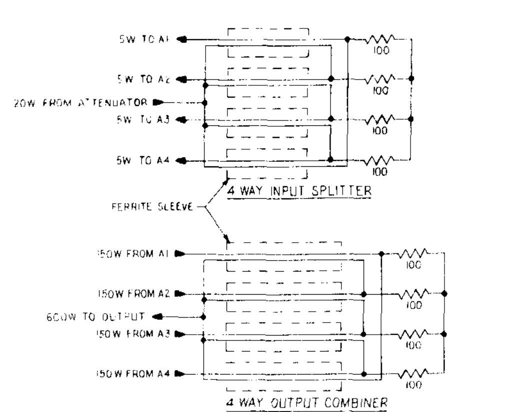


fig. 3A. Interconnection diagram for 4-way input splitter and output combiner.

description	*quantity*
PC board	*2*
bead, Stackpole No. 57-2857	*4*
standoff, Sealectro, 023-5702-000-709	*9*
insulator, H.H. Smith No. 2604	*1*
resistor, 220 ohm, 2 watts	*8*
No. 16 buss — 4-1/2 inch	*8*
sleeving — 2.9 inch (teflon)	*8*

fig. 3B. Parts list for 4-way input splitter and output combiner.

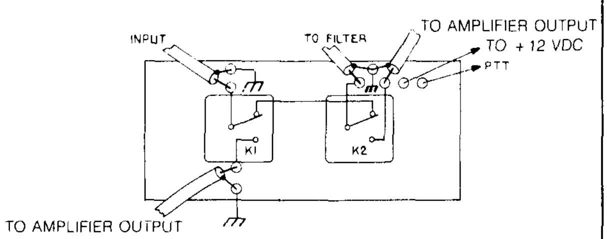
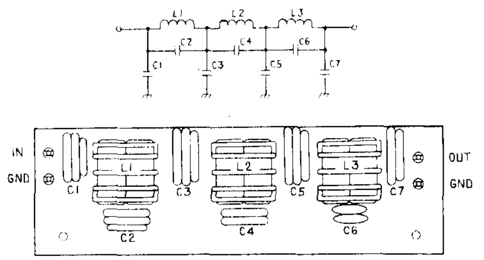


fig. 4. Transmit/receive, switch connections.

The *input attenuator* consists of a resistive power divider that incorporates high frequency compensation to achieve bandpass response flatness. The resistors used are of the "non-inductive" type and are rated at 25 watts.

A 60-ampere panel meter monitors the DC current drain from the battery. (This was achieved using a 40-amp meter. The dial reading is multiplied by 1.5.) On CW it is possible to get readings as high as 60 amperes. Though difficult to read on the meter, PEP currents on SSB are as high as 75 amperes. The average SSB power consumption is less than 200 watts, or about 15-18 amperes DC. The average automobile battery and electrical system should not have any problem powering this amplifier. It is,



band (meters)	*L1*	*L2*	*L3*	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*
75/80	*2.0*	*1.6*	*1.6*	*458*	*78*	*848*	*370*	*760*	*296*	*290*
40	*1.2*	*0.9*	*0.9*	*282*	*47*	*526*	*229*	*470*	*180*	*180*
15/20	*0.4*	*0.4*	*0.4*	*94*	*15*	*182*	*82*	*164*	*68*	*68*

fig. 5A. Low-pass filter schematic, parts placement diagram, and component values.

item	*description*	*quantity*
C1	*capacitor, 390 pF, ceramic, 2 kV, 5 percent*	*1*
C1	*capacitor, 68 pF, ceramic, 3 kV, 5 percent*	*1*
C2	*capacitor, 39 pF, ceramic, 3 kV, 5 percent*	*2*
C3	*capacitor, 390 pF, ceramic, 2 kV, 5 percent*	*2*
C3	*capacitor, 68 pF, ceramic, 3 kV, 5 percent*	*1*
C4	*capacitor, 270 pF, ceramic, 2 kV, 5 percent*	*1*
C4	*capacitor, 100 pF, ceramic, 4 kV, 5 percent*	*1*
C5	*capacitor, 390 pF, ceramic, 2 kV, 5 percent*	*1*
C5	*capacitor, 270 pF, ceramic, 2 kV, 5 percent*	*1*
C5	*capacitor, 100 pF, ceramic, 4 kV, 5 percent*	*1*
C6	*capacitor, 120 pF, ceramic, 3 kV, 5 percent*	*2*
C6	*capacitor, 56 pF, ceramic, 3 kV, 5 percent*	*1*
C7	*capacitor, 120 pF, ceramic, 8 kV, 5 percent*	*2*
C7	*capacitor, 50 pF, ceramic, 3 kV, 5 percent*	*1*
L1	*inductor, 2 μH*	*1*
L2,L3	*inductor, 1.6 μH*	*2*
	PC board	*1*

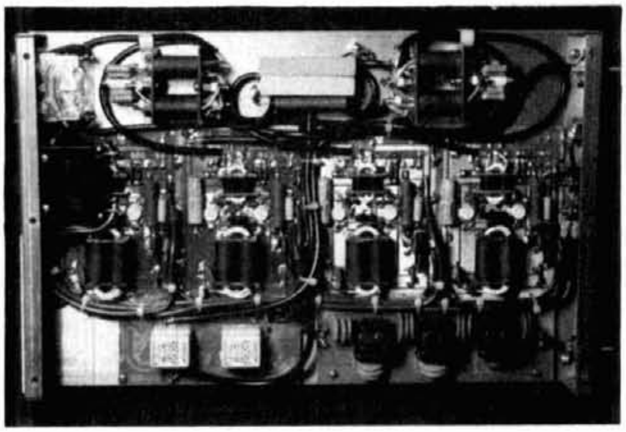
fig. 5B. Parts list for FL1 filter subassembly (75 and 80 meters). Note: In this and other parts lists, repetition of the line designation signifies adding these components to make one effective component. For example, under C1, 390 and 68 pF capacitors are combined to achieve 458 pF.

item	*description*	*quantity*
C1	*capacitor, 100 pF, ceramic, 4 kV, 5 percent*	*2*
C1	*capacitor, 82 pF, ceramic, 5 kV, 5 percent*	*1*
C2	*capacitor, 47 pF, ceramic, 3 kV, 5 percent*	*1*
C3	*capacitor, 270 pF, ceramic, 2 kV, 5 percent*	*1*
C3	*capacitor, 200 pF, ceramic, 3 kV, 5 percent*	*1*
C3	*capacitor, 56 pF, ceramic, 3 kV, 5 percent*	*1*
C4	*capacitor, 100 pF, ceramic, 3 kV, 5 percent*	*1*
C4	*capacitor, 82 pF, ceramic, 5 kV, 5 percent*	*1*
C4	*capacitor, 47 pF, ceramic, 3 kV, 5 percent*	*1*
C5	*capacitor, 270 pF, ceramic, 2 kV, 5 percent*	*1*
C5	*capacitor, 200 pF, ceramic, 3 kV, 5 percent*	*1*
C6	*capacitor, 68 pF, ceramic, 3 kV, 5 percent*	*1*
C6	*capacitor, 56 pF, ceramic, 3 kV, 5 percent*	*2*
C7	*capacitor, 68 pF, ceramic, 3 kV, 5 percent*	*1*
C7	*capacitor, 56 pF, ceramic, 3 kV, 5 percent*	*2*
L1	*inductor, 1.2 μH*	*1*
L2,L3	*inductor, 0.9 μH*	*2*
	PC board	*1*

fig. 5C. FL2 filter subassembly (40 meters). See note in fig. 5B.

item	description	quantity
C1	capacitor 47, pF, ceramic, 3 kV, 5 percent	2
C2	capacitor, 15 pF, ceramic, 5 kV, 5 percent	1
C3	capacitor, 82 pF, ceramic, 5 kV, 5 percent	1
C3	capacitor, 100 pF, ceramic, 4 kV, 5 percent	1
C4	capacitor, 82 pF, ceramic, 5 kV, 5 percent	1
C5	capacitor, 39 pF, ceramic, 3 kV, 5 percent	1
C5	capacitor, 56 pF, ceramic, 3 kV, 5 percent	1
C5	capacitor, 68 pF, ceramic, 3 kV, 5 percent	1
C6	capacitor, 68 pF, ceramic, 3 kV, 5 percent	1
C7	capacitor, 68 pF, ceramic, 3 kV, 5 percent	1
L1	inductor, 0.4 μH	1
L2,L3	inductor, 0.37 μH	2
	PC board	1

fig. 5D. FL3 filter subassembly (15-20 meters). See note in fig. 5B.



All components are clearly visible in bottom view of kilowatt linear amplifier.

however, suggested that you use at least No. 8 wire for the DC power cable.

filtering cooling and testing

RF filtering is necessary to meet FCC requirements of minimum 40 dB harmonic rejection (see **fig. 5**). A seven-pole elliptical filter is used in the 75-meter unit. Typical harmonic performance was better than 50 dB down from the main carrier.

Cooling was found to be no problem on SSB. Average voice conditions will not cause dangerous overheating if the amplifier is mounted in a well-ventilated area. But just in case, a temperature sensor switch inserted in the T/R relay circuit will shut the amplifier down if the temperature exceeds a preset level of approximately 150 degrees F, thus preventing serious damage to the equipment.

After all the assembly and wiring are done, some preliminary testing is required before applying power to the amplifier (see **fig. 6** for overall assembly parts layout). Using an ohmmeter, connect the black lead to ground and the red lead to the 12-volt line to make sure there are no shorts. Connect the red lead to each collector of all eight transistors to check for short circuits. Measure approximately 2.5 ohms to ground at each base and 12.5 ohms to ground at each collector. Measure continuity from the center pin of the input to the center pin of the output connector. However, neither one of the RF connector center pins should read short to ground.

Because this mobile amplifier was designed for

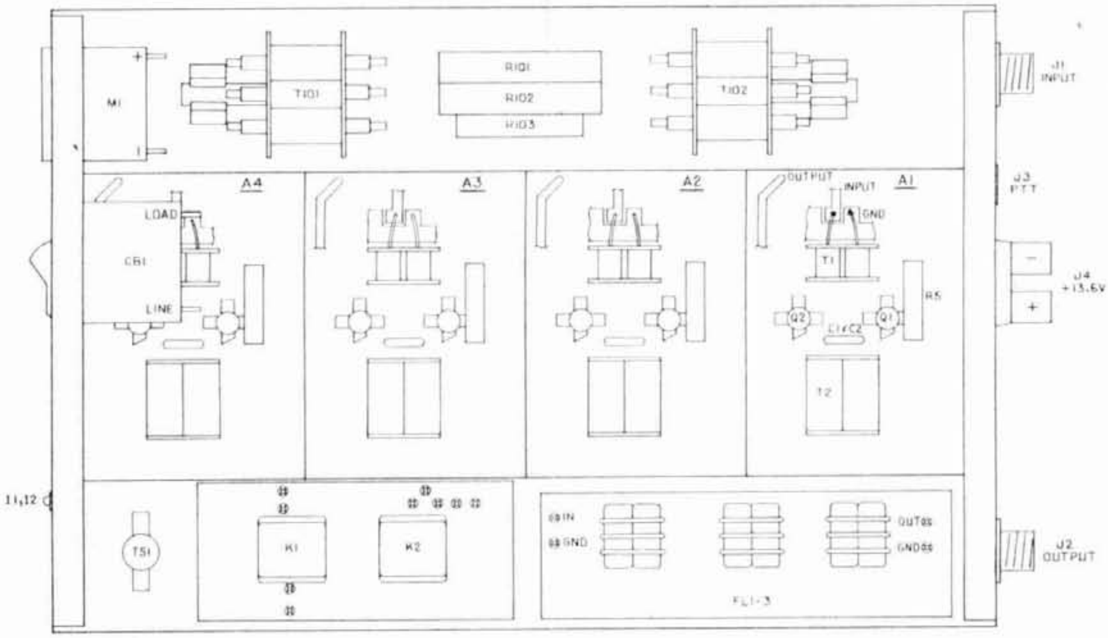


fig. 6A. Overall assembly and parts location guide.

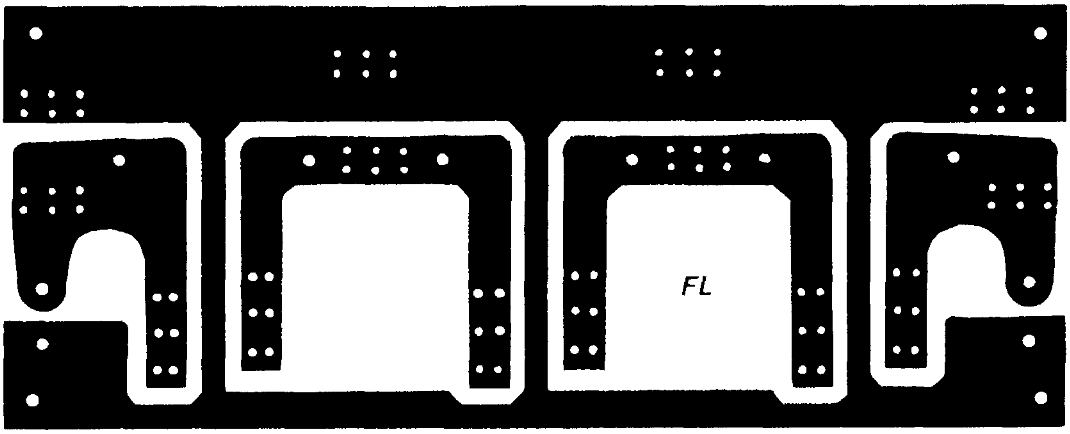


fig. 7A. Filter printed circuit board.

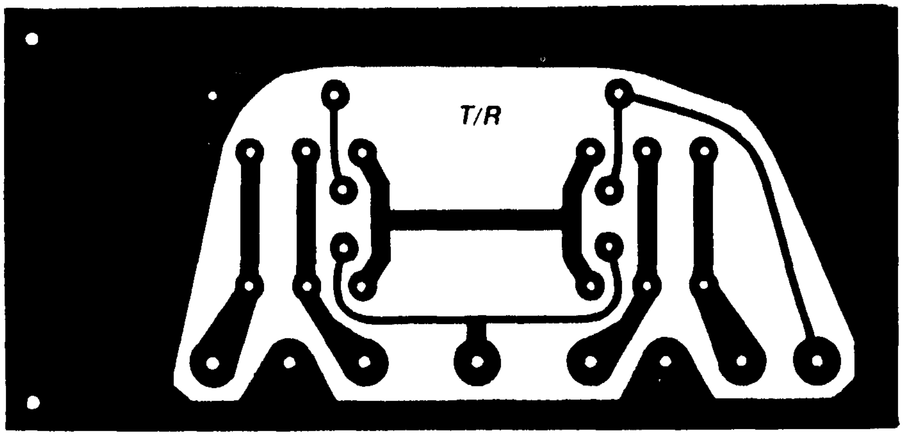


fig. 7B. T/R switching printed circuit board.

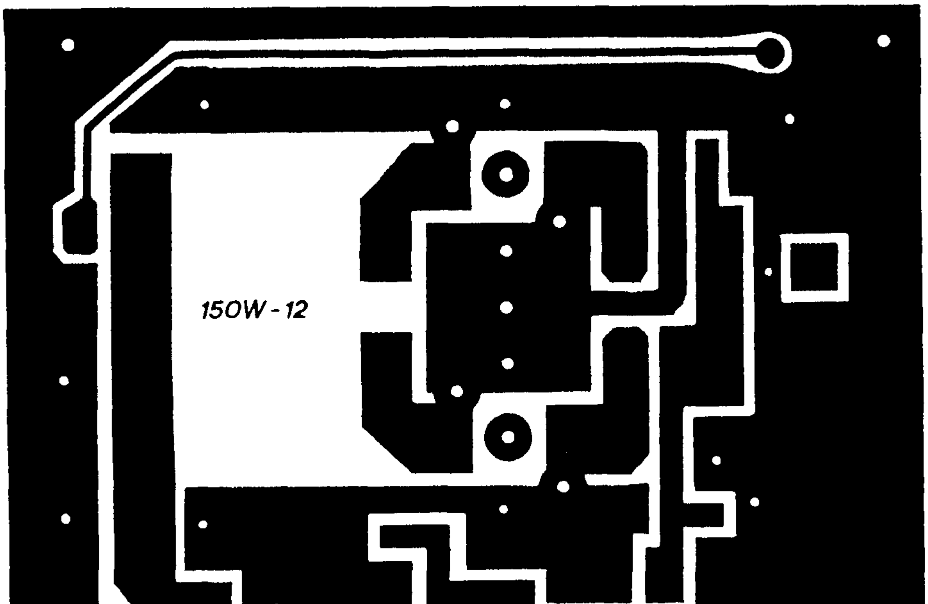


fig. 7C. 150-watt amplifier printed circuit board.

item	description	quantity
cabinet	panel, front	1
and	panel, rear	1
heatsink	cover, bottom	1
enclosure	bracket, mounting	1
	heatsink, 15 inches, Thermalloy No. 6130	1
A1-A4	amplifier, RF, 150 watt	4
CB1	circuit breaker, 60 amps, Airpax No. UPGX6-1-52-503	1
CR101,CR102	1N4002 diode	2
FL1-3	filter, low-pass	3
I1	lamp, LED red, Monsanto No. MV5053	1
I2	lamp, LED green, XC556-G	1
J1,J2	connector, Amphenol No. SO238	2
J3	connector, PTT, Cinch No. S-302-AB	1
J4	connector, DC power, H.H. Smith No. 269RB	1
K1,K2	transmit/receive relay, Guardian No. 1365PC-2C-12 VDC	2
M1	meter, 0-60 amperes	1
R101, R102	resistor, non-inductive, 12 ohm, 25 watt	2
R103	resistor, non-inductive, 100 ohm, 10 watt	1
R104,R105	resistor, 390 ohm, 1/2 watt	2
T101,T102	divider/combiner	2
	T/R PC board	1
	cables, various, 50 ohm	16
	lockwasher, No. 4	95
	screw, 4/40 × 3/8-inch round	24
	screw, 4/40 × 1/2-inch round	7
	screw, 4/40 × 5/16-inch round	16
	screw, 6/32 × 5/16-inch flat	10
	screw, 6/32 × 5/16-inch round	6
	spacer, 1/4-inch	7
	standoff, teflon, Useco No. 1456	3
	washer, No. 4 flat	48
TS1	thermal switch, Therm-o-disc No. CLR 160°	1

fig. 6B. Parts list for overall assembly.

single band operation, a single low-pass filter was installed. If you want to use yours on more than one band, you can build the three filters described in the parts list and use them externally. If you decide to do so, be careful not to operate the amplifier on the "wrong" band for the filter used; doing so can cause permanent damage to the amplifier. It will also be necessary to delete the built-in filter unless you install the 15-20 meter filter internally and use the two other filters externally. The built-in filter will automatically pass both other bands if left in permanently.

conclusion

Although a complete and detailed parts list, including schematics and PC board layouts (see **fig. 7A, B, C**), has been provided, this article is intended for use by the licensed Radio Amateur only. Additional information can be provided by the author at the reader's request by mail only, provided the request is accompanied by a copy of a valid Amateur Radio license and a SASE. No other inquiries will be answered.

This amplifier was designed to be used on 160/80/75/40 and 20 MHz. Any attempt to extend the frequency range will most likely result in the destruction of the RF power transistors.

Parts for this project are available from the author at $495.00 for all parts included in the parts list, or $339.00 for all listed parts except transistors. Only one filter (for 15/20 meters) is included in these packages. Contact Frank Kalmus, WA7SPR, 7016 NE 138th Street, Kirkland, Washington 98034, for information.

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DX FORECASTER

Garth Stonehocker, KØRYW

more on ionosphere matching

A method of tailoring an antenna system for maximum signal at a DX location was presented in last month's column. A short computer program for determining the angle of the maximum signal lobes from horizontal antennas, for specific antenna heights above ground, was included.

Correlating this take-off angle with distance requires a few calculations, however. For an approximation, first divide the distance between the transmitting and receiving location (determined from a map with mileage markers or a globe) into equal interval hops. Then, using this hop distance, refer to **fig. 1** to find the required departure (or take-off) angle.

But how can you determine which of the several ionospheric heights provided in **fig. 1** should be used? Simply refer to **table 1**, which indicates representative mid-latitude heights appropriate for use at various times of the day. Using **fig. 1** and **table 1** for the computer program modifications shown in **fig. 2**, you have sufficient information to determine the antenna height that will enhance your DX performance.

To use **table 1**, add the increment (cumulatively) for each month between the months listed or subtract the increment after June. For example, the height of the ionosphere in March at noon local time is: 235 + (33•2) = 301 km. For those who have a computer, the MINIMUF 3.5 program can be used to obtain several useful operating parameters, including take-off angle (departure angle) for the path of interest.[1] Modify the program by inserting the new lines indicated in **fig. 2**.

This modification provides an hourly indication of MUF with great circle distance in kilometers, azimuthal bearings to station and take-off angle in degrees for the path.

last-minute forecast

The second week of the month is expected to favor DX on the high bands, with 10 to 30 meter performance correlating with the beginning of a more energetic flux and sunspot period for the year. Transequatorial propagation, enhanced by any geomagnetic field disturbances toward the end of the week, should provide the best openings of the month.

Listen to WWV at 18 minutes after the hour for high values of the A and K indices. The last week will probably be best for low-band operation although there is a probability that the geomagnetic field will also be disturbed then. Work the stations while you can before the static builds over the coming months.

No significant meteor showers are scheduled to appear in February. A full moon will occur on the 5th, with its perigee on the 8th.

band-by-band summary

Ten meters will be open (local time) to the southeast for a short period before noon, to the south at noon, and to the southwest in the afternoon. The openings will be longer and more frequent when the solar flux is at its 27-day cycle maximum.

Fifteen and twenty meters, almost always open to some part of the world, will be the main daytime DX bands. Twenty should stay open on long southern paths into the night, while 15 will drop out in the late afternoon. Operate 15 first and move down to 20 meters. DX is 5000 to 7000 miles (8000 to 11,200 km) on these bands and one-long-hop transequatorial propagation is also possible even more often than on 10 meters. In addition transequa-

table 1. Approximate diurnal height of ionosphere during the year.

local time:	midnight	6 A.M.	noon	6 P.M.
height (km):	all 283	265-290	235-400	225-310
increment:		5	33	30
month:		January - June	January - June	Equinox - June

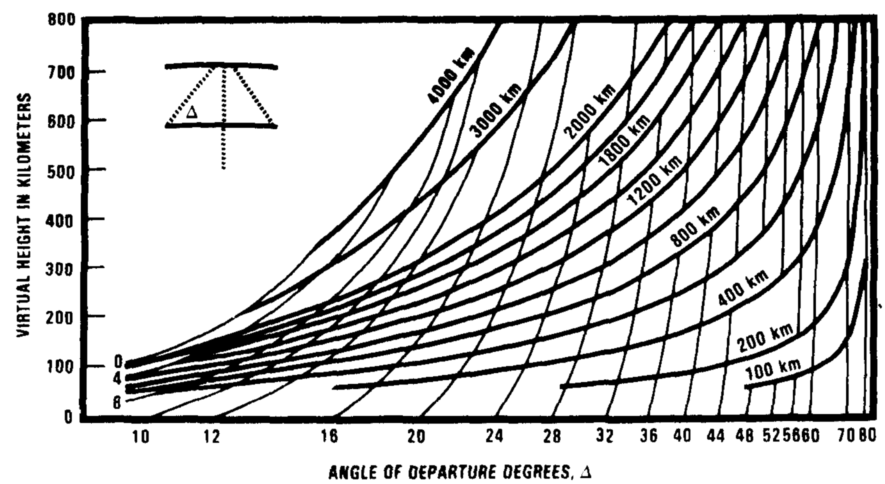

fig. 1. Transmission curves showing vertical angles.

FEBRUARY

WESTERN USA

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

MID USA

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

EASTERN USA

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

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

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

```
    :
 652 H2=-176+(1490/M2)
 653 REM CALC T.O. ANGLE
 654 Q5=ATN(H2/Q4)
 655 Q6=Q5*R1
    :
 695 PRINT "GREAT CIRCLE DISTANCE, XMTR TO RCVR=",Q1
 696 PRINT "GREAT CIRCLE BEARING=",F,"OR",F1
 698 PRINT "TAKE OFF ANGLE=",Q6
    :
1071 Q1=G1*R1*111.12
1072 J1=0
1073 IF Q1<4000 GO TO 1080
1074 J1=1
1075 Q2=Q1
1076 FOR J1=1 TO 6
1077 Q2=Q2-4000
1078 IF Q2<4000 GO TO 1080
1079 NEXT J1
1080 Q3=Q1/(J1+1)
1082 Q4=Q3/2
1085 K6=1.59*G1
    :
1115 F3=100
    :
1271 REM CALCULATE BEARING, XMTR TO RCVR, F
1272 E=(SIN(L2)-(SIN(L1)*COS(G1)))/(COS(L1)*SIN(G1))
1274 F=ACS(E)*R1
1276 F1=360-F
    :
1772 F2=G2/M9
1774 IF F2>F3 THEN 1779
1776 F3=F2
    :
1782 G3=G2
1784 M2=G3/F3
1786 IF M2>2.2 GO TO 1790
1788 M2=2.2
    :
```

fig. 2. Modified MINIMUF 3.5 program listing.

torial propagation will favor evening hours during periods of high solar flux and disturbed geomagnetic field conditions.

Thirty and forty meters are both day and night bands. Intermediate distances (1000 to 1500 miles or 1500 to 2200 km) in any direction represents daytime DX. Nighttime DX on these bands may be expected to offer greater distance paths than on 80 meters and, like 80, follow the darkness path across the sky. Reduced midday signal strengths and distances may occur on days of high solar flux values or periods of anomalous absorption, with 30-meter openings disappearing in the pre-dawn hours on the morning after a high solar flux value has occurred.

Eighty and one-sixty meters will exhibit short-skip propagation during the daylight hours and lengthen for DX at dusk. These bands follow darkness, opening to the east just before your sunset, swinging more to the south near midnight, and ending up in the Pacific areas during the hour or so before dawn. Except for daytime short-skip signal strengths, high solar flux values hardly affect these bands. On some days, however, the condition known as anomalous absorption will diminish day *and* night signal strengths. The 160-meter band opens later and ends earlier.

reference

1. Robert B. Rose, K6GKU, "MINIMUF: A Simplified MUF-Prediction Program for Microcomputers," *QST*, December, 1982, page 36.

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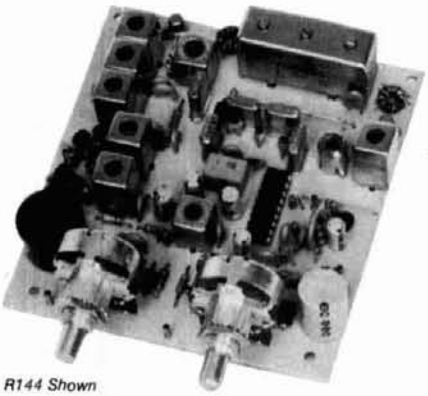

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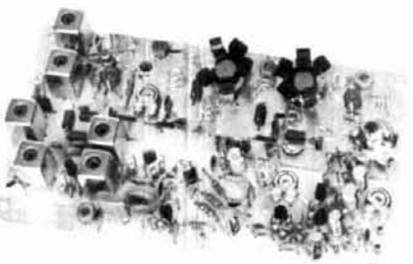

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LNG-144	137-150 MHz	$49
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LNG-40	30-46 MHz	$64
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- P30W, VHF Wired/Tested $33
- P432K, UHF Kit less case $21
- P432W, UHF Wired/Tested $36

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Model	Tuning Range	Price
HRA-144	143-150 MHz	$49
HRA-220	213-233 MHz	$49
HRA-432	420-450 MHz	$59
HRA-( )	150-174MHz	$69
HRA-( )	450-470 MHz	$79

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	Antenna Input Range	Receiver Output
VHF MODELS	28-32	144-148
Kit with Case $49	50-52	28-30
Less Case $39	50-54	144-148
Wired $69	144-146	28-30
	145-147	28-30
	144-144.4	27-27.4
	146-148	28-30
	144-148	50-54
	220-222	28-30
	220-224	144-148
	222-226	144-148
	220-224	50-54
	222-224	28-30
UHF MODELS	432-434	28-30
Kit with Case $59	435-437	28-30
Less Case $49	432-436	144-148
Wired $75	432-436	50-54
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For VHF,	28-30	144-146
Model XV2	28-29	145-146
Kit $79	28-30	50-52
Wired $149	27-27.4	144-144.4
(Specify band)	28-30	220-222*
	50-54	220-224
	144-146	50-52
	50-54	144-148
	144-146	28-30
For UHF,	28-30	432-434
Model XV4	28-30	435-437
Kit $99	50-54	432-436
Wired $169	61.25	439.25
	144-148	432-436*

*Add $20 for 2M input

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

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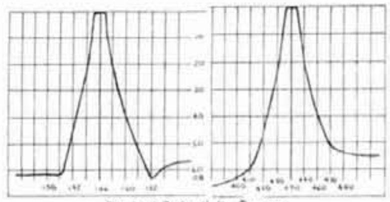

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the high-tech repeater: designing and building an FM translator

Modular construction simplifies assembly, operation, and maintenance

In "Linear Translators," (*ham radio*, September, 1983, page 14) James Eagleson, WB6JNN, described narrowband techniques useful in the design of improved FM repeaters. This article extends that discussion to include the design of lossless feedback amplifiers with low SWR and low noise figure; theory, design and performance of the valid signal detector; techniques for identifying a translator; and site selection and sensitivity/transmit power considerations for putting up a co-channel repeater. — **Editor.**

The 146.34/94 repeater designed and built by the Sierra Amateur Radio Club in Ridgecrest, California, is not actually a repeater, but rather an FM translator.

In a generic sense, translators *are* repeaters, in that both perform similar functions. Both translators and repeaters receive signals on one frequency and retransmit them, with increased power, on a second frequency.

There are important differences, however. A repeater is a transmitter with its audio input connected to the audio output of a receiver. A translator, on the other hand, heterodynes the received signal to the intermediate frequency (IF), amplifies it, and then heterodynes it to the transmit frequency. In a translator, the signal never exists as audio.

The primary advantage of true repeaters is that they can be built from surplus or otherwise easily obtainable parts. Translators — often representing the "state-of-the-art" — must be custom-designed and custom-built from parts that are likely to be more costly and perhaps difficult to find. But because translators offer improved performance and excellent signal quality, we opted to design a translator rather than a repeater and accept both the increased challenge and expense.

Design and construction of the translator was a shared effort. Although John Piri, WD6CSV, and I were responsible for overall system design and construction, Chuck Swedblom, WA6EXV, took charge of design and construction of the identifier. Ron Skatvold, WB6VXI, designed and built the transmit power amplifier. George Kreager, KB6HC, was responsible for construction of the transmit and receive filters, and Elvy Hopkins, ND6Q, designed and supervised construction of the antennas, feedlines, and masts.

Many others assisted with general planning, frequency choice, site selection, and innumerable additional details. The project, from initial conception to installation and operation, took approximately 10 months.

translator design: overview

The translator was designed and constructed as seven modules, as shown in the block diagram of **fig. 1**. These modules include the down-converter, the IF section, the up-converter, the power amplifier, the control module, the valid signal detector, and the identifier. The down-converter receives the signals

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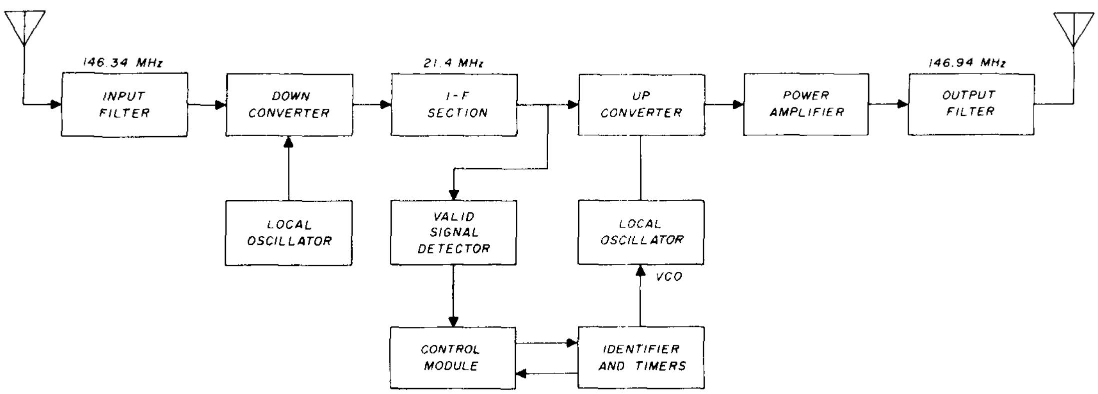

fig. 1. Block diagram of translator. No audio circuits are used in this 2-meter FM repeater.

passed by the input filter and heterodynes them to the 21.4 MHz IF. The IF section filters and amplifies these signals. A total of 10 poles of crystal filtering are included so that the only signals retransmitted are those originating in the translator's input passband. The IF section provides the major amount of amplification, with over 100 dB of gain. The up-converter heterodynes the IF signal to the transmit frequency. In addition, it has a crystal oscillator for inserting a substitute carrier during identification if there is none at the input. The power amplifier amplifies the 10-mW signal from the up-converter to the 10-watt level. The identifier controls the timing of the translator control and generates the identifier tones. The timers for identifying the translator, timing out the transmitter, and setting the code rate are included in the identifier. The identifier depends upon input from the valid signal detector. The valid signal detector samples the 21.4 MHz IF to measure the signal-to-noise ratio of the signal in the IF passband. When the signal-to-noise ratio is above a preset level, the transmitter is turned on and the identifier starts timing. The control module controls both the transmitter and the carrier insertion oscillator.

The sensitivity of the translator is very good — about − 125 dBm (0.12 microvolt) at the receive filter. Limited transmit power and directional antennas control the coverage area of the translator.

operation

The site selection study was carefully performed, taking into consideration the club's desire to have a semi-local repeater, the lay of the land, the distribution of population centers, and the location of existing repeaters. Briefly, the area consists of a very large valley surrounded on all sides by mountains rising to peaks 5000 to 8000 feet high, with population centers small and sparsely located. To serve the community and the major highway nearby, and to keep the repeater truly local, the site selection committee recommended that the translator be located not on a mountain top, but 200 feet above the floor of the southern end of the Indian Wells Valley, using north-facing directional antennas. The site selection study showed that a balanced repeater — neither an alligator nor an elephant — with a transmit power of approximately 10 watts would cover the desired area.

The site selected allows the translator to serve Amateurs using handheld transceivers in the Ridgecrest area and those using proper mobile equipment transmitting 2 watts or more on the nearby highway for more than 50 miles. The only co-channel interference occurs with base stations operating in the overlap zone with a repeater to the north. No tone squelch is necessary because there are only one or two Amateurs in the overlap zone, and they generally use directional antennas.

The translator was designed to provide high-quality signal reproduction indistinguishable from simplex. (Indeed, if the user's transmitter is slightly off frequency, the translator output is off frequency a like amount.) On-the-air experience confirms that this goal was met; when the output is compared with the input, no discernible difference can be heard. In fact, to the first-time user, the identifier is the only clue that there is a repeater on the channel.

To keep the design simple the translator has a very short squelch tail, and no carrier tail at all. We were surprised to discover how many transient Amateurs were confused by the lack of the usual carrier tail. As an experiment we tried using the translator *with* a carrier tail. After a trail period of two months the club membership voted to remove the carrier tail; operation without it is so clean that the presence of the tail was actually a nuisance to local operators.

The translator provides reliable coverage for 50 miles

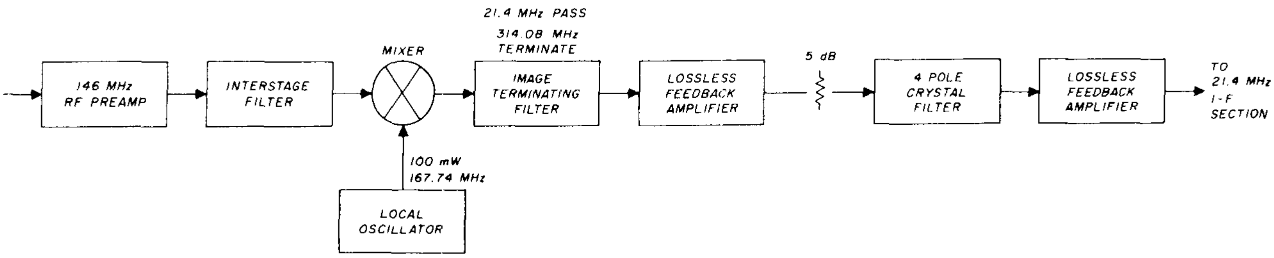

fig. 2. Down-converter block diagram. The down-converter is designed for wide dynamic range.

to the north. Because everything (except the backup-power batteries) is solid-state and designed for reliability, we have enjoyed excellent results. Periodic maintenance to service the nickel cadmium emergency power batteries and retune the crystal oscillators is scheduled once every two years. Only one failure, caused by the failure of a 2N2925 transistor in the control module, has occurred in seven years of service.

down-converter design

The down-converter, shown in **fig. 2**, consists of a crystal-controlled local oscillator, an RF preamplifier, an RF mixer, and the first stage of the IF amplifier with a 4-pole pair crystal filter. The IF chosen was 21.4 MHz because this was the highest frequency for which high-performance crystal filters were readily available. This module was designed for weak-signal sensitivity in the presence of strong interfering signals. Because the transmitter and receiver operate simultaneously, the potential for intermodulation distortion is ever-present; consequently, intermodulation performance was given high priority. *Failure to avoid intermodulation distortion causes repeaters to respond to signals at frequencies other than the designed input frequency.* We also wanted to design the translator for superior intermodulation performance in order to reduce the problems of keeping cavities tuned "just right."

For first-rate intermodulation performance it is essential to limit the gain before narrowband (crystal) filtering. For this reason, the preamp gain was limited to little more than 10 dB. In addition, a crystal filter was included as close as possible to the down-converter mixer as well as at the end of the IF chain. Lossless feedback was employed with the RF preamp to achieve low SWR and low noise figure simultaneously. The interstage bandpass filter has 1 dB of insertion loss. The interstage filter includes a notch at the image frequency and another notch at the most prominent spurious response frequency.

The RF mixer was also built from scratch. With a 100-mW LO the conversion loss was less than 5 dB, and the third-order intermod intercept point was +23 dBm. The image-termination filter following the mixer represents a 50-ohm match at 21.4 MHz and an open circuit at 146 MHz. It also includes a short circuit at the RF + LO frequency, which gives better intermodulation distortion than a 50-ohm match at that frequency.[1]

The crystal filter input impedance outside of its passband is significantly higher than the midband value. Reflecting a high impedance to an amplifier seriously reduces the third-order intercept performance of the amplifier. It is, therefore, desirable to transform to a low impedance the above-nominal impedance reflected to the amplifier for signals outside the crystal filter passband. The impedance inverting property of a properly designed Pi network is desirable for this purpose. Certain L networks will also provide the same above-nominal impedance transformation, but the Pi network has the advantage of easy tunability with both variable capacitors returning to ground. For these reasons, all crystal filter impedance matching networks were of this design.

When the down-converter was designed it did not include the lossless feedback amplifier and 5-dB attenuator. We found that the RF preamplifier and mixer could handle a weak signal in the presence of multiple high-level inputs. But the output impedance of the mixer would change from a 50-ohm match with input levels above −10 dBm (−20 dBm at the input to the RF preamplifer), thus seriously degrading the passband flatness of the crystal filter in the presence of a strong off-frequency signal — in particular, the repeater output. An interstage amplifier with low noise figure, low intermodulation distortion, and a constant output impedance was needed. To keep distortion down, a low-gain amplifier was needed, but that implies feedback to limit gain. To achieve low gain, low noise, and low distortion, a lossless feedback amplifier was the answer.[2] Unfortunately, such amplifiers pass the impedance seen at the input to the output with little isolation. The 5-dB attenuator (**fig. 2**) was included so that the crystal filter is presented with a constant impedance with all RF input levels. The amplifier was designed with 6-dB gain, a low value in the interest of improved intermod performance. The transis-

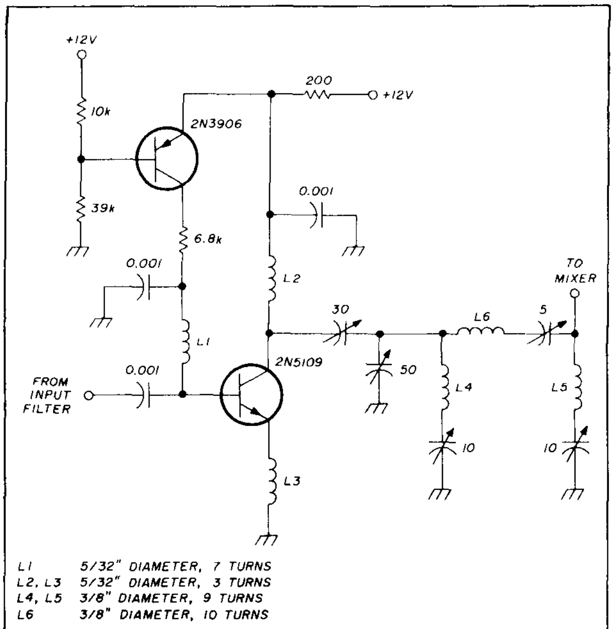

fig. 3. RF preamplifier schematic. Inductive reactance emitter degeneration is used to improve the preamp input SWR without significantly degrading the noise figure.

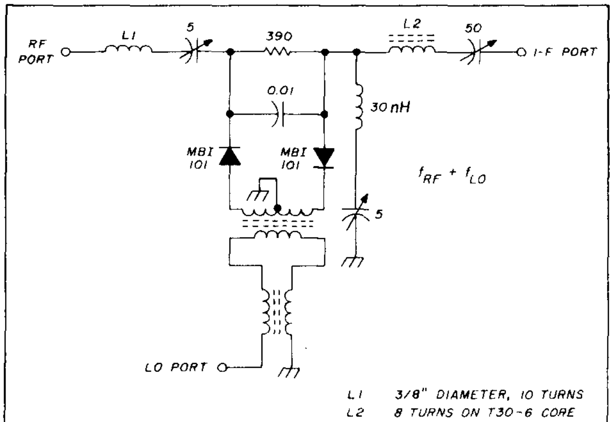

fig. 4. Single balanced mixer used in the down-converter and the up-converter. The transformers are wound on ferrite beads (μo = 64). The 30 nH and 5 pF variable capacitor comprise the f_{RF} + f_{LO} (314 MHz) termination impedance.

tor was biased for high third-order intermodulation intercept, and yielded better than a 3-dB noise figure. This design provides a good match for preserving the crystal filter passband flatness, and has low noise figure. Unfortunately, it does degrade the intermod distortion performance slightly.

Noise figure and gain calculations showed that the noise figure of the first stage following the crystal filter was important. The best noise figure attainable with conventional amplifiers was approximately 5 or 6 dB, which was insufficient. The problem was that the crystal filter must have an impedance match to have a flat passband response. However, having a match with a conventional amplifier guarantees a poor noise figure.[3] Again the solution was a lossless feedback amplifier for the IF amplifier following the crystal filter. By favorably biasing the amplifier for improved noise figure, a 2-dB noise figure was attained. A conventional amplifier was cascaded with the lossless feedback amplifier for a net gain of 30 dB in the down-converter.

The local oscillator (LO) for the down-converter (and the up-converter) uses double-tuned interstage filtering to keep all spurious outputs in the LO output below 60 dBc.[4] The local oscillator puts out 100 mW of LO power to the mixer.

Figure 3 is the schematic of the RF preamplifier. The 2N3906 was included to control the collector current through the 2N5109 independently of temperature. The 146-MHz preamp has 11 dB of gain. It achieves a 3-dB noise figure with an input SWR of approximately 2:1. The SWR of the preamp must be low so that the response of the RF input filter, which precedes the preamp, will not be distorted. Low SWR and low noise figure were achieved with lossless feedback. The lossless feedback was obtained with inductive reactance in the emitter of the RF transistor,[5] which in turn determined the SWR. An SWR of nearly 1:1 is possible, but at the expense of the noise figure. The value of inductance chosen was a compromise between low noise and low SWR.

Figure 4 is the schematic of the RF mixer. It was designed to convert an RF signal to the IF. To keep the intermodulation distortion down, 100 mW of LO power was applied to the mixer. The 390-ohm resistor develops a back bias voltage from the LO current flowing through the diodes. This bias voltage increases the reverse voltage for the off state of the diodes, which allows a greater peak-to-peak RF input level for the same distortion level. A single balanced mixer, it requires a diplexer to separate the RF from the IF, which share a common port. Generally a diplexer is composed of high-pass and low-pass filter sections sharing the common port. However, it was considerably easier to design and tune a diplexer made from series-tuned filter sections. This is acceptable in a frequency converter for use in a repeater, where RF bandwidth is not a consideration.

IF module

The IF (21.4 MHz) was chosen to take advantage of readily available high-quality crystal filters. Although no problem has been observed, a higher frequency

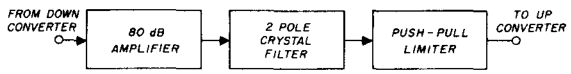

fig. 5. IF module block diagram. This module is physically located in two separate enclosures. An additional 25 dB of IF gain is included in the down-converter enclosure.

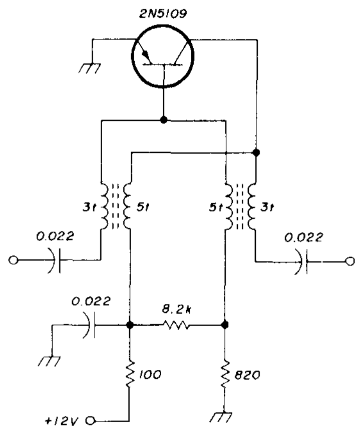

fig. 6. 6 dB lossless feedback IF amplifier. For higher gain reduce 3 turn windings to 1 or 2 turns. For lower noise figure increase 100 ohm resistor to 330 ohms. The 0.022 μF capacitors are very small monolithic ceramics.

would have made image rejection and spurious response suppression more effective. The IF section block diagram is shown in **fig. 5**. More than 100 dB of IF gain was used, resulting in 20 dB of excess gain before limiting. The excess gain was desired to ensure that the limiter was hard limited under all conditions. It was not possible to put that much gain in one box without the risk of oscillations from feedback. To prevent that from happening, the gain stages were distributed among three separate enclosures. The use of double-shielded interconnecting coax cables also minimized coupling.

Figure 6 is the schematic of the lossless feedback IF amplifier used on each side of the crystal filter. The two amplifiers differ only in the turns ratios of the transformers and the bias currents of the transistors. To keep the circuit physically small, the transformer cores were 0.100-inch diameter ferrite toroids with a permeability of 125. Considerable care must be used in the layout of this amplifier so that stray reactances do not degrade performance. This amplifier design is useful to about 50 MHz.

The translator includes a limiter in the IF to maintain constant power level to the up-converter mixer. A 2-pole-pair crystal filter precedes the limiter to prevent off-frequency IF amplifier noise from suppressing a weak signal in the limiter. The effectiveness of a limiter is degraded if limiting is not symmetrical; that is, if limiting of the positive and negative swings of the IF waveform are not equal. To achieve symmetrical limiting, a push-pull limiter was employed. By ensuring that the limiter is limited even on noise, there is no variation in translator performance with signal strength, supply voltage, or ambient temperature.

We decided not to include SSB signal-handling capability for this repeater. The only changes necessary for passing SSB would be to use AGC instead of limiting, and to use a linear transmit amplifier. A limiter was chosen to provide constant signal amplitude to the up-converter with minimum circuit complexity. If AGC were to be used instead, the amplitude components of a weak signal would have required a linear power amplifier to keep intermodulation products from splattering across adjacent channels.

up-converter

Figure 7 is the block diagram of the up-converter. A 4-pole crystal filter was included just before the IF signal was up-converted to the transmit frequency. This guarantees that the only signals transmitted are within the transmit channel bandwidth.The up-converter heterodynes the 21.4 MHz signal to 146.94 MHz.

Because there are no audio circuits in the translator, the repeater cannot be identified in the usual manner of inserting audio tones into the modulator. In this translator the identification modulation is accomplished by frequency modulating the crystal-controlled local oscillator in the up-converter with the identifier tones. This conveniently adds the identifier tones to the user's signal. If no carrier is present during the identification time, a substitute carrier is inserted from a crystal oscillator.

The up-converter mixer is identical to the mixer in the down-converter. It is very important to have a low distortion mixer in the up-converter so that spurious outputs are below the FCC limits. The IF amplitude was adjusted, with the limiter bias current, until the spurs were sufficiently below the FCC limits. This resulted in approximately 1-mW output from the mixer. Several stages of 146-MHz amplification were required to raise the 1 mW to the final 10-watt level. Most of that gain was provided by the power amplifier module. The power amplifier was designed as class C for high efficiency.

When there is no input to the repeater, the output from the crystal filter in the up-converter is full-power noise. If the control module calls for the translator to

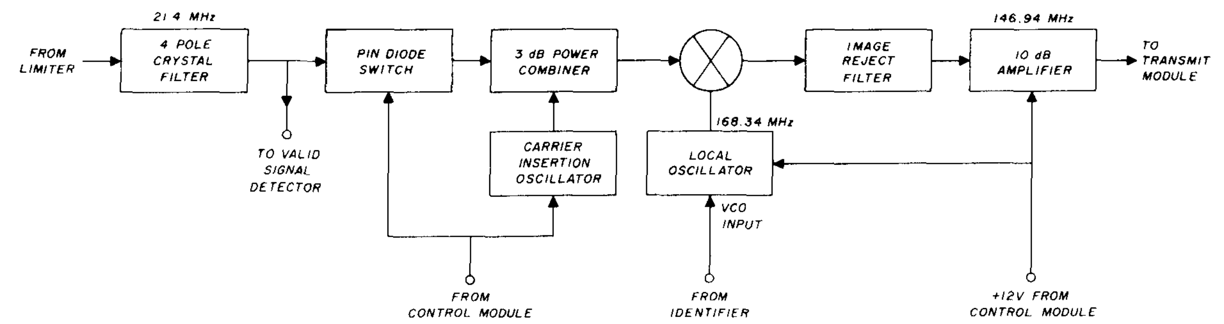

fig. 7. Up-converter block diagram. A high-level mixer is necessary to keep spurs low. The PIN diode blocks noise out of the IF if no carrier is present.

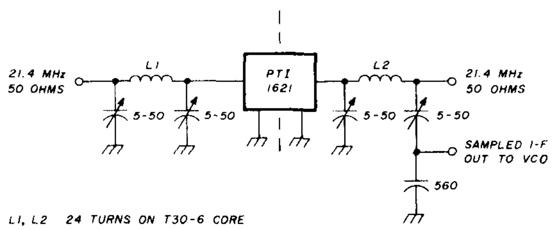

fig. 8. Piezo Tech 4 pole-pair crystal filter and matching networks. Found in up-converter. The 560 pF capacitor is omitted in the down-converter version. Careful tuning resulted in better than ±0.1 dB passband flatness.

be identified when there is no input signal, the carrier insertion oscillator is turned on. Summing the full-power noise and the carrier insertion oscillator signal would result in equal carrier power and noise power, which would give a 3-dB signal-to-noise ratio for the identifier. A PIN diode was used to block the noise coming out of the IF when the carrier insertion oscillator is on. This diode attenuates the IF noise sufficiently to yield about a 30-dB signal-to-noise ratio when the carrier is inserted locally.

Figure 8 shows the up-converter crystal filter matching network. A small amount of the IF signal is sampled at the output of the crystal filter for use by the valid signal detector circuit. Sampling with a low-impedance tap minimized the effects of the high SWR of the PIN diode when it conducts.

identifier/control module

The control module controls the repeater operation. In addition to its obvious tasks, it controls the PIN diode switch and the carrier insertion oscillator to insert a substitute carrier when needed for identification. The control module receives its inputs from the valid signal detector and the time-out timer. The valid signal detector, described in the following section, determines the signal-to-noise ratio of received signals. When the signal-to-noise is above a preset level, the transmitter is turned on and the time-out timer is started. The timer is reset on loss of carrier.

The identifier controls the timing of the repeater and generates the identifier tones. The identifier uses the valid signal detector output for control. The timers for identifying the repeater, timing out the transmitter, and setting the code rate, were included in the identifier. Control for the timers comes from the control module.

valid signal detector

The valid signal detector samples the 21.4-MHz IF signal to measure the signal-to-noise ratio in the IF passband. The signal-to-noise ratio is measured by evaluating the amplitude variations in the IF signal. The IF signal consists of frequency modulated (FM) signals superimposed on amplitude modulated (AM) signals. The FM signals are the desired signals and the AM signals are undesired, usually noise. It can be easily appreciated that a clean FM signal will have no AM components in it, and that noise is composed of AM and FM components. What is not so evident is the strong AM components of noise after the signal is hard limited and bandpass filtered. A hard limiter converts any signal, even one with significant amplitude variations such as noise, into a constant power, wideband signal with no amplitude variations. After bandpass filtering to the original frequency and bandwidth, the signal will have constant *power*, but not necessarily constant amplitude.[6] A noise-free FM signal will be a constant amplitude (and constant power) frequency-modulated sine wave, but noise will be band limited noise with fluctuating amplitude with the same

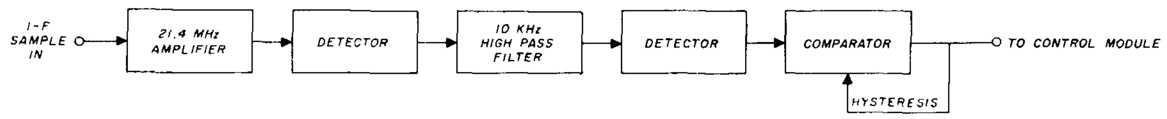

fig. 9. Valid signal detector block diagram. This circuit measures the signal-to-noise ratio in the IF.

average power level. After bandpass filtering then, hard-limited noise will once again have amplitude variations similar to the original noise. It is this characteristic that the operation of the valid signal detector depends upon.

Figure 9 is the valid signal detector block diagram. The IF signal is sampled after the post-limiter crystal filter. The valid signal detector amplifies the IF signal and provides envelope detection. The envelope detector furnishes a voltage proportional to the instantaneous IF signal amplitude. As a result of the limiter, the IF power applied to the detector is constant. If no carrier is present, full power noise is applied to the detector, which produces a fluctuating DC voltage. In this case, the frequency components of the detector output extend from DC to 15 kHz, the IF bandwidth. When a strong carrier is introduced, the limiter suppresses the noise so that the output of the detector becomes a noise-free DC voltage. It can be seen therefore, that the high-frequency components of the detector output correspond to the sidebands of a carrier, either AM sidebands or noise. In theory, and in practice, any incidental AM on an FM signal is limited to roughly 3-kHz bandwidth. Therefore, the signal-to-noise ratio of a received signal can be determined by measuring the amplitude of the 10- to 15-kHz components of the envelope-detected signal.

The components resulting from the noise level are extracted by high-pass filtering of the detected signal. The detector following the high-pass filter then provides a DC voltage level inversely related to the signal-to-noise ratio. Actually, the DC level is equal to a constant minus the received signal strength, but for practical purposes it provides a very good approximation to signal-to-noise ratio. The threshold for the comparator in the valid signal detector has significant amount of hysteresis. Hysteresis was included so that any signal that brings up the repeater is workable, but a fading signal will not be cut off until the bitter end.

The valid signal detector has provided outstanding service. It is so effective that even weak signals reliably bring up the translator, but noisy, uncopyable signals are virtually never heard. The only problem that occurs is with signals with severe multipath distortion. Multipath distortion can create a poor signal-to-noise ratio during modulation, even though the signal has acceptable signal-to-noise ratio when not modulated. This occurs when destructive interference causes notches in the signal amplitude at several frequencies in the modulation bandwidth. The result is a drop in the signal strength during modulation, and the reduced strength of the modulated signal does not have sufficient signal-to-noise ratio to keep the translator on. When this happens, the person transmitting brings up the translator whenever he or she pauses, but gets cut off as soon as he or she speaks. Such signals are unintelligible anyway; it just sounds like the valid signal detector is unnecessarily cutting off a copyable signal.

input/output filters, antennas

The RF input and output filters were constructed from a design put forth by Tilton.[7] The filters provide a 50 dB notch at the rejection frequency with a 1 dB insertion loss. This is identical to the performance predicted in the reference, even though silver plating was not applied as in the original filters. To enhance the output-to-input isolation for the repeater, separate transmit and receive antennas, spaced about 70 feet apart, were used. The antennas are surplus commercial five-element Yagi antennas. To retune to the Amateur band, we set up a ground effect antenna range[8] and found we could achieve the same gain as the original five-element antennas with only four elements, using the original boom. The side lobes with four elements were slightly stronger than with five elements, but still met our requirements.

squelch/carrier tail considerations

A few comments on the operational characteristics of this repeater are included here for the benefit of any who might seek to advance FM translator design. When the translator was designed we understood that pure noise out of the IF would cause intermodulation products in the class C power amplifier. For that reason the valid signal detector squelch response time was made short — around 50 ms. When someone listens to a weak signal on a frequency up to 1 MHz away while there is a conversation going on over the translator, the noise burst at the end of each transmission through the translator blanks out the weak station for the duration of the squelch tail. It turns out that this phenomenon is not particularly noticable: it has not been noticed, even in locale in which almost all 2-meter activity is weak-signal work.

It appears that the main annoyance is the translator's emission of a full-bandwidth (15 kHz) noise burst at the end of each transmission. The typical squelch circuit in the user's receiver responds to this noise burst in the same way it would if there were no carrier on channel and squelches the receiver audio. That is then followed by a clean carrier tail that unsquelches the radio. After the carrier tail times out, the user's radio again squelches. The result at the user's receiver is two squelch bursts for one end-of-transmission. (This phenomenon does not occur with a conventional repeater because its audio stages limit the bandwidth of the noise burst so that the typical squelch circuit will not respond.) Solving this problem with translators is not easy; it will occur with class C and linear power amplifiers alike. One temporary solution is to make an inordinately long carrier tail so that the second burst is likely to be taken up by another user; any suggestions from readers for providing a clean carrier tail would be appreciated.

conclusion

This article has outlined the objectives and results of a project for the design and construction of a translator/repeater. Designed and constructed entirely "from scratch," the repeater has met all performance goals and has operated with minimal service for 7 years. Any comments or suggestions from readers will be appreciated. If you wish to receive a response, send an SASE to the author at the address at the beginning of this article.

acknowledgement

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IC-730 8-band 200w PEP xcvr w/mic	$829.00	569.95
FL-30 SSB filter (passband tuning)	59.50	
FL-44A SSB filter (2nd IF)	159.00	144.95
FL-45 500 Hz CW filter	59.50	
EX-195 Marker unit	39.00	
EX-202 LDA interface; 730/2KL/AH-1	27.50	
EX-203 150 Hz CW audio filter	39.00	
EX-205 Transverter switching unit	29.00	
SM-5 8-pin electret desk microphone	39.00	
HM-10 Scanning mobile microphone	39.50	
MB-5 Mobile mount	19.50	
IC-720A 9-band xcvr/.1-30 MHz rcvr	$1349.00	869.95
FL-32 500 Hz CW filter	59.50	
FL-34 5.2 kHz AM filter	49.50	
SM-5 8-pin electret desk microphone	39.00	
MB-5 Mobile mount	19.50	
IC-745 9-band xcvr w/.1-30 Mhz rcvr	$999.00	789.95
PS-35 Internal power supply	160.00	144.95
CFJ-455K5 2.8 kHz wide SSB filter	4.00	
HM-12 Hand microphone	39.50	
SM-6 Desk microphone	39.00	
*See IC-740 list above for other options (*)		

	Regular	SALE
IC-751 9-band xcvr/.1-30 MHz rcvr	$1399.00	1199
PS-35 Internal power supply	160.00	144.95
FL-32 500 Hz CW filter (1st IF)	59.50	
FL-63 250 Hz CW filter (1st IF)	48.50	
FL-52A 500 Hz CW filter (2nd IF)	96.50	89.95
FL-53A 250 Hz CW filter (2nd IF)	96.50	89.95
FL-33 AM filter	31.50	
FL-70 2.8 Khz wide SSB filter	46.50	
HM-12 Hand microphone	39.50	
SM-6 Desk microphone	39.00	
CR-64 High stability reference xtal	56.00	
RC-10 External frequency controller	35.00	
MB-18 Mobile mount	19.50	
Options: 720/730/740/745/751	**Regular**	**SALE**
PS-15 20A external power supply	$149.00	134.95
EX-144 Adaptor for CF-1/PS-15	6.50	

ICOM

Options - continued	Regular	SALE
CF-1 Cooling fan for PS-15	45.00	
EX-310 Voice synth for 751, R-71A	39.95	
SP-3 External base station speaker	49.50	
Speaker/Phone patch - specify radio	139.00	129.95
BC-10A Memory back-up	8.50	
EX-2 Relay box with marker	34.00	
AT-100 100w 8-band automatic ant tuner	349.00	314.95
AT-500 500w 9-band automatic ant tuner	449.00	399.95
AH-1 5-band mobile antenna w/tuner	289.00	259.95
PS-30 Systems p/s w/cord, 6-pin plug	259.95	233.95
OPC Optional cord, specify 2 or 4-pin	5.50	
GC-4 World clock	99.95	94.95
HF linear amplifier	**Regular**	**SALE**
IC-2KL w/ps 160-15m solid state amp	1795.00	1299
VHF/UHF base multi-modes	**Regular**	**SALE**
IC-251A* 2m FM/SSB/CW transceiver	$749.00	499.95

***$50 Factory Rebate** - until gone!*

	Regular	SALE
IC-551D 80 Watt 6m transceiver	$699.00	599.95
EX-106 FM option	125.00	112.95
BC-10A Memory back-up	8.50	
SM-2 Electret desk microphone	39.00	
IC-271H 100w 2m FM/SSB/CW xcvr	899.00	759.95
PS-35 Internal power supply	160.00	144.95
PS-15 external power supply	149.00	134.95
CF-1 Cooling fan for PS-15	45.00	
EX-144 PS-15/CF-1 fan adaptor	6.50	
AG-25 Mast mtd. GaSFET preamp	84.95	
IC-471H 75w 430-450 SSB/CW/FM xcvr	1099.00	989.95
PS-35 Internal power supply	160.00	144.95
PS-15 20A power supply	149.00	134.95
CF-1 Cooling fan for PS-15	45.00	
EX-144 PS-15/CF-1 fan adaptor	6.50	
AG-35 Mast mounted preamp	84.95	
IC-271A 25w 2m FM/SSB/CW xcvr	699.00	619.95
PS-25 Internal power supply	99.00	89.95
AG-20/EX-338 2m preamplifier	56.95	
IC-471A 25w 430-450 SSB/CW/FM xcvr	799.00	699.95
AG-1 Mast mounted 15dB preamp	89.00	
PS-25 Internal power supply	99.00	89.95
Common accessories for 271A/H and 471A/H		
SM-6 Desk microphone	39.00	
EX-310 Voice sythesizer	39.95	
TS-32 CommSpec encode/decoder	59.95	
UT-15 Encoder/decoder interface	12.50	
UT-15S UT-15S w/TS-32 installed	79.95	
VHF/UHF mobile multi-modes		
IC-290H 25w 2m SSB/FM xcvr, TTP mic	549.00	489.95
IC-490A 10w 430-440 SSB/FM/CW xcvr	649.00	579.95
VHF/UHF/1.2 GHz FM	**Regular**	**SALE**
IC-22U 10w 2m FM non-digital xcvr	299.00	249.95
EX-199 Remote frequency selector	35.00	
IC-27A Compact 25w 2m FM w/TTP mic	369.00	329.95
IC-27H Compact 45w 2m FM w/TTP mic	409.00	369.95
IC-37A Compact 25w 220 FM, TTP mic	449.00	359.95
IC-47A Compact 25w 440 FM, TTP mic	469.00	419.95
UT-16/EX-388 Voice synthesizer	29.95	
IC-120 1w 1.2 GHz FM transceiver	499.00	449.95
ML-12 10w amplifier	339.00	299.95
6m portable	**Regular**	**SALE**
IC-505 3/10w 6m port. SSB/CW xcvr	$449.00	399.95
BP-10 Internal Nicad battery pack	79.50	
BP-15 AC charger	12.50	
EX-248 FM unit	49.50	
LC-10 Leather case	34.95	
SP-4 Remote speaker	24.95	

Hand-held Transceivers

Deluxe models	Regular	SALE
IC-02AT for 2m	349.00	299.95
IC-04AT for 440 MHz	379.00	339.95
Standard models	**Regular**	**SALE**
IC-2A for 2m	239.50	189.95
IC-2AT with TTP	269.50	199.95
IC-3AT 220 MHz, TTP	299.95	239.95
IC-4AT 440 MHz, TTP	299.95	239.95

Accessories for Deluxe models	Regular
BP-7 425mah/13.2V Nicad Pak - use BC-35	67.50
BP-8 800mah/8.4V Nicad Pak - use BC-35	62.50
BC-35 Drop in desk charger - all batteries	69.00
BC-60 6-position gang charger, all batts	SALE 359.95
BC-16U Wall charger - BP7/BP8	10.00
Accessories for both models	**Regular**
BP-2 425mah/7.2V Nicad Pak - use BC35	39.50
BP-3 Extra Std. 250 mah/8.4V Nicad Pak	29.50
BP-4 Alkaline battery case	12.50
BP-5 425mah/10.8V Nicad Pak - use BC35	49.50
CA-2 Telescoping 2m antenna	10.00
CA-5 ⅝-wave telescoping 2m antenna	18.95
FA-2 Extra 2m flexible antenna	10.00
CP-1 Cig. lighter plug/cord - BP3 or Dlx	9.50
DC-1 DC operation pak for standard models	17.50
LC-02AT Leather case for Dlx models w/BP-7/8	39.95
LC-2AT Leather case for standard models	34.95
LC-11 Vinyl case for standard models	17.95
LC-14 Vinyl case for Deluxe models w/BP-7/8	17.95
RB-1 Vinyl waterproof radio bag	30.00
HH-SS Handheld shoulder strap	14.95
HM-9 Speaker microphone	34.50
HS10 Boom microphone/headset	19.50
HS-10SA Vox unit for HS-10 (deluxe only)	19.50
HS-10SB PTT unit for HS-10	19.50
ML-1 2m 2.3w in/10w out amplifier	SALE 79.95
ML-25 2m 2.3w in 20w out amplifier	SALE 179.95
SS-32M Commspec 32-tone encoder	29.95

Shortwave receivers	Regular	SALE
R-71A 100 Khz-30 Mhz digital receiver	$799.00	689.95
FL-32 500 Hz CW filter	59.50	
EX-310 Voice synthesizer	39.95	
RC-11 Wireless remote controller	59.95	
CR-64 High stability oscillator xtal	56.00	
R-70 100 Khz-30 Mhz digital receiver	749.00	569.95
EX-257 FM unit	38.00	
IC-7072 Transceive interface, 720A	112.50	
FL-44A SSB filter (2nd IF)	159.00	144.95
FL-63 250 Hz CW filter (1st IF)	48.50	
SP-3 External speaker	49.50	
CK-70 (EX-299) 12v DC option	9.95	
MB-12 Mobile mount	19.50	

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19" HI-RESOLUTION COLOR X—Y DISPLAY

Thru a special purchase we got hold of 50 brand new 19" color displays. They were made by Wells Gardner for one of the largest arcade video game manufacturers in the world. The displays feature built in red, green and blue amplifiers, 19" color tube made by Wells Gardner. User supplied external horizontal and vertical scan oscillators which allows precise user control over screen resolution. A real plus! Requires 25 V - 0 - 25 V input for amps, available separately. Some spec's for you technical people: signal inputs "X" horizontal 16 V P-P ±8 V, "Y" vertical 12 V P-P ±6 V; "Z" beam drive, 4 V max brightness, 1.0 volt black level. Writing rates "X" amp is .05 inch/usec, "Y" amp is .0375 inch/usec. Great for making your own video games, oscilloscope monitors, or adapting for home computer use.

Supplied with schematic. $199.00 ea.
Shpg. Wt. 45 Lbs. MOT-19C 2/$375.00

Supplied with schematic. Quantity pricing available.
Shpg. Wt. 45 Lbs. MOT-19C $199.00 ea, $375.00/2

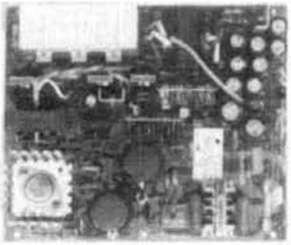
TRANSFORMER FOR ABOVE Shpg. Wt. 15 Lbs. $12.00

CAD CAM KEYBOARD

We only have a very limited quantity of these high reliability, beautifully layed out 8 bit, serial output keyboards. These were made by Keytronics for use in a Cad-Cam system. The board is made up of 3 sections. The typewriter format section has 2 control keys plus full upper and lower case alpha-numerics. The 42 keyswitch pad, when used with appropriate logic, allows extensive, precise manipulations of displayed data such as close up, moving information, sketching, etc. The third section consists of 27 keys which include a numeric scratch pad, 4 way cursor control plus some command keys. On board are 3 LSI's including an Intersil IM6402, INS8048, and NS2716 UV PROM which contains the programs for manipulating data, plus other circuitry and an alert beeper. The keyboard requires +5 V and −12 V. Each one will come with schematics. New and unused. Shpg. Wt. 4 Lbs. KYBRD No. 6 $45.00

Less than 100 on hand - Order Now!

Multi-Voltage MICRO-PROCESSOR POWER SUPPLY BOARD



This regulated multi-voltage switching power supply board is made by KEPCO (their part no. MRM 174KF) and is still in production (. . . regular price $124.95). It was originally part of the Zorba portable PC. The four outputs are as follows: & +5 VDC @ 5 A, +12 VDC @ 2.8 A, +12 VDC @ 2 A, and −12 VDC @ .5 A. The +12 VDC @ 2 A is very heavily filtered so it could be used on a glitch free monitor. The −12 VDC @ .5 A can be changed to −5 VDC just by changing the onboard 7912 regulator chip to a 7905. The board's lightweight and small size should make it perfect for many projects. All new and provided with a schematic. The input is jumper selectable 110/220. New, unused.

Quanity prices available. $49.95
Shpg. Wt. 2 Lbs. ea. SPL-471-33B 2/$90.00

USER PROGRAMMABLE KEYBOARDS

A fantastic find and a super buy for the computer hobbyist. Brand new, user programmable keyboards made by Keytronics Corp. They are user programmable because the onboard encoding generator outputs hex codes to the user supplied 2716 or equivalent EPROM. The EPROM can be programmed by the user to virtually any encoding scheme: ASCII; EBCDIC(C); EBCDIIC; BAUDET or others just by setting the EPROM to the particular specification. The keyboard is well constructed and layed out. The board is layed out in an ASCII configuration with control codes, full numerics, upper and lower case with electronic shift lock, plus a numeric scratch pad to the right with 4 way cursor controls. Absolutely beautiful!! Each one comes with schematic, and data. This will be a fast seller, so order early!.

Shpg. Wt. 4 Lbs. KYBD 7 $45.00 each

2716 EPROM's

These 2716 EPROM's run on a single 5 vdc power supply. They are "pulls" from little-used equipment and have been erased and checked OK. We got a super deal on these, which means YOU get a super deal on these! Each one with data.

Shpg. Wt. 1/4 Lb. SP-328 A-35 $2.00

Single 5 V 2716 EPROM, programmed for ASCII for use in the above keyboard (Kybd. 7) SP-328 B-35 $6.00

AAA Nicad Batteries

We have unused, AAA size, rechargeable, nicad batteries. They come 3 in a shrink wrapped package, but can always be cut apart and used individually. The output is 1.2 v per cell (3.6 v/pac) at 180 mAH. SP-67 A-35 $3.50

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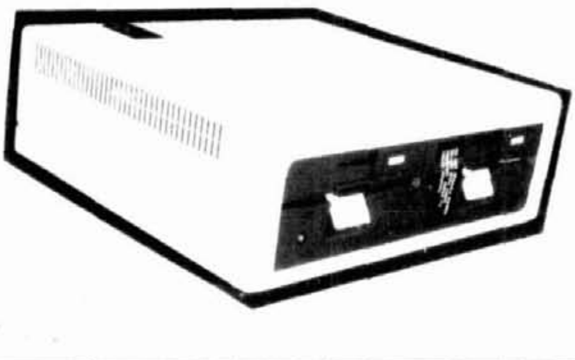
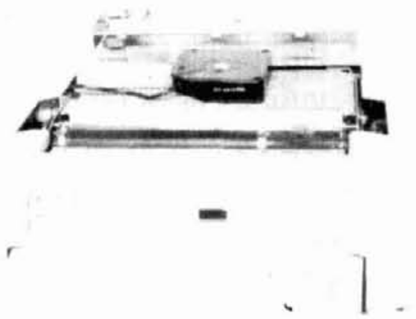
DUAL FLOPPY DISC DRIVES



BRAND NEW, single sided, dual floppy disc drives made for Digital Equipment Corp. (DEC). This beautiful piece of computer hardware consists of 2 Shugart compatible TEAC 40 track, double density, 5¼" mini-floppy disc drives brand new in the case with their own regulated, switching power supply, cooling fan & on/off switch. Each unit also comes with a line cord & documentation. These were made for DEC, but are also compatible with other personal computers such as IBM, TRS 80 models I, II, & the Color Computer, and other Shugart compatible interfaces. Naturally, you supply the cables and disc controller card to suit your particular system. The RX-180 AB runs off of 115/230 VAC 50/60 Hz. w/out any modifications to the drives. Each system comes in the original factory box and are guaranteed functional. A blockbuster of a buy !!
Shpg. wt. 21 lb. stock no. RX 180AB $250.00
RX 180 AB modified to run w/ the TI 99/4A $285.00
Disc drive cable for Radio Shack Model I $15.00

HIGH SPEED KSR PRINTER TERMINAL



World famous, high speed G. E. Terminet 1200 RS 232 KSR printer terminals are now in stock ready for shipment to you. This has to be one of the finest letter quality printers ever offered at a bargain price. These terminals can be used as an RS 232 asynchronous communications terminal or used in the local mode as a typewriter. The terminals were removed from service for upgrading. Highlights of these machines are: Standard RS 232, full duplex, asynchronous data comm., fully formed upper and lower case letters, 128 character ASCII set, selectable baud rates of 110, 300, or 1200 BPS, 80 columns on pin feed paper, and less weight & size than an ASR 35 teletype with far less racket. They are virtually electronically foolproof as every pc board is Pico fuse protected. Should your machine not work, just check the on board fuses & 9 out of 10 times that is where the problem lies. Schematics are provided w/ each machine sold. Current price of this machine new is over $2000.00 ! Our meager price for this fantastic printer is only 10% of this: $200.00 each!!! Visually inspected prior to shipment to insure completeness. Shpd. truck freight collect. $200.00

IBM 745 SELECTRIC BASED TYPEWRITER PRINTERS

Send S.A.S.E. for free data sheet

These rugged, handsome printers were made for one of the giants of the computer industry. They can be used as a standard typewriter or as a printer in a word processing system for true letter quality printing. Solenoids were added to the selectric mechanism which disabled the manual repeat function but still allows electronic repeat functions. It uses standard IBM typing balls. The voltage requirements are standard 115 VAC, 5 VDC at 100 ma, and 24 VDC at 4 amps. All are new in factory boxes, but may require adjustments. We provide literature and schematics with 1 ribbon and cleaning tools. With the addition of our Centronics to Selectric I/O adapter, you could easily interface this printer to almost any micro computer system.
Typewriter Printer stock no. RE 1000 A $375.00, 745 manual $30.00
Shpg wt approx. 80 Lbs, shpd by truck, collect.

CENTRONICS TO SELECTRIC INTERFACE

This interface will adapt a Redactron Selectric I/O typewriter mechanism to be used as a parallel ASCII compatible printer. The parallel input port provides compatibility to Centronics standards for both "busy" and "acknowledge" protocols. The interface requires only +5 VDC at 350 ma. This interface is fully built, less power supply, is guarenteed operational, and comes with data. Shpg wt. 15 lbs DE 201 A, $245.00

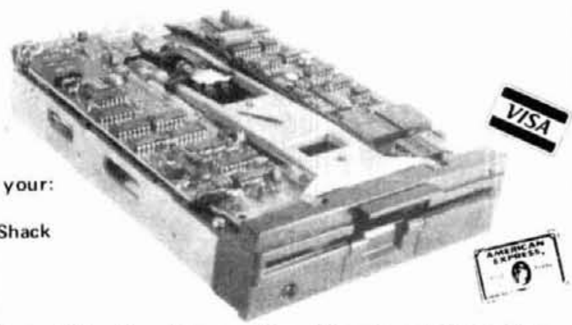
FANTASTIC MASS STORAGE DISC DRIVE DEAL

1 MEG. quad disc drives, plus cases and power supplies for same. Listed below are the disc drives. Please call for more info. on the other components.

1/2 Height 1 Megabyte Disc Drives

Here we go with another blockbuster buy on disc drives which should make the competition's head spin. We are offering brand new, Mitsubishi no. 4853, ½ height, 1 megabyte, mini-floppy disc drives. These drives are beautiful. They are fully 34 pin, Shugart compatible. All are double sided, double density, 80 track /side units. Each runs on +5 vdc 0.5 amps & +12 vdc .7 amps. Just the drives to use with your IBM, Sanyo or other computer. Each order will come with schematics and pinout data
Shpg. wt. 4 lb. SPL-85C-35 $175.00 each 2/ $325.00

Use with your:
- IBM
- Radio Shack
- Heath
- Xerox
- Sanyo



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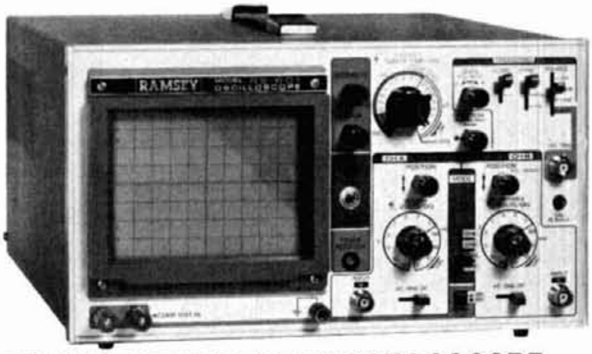


20 MHz DUAL TRACE OSCILLOSCOPE

Unsurpassed quality at an unbeatable price, the Ramsey oscilloscope compares to others costing hundreds more. Features include a component testing circuit for resistor, capacitor, digital circuit and diode testing • TV video sync filter • wide bandwidth & high sensitivity • internal graticule • front panel trace rotator • Z axis • high sensitivity x-y mode • regulated power supply • built-in calibrator • rock solid triggering. *USA — add $10.00 per unit for postage, overseas orders add 15% of total order for insured surface mail.

$399.95*

45 MHz DUAL SWEEP OSCILLOSCOPE

The Ramsey 625 is a dual time base, delayed sweep unit that includes a built-in signal delay line to permit clear viewing during very short rise times of high frequency waveforms. Other features include: variable trigger holdoff • 20 calibrated sweep time ranges from 0.5 s/div. to 0.2 μS/div. • fully adjustable sweep time • X5 sweep magnification • five trigger sources, CH1, CH2, LINE EXTernal and INTernal (V mode) • front panel x-y operation, Z axis input • sum difference of CH1, and CH2 waveforms displayed as single trace • sweep gate and sweep output • auto focus • single sweep. *USA — add $10.00 per unit for postage, overseas orders add 15% of total order for insured surface mail.

$799.95*

RAMSEY D-1100 VOM MULTITESTER

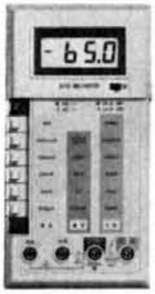
Compact and reliable, designed to service a wide variety of equipment. Features include • mirror back scale • double-jeweled precision moving coil • double overload protection • an ideal low cost unit for the beginner or as a spare back-up unit.

$19.95 test leads and battery included

NEW RAMSEY 1200 VOM MULTITESTER

Check transistors, diodes and LEDs with this professional quality meter. Other features include, decibel scale • 20K volt metering system • 3½" mirrored scale • polarity switch • 20 measuring ranges • safety probes • high impact plastic case

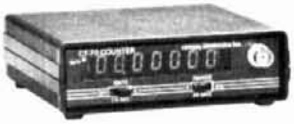
$24.95 test leads and battery included



RAMSEY D-3100 DIGITAL MULTIMETER

Reliable, accurate digital measurements at an amazingly low cost • in-line color coded push buttons, speeds range selection • abs plastic tilt stand • recessed input jacks • overload protection on all ranges • 3½ digit LCD display with auto zero, auto polarity & low BAT. indicator

$49.95 test leads and battery included



CT-70 7 DIGIT 525 MHz COUNTER

Lab quality at a breakthrough price. Features • 3 frequency ranges each with pre amp • dual selectable gate times • gate activity indicator • 50mV @ 150 MHz typical sensitivity • wide frequency range • 1 ppm accuracy

$119.95 wired includes AC adapter

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

CT-90 9 DIGIT 600 MHz COUNTER

The most versatile for less than $300. Features 3 selectable gate times • 9 digits • gate indicator • display hold • 25mV @ 150 MHz typical sensitivity • 10 MHz timebase for WWV calibration • 1 ppm accuracy

$149.95 wired includes AC adapter

CT-90 kit $129.95
OV-1 0.1 PPM oven timebase 59.95
BP-4 nicad pack 8.95

CT-125 9 DIGIT 1.2 GHz COUNTER

A 9 digit counter that will outperform units costing hundreds more. • gate indicator • 24mV @ 150 MHz typical sensitivity • 9 digit display • 1 ppm accuracy • display hold • dual inputs with preamps

$169.95 wired includes AC adapter

BP-4 nicad pack 8.95

CT-50 8 DIGIT 600 MHz COUNTER

A versatile lab bench counter with optional receive frequency adapter, which turns the CT-50 into a digital readout for most any receiver • 25 mV @ 150 MHz typical sensitivity • 8 digit display • 1 ppm accuracy

$169.95 wired

CT-50 kit $139.95
RA-1 receiver adapter kit 14.95

DM-700 DIGITAL MULTIMETER

Professional quality at a hobbyist price. Features include 26 different ranges and 5 functions • 3½ digit, ½ inch LED display • automatic decimal placement • automatic polarity

$119.95 wired includes AC adapter

DM-700 kit $99.95
MP-1 probe set 4.95

PS-2 AUDIO MULTIPLIER

The PS-2 is handy for high resolution audio resolution measurements, multiplies UP in frequency • great for PL tone measurements • multiplies by 10 or 100 • 0.01 Hz resolution & built-in signal preamp/conditioner

$49.95 wired

PS-2 kit $39.95

PR-2 COUNTER PREAMP

The PR-2 is ideal for measuring weak signals from 10 to 1,000 MHz • flat 25 db gain • BNC connectors • great for shifting RF • ideal receiver/TV preamp

$44.95 wired includes AC adapter

PR-2 kit $34.95

PS-1B 600 MHz PRESCALER

Extends the range of your present counter to 600 MHz • 2 stage preamp • divide by 10 circuitry • sensitivity: 25mV @ 150 MHz • BNC connectors • drives any counter

$59.95 wired includes AC adapter

PS-1B kit $49.95

ACCESSORIES FOR RAMSEY COUNTERS

Telescopic whip antenna—BNC plug	$ 8.95
High impedance probe, light loading	16.95
Low pass probe, audio use	16.95
Direct probe, general purpose use	13.95
Tilt bail, for CT-70, 90, 125	3.95

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RAMSEY

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NEW products

hi-res color SSTV converter

A new high-resolution color SSTV converter has been added to Robot's line of Amateur Radio products. Designated the Model 1200C, it is capable of transmitting color video images said to rival broadcast television in picture quality. The Model 1200C has three selectable 6-bit memory planes that combine to form 262,244 color combinations in a 256 × 240 line full screen display.

Eight different black and white and color transmission formats are available with automatic selection on receive. Up to six separate pictures may be stored in memory. The unit accepts color or black and white composite video from standard TV cameras and has RGB, composite or RF modulated video output.

One distinctive feature of the Model 1200C is the 8-bit parallel I/O ports for computer interface. This allows total access to each individual pixel by a host computer for image processing, transformation, storage and recall, and graphics. This port also allows the connection to a printer for black and white or color hard copy picture printing.

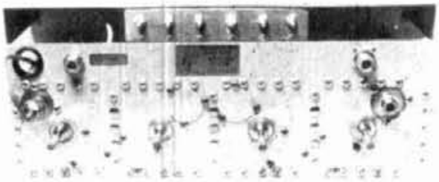
The Model 1200C features touch sensitive front panel switches for full station control and several automatic functions for unmatched ease of use. Fine tuning, speed switching and color or black and white detection are automatically accomplished without operator intervention.

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

Circle #175 on Reader Service Card.

bandpass duplexer

Sinclair Radio Laboratories' new P-4440E combines the low loss of a Res-Lok aperture-coupled filter on transmit with the high selectivity of a combiner filter on receive, making it an appropriate choice for single antenna operation of trunking or cellular base stations. The Res-Lok four-cavity bandpass section has typically 0.5 dB insertion loss and provides nearly 50 dB of noise suppression, which, when added to the typically 35-40 dB noise suppression provided by most cavity ferrite transmitter combiners, provides nearly 90 dB noise suppression overall. The six-pole comb-line filter on the receive side provides



over 85-dB carrier suppression, a figure which is more than adequate for most system applications. In addition, both the transmit and receive bandpass windows are a full 15 MHz wide, a fact which allows sparing of this component on a multi-site basis without the need to have facilities for retuning.

For further information, contact Sinclair Radio Laboratories Inc., 675 Ensminger Road, Tonawanda, New York 14150.

Circle #312 on Reader Service Card.

remote coax switch

A remote coax switch for convenient switching of up to four antennas is now available from Heath. It mounts easily on a tower or mast and consists of a remote RF switching unit and an indoor control unit. The two units are connected by a single coaxial cable which handles both RF and control signals. The remote unit is rain tight and mounts with a single clamp. The control unit contains the power supply and provides switching signals to the remote unit. The HD-1481 switch handles 2000 watts PEP with a VSWR of 1.15:1 or less below 30 MHz.

For complete details and/or to receive a free copy of the latest Heathkit catalog, contact Heath Company, Benton Harbor, Michigan 49022.

Circle #308 on Reader Service Card.

"Decode-A-Pad"

The Engineering Consulting touch-tone to RS-232-C interface for home computers allows reception of all 16 DTMF touchtones as fast as they can be transmitted. The computer does all the work at 300 baud; each digit is displayed as it is transmitted. With the Decode-A-Pad, you can receive coded strings, decode any number of digits, and program as many multi-digit codes as you want — all in BASIC. Sample programs to get you started are included in the price.

Now you can use your handheld radio to control your computer, which can then be used to control your remote base or turn on and off relays, for example.

NEW products

The Model DAP1 is priced at $89.95, which includes domestic shipping.

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

Circle #107 on Reader Service Card.

vented actuator boot

The new QIK-PRO Boot from Paullin Industries offers improved actuator protection against condensation with new top and bottom "flow-thru" vents to relieve moisture. These boots, custom-designed for satellite actuators, are made of neoprene rubber with self-retrieving folds for longer life and improved ice removal. The extra-long life is the result of a heat-curing process that provides the highest infra-red, ozone, and ultraviolet test ratings.

The QIK-PRO Actuator Boot has been redesigned to fit 1-1/8 x 2-1/4-inch actuators without adapters. Two ties are provided to seal the boot tighter, protecting the actuator equipment against moisture, dust, ice and rain.

For more information, contact Paullin Industries, 1446 State Route 60, Ashland, Ohio 44805.

Circle #307 on Reader Service Card.

new Hamtronics® catalog

The 1985 mail order catalog from Hamtronics features 40 pages of items of interest to the VHF/UHF/OSCAR enthusiast. Both new products — including a simplex autopatch kit, a repeater COR with courtesy beep, GaAs FET receiver preamps, active antennas for scanners, and repeater PA kits — and the firm's already popular lines of FM and AM receivers and 800 MHz scanner converters are described.

For a free copy, contact Hamtronics, Inc., 65-F Moul Road, Hilton, New York 14468-9535. (For overseas mailing, please send $2 or 4 IRCs.)

Circle #154 on Reader Service Card.

Larsen's FB2-450

Larsen's new FB2-450 antenna features an exclusive Kulrod T™ teflon-coated finish for corrosion resistance and improved performance. The lightweight, fixed-base antenna is said to offer a reliable, economical alternative to larger base station antennas for a variety of base station applications.

The 5/8 over 1/2-wave collinear whip with four integral ground plane radials delivers 4.5 dB gain, compared to a 1/4-wave antenna on a suitable ground plane. The FB2-450 operates in the 450-470 MHz frequency range and ensures low loss with "N" type hardware. It comes complete

with bracket and hose clamps for mounting on a 1-1/2 to 2-1/2-inch diameter pole.

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

Circle #306 on Reader Service Card.

direction finding accessory for VHF/UHF receivers

Doppler Systems' latest line of radio direction finding units operates with any narrowband FM receiver in the 27 to 500 MHz range to provide fast location of interfering signals. No receiver modifications are required—the direction finder connects to the receiver's antenna and external speaker jacks.

Four modes are available, providing a range of optional display and remote output features: a 16 LED compass rose; a 3-digit bearing in degrees; an RS232C output for computer analysis, triangulation, data logging, etc.; and

short circuits

microstrip program

In K8UR's "Microstrip Impedance Program," (December, 1984, pages 84-86) corrections should be made to lines 230 and 280 of **fig 1**. **Line 230**, ER [− .0724 should read ER ↑ − .0724. In **line 280**,] − .5) should read ↑ − .5). **Line 80** in the HP67 program listing (**fig. 2B**) should read:

hy^x	35 63

trap antenna

In W4MB-s article "design your own trap antenna" (October, 1984, page 37) the formula for Z_n should be corrected to read as follows:

$$Z_n = 60\ (\log_e \lambda_n/D_n - 1)$$

Also, do not confuse LN with (L(N). They are different. LN = natural logarithm to the base e.

NEW products

a synthesized voice output. The speech synthesizer is designed for mobile use, as it eliminates the need for the driver to watch the display.

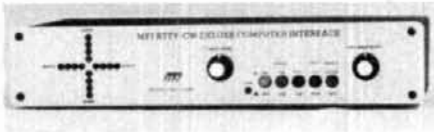
The system operates by continuously summing the outputs of four antennas, simulating the motion of a single rotating antenna. As the simulated antenna moves toward the RF source, an increase in the apparent signal frequency occurs, and as the antenna moves away from the source, this frequency decreases. This up-down (Doppler) frequency shift is detected by the FM receiver and is present as a 300 Hz tone on the audio output. The phase of the tone is measured and used to compute the bearing without affecting the normal operation of the receiver.

For more information contact Doppler Systems, 5540 E. Charter Oak, Scottsdale, Arizona 85254.

Circle #305 on Reader Service Card.

RTTY/CW computer interface

A new RTTY/CW deluxe computer interface, featuring variable tuning for all shifts and built-in RS-232 compatibility FM-AM modes of operation, is available from MFJ Enterprises, Inc.



The MFJ-1229 features a 16-LED crosshair mark and space tuning array that simulates a scope ellipse for easy, accurate tuning even under poor signal-to-noise conditions. It also operates in both FM and AM modes, using FM for general use, off-shift copy, drifting signals and moderate signal and QRM levels, and AM for weak-signal conditions or when there are strong stations nearby. The MFJ-1229 transmits on both 170 and 850 Hz with variable shift tuning as well as push-button 170 Hz for added convenience and versatility.

The 1229 can be used with most home computers and with a large variety of software.

Additional features include AFSK and FSK keying, front panel sensitivity control, a normal/reverse switch that eliminates retuning while checking for inverted RTTY, mark and space outputs for true scope tuning, and a Kantronics-compatible socket.

All inputs are buffered and can be inverted using an internal DIP switch. External trim pots are accessible from the rear, allowing adjustment of the audio input levels. The MFJ-1229 uses 18 VDC or 110 VAC with an optional AC adaptor. The interface measures 12-1/2 x 2-1/2 x 6 inches and is housed in a black aluminum cabinet with a brushed aluminum front.

For more information on the MFJ-1229 Deluxe RTTY/CW Computer Interface, contact MFJ Enterprises, Inc., 921 Louisville Road, Starkville, Mississippi 39759.

Circle #173 on Reader Service Card.

Great Circle slide

Xantek has announced the availability of a Great Circle Slide for its DX EDGE®. Used with the DX EDGE, this slide lets stations determine beam headings (great circle bearings) to any location in the world with enough accuracy for almost any purpose. It also shows the beam heading to use for pointing an antenna along the Gray Line.

Slides are available for latitudes of 60, 50, 40, 30, 20, and 10 degrees (all north or south), and 0 degrees (the equator). (Order the slide for the latitude nearest your station.)

Each slide shows 16 true great circles spaced at intervals of 22-1/2 degrees. Both the short path and long path are shown. The same size as the DX EDGE map, the slide is made of thin transparent vinyl so that it fits over the map and under the monthly slide. The price of the Great Circle Slide is $3.00 when purchased together with the DX EDGE and $5.00 when purchased separately. Prices include shipping and handling.

For further information, contact Xantec, Inc., P.O. Box 834, Madison Square Station, New York, NY 10159.

Circle #304 on Reader Service Card.

interface development system

The 'eZ SYSTEM' is a low cost, simple and practical hardware development system that provides quick access to a personal computer's bus expansion slot for rapid circuit development. The system features three major components: the 'eZ BOARD,' a solderless prototyping board that

connects to the expansion slot of the micro-computer through an integral 18-inch flat cable, allowing the user to work freely without interfering with their system unit; the 'eZ CARD,' a prototyping board that features a fully buffered address, data and control bus, and the 'eZ BOOK,' a helpful technical guide to the computer system and contains several practical, useful circuits for projects such as an A/D conversion, parallel port, and joystick interface.

The eZ System is available for the IBM-PC and XT, for Apple, and Commodore computers, or other computers housing the same bus arrangement.

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

Circle #302 on Reader Service Card.

do-it-yourself autopatch

KIE Enterprises has developed a simplex telephone autopatch system called "LETUS-PATCH" for the VIC-20 or Commodore-64 computers. The system (not including the cost of the computer or the transceiver) can be built for less than $50.00.

Features of the autopatch include multiple-user "up codes" with individual long-distance privilege designation, general admission "up codes," busy phone and ringing phone indication (on or off). Also included are answer or interrupt busy phone "up codes," automatic ID'er, remote enable/disable capabilities, and voice delay switching of the phone conversation for those with slow response transceivers.

For those whose telephone service no longer requires dialing a "1" before the area code, a prefix/area code table per "up code" can be added. All phone numbers used are logged onto cassette tape by "up code," date, and time to comply with FCC requirements and to allow multiple user toll charge distribution when cross-referenced with your phone bill.

The program, written in BASIC, requires approximately 3K of memory. Extensive prefix or area code tables may require memory expansion for the VIC-20.

The "do-it-yourself" package consists of circuit diagrams, circuit descriptions, parts lists, program listing, program narrative, and a cassette tape with a starter program ready to load. The price is $20.00.

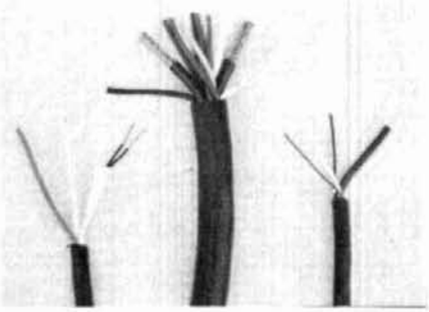
For more information, contact KIE Enterprises, P.O. Box 72, Running Springs, California 92382.

Circle #301 on Reader Service Card.

actuator cable

Nemal Electronics International has introduced a new line of direct burial actuator cable for satellite earth station and communications applications. Each type provides the proper cabling for both motor power and sensor/control in a single polyethylene jacket suitable for direct

NEW products



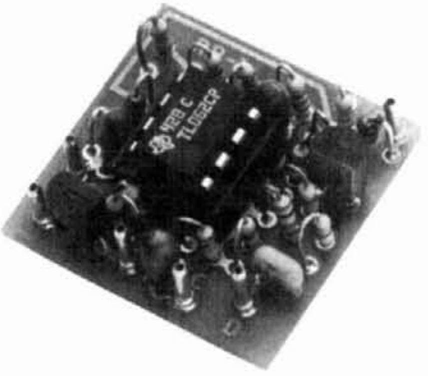
burial. Nemal ST-1 consists of 2 conductors of 16 gauge and 2 conductors of 22 gauge with foil shield and drain wire; ST-2 contains 2 conductors of 12 gauge and 3 conductors of 22 gauge with foil shield and drain wire. Nemal also offers a line of five types of satellite control cables which contain motor, sensor, polarotor, and coaxial signal lines.

For additional information, contact Nemal Electronics International, Inc., 12240 N. E. 14th Avenue, North Miami, Florida 33161.

Circle #166 on Reader Service Card.

reverse burst accessory

Communications Specialists has introduced the RB-1 reverse burst accessory. The RB-1 eliminates the long squelch tail heard with some reed type and other sub-tone decoders. Used in conjunction with decoders that offer squelch tail elimination, the RB-1 will delay the transmitter turn-off time and reverse the phase of the en-



coded tone, immediately stopping the decoder and eliminating the squelch tail. The RB-1 is available from stock and sells for $14.95.

For more information, contact Communications Specialists, Inc., 426 West Taft Avenue, Orange, California 92665-4296.

Circle #120 on Reader Service Card.

8-pole crystal filters

International Radio Inc. has announced its line of 8-pole crystal filters designed to improve the selectivity in Kenwood and ICOM products. Designed with low insertion loss and ripple, the filters offer excellent selectivity and shape factor. Filers are available for both SSB and CW operation, and depending on the radio, can be either 1st or 2nd IF or cascaded.

For more information, contact International Radio Inc., 1532 S.E. Village Green Drive, Port St. Lucie, Florida 33452.

Circle #109 on Reader Service Card.

VHF FM monitor receiver

Ace Communications, Inc. has introduced a new VHF FM monitor receiver, model AR-33. The AR-33 is a featherweight microprocessor controlled VHF FM portable receiver covering the 140 to 170 MHz band in 5 kHz steps. Frequencies are selected by a thumbwheel switch and slide switch for 5 kHz increments. The receiver employs CMOS microprocessor technology to offer a variety of features at an economical price,

as well as small size and light weight. The actual size of the receiver is approximately 5-1/4 × 2-1/2 × 1-1/8 inches (130 × 63 × 26 mm) and weighs less than 200 grams.

For further information, contact Ace Communications, Inc., 22511 Aspan Street, Lake Forest, California 92630.

Circle #164 on Reader Service Card.

NEW products

voice operated squelch

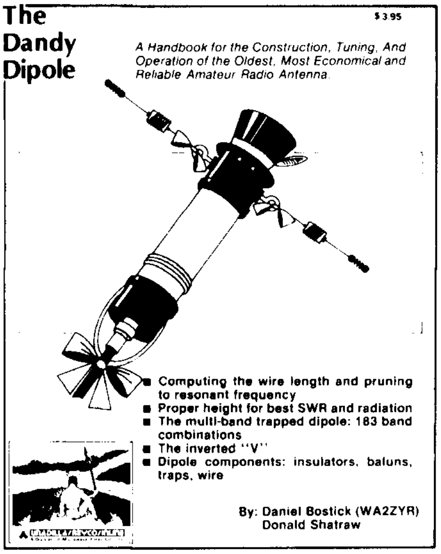
CMC Communications offers a Voice Operated Squelch on a small circuit board for mounting inside most SSB transceivers and receivers. The VOS requires that different and select components of the voice spectrum to be present at the same time to operate. It ignores heterodynes and noise, regardless of level, yet it is extremely sensitive to weak signals when the human voice is present. All adjustments are made at the factory and a remote on/off switch is provided. Simple connections are made to the AF Gain Control and 9 or 12 VDC.

For further information, contact CMC Communications, Inc., 5479 Jetport Industrial Blvd., Tampa, Florida 33614.

Circle #125 on Reader Service Card.

dipole handbook

The Dandy Dipole from Microwave Filter is a new 24-page handbook for constructing over 180 variations of the oldest, most reliable, and simplest Amateur Radio antenna known. It shows where and how to place it, how to quickly design a multiband dipole — using traps — without guessing at the wire lengths.



The contents include computing the wire length and pruning to resonant frequency; proper height for best SWR and radiation; the multiband trapped dipole, 183 band combinations (complete wiring tables); inverted "V" and dipole components as insulators, baluns, traps and wire.

The book was written by Daniel Bostick, WA2ZYR, and Donald Shatraw, Microwave Filter Company technical consultants.

The cost is $3.95 plus $1.00 for shipping. For more information, contact Microwave Filter Company, Inc., 6743 Kinne Street, East Syracuse, New York 13057.

Circle #148 on Reader Service Card.

book REVIEW

The Hidden Signals on Satellite TV by Tom Harrington, W8OMV, and Bob Cooper, VP5D

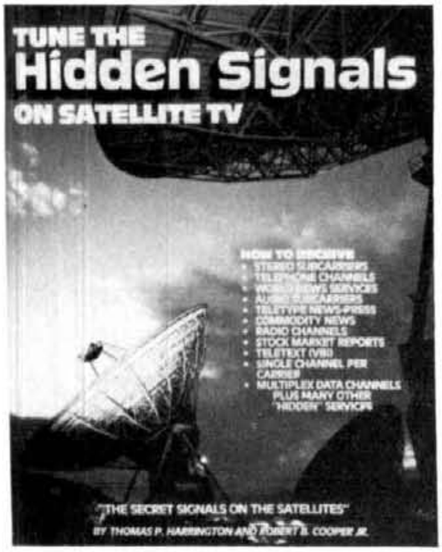
Owners of TVRO systems may be unaware of the multitude of signals carried by geostationary satellites. Besides the video services, these signals include audio and teletype news services, high speed data systems, teletext, and stock services, to name just a few.

Access to these signals is actually very easy. It can be accomplished simply by tuning the audio subcarrier control on many of the TVRO tuners currently being sold. With the addition of an FM stereo tuner, high quality stereo services can also be received and enjoyed by TVRO owners.

This book starts off with an introductory chapter that gives the reader a brief history of satellite communications, describes multiplexed audio and data signals, and lists the various types of transmissions. A spectrum overview from 0-30,000 MHz and a description of where the "hidden signals" are also provided.

Chapter Two delves into the technical "nitty gritty" of audio subcarriers, how they get there and how they can be found. In addition to a technical description, a review of several different pieces of commercial gear currently available to decode this subcarrier information is provided. A program listing by service and satellite is also included. Charts, graphs, and oscilloscope photographs are all provided to help you set your station.

Chapter Three discusses telephone (SSB/FDM) systems, their use, and your responsibilities in receiving these services. There are currently two types of voice and data signal channels on satellites these days. The most common uses SSB run through a frequency division multiplexer. This spectrum-efficient system allows many different signals to be combined together into a single signal for transmission to a satellite.



The second method of access is via SCPC (single channel per carrier). SPSC is not as spectrum effective as the FDM systems, but is less expensive to install. The equipment required is much less complex and needs relatively low power. Information is given on how to hook up SSB receivers to TVRO receivers to decode this interesting information.

Chapter Four is a rather complete and inclusive section on SCPC satellite systems. Equipment in use is fully covered and examples are given of some of those services using SCPC transmissions. Frequency allocations are listed by satellite, service, companding, bandwidth and pre-emphasis to help the listener tune in these signals.

Chapters Five and Six cover satellite networks and basic teletext, providing plenty of history as well as technical details. Chapter Seven deals with a number of other teletext operations, and Chapter Eight discusses miscellaneous services that can be found on satellites. Chapter Eight also has a complete detailed section on the Hughes C-band domestic satellite facilities.

The information contained in this book is not intended to encourage the misuse of satellite services. Rather it has been prepared by the authors as a primer on what is available there. *FCC rules and regulations do not prohibit SWL'ing. They do prohibit selling or deriving a commercial benefit from what is received.* The ultimate responsibility lies with the user.

In some areas, technical descriptions in this book are not exactly what the engineer may want. However, the average TVRO owner, TV technician, or beginning TVRO dealer will find this book to be a good reference manual to have on the shelf.

The Hidden Signals on Satellite TV is published by Universal Electronics, 4555 Grove Road, Suite 34, Columbus Ohio 43232. Copies are available from Ham Radio's Bookstore, Greenville, NH 03048, $14.95 plus $3.50 shipping and handling.

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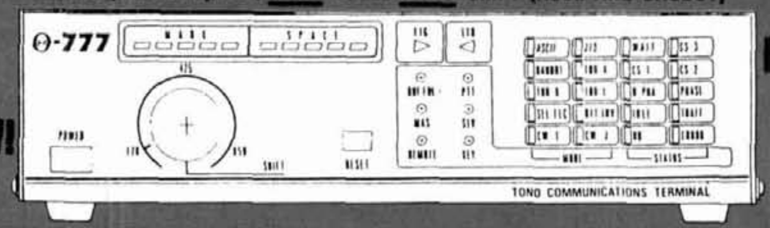

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3CX400U7/8961	255.00	4687	P.O.R.	8106	5.00
3CX1000A7/8283	526.00	5675	42.00	8117A	225.00
3CX3000F1/8239	567.00	5721	250.00	8121	110.00
3CW30000H7	1700.00	5768	125.00	8122	110.00
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3X3000F1	567.00	5836	232.50	8156	12.00
4-65A/8165	69.00	5837	232.50	8233	60.00
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4-400B/7527	110.00	5876/A	42.00	8462	130.00
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4CX350F/8322	115.00	6146W/7212	17.95	8647	168.00
4CX350FJ/8904	140.00	6156	110.00	8683	95.00
4CX600J/8809	835.00	6159	13.85	8877	465.00
4CX1000A/8168	242.50*	6159B	23.50	8908	13.00
4CX1000A/8168	485.00	6161	325.00	8950	13.00
4CX1500B/8660	555.00	6280	42.50	8930	137.00
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4X150A/7034	60.00	6939	22.00	6HF5	8.73
4X150D/7609	95.00	7094	250.00	6JG6A	6.28
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416C	62.50	7289/2C39	34.00	6LQ6 G.E.	7.00
572B/T160L	49.95	7325	P.O.R.	6LQ6/6MJ6 Sylvania	9.00
592/3-200A3	211.00	7360	13.50	6ME6	8.90
807	8.50	7377	85.00	12AT7	3.50
811A	15.00	7408	2.50	12AX7	3.00
812A	29.00	7609	95.00	12BY7	5.00
813	50.00	7735	36.00	12JB6A	6.50

NOTE * = USED TUBE   NOTE P.O.R. = PRICE ON REQUEST

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"FILTERS"

COLLINS Mechanical Filter #526-9724-010 MODEL F455Z32F

455KHZ at 3.2KHz wide. May be other models but equivalent. May be used or new. $15.99

ATLAS Crystal Filters

5.595-2.7/8/LSB, 5.595-2.7/LSB 8 pole 2.7KHz wide Upper sideband. Impedence 800ohms 15pf In/800ohms 0pf out.	19.99
5.595-2.7/8/U, 5.595-2.7/USB 8 pole 2.7Khz wide Upper sideband. Impedence 800ohms 15pf In/800ohms 0pf out.	19.99
5.595-.500/4, 5.595-.500/4/CW 4 pole 500 cycles wide CW. Impedance 800ohms 15pf In/800ohms 0pf out.	19.99
9.0USB/CW 6 pole 2.7KHz wide at 6dB. Impedance 680ohms 7pf In/300ohms 8pf out. CW-1599Hz	19.99

KOKUSAI ELECTRIC CO. Mechanical Filter #MF-455-ZL/ZU-21H

455KHz at Center Frequency of 453.5KC. Carrier Frequency of 455KHz 2.36KC Bandwidth.

Upper sideband. (ZU)	19.99
Lower sideband. (ZL)	19.99

****

CRYSTAL FILTERS

NIKKO	FX-07800C	7.8MHz	$10.00
TEW	FEC-103-2	10.6935MHz	10.00
SDK	SCH-113A	11.2735MHz	10.00
TAMA	TF-31H250	CF 3179.3KHz	19.99
TYCO/CD	001019880	10.7MHz 2pole 15KHz bandwidth	5.00
MOTOROLA	4884863B01	11.7MHz 2pole 15KHz bandwidth	5.00
PTI	5350C	12MHz 2pole 15KHz bandwidth	5.00
PTI	5426C	21.4MHz 2pole 15KHz bandwidth	5.00
PTI	1479	10.7MHz 8pole bandwidth 7.5KHz at 3dB, 5KHz at 6dB	20.00
COMTECH	A10300	45MHz 2pole 15KHz bandwidth	6.00
FRC	ERXF-15700	20.6MHz 36KHz wide	10.00
FILTECH	2131	CF 7.825MHz	10.00

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CERAMIC FILTERS

AXEL	4F449	12.6KC Bandpass Filter 3dB bandwidth 1.6KHz from 11.8-13.4KHz	10.00
CLEVITE	TO-01A	455KHz+-2KHz bandwidth 4-7% at 3dB	5.00
	TCF4-12D36A	455KHz+-1KHz bandwidth 6dB min 12KHz, 60dB max 36KHz	10.00
MURATA	BFB455B	455KHz	2.50
	BFB455L	455KHz	3.50
	CFM455E	455KHz +-5.5KHz at 3dB , +-8KHz at 6dB , +-16KHz at 50dB	6.65
	CFM455D	455KHz +-7KHz at 3dB , +-10KHz at 6dB , +-20KHz at 50dB	6.65
	CFR455E	455KHz +-5.5KHz at 3dB , +-8KHz at 6dB , +-16KHz at 60dB	8.00
	CFU455B	455KHz +-2KHz bandwidth +-15KHz at 6dB, +-30KHz at 40dB	2.90
	CFU455C	455KHz +-2KHz bandwidth +-12.5KHz at 6dB , +-24KHz at 40dB	2.90
	CFU455G	455KHz +-1KHz bandwidth +-4.5KHz at 6dB , +-10KHz at 40dB	2.90
	CFU455H	455KHz +-1KHz bandwidth +-3KHz at 6dB , +-9KHz at 40dB	2.90
	CFU455I	455KHz +-1KHz bandwidth +-2KHz at 6dB , +-6KHz at 40dB	2.90
	CFW455D	455KHz +-10KHz at 6dB , +-20KHz at 40dB	2.90
	CFW455H	455KHz +-3KHz at 6dB , +-9KHz at 40dB	2.90
	SFB455D	455KHz	2.50
	SFD455D	455KHz +-2KHz , 3dB bandwidth 4.5KHz +-1KHz	5.00
	SFE10.7MA	10.7MHz 280KHz +-50KHz at 3dB , 650KHz at 20dB	2.50
	SFE10.7MS	10,7MHz 230KHz +-50KHz at 3dB , 570KHz at 20dB	2.50
	SFG10.7MA	10.7MHz	10.00
NIPPON	LF-B4/CFU455I	455KHz +-1KHz	2.90
	LF-B6/CFU455H	455KHz +-1KHz	2.90
	LF-B8	455KHz	2.90
	LF-C18	455KHz	10.00
TOKIN	CF455A/BFU455K	455KHz +-2KHz	5.00
MATSUSHIRA	EFC-L455K	455KHz	7.00

****

SPECTRA PHYSICS INC. Model 088 HeNe LASER TUBES

POWER OUTPUT 1.6MW.	BEAM DIA. .75MM	BEAM DIR. 2.7MR	8KV STARTING VOLTAGE DC
68K OHM 1WATT BALLAST	1000VDC +-100VDC	At 3.7MA	$59.99

ROTRON MUFFIN FANS Model MARK4/MU2A1

115 VAC 14WATTS 50/60CPS IMPEDENCE PROTECTED-F 88CFM at 50CPS $ 7.99

105CFM at 60CPS THESE ARE NEW

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TYPE	PRICE	TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
2N1561	$25.00	2N5920	$ 70.00	40608 RCA	$ 2.48	BFY90	$ 1.50
2N1562	25.00	2N5921	80.00	40673 RCA	2.50	BLW60C5	15.00
2N1692	25.00	2N5922	10.00	40894 RCA	1.00	BLX67	12.25
2N2857	1.55	2N5923	25.00	60247 RCA	25.00	BLX67C3	12.25
2N2857JAN	4.10	2N5941	23.00	61206 RCA	100.00	BLX93C3	22.21
2N2857JANTX	4.50	2N5942	40.00	62800A RCA	60.00	BLY87A	7.50
2N2876	13.50	2N5944	10.35	62803 RCA	100.00	BLY88C3	13.08
2N2947	18.35	2N5945	10.00	430414/3990RCA	50.00	BLY89C	13.00
2N2948	13.00	2N5946	12.00	3457159 RCA	20.00	BLY90	45.00
2N2949	15.50	2N5947	9.20	3729685-2 RCA	75.00	BLY92	13.30
2N3118	5.00	2N6080	6.00	3729701-2 RCA	50.00	BLY94C	45.00
2N3119	4.00	2N6081	7.00	3753883 RCA	50.00	BLY351	10.00
2N3134	1.15	2N6082	9.00	615467-902	25.00	BLY568C/CF	30.00
2N3287	4.90	2N6083	9.50	615467-903	40.00	C2M70-28R	92.70
2N3288	4.40	2N6084	12.00	2SC568	2.50	C25-28	57.00
2N3309	4.85	2N6094	11.00	2SC703	36.00	C4005	2.50
2N3375	17.10	2N6095	12.00	2SC756A	7.50	CD1659	20.00
2N3478	2.13	2N6096	16.10	2SC781	2.80	CD1899	20.00
2N3553	1.55	2N6097	20.70	2SC1018	1.00	CD1920	10.00
2N3553JAN	2.90	2N6105	21.00	2SC1042	24.00	CD2188	18.00
2N3632	15.50	2N6136	21.85	2SC1070	2.50	CD2545	24.00
2N3733	11.00	2N6166	40.24	2SC1216	2.50	CD2664A	16.00
2N3818	5.00	2N6267	142.00	2SC1239	2.50	CD3167	92.70
2N3866	1.30	2N6304	1.50	2SC1251	24.00	CD3353	95.00
2N3866JAN	2.20	2N6368	30.00	2SC1306	2.90	CD3435	26.30
2N3866JANTX	3.80	2N6439	55.31	2SC1307	5.50	CD3900	152.95
2N3866JANTXV	4.70	2N6459	18.00	2SC1424	2.80	CM25-12	20.00
2N3866AJANTXV	5.30	2N6567	10.06	2SC1600	5.00	CM40-12	27.90
2N3924	3.35	2N6603	13.50	2SC1678	2.00	CM40-28	56.90
2N3926	16.10	2N6604	13.50	2SC1729	32.40	CME50-12	30.00
2N3927	17.25	2N6679	44.00	2SC1760	1.50	CTC2001	42.00
2N3948	1.75	2N6680	80.00	2SC1909	4.00	CTC2005	55.00
2N3950	25.00	021-1	15.00	2SC1945	10.00	CTC3005	70.00
2N3959	3.85	01-80703T4	65.00	2SC1946	40.00	CTC3460	20.00
2N4012	11.00	35C05	15.00	2SC1947	10.00	DV2820S	25.00
2N4037	2.00	102-1	28.00	2SC1970	2.50	DXL1003P70	22.00
2N4041	14.00	103-1	28.00	2SC1974	4.00	DXL2001P70	19.00
2N4072	1.80	103-2	28.00	2SC2166	5.50	DXL2002P70	14.00
2N4080	4.53	104P1	18.00	2SC2237	32.00	DXL3501AP100F	47.00
2N4127	21.00	163P1	10.00	2SC2695	47.00	EFJ4015	12.00
2N4416	2.25	181-3	15.00	A2X1698	POR	EFJ4017	24.00
2N4427	1.25	210-2	10.00	A3-12	14.45	EFJ4021	24.00
2N4428	1.85	269-1	18.00	A50-12	24.00	EFJ4026	35.00
2N4430	11.80	281-1	15.00	A209	10.00	EN15745	20.00
2N4927	3.90	282-1	30.00	A283	6.00	FJ9540	16.00
2N4957	3.45	482	7.50	A283B	6.00	FSX52WF	58.00
2N4959	2.30	564-1	25.00	A1610	19.00	G65739	25.00
2N5016	18.40	698-3	15.00	AF102	2.50	G65386	25.00
2N5026	15.00	703-1	15.00	AFY12	2.50	GM0290A	2.50
2N5070	18.40	704	4.00	AR7115	20.00	HEP76	4.95
2N5090	13.80	709-2	11.00	AT41435-5	6.35	HEPS3002	11.40
2N5108	3.45	711	4.00	B2-8Z	10.70	HEPS3003	30.00
2N5109	1.70	733-2	15.00	B3-12	10.85	HEPS3005	10.00
2N5160	3.45	798-2	25.00	B12-12	15.70	HEPS3006	19.90
2N5177	21.62	3421	28.00	BAL0204125	152.95	HEPS3007	25.00
2N5179	1.04	3683P1	15.00	BF25-35	56.25	HEPS3010	11.34
2N5216	56.00	3992	25.00	B40-12	19.25	HF8003	10.00
2N5470	75.00	4164P1	15.00	B70-12	55.00	HFET2204	112.00
2N5583	3.45	4243P1	28.00	BF272A	2.50	HP35821	38.00
2N5589	9.77	4340P3	18.00	BFQ85	2.50	HP35826B	32.00
2N5590	10.92	4387P1	27.50	BFR21	2.50	HP35826E	32.00
2N5591	13.80	7104-1	28.00	BFR90	1.00	HP35831E	30.00
2N5596	99.00	7249-2	10.50	BFR91	1.65	HP35832E	50.00
2N5636	12.00	7283-1	37.50	BFR99	2.50	HP35833E	50.00
2N5637	15.50	7536-1	30.00	BFT12	2.50	HP35859E	75.00
2N5641	12.42	7794-1	10.50	BFW16A	2.50	HP35866E	44.00
2N5642	14.03	7795	15.00	BFW17	2.50	HXTR2101	44.00
2N5643	25.50	7795-1	15.00	BFW92	1.50	HXTR3101	7.00
2N5645	13.80	7796-1	24.00	BFX44	2.50	HXTR5101	31.00
2N5646	20.70	7797-1	36.00	BFX48	2.50	HXTR6104	68.00
2N5651	11.05	40081 RCA	5.00	BFX65	2.50	HXTR6105	31.00
2N5691	18.00	40279 RCA	10.00	BFX84	2.50	HXTR6106	33.00
2N5764	27.00	40280 RCA	4.62	BFX85	2.50	J310	1.00
2N5836	3.45	40281 RCA	10.00	BFX86	2.50	J02000	10.00
2N5842	8.45	40282 RCA	20.00	BFX89	1.00	J02001	25.00
2N5847	19.90	40290 RCA	2.80	BFY11	2.50	J04045	24.00
2N5849	20.00	40292 RCA	13.05	BFY18	2.50	KD5522	25.00
2N5913	3.25	40294 RCA	2.50	BFY19	2.50	KJ5522	25.00
2N5916	36.00	40341 RCA	21.00	BFY39	2.50	M1106	13.75

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M1107	$16.75	MRF458	$20.70	NE02160ER	$100.00	SD1009	$15.00
M1131	5.15	MRF464	25.30	NE021350	5.30	SD1009-2	15.00
M1132	7.25	MRF466	18.97	NE13783	61.00	SD1012	10.00
M1134	13.40	MRF472	1.50	NE21889	43.00	SD1012-3	10.00
M9116	29.10	MRF475	3.10	NE57835	5.70	SD1012-5	10.00
M9579	6.00	MRF476	3.16	NE64360ER-A	100.00	SD1013	10.00
M9580	7.95	MRF477	20.00	NE64480 (B)	94.00	SD1013-3	10.00
M9587	7.00	MRF479	8.05	NE73436	2.50	SD1013-7	10.00
M9588	5.20	MRF492	23.00	NE77362ER	100.00	SD1016	15.00
M9622	5.95	MRF502	1.04	NE98260ER	100.00	SD1016-5	15.00
M9623	7.95	MRF503	6.00	PRT8637	25.00	SD1018-4	13.00
M9624	9.95	MRF504	7.00	PT3127A	5.00	SD1018-6	13.00
M9625	15.95	MRF509	5.00	PT3127B	5.00	SD1018-7	13.00
M9630	14.00	MRF511	10.69	PT3127C	20.00	SD1018-15	13.00
M9740	27.90	MRF515	2.00	PT3127D	20.00	SD1020-5	10.00
M9741	27.90	MRF517	2.00	PT3127E	20.00	SD1028	15.00
M9755	16.00	MRF525	3.45	PT3190	20.00	SD1030	12.00
M9780	5.50	MRF559	1.76	PT3194	20.00	SD1030-2	12.00
M9827	11.00	MRF587	11.00	PT3195	20.00	SD1040	5.00
M9848	35.00	MRF605	20.00	PT3537	7.80	SD1040-2	20.00
M9850	13.50	MRF618	25.00	PT4166E	20.00	SD1040-4	10.00
M9851	20.00	MRF626	12.00	PT4176D	25.00	SD1040-6	5.00
M9860	8.25	MRF628	8.65	PT4186B	5.00	SD1043	12.00
M9887	2.80	MRF629	3.45	PT4209	25.00	SD1043-1	10.00
M9908	6.95	MRF641	25.30	PT4209C/5645	25.00	SD1045	3.75
M9965	12.00	MRF644	27.60	PT4556	24.60	SD1049-1	2.00
MM1500	25.00	MRF646	29.90	PT4570	7.50	SD1053	4.00
MM1550	10.00	MRF648	33.35	PT4577	20.00	SD1057	10.00
MM1552	50.00	MRF816	15.00	PT4590	5.00	SD1065	4.75
MM1553	50.00	MRF823	20.00	PT4612	20.00	SD1068	15.00
MM1607	8.45	MRF846	44.85	PT4628	20.00	SD1074-2	18.00
MM1614	10.00	MRF892	35.50	PT4640	20.00	SD1074-4	28.00
MM1810	15.00	MRF894	46.00	PT4642	20.00	SD1074-5	28.00
MM1810	15.00	MRF901 3 Lead	1.00	PT5632	4.70	SD1076	18.50
MM1943	1.80	MRF901 4 Lead	2.00	PT5749	25.00	SD1077	4.00
MM2608	5.00	MRF902/2N6603JAN	15.00	PT6612	25.00	SD1077-4	4.00
MM3375A	17.10	MRF902B	18.40	PT6619	20.00	SD1077-6	4.00
MM4429	10.00	MRF904	2.30	PT6708	25.00	SD1078-6	24.00
MM8000	1.15	MRF905	2.55	PT6709	25.00	SD1080-7	7.50
MM8006	2.30	MRF911	2.50	PT6720	25.00	SD1080-8	6.00
MM8011	25.00	MRF965	2.55	PT8510	15.00	SD1080-9	3.00
MPSU31	1.01	MRF966	3.55	PT8524	25.00	SD1084	8.00
MRA2023-1.5	42.50	MRF1000MA	32.77	PT8609	25.00	SD1087	15.00
MRF134	10.50	MRF1004M	31.05	PT8633	25.00	SD1088	22.00
MRF136	16.00	MRF2001	41.74	PT8639	25.00	SD1088-8	22.00
MRF171	35.00	MRF2005	54.97	PT8659	25.00	SD1089-5	15.00
MRF208	11.50	MRF5176	24.00	PT8679	25.00	SD1090	15.00
MRF212	16.10	MRF8004	2.10	PT8708	20.00	SD1094	15.00
MRF221	10.00	MSC1720-12	225.00	PT8709	20.00	SD1095	15.00
MRF223	13.00	MSC1821-3	125.00	PT8727	29.00	SD1098-1	30.00
MRF224	13.50	MSC1821-10	225.00	PT8731	25.00	SD1100	5.00
MRF227	3.45	MSC2001	30.00	PT8742	19.10	SD1109	18.00
MRF230	2.00	MSC2010	93.00	PT8787	25.00	SD1115-2	7.50
MRF231	10.00	MSC2223-10	245.00	PT8828	25.00	SD1115-3	7.50
MRF232	12.07	MSC2302	POR	PT9700	25.00	SD1115-7	2.10
MRF237	3.15	MSC3000	35.00	PT9702	25.00	SD1116	5.00
MRF238	13.80	MSC3001	38.00	PT9783	16.50	SD1118	22.00
MRF239	17.25	MSC72002	POR	PT9784	32.70	SD1119	5.00
MRF245	35.65	MSC73001	POR	PT9790	56.00	SD1124	50.00
MRF247	31.00	MSC80064	35.00	PT31083	20.00	SD1132-1	15.00
MRF304	36.00	MSC80091	10.00	PT31962	20.00	SD1132-4	12.00
MRF306	50.00	MSC80099	3.00	PTX6680	20.00	SD1133	9.50
MRF313	11.15	MSC80593	POR	RE3754	25.00	SD1133-1	10.00
MRF314	29.21	MSC80758	POR	RE3789	25.00	SD1134-1	2.50
MRF315	28.86	MSC82001	33.00	RF35	16.00	SD1134-4	12.00
MRF316	55.43	MSC82014	33.00	RF85	17.50	SD1134-17	12.00
MRF317	63.94	MSC82020M	130.00	RF110	21.00	SD1135	10.25
MRF412	18.00	MSC82030	33.00	S50-12	23.80	SD1135-3	12.00
MRF420	20.12	MSC83001	40.00	S3006	15.00	SD1136	12.50
MRF421	25.00	MSC83003	82.00	S3007	10.00	SD1136-2	12.50
MRF422	38.00	MSC83005	70.00	S3031	22.00	SD1143-1	10.00
MRF427	17.25	MSC83026	POR	SCA3522	5.00	SD1143-3	17.00
MRF428	63.00	MSC83303	POR	SCA3523	5.00	SD1144	4.00
MRF433	12.07	MSC84900	60.00	SD345	5.00	SD1145-5	15.00
MRF449/A	12.65	MT4150	14.40	SD445	5.00	SD1146	15.00
MRF450/A	14.37	MT5126	25.00	SD1004	15.00	SD1147	15.00
MRF452/A	17.00	MT5596(2N)	99.00	SD1007	15.00	SD1188	10.00
MRF453/A	18.40	MT5768(2N)	95.00	SD1007-2	15.00	SD1189	24.00
MRF454/A	20.12	MT8762	25.00	SD1007-4	15.00	SD1200	1.50
MRF455/A	16.00	NE02136	2.00	SD1007-5	15.00	SD1201-2	15.00

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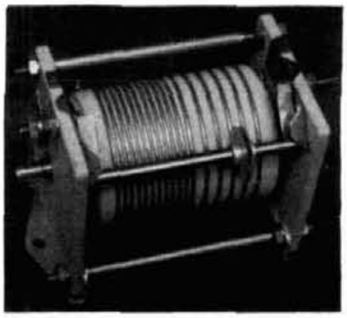
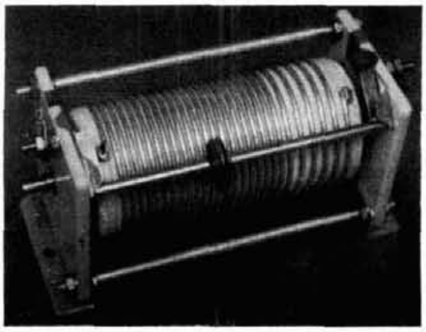
E.F. JOHNSON ROLLER INDUCTORS



MODEL 229-0201-01
10UH at 3AMPS MAX. $36.99



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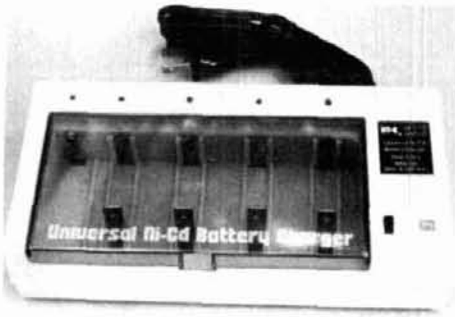

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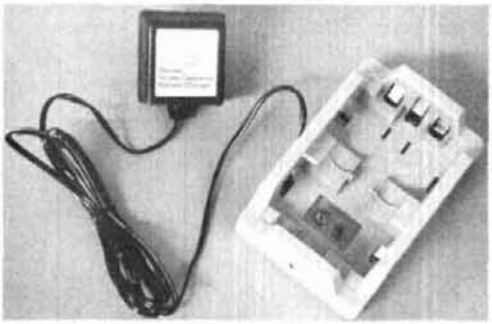

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5.1	20	38	80	220	8	36
6.8	22	39	82	240	9	51
7	24	40	100	250	12	62
8.2	25	43	110	300	15	
9.1	27	44	120	360	16	
10	27.5	47	123	470	18	
11	28	50	125	500	20	
12	30	51	140	820	22	
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SD1225-1	15.00	SD1405	21.00	SD1511H3	75.00	SRF2741	40.00	SD1283-4	10.00	SD1444	3.25	SRF769H	20.00	TRW3	5.00
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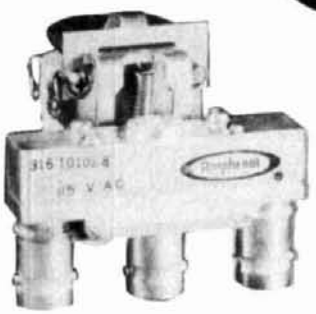

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ATLAS 350XL owners group. Send QSL card with s/n your rig. Know anyone who repairs them? Have any technical information to share? Any questions? Rod, N5NM, Box 2169, Santa Fe, NM 87504.

CHASSIS and cabinet kits. SASE K3IWK.

SCHEMATICS: Radio receivers 1920/60's. Send name brand, model, SASE, Scaramella, P.O. Box 1, Woonsocket, RI 02895-0001. (602) 897-2534.

TI 99/4A Random text, keyboard, send, receive, code practice programs. Dr. Code "General" sends International Morse code and prints on screen; you choose: speed, tone, which characters to be sent, spacing, and more! Dr. Code "Speech" same as "General" with speech; you choose how many characters before speech check. For cassette of both copyrighted programs and conditional copying privileges, send $10.00 plus $3.00 shipping and handling to N5ESF, Rt. 1, Box 1326, Lake Charles, LA 70601. Phone (318) 436-2048, no collect calls please; satisfaction or money back.

TECHNICAL BOOKS. "Electronics with Digital and Analog Integrated Circuits" by Richard Higgens of the University of Oregon/Eugene. Combines the best of the "electronics for scientists" and the "hobbyist" or "how to" approach. Circuit principles and "golden rules", which won't become obsolete with envolving technology, are emphasized. $30.95 + 3.50 shipping. "Digital Design" by Morris Mano of California State University. Presents the basic tools used in the design of digital circuits. $33.95 + 3.50 shipping. Check or money order. Technical Advice, Inc., Box 4757, Englewood, CO 80155.

CUSTOM embroidered emblems — Cloisonne enameled pins, your design, low minimum, excellent quality, free booklet. A.T. Patch Co., Dept. 65, Littleton, NH 03561. (603) 444-3423.

HAM RADIO Magazine collection. Bound volumes 1972, 1973, 1974 and 1975. In HR binders 1976, 1977, 1978 and 1979. $120 for lot plus UPS shipping. US only. W4UCH, Box 1065, Chautauqua, New York 14722 (716) 753-2654.

WANTED: Cash paid for used speed radar equipment. Write or call: Brian R. Esterman, PO Box 8141, Northfield, Illinois 60093. (312) 251-8901.

WANTED: Old microphones, remote mixers other misc related items. All pre-1935. Box Paquette, 107 E. National Avenue, Milwaukee, WI 53204.

WANTED: Used microwave equipment. D. Mitchell, K8URL, 1 Cider Mill Lane, Upton, MA 01568. (617) 529-4638.

RECONDITIONED TEST EQUIPMENT $1.00 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

RTTY-EXCLUSIVELY for the Amateur Teleprinter. One year $7.00. Beginners RTTY Handbook $8.00 includes journal index. P.O. Box RY, Cardiff, CA 92007.

"HAMS FOR CHRIST." Reach other Hams with a gospel tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

VERY in-ter-est-ing! Next 4 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60189.

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.

COMING EVENTS

Activities — "Places to go . . ."

MICHIGAN: The Cherryland Amateur Radio Club's 12th annual Swap 'N Shop, Saturday, February 9, Immaculate Conception Middle School Gymnasium, 218 Vine Street, Traverse City. 9 AM to 2:30 PM. General admission $2.50. Single tables $3.00. Talk in on 146.85 and 146.52 simplex. For information: Paul Nepote, KA8HIB, Chairman, 802 Fern St., Traverse City, MI 49684. Please SASE.

FLORIDA: *The Fort Myers City of Palms ARC's annual* Hamfest, Saturday, February 23, Moose Hall, 1900 Park Meadow Drive. ARRL volunteer license exams will be given by previous registration only, no walk-ins. Indoor flea market tables $10.00. Admission $3.00 at door, no mail orders. Ample free parking. Talk in on 146.28-146.88.

OHIO: Dayton Hamvention, April 26, 27, 28, Hara Arena and Exhibition Center, Dayton. Admission $8 advance, $10 at door. Good for all three days. Banquet $14 advance, $16 at door. Flea market space $17 in advance for all three days. Technical, ARRL and FCC forums. New products and exhibits. Special group meetings. YL forum. International VHF/UHF conference. Amateur of the Year Award. Special achievement awards. Pre-registration starts January 1, 1985. For further information; Dayton Amateur Radio Association, Box 44, Dayton, OH 45401 or phone (513) 433-7720.

MASSACHUSETTS: The Mount Tom Amateur Repeater Association will host its first annual indoor Flea Market, March 3, 9 AM to 4 PM, Knights of Columbus Hall, Elder Council 69, Granby Road, Chicopee. General admission $1.00. Kids and spouse free. Tables $8.00 door; $7.00 advance. Set up 8-9 AM. Food and drink. Contact Mickey Yale, N1CDR, 6 Laurel Terrace, Westfield, MA 01085. (413) 562-1027.

OHIO: Teays Amateur Radio Club's 7th annual Hamfest, March 3, K.C. Lodge, Circleville. Sellers set up 6 AM. Open to public 8 AM. Advance tickets $2.00, at door $3.00. 8' tables $4.00 advance, $5.00 at door. For table reservations SASE to Joe Subich, AD8I, 7825 State Rt. #188, Circleville, Ohio 43113. Talk in on Circleville repeater 147.18. For information: Len Campbell, WB8PPH, 8951 State Rt. #188, Circleville, Ohio 43113.

MISSOURI: The Jefferson Barracks Amateur Radio Club's 25th annual Amateur Radio Auction, Friday night, March 8, St. Louis Firefighters Hall, 5856 Gravois at Christy, in south St. Louis City. Starting time 7:30 PM. This is the Silver Anniversary of this event and the club is going all out to make this a memorable event. For information: Jefferson Barracks ARC, c/o Carl H. Hohenberger, WØBZP, 5266 Parker Avenue, St. Louis, MO 63139.

WISCONSIN: The Ozaukee Radio Club's 7th annual Swapfest, Saturday, May 4, 8 AM to 1 PM, Circle B Recreation Center, Highway 60, Cedarburg. Admission $2.00 in advance, $3.00 at the door. 4' tables $2.00 each advance only. Food and refreshments available. Sellers admitted at 7 AM for setup. For tickets, tables, maps or information send business SASE to 1985 ORC Swapfest, 101 E. Clay St., Saukville, WI 53080.

VIRGINIA: The Vienna Wireless Society's annual Winterfest, Sunday, February 24, Vienna Community Center, 120 Cherry Street, Vienna. Admission $4.00. Doors open at 8 AM. For vendor and tailgate applications SASE to Earl Hohbein, N4FSW, 4602 Lawn Court, Fairfax, VA 22032. Coffee and food available. Talk in via NVFMA 146.31/91 and VWS 146.085.685 and 147.51 simplex. For information: Vienna Wireless Society, PO Box 418, Vienna, VA 22180.

WISCONSIN: The Tri-County Amateur Radio Club's annual Hamfest, March 17, 8 AM to 3 PM, Jefferson County Fairgrounds, Jefferson. Tickets $2.50 advance, $3.00 at door. Tables $3.00 advance, $4.00 at door. Plenty of food and free parking. Doors open at 7 AM for sellers only. Talk in on 144.89/145.49, 146.22/146.82, 146.52/146.52. For information, tickets and tables SASE to Bob Barker, K9RIJ, 724 Burdick, Milton, WI 53563.

MARYLAND: BARC, the Baltimore Amateur Radio Club's 1985 Greater Baltimore Hamboree and computerfest, March 31, Maryland State Fairgrounds Exhibition Complex, Timonium. Gates open 8 AM. Admission $4.00, children under 12 free. Amateur radio, personal computer and small business computer dealers, guest speakers, large, hard surface outdoor tailgate area. Food service, free parking. Overnight accommodations available in immediate area. For information and table reservations: GBH & C, PO Box 95, Timonium, MD 21093-0095. (310) 561-1282.

TEXAS: The Midland Amateur Radio Club's annual St. Patrick's Swapfest, Saturday, March 16, 10 AM to 5 PM and Sunday, March 17, 8 AM to 2:30 PM, Midland County Exhibit Building, north of Highway 80. Pre-registration $5, $6 at the door. Tables $6 each. Refreshments and food available. Volunteer examiner tests for all categories. For information and reservations: Midland ARC, PO Box 4401, Midland, TX 79704.

WASHINGTON: The Mike and Key Amateur Radio Club's 4th annual Electronic Flea Market, March 9, 9 AM to 7 PM, Western Washington Fairgrounds, Puyallup. Admission $2.00. Spouse and kids free. Flea market tables $15.00. Consignments 10%. Dealers, exhibitors and demonstrations. Satellite station. Packet station. Super snack bar. Free parking. For reservations: Electronic Flea Market, 20903 NE 77th, Redmond, WA 98052. (206) 883-3012.

MICHIGAN: The 2nd annual Amateur Radio Auction sponsored by the Holland Amateur Radio Club, Saturday, March 9, Hudsonville High School Auditorium, 5051 32nd Avenue, Hudsonville. No admission fee. Equipment can be checked in from 8 AM to 12 noon. Auction 9 AM to 1 PM. A 10% donation for each item sold. Refreshments available. Talk in on 146.06 and 52. For information: Dan Ruiter, KC8KN, 7106 Michael Drive, Hudsonville, MI 49426.

MINNESOTA: The Robbinsdale Amateur Radio Club's 4th annual Midwinter Madness Hobby Electronics Show, February 23, 8 AM to 2 PM, Totino-Grace High School, 1350 Gardena Avenue NE, Fridley (suburb of Minneapolis). Admission $4 at door. Manufacturers, dealers, flea market. Talk in on 147.60/00 KØLTC Repeater and 146.52 simplex. For information: Robbinsdale ARC, PO Box 22613, Robbinsdale, MN 55422 or call Bob (612) 533-7354. All Amateur Radio tests will be given. For information: Elmo Nygard, 4151 Adair Avenue N., Robbinsdale, MN 55422.

INDIANA: The LaPorte ARC's winter Hamfest, Sunday, February 24, at the LaPorte Civic Auditorium. Donation $2.50. Tables $2.00 advance; $2.50 at door. Talk in on 52 simplex. For information and reservations: LARC, PO Box 30, LaPorte, IN 46350.

MICHIGAN: The 15th annual Livonia Amateur Radio Club's Swap 'n Shop, Sunday, February 24, 8 AM to 4 PM, Churchill High School, Livonia. Plenty of tables, refreshments and free parking. Talk in on 144.75/5.35 and 52 simplex. For information or table reservations SASE to Neil Coffin, WA8GWL, c/o Livonia ARC, PO Box 2111, Livonia, MI 48151.

OREGON: The 5th annual Salem Mini-Hamfair, February 23, Polk County Fairgrounds. Seminars, commercial displays, Amateur license exams and a large flea market. Admission $4.00. Flea Market set up 8 AM. Doors open 9 AM. Talk in on 146.25/.86 and 146.52. For information: Sales Repeater Association, PO Box 784, Salem, OR 97308.

KENTUCKY: Annual Glasgow Swapfest, Saturday, February 23, 8 AM till ????? Glasgow Flea Market Building, 2 miles south of Glasgow off 31E. Free coffee, free parking, large flea market and a friendly gathering of hams. Admission $2.00. No extra charge for exhibitors. One free table per exhibitor. Extra tables $3.00 each. Talk in on 146.34/94 or 147.63/03. For information: N4HCO, Rt. #4, Box 354, Glasgow, KY 41241.

OHIO: The Cuyahoga Falls Amateur Radio Club's 31st annual Electronic Equipment Auction and Hamfest, Sunday, February 24, North High School, Akron. 8 AM to 3 PM. Tickets $3.00 at the door. Sellers may bring own tables or some will be available to rent. Talk in on 87/27. For information or reservations SASE to Bill Sovinsky, K8JSL, 2305 — 24th St., Cuyahoga Falls, Ohio 44223 or call (216) 923-3830.

OHIO: The 24th annual Mansfield Mid-Winter Hamfest/Auction, Sunday, February 10, Richland County Fairgrounds, Mansfield. Doors open to public 8 AM. Tickets $3.00 advance, $4.00 at door. Tables $5.00 advance; $6.00 door. Half tables available. Talk in on 146.34/94. For information, advanced tickets/tables: SASE to Dean Wrasse, KB8MG, 1094 Beal Road, Mansfield, Ohio 44905. (419) 589-2415. An ARRL/VEC license exam will be held at Mansfield campus, Ohio State University, North Central Technical College at 1 PM day of the Hamfest. SASE with 610 and check for $4 payable to ARRL/VEC to: Lloyd Nelson, N8BAZ, 630 Oak St., Lot 82, Mansfield, Ohio 44907.

Operating Events — "Things to do . . ."

FEBRUARY 1-10: The North Okanagan Radio Amateur Club will operate a special station to commemorate the 25th anniversary of the Vernon Winter Carnival, the largest in Western Canada. Listen for VE7NOR, our club station, from 2100Z to 2400Z daily. Frequencies 28.525, 21.375 and 14.225. For a special certificate send $1.00 or 2 IRC's to cover postage along with QSL information to: Box 1706, Vernon, BC, Canada V1T 7T9.

MARCH 9 and 10: West Coast 160 Bulletin CW Contest. 0000 GMT 3/9 to 2359 GMT 3/10. Single operators only. Exchange RST, QTH. Subscribers, non subscribers. Scoring: 10 points per QSO. Multipliers states, VE prov. country. Log info date, time rs(t), QTH. Send logs to R. Koziomkowksi, 5 Watson Drive, Portsmouth, RI 02871. Must be postmarked before April 30, 1985.

MARCH 16 and 17: DARC International SSTV Contest. 1200 UTC 3/16 to 1200 UTC 3/17. All for SSTV authorized bands. Exchange only two way video count. Exchange call sign signal report and QSO serial number on video. Logs must indicate date, time (UTC), call sign of station worked and complete exchange for each valid QSO. Name and address of entrants. Mail contest logs to Heinz Moestl, DE8BUS, PO Box 1123, D6473 Gedern 1, W. Germany.

THE GUERRI REPORT

Ernie Guerri
W6MGI

superchips come of age

About five years ago the Department of Defense embarked on an ambitious program to develop a family of Very High Speed Integrated Circuits (VHSIC).The objective was to design a group of VLSI chips with 1.25 micron features and a computational throughout of 5×10^{11} gate-Hertz. The program has cost over $350 million, but has yielded some impressive results. Signal processing chips capable of performing 100 million multiplications per second, memories with densities of 5 million transistors per square inch, a complete vector arithmetic processor and a self-contained convolutional decoder (a form of detector that can recognize very complex codes without going through all the arithmetic) have now been implemented.

Although some of the chips being fabricated have specialized military functions, most are designed to form a family of arithmetic and signal processing functions. Both bipolar and CMOS designs have been implemented, and some include current mode logic, which can perform subnanosecond operations. All of this exciting work is intended to be available eventually for commercial use. The next phase of the DoD program will aim at 0.5 micron features and nearly 100 times the speed — by the end of this decade!

advanced materials serve RF needs

We sometimes forget the key role that proper materials selection plays in the correct performance of many products. For example, we all know that a stable oscillator requires a tuned circuit with a high Q; that the active element must have carefully controlled gain and phase characteristics; and that all these parameters change with temperature. In the region below 100 MHz, the most stable oscillators have been traditionally built using silicon dioxide (quartz) crystal elements as the resonator. In the VHF and microwave region, cavity resonators have been the principal alternative.

The ideal resonator would have a very high Q, zero temperature coefficient, high permittivity (low radiation losses) and be supported by a dielectric with no electrical or thermal losses. Designers of semiconductor oscillators find series resonant (low impedance) tank circuits convenient. This means that a high Q series tank will have high capacity and low equivalent inductance. The modern alchemists have been at work on the problem and have now given us nearly perfect materials with which to solve the problem. Dielectric resonators made of ceramic materials with high dielectric constants (over 30), have made possible microwave resonators with unloaded Q's of 25,000 at 4 GHz and over 10,000 at 12 GHz. These materials have extremely low losses and excellent temperature characteristics, making possible the production of oscillators offering crystal-like performance at microwave frequencies

But hold on to your hat! In the search for the best dielectric materials to support these resonators, the thermal tiles used to protect the Space Shuttle on re-entry emerged as an optimum material. With a dielectric constant of 1.15 and legendary thermal characteristics, the tiles, made of foamed quartz, become a nearly perfect enclosure/support for a dielectric resonator. Using this combination of advanced materials, a major defense contractor has fabricated an oscillator that exhibits only ± 10 kHz drift per month — at over 6 GHz!

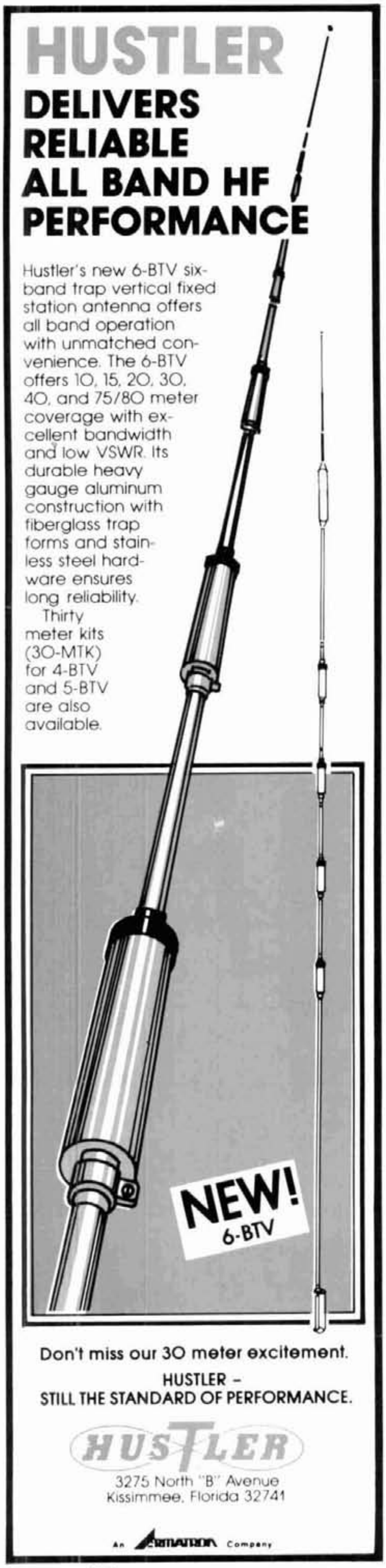
Gallium arsenide digital circuits are already available in the 4 GHz region, so it shouldn't be too long before we can have phase locked loops at 5 GHz or so. Combined with SAW or dielectric resonator filters, image-free upconversion receivers through 2300 MHz can be a reality for Amateurs of the next decade.

telephones to be more versatile

Over the past few years the plain old family telephone has become a hot consumer product. We've seen a proliferation of telephones that offer just about every convenience we could want in a single desk instrument. Up to 60 memories, on-hook dialing, full duplex speakerphone, as well as time and message unit recording, are now available in a multitude of styles at competitive prices. All of this capability has been made possible by the development of specialized ICs which have considerable processing power in their structure.

Most telephones now have 12-digit keypads, with each digit identified by a unique tone. If each digit is thought of as a single data "bit," then our ordinary keypad becomes a 12-bit code generator. Twelve bits equals 2^{12}, or 4096 possible codes if we use each tone just once in a 12-digit binary number. If your telephone were used as a small programmable data instrument, then you would have more than enough codes, and ample data resolution, to control most of the common household items that now each have individual and far less accurate, controllers. Household heating and cooling, selection of cooking times and temperatures, cost-effective regulation of hot water use and temperature, security entry codes, and choice of entertainment channels, for example, can all be controlled, changed, and recorded on our ordinary telephone. Moreover, because the telephone is connected to the rest of the world, we can change this household data from remote locations as the need arises. For Amateurs, the possibilities are especially appealing. Many repeaters now have their functions controlled by tone decoders, in addition to having all the usual auto-patch facilities. Antenna rotor controllers that accept bearing instructions from the telephone touchpad, remote frequency setting of transceivers, and a variety of data management functions will all become much easier and require only a single instrument for control. Someday we may even be able to reach out and . . . well, you know.

ham radio



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- SC-8T soft case for TH-21AT/41AT
- TU-6 programmable sub-tone unit
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TH-21A/41A

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TH-21AT/41AT
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