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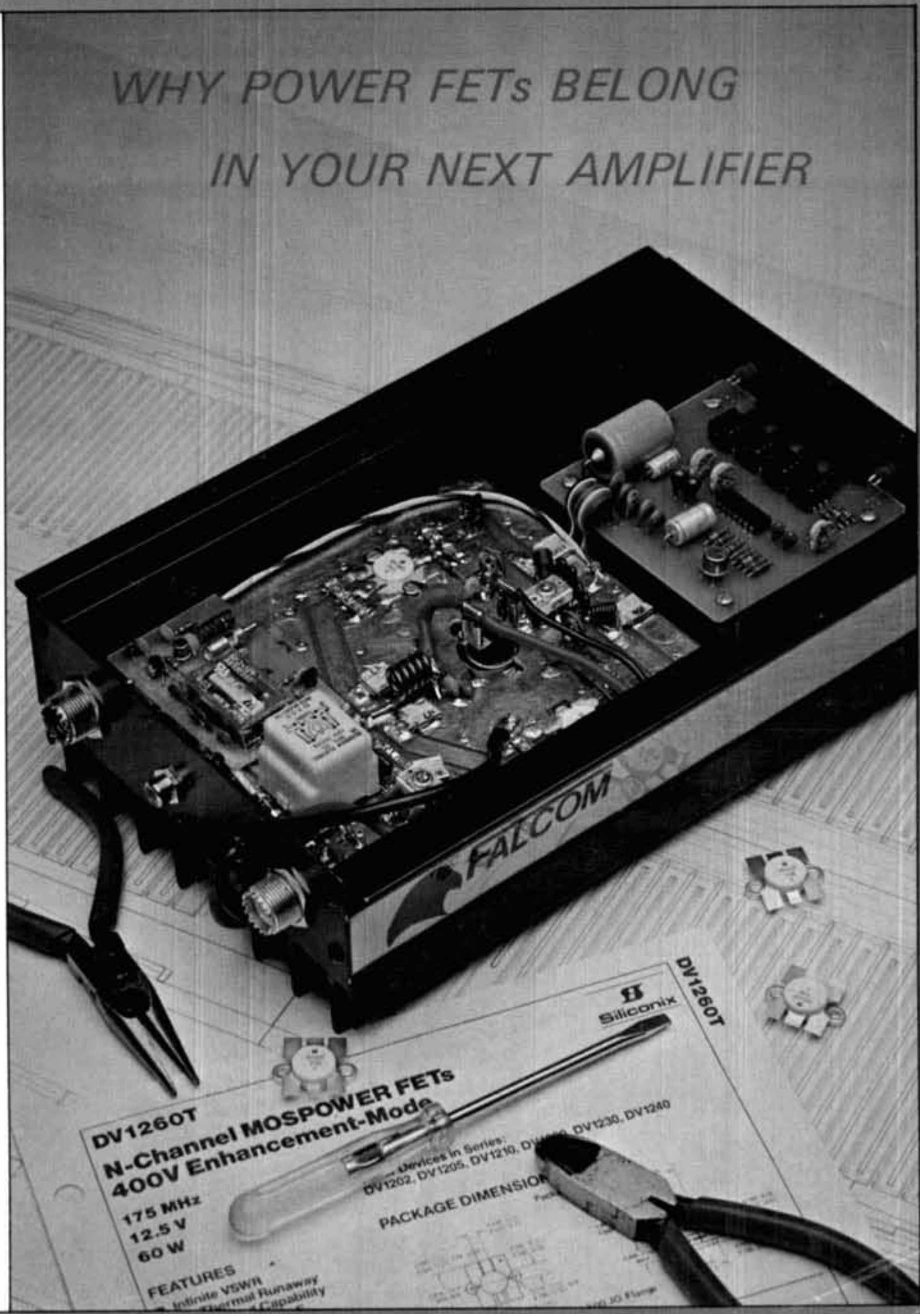
NEW: W1JR's VHF/UHF WORLD

ham radio magazine



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hr

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TR-2500 FEATURES:

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- **LCD digital frequency readout**
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- **Memory scan**
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- **UP/DOWN manual scan**
- **Built-in tuneable sub-tone encoder**
  Tuneable (variable resistor) to desired CTCSS tone.
- **Built-in 16-key autopatch encoder**
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- **Repeater reverse switch**
- **Keyboard frequency selection**
- **Extended frequency coverage**
  Covers 143.900 to 148.995 MHz in 5-kHz steps.
- **Optional power source**
  Using optional MS-1 mobile or ST-2 AC charger/power supply, radio may be operated while charging. (Automatic drop-in connections.)

Actual size

- **High impact plastic case**
- **Battery status indicator**
- **Two lock switches**
  Prevent accidental frequency change and accidental transmission.

Standard accessories include:

- Flexible antenna with BNC connector
- 400 mAH Ni-Cd battery pack
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Optional accessories:

- ST-2 Base station power supply/charger (approx. 1 hr.)
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TR-3500

70 CM FM Handheld

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More information on the TR-2500 and TR-3500 is available from all authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

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contents

COVER: Siliconix, Inc.

REFLECTIONS

Lost Weekend

With winter rapidly approaching, this past weekend was supposed to be spent cutting, splitting, and stacking wood for our stoves; operating for a few hours in the contest (CQ WW CW); and compiling the results of the last few questions of the September reader survey. Who could predict that my high tree-supported wire antennas would be belted with almost nonstop gusty winds and twice need repair — and a five-band trap vertical need a midnight pruning? I didn't count the number of times I ran back and forth from the shack to the vertical, but it numbered in the *scores.* (There wasn't much difference in temperature between the bitter cold outside and the shack . . . I hadn't yet cranked up the stove.)

After relaxing from the contest, I looked forward to leisurely compiling the thoughtful responses to the question that asked readers to tell us how they thought *ham radio* might be improved.

I read each and every answer to that question at least twice. Many comments were just what we'd expected. While some were indeed eye-opening, none were shocking. Here's what I found:

About your Amateur interest. The average reader of *ham radio* holds at least an Advanced class license (Extra, 33 percent; Advanced, 39 percent; General, 16.5 percent; Technician, 7 percent; Novice, 1.4 percent; no license, 1.4 percent) and has been licensed for 19 years. (33 readers in our sample have each been licensed for over 51 years.)

You operate mostly on SSB/AM. (CW and FM modes are just about tied for second place.) More than half the time you spend on 80 through 10, though the VHF bands attract the second largest group. A little over half of you build your own equipment; considering the level of interest indicated in construction articles, probably more of you would like to. Of those who build, half build from kits and half from "scratch."

How does this translate into hours spent on all facets of Amateur Radio? According to our poll, half our readers spend at least ten hours per week in operation or related activities.

Over half of you own personal computers. And of the half that don't, a third plan to purchase one within the coming year. What isn't clear is how many of you who own computers use them in Amateur Radio applications. (*Let us know.*)

About *ham radio*. What do readers want from us? Specifically, you asked for more articles on antennas (the #1 favorite subject overall), receivers, and using computers for Amateur Radio. There was a general request — almost across the board — for more construction articles, and almost as much interest in articles of a more theoretical nature. Many different subjects attracted your attention (not surprising in view of your diversified backgrounds, occupations, and interests); we'll use this information to plan future issues.

To which magazines do your subscribe? *ham radio*, of course (98.5 percent, and to a lesser extent, the three other brand names. (This comes as no surprise, considering that it was *our* readership that was polled.)

Which best suits your needs? This question really brought out the diversity of our readership. No, you don't think that *ham radio* is tops in terms of reporting on station activities, contesting, politics, news stories, or nostalgia. You buy the other books for that. That's fine. We at *ham radio* aren't trying to be a something-for-everybody magazine. We're just trying to provide the best technical ham magazine you can obtain. That has always been our charter.

I want to thank all who responded, and especially the hundreds of readers who took the time to expand their views in additional comments and even lengthy letters. (One reader even sent an hour-long audio tape.) The quantity and quality of positive suggestions supplied would be highly gratifying to any editor; as the months and years unfold, I'll do my best to put your advice to work. One major reader request has already been incorporated: starting in this issue, Joe Reisert, W1JR, will contribute a monthly column on VHF/UHF. Joe's many technical and operating accomplishments should be of interest to old and new readers alike.

As this issue went to press, we heard of the untimely passing of Vic Clark, W4KFC, President of the ARRL, over the Thanksgiving weekend. To me, Vic personified Amateur Radio. He was a dedicated ham, a kind person who was always thinking of ways to improve the hobby. He will be missed.

Rich Rosen, K2RR
Editor-in-Chief

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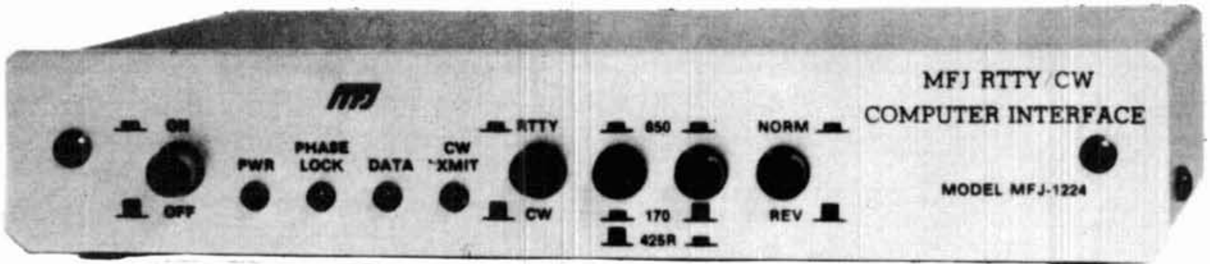

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A sharp 8 pole active filter for 170 Hz shift and CW allows good copy under crowded, fading and weak signal conditions.

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More Details? CHECK—OFF Page 116

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presstop de W9JUV

ARRL PRESIDENT VIC CLARK, W4KFC, PASSED AWAY SUDDENLY November 25. He had complained of chest pains Thanksgiving day, and went to the hospital for examination. He seemed to be doing OK, but was still in the hospital for observation Friday night when a sudden heart attack claimed him. Vic had suffered some health problems in the past few years.

Vic, A "Ham's Ham," Served Amateur Radio With Distinction for most of his life. He had been an ARRL director, played key roles on FCC/Amateur advisory committees and in various International Amateur Radio Union activities, yet always found time to get on the air. A top CW contest operator and DXer, W4KFC's call was for many years invariably found among the top scores in the Sweepstakes and DX frays. Just a week before his death Vic was made a Fellow of the Radio Club of America, "for leadership in Amateur Radio organization, including WARC preparation and implementation." When a League director recently expressed concern that Vic was pushing himself too hard he replied that he wouldn't feel he'd done his part if he didn't die "in the saddle."

Memorial Services Were Held November 30 in Washington, DC; contributions in Vic's memory can be made to the ARRL Foundation c/o ARRL. He's survived by his wife, Hester, WA4PAE, *and six children, three of them also Amateurs.* W4KFC, *a Silent Key at 66.*

New ARRL President Is Carl Smith, WØBWJ, as automatically provided by the League By-Laws. Succeeding Carl as First Vice President is Larry Price, W4RA. A retired airline captain who learned aerial gunnery from Lt. Barry Goldwater back in 1940, Carl is well known and respected in both domestic and international Amateur circles. His work on the 1979 WARC also led to constructive working relationships with key people at the FCC, as well. No radical changes in ARRL direction are expected under Carl's direction.

ARRL'S WISH FOR VEC COMPENSATION WAS ANSWERED when the House and Senate passed the FCC Authorization (funding) Bill just before Thanksgiving. Smooth political manuevering by Senator Barry Goldwater, who'd reversed his earlier opposition to any fees in the program, resulted in the fee-permitting amendment being attached to the FCC bill. It was then passed without dissent. FCC Chairman Fowler also supported the pro-fee change.

ARRL Can Now Proceed To Develop Its Own VEC Role; its Executive Committee had put its program on hold pending outcome of the fee question. However, it could still be some time before fees are actually incorporated into the rules. With such delicate questions as fee allocation and acceptable accounting procedures unanswered, the Commission will probably decide that a formal rule-making procedure—usually a matter of months—is called for.

In The Meantime A Number Of Other Organizations including educational institutions have expressed their interest in becoming VECs. It now appears a distinct possibility that, at least in some areas, we could end up with more than one VEC!

10-METER REPEATERS WILL REMAIN LIMITED TO 29.5-29.7 MHZ, at least for the immediate future. Acting on PR Docket 83-485, the Commission decided the interference potential with satellite downlinks and other 10 meter users was too great to justify any change. The ARRL, which initially supported expansion, had filed against any change at this time pending results of the further Notice of Proposed Rule Making on phone band expansion.

Phone Band Expansion Has Been Pushed To The Back Burner, with current FCC resources occupied with the volunteer exam program, Amateur involvement in rules enforcement, and of course the "No-Code" license. Latest Washington readings indicate action on the no-code license is very close, possibly as a "Christmas present" to the Amateur community.

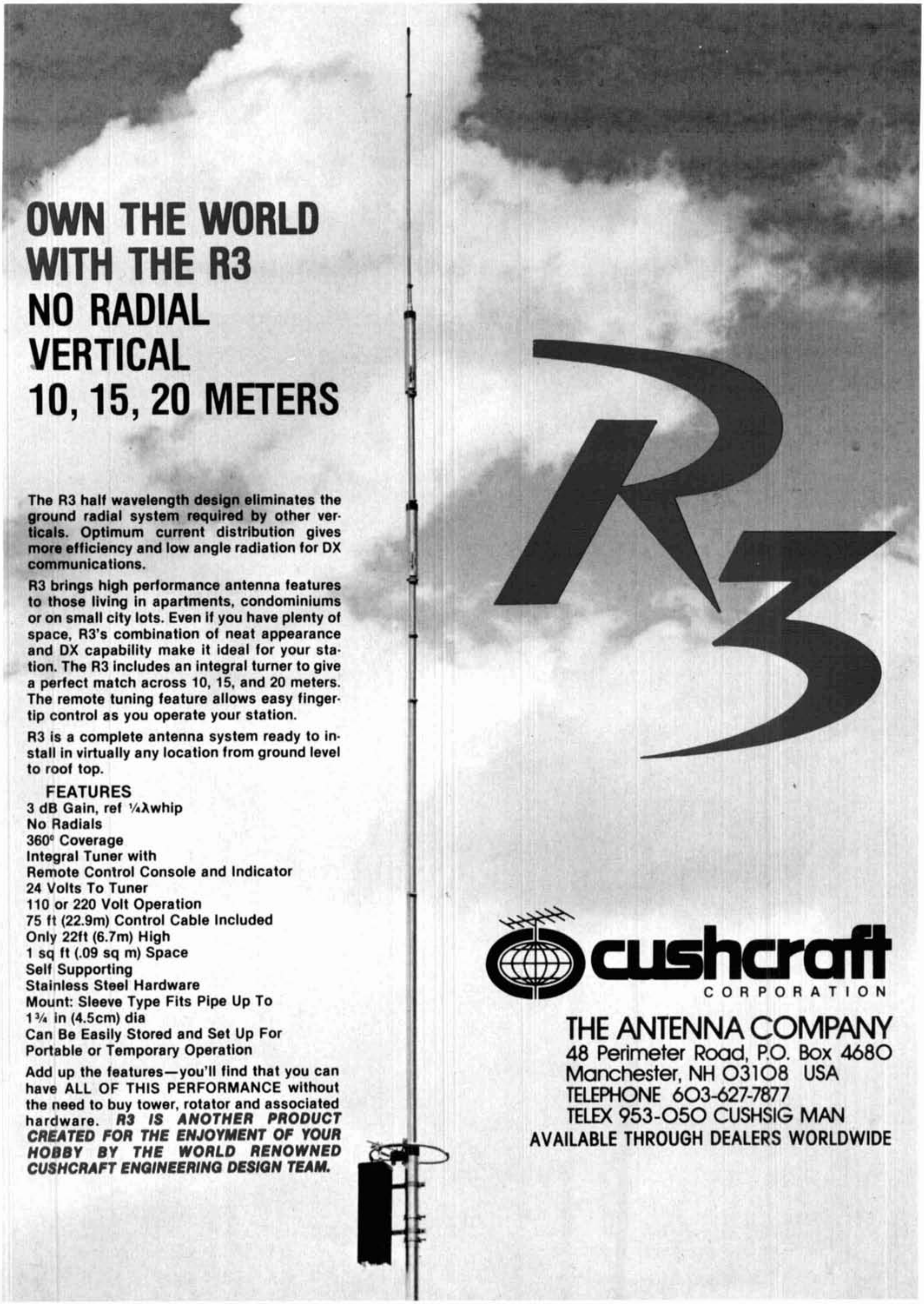
W5LFL DID GET ON THE AIR FROM THE SPACE SHUTTLE, with a full-quieting signal into a hand-held and rubber duckie. At press time the first confirmed QSO was WA1JXN/7 in Montana on orbit 40, though he may also have worked the West Coast on an earlier pass. Lots of media exposure has also been reported. QSL and SWL cards should go c/o ARRL with an SASE.

PRESSURE ON THE 220-MHZ BAND IS STILL INCREASING, with the FCC's Office of Science and Technology now suggesting that the 220-225 MHz allocation be the subject of an FCC Notice of Proposed Rule Making. Though Amateurs are currently the sole users, the band is actually shared with government and land mobile on a co-prime basis.

Band Usage Could Be The Principal Determinant of its future, both in quantity and quality. One way that might help preserve the band would be to make it Amateur Radio's prime high tech "workplace," with, for example, packet radio and various wideband techniques. This is one of the approaches the ARRL is planning to take.

WB6JAC'S CONVICTION FOR TRANSMITTING OBSCENITY on the Amateur bands has been reversed in the U.S. Ninth District Court of Appeals. Though the court did not dispute that Burton had transmitted "obscene" language, it said the government prosecutors had failed to show his actions aroused any "prurient interests!" His convictions for operating without a license still stand. However, such cases may be easier to sustain in the future. Another amendment to the FCC Authorization Bill extends Commission authority over "Dial-A-Porn" telephone businesses since their content is potentially available to children, and that's justification for not providing it First Amendment protection. Since Amateur Radio is operated primarily in homes or family automobiles, the same sanctions could be applied.

Rick Cooper, The Former Exponent Of Unlicensed "HF" Operation, has surfaced again as a result of the Burton reversal. In a rambling letter to the Amateur Radio media, he and his "Communications Attorney Service" promised to support Burton in a lawsuit against "...ARRL, FCC and all radio hams who conspired to deprive Mr. Burton of his constitutional rights...."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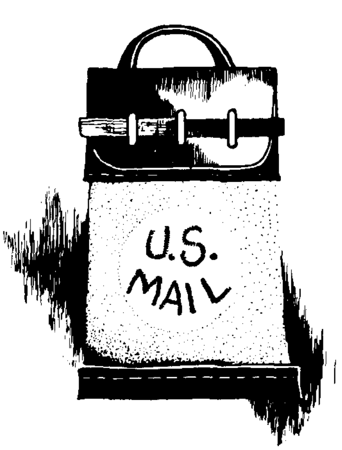

comments

10-meter beacon

Dear HR:

The 10-meter beacon described in the September, 1983 issue of *ham radio* ("Comments," page 13) has been moved from Niantic, Connecticut, to just outside of Rochester, New York. It is now about 10 miles (16 km) south of Rochester at 43° 02′ N, 77° 41′ W, in grid square FN 13 using the Maidenhead Grid Locator system. The power is still 4 watts output and the antenna is a dipole up about 20 feet (6 meters). The beacon, on 28.286 MHz CW, is on the air 24 hours a day.

W. Keith Hibbert, KA1YE
Rush, New York

TOM remembered

Dear HR:

I read your "Reflections" column in October, 1983, *ham radio*. I don't think I've ever been so pleased to read *anything* in Amateur Radio publications.

I was fortunate. I read "TOM" early in my exposure to Amateur Radio. Whenever a bad practice would make an appearance, TOM would be there with the way to get back on the track. It seemed that all Amateurs had tremendous respect for TOM, and as a result, he had a tremendous effect upon the behavior of the majority of licensed operators.

As I remember, I was perhaps one of the first to complain about lists. I wrote to — was his name Newkirk? — the DX editor of *QST* at the time and registered my protest against what I perceived to be a cancer growing on DXCC. Of course, nothing happened except that as time passed, DXCC became less of an accomplishment. Naturally, if the real competition is removed from DXCC (or any other award), the award becomes less desirable to the true DXer. I wonder what sense of accomplishment one receives from Honor Roll status when he knows that the certificates should be made out in the name of the do-good MC?

I am proud of my DXCC, 5B DXCC, WAZ, etc. I have 308 confirmed and every last one is self-earned! To disprove the equipment dodge, I have only modest equipment, but it has been put together with DX in mind, using a tri-band beam. But I expect that if one wants to work DX, he must equip himself with DX gear just as an automobile racer equips himself. (I don't ever remember TOM saying it was wrong to run legal power — or to use gain antennas.)

With the MC type of DX, you stand in line and take your turn! This should never have been allowed to happen. I blame all of the DX commentators for forgetting that DX is a competition and that the chase is where the fun is. I'm very pleased that *ham radio* has brought the issue out of the closet. Perhaps continued exposure of this practice will make it dry up and disappear. If it is ridiculed sufficiently — and often — I feel sure that many Amateurs will avoid it, and in so doing regain the thrill of DXing.

Walter Camuso, W1ESN
Vero Beach, Florida

avoiding splatter

Dear HR:

W5XW's excellent letter (December, 1983) commenting on the poor waveform of the sidetone of some keyers is correct. A poor waveform would cause splatter if fed into the audio input of a transmitter. My own homebrewed circuit uses a Twin-T audio oscillator and produces a good waveform output that has been checked on an oscilloscope. And my on-the-air tests have shown that there was far less interference caused than when you yell AHHHHHH into the microphone, or the side bands caused by normal conversation. I did check on a buddy's commercial keyer's sidetone, and it was poor, just as Bob said.

The relay technique I described was not used in the audio input circuit, but was used in the keying circuit because the frequency of the relay was far too low for a good audio signal. It acted just like the dots of my old Vibroplex, when I tested the idea years ago. And as I said, I did prefer the automatic keyer because it gave a steadier output, as would be expected.

The low-duty cycle technique, used with a dummy load, is very effective when tuning up because before you tune for your plate current dip, your plate dissipation can temporarily be quite high, and at times reach dangerous levels. Another good reason for first using a proper dummy load is that when your final amplifier is tuned up, you don't have to touch its controls when you switch to your antenna tuner. This technique naturally eliminates the interaction problem between transmitter and tuner controls that is so often present when you tune up directly without first using a dummy load. The more you use your dummy load, the less QRM you make on the bands.

So to avoid splatter as mentioned by W5XW, do as he suggests, unless your audio side tone output is a good sine wave; just use dots and key your transmitter directly. (And thanks, Bob, for your precautionary letter. I had not been aware of the poor quality of sidetone wave shapes of the kind of units he discussed until he brought it to my attention.)

William Vissers, K4KI
Cocoa Beach, Florida

Note: As this issue went to press, Siliconix announced the sale of the RF portion of its MOSFET power transistor business to the PHI Division of M/A-Com, in Torrance, California. *Siliconix will continue to supply these parts until M/A-Com is in full production of the product.* — Editor

power FETs:
trend for VHF amplifiers

Use these MOSFETS for better thermal stability, lower noise, easier matching, and higher voltage operation

The dull black fins of heatsinks have all but replaced the glow of vacuum tubes as the distinguishing visual feature of power amplifiers designed for Amateur use. Bipolar junction power transistors offer many advantages and have, among amplifier designers, become the device of choice over vacuum tubes in many applications. However, just as bipolar junction transistors have largely replaced vacuum tubes as technology has advanced, it now appears that bipolar transistors are being challenged by field effect transistors (specifically RF power MOSFETs) in the RF power amplifier field.

In this article we will discuss some of the features that make the RF power MOSFET (variously known as VMOS, TMOS, DMOS, etc. by different manufacturers) an impressive RF power amplifier. We will also touch on some of the problems that accompany their use. Measurements made on several actual VHF mobile power amplifiers will serve to illustrate the discussion. The amplifiers examined are 50 and 100 watt 2-meter units and a 100 watt unit for 220 MHz.

advantages

When compared to conventional bipolar transistors, the RF power MOSFET offers the following advantages:

Thermal stability. The current gain (Beta) of a typical bipolar transistor increases with temperature. As a result, the collector current can increase with temperature, which results in still higher temperatures and even higher currents, and can lead to thermal runaway. Careful circuit design is required to prevent this problem. On the other hand, at high power levels the transconductance of a power FET decreases with temperature, and an increase in temperature results in a decrease in current, which tends to be self-stabilizing. This stabilization also applies across the chip and serves to prevent destructive phenomena characteristic of a bipolar device: current hogging, hot spotting, and secondary breakdown. Also, no internal source ballasting resistors — with their inherent gain reduction, increased parasitic capacitance, and increased fabrication costs — are required.

Another advantage of this temperature characteristic is the ability to parallel several power FETs without the need for careful device matching. With VHF amplifiers, the number of devices that can be paralleled is limited more by the physical problem of additional parasitic reactances than anything else.

Low noise. A power FET generates far less broadband noise, typically 10 dB better, than a comparable bipolar transistor. This is due partially to the absence of a forward-biased junction and its associated shot noise. This low noise has the potential for significant reduction of transmitter noise levels, which can be beneficial at repeater sites or at any location where other equipment is operating in close proximity.

Low spurious. The transfer characteristic of a typical power FET displays no abrupt changes in shape. This means that when biased for Class AB operation, as in a typical linear power amplifier application, there will be lower high-order inter-

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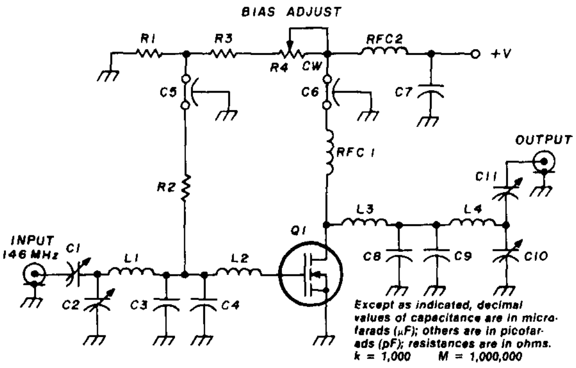

parts list

designation	*description*
C1	4-40 pF mica trimmer
C2	2-20 pF mica trimmer
C3,C4	100 pF leadless mica
C5,C6	1000 pF feedthrough
C7	1000 pF disc ceramic
C8,C9	100 pF leadless mica
C10	2-20 pF mica trimmer
C11	4-40 pF mica trimmer
L1	0.025μH
L2	0.003μH
L3	0.003μH
L4	0.025μH
Q1	Siliconix DV1260T
R1	1 K, ¼ watt
R2	10 K, ¼ watt
R3	2.2 K, ¼ watt
R4	10 K, trimmer pot
RFC1,2	9 turns No. 20 wire, 5/32 inch diameter

fig. 1. 2-meter test amplifier schematic.

modulation products than in a similarly operated bipolar transistor.

Input impedance. The power FET gate is essentially an MOS capacitor. At low frequencies this results in much higher input impedances than the equivalent bipolar device. At VHF the ratio is less favorable. However, the FET device still tends to look capacitive, as opposed to the inductive reactance presented by bipolar devices, which simplifies the design of the input matching networks.

Reduced feedback. Power FETs have reduced internal feedback paths. The higher input impedance results in gate drive voltages several times as high as typical base drive voltages, with two benefits: first, the voltage induced across the source impedance affects the input voltage of the FET proportionally less than the equivalent voltage across the emitter inductance in a bipolar transistor circuit. Second, the effect of reverse transfer capacitance, already low in the power FET, is further reduced by the lower voltage gain.

Parameter changes. The transfer parameters of the RF power FET are quite insensitive to power level. This translates into smooth tuning of the input and output, along with continuous input/output curves, and contrasts with bipolar devices that tend to require retuning at each power level. Bipolar devices also tend to have jumps in power output due to parameters changing with power level.

Simplified circuit design. Gate leakage current is in the nanoampere or sub-nanoampere range resulting in essentially no bias power being used. Thus, simple, low-power bias circuits can be utilized. In addition, the negative temperature coefficient of the FET allows the use of bias supplies without the complex temperature compensation schemes common to bipolar designs. In some higher power designs, it is still desirable to use temperature compensation. However, the compensation is to reduce variations in circuit performance with temperature, not to protect the devices.

Higher operating voltage. Although the practical circuits we will consider in this article are oriented toward mobile VHF power amplifiers, the newer high voltage FETs reaching the market present exciting possibilities for base station use. As supply voltage increases, current decreases and impedance levels increase. At a fixed power level, doubling the voltage halves the current and quadruples the impedance. Increased impedance reduces the effect of parasitic inductance elements and makes the internal leads of the transistor a less critical part of the matching networks. Capacitor values in the matching networks become more reasonable and bypassing gets much easier. Finally, increased impedance allows easier broadband transformer design.

Ruggedness. The previously discussed thermal properties of the FET are often mentioned as the reason for their toughness when compared to bipolar devices.

Another equally important factor contributing to this quality is the FETs' voltage ratings. For example, the gate in the Siliconix devices, specified for 13.6 volts service, will withstand at least 30 volts with respect to the source or drain, and the drain will withstand at least 45 volts with respect to the source. Devices with even higher voltage ratings are available.

The result of these high breakdown voltages and favorable temperature characteristics is an amplifier that can withstand considerable abuse. Neither reasonable amounts of excessive input power nor high VSWR loads will cause any problems for the FET.

commercially available RF power MOSFETS

The preceeding discussion of the advantages of RF power MOSFETs is relevant only if you can purchase the devices and actually use them in an amplifier. **Table 1** lists some important parameters of a sample of the RF power MOSFETs available from Siliconix, Motorola, and Acrian, respectively. (Other manufacturers offer RF power MOSFETs, so your choice is not limited to these three. Also note that these are only partial lists, and that the selection continues to increase as time passes.)

The purpose of **table 1** is simply to illustrate the ranges of some of the devices available and to list the performance of the particular devices under certain sets of circumstances. The devices are useful under conditions other than those listed. For example, the Motorola devices specified at 28 volts perform very well, although at reduced gain and power levels, at 13.6 volts. The higher power levels listed are PEP ratings. Thermal considerations make steady-state power outputs at higher power levels impractical. Higher power levels require the paralleling of devices, fans, and other parts.

building a test amplifer

The Siliconix DV1260T, described in **table 1**, is a particularly interesting device for use in VHF mobile power amplifiers. The rest of this article will be devoted to examining the use of this device in several practical circuits.

The first step was to build a lab model of a single-transistor 2-meter amplifier in order to verifiy the Siliconix data and explore possible problems in the areas of stability, DC voltages, gain, and RF matching. The design goal was a 50-watt amplifier usable for both FM and SSB.

Fig. 1, a schematic of the amplifier, reveals a straightforward approach. Both input and output matching networks use double L sections. The double L sections result in lower losses than single section networks. The input network transforms a gate impedance of 1 ohm to 50 ohms. The 1-ohm gate impedance is essentially resistive at these frequencies because the input capacity is near series resonance with the lead inductance. If done in a single L sec-

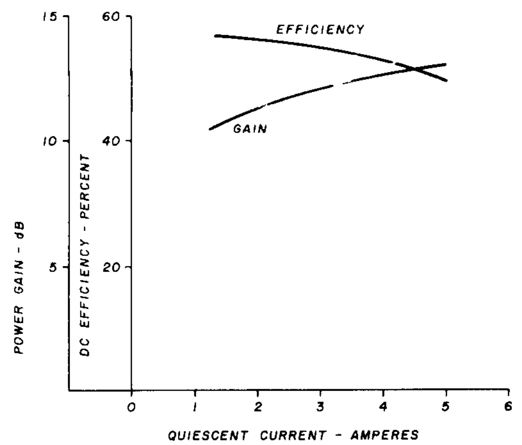

fig. 2. Gain and efficiency of 2-meter test amplifier as function of quiescent current at 50-watt output level.

table 1. Selected RF power MOSFETs available from Siliconix, Motorola, and Acrian.

device	price	typical performance at 2 meters
Siliconix RF power MOSFETs		
DV1220S	$21.90	20 watts out with 10 dB gain at 13.6 volts
DV1240U	31.03	40 watts out with 9 dB gain at 13.6 volts
DV1260T	44.80	60 watts out with 9 dB gain at 13.6 volts
DV2820S	20.75	20 watts out with 12 dB gain at 28.0 volts
DV2840S	44.20	40 watts out with 12 dB gain at 28.0 volts
DV2880U	84.35	80 watts out with 10 dB gain at 28.0 volts
DV28120T	100.80	120 watts out with 10 dB gain at 28.0 volts
DVD150T	100.80	150 watts out with 12 dB gain at 120.0 volts
Motorola power MOSFETs		
MRF136	16.00	20 watts out with 15 dB gain at 28 volts
MRF171	35.00	50 watts out with 15 dB gain at 28 volts
MRF172	65.00	80 watts out with 12 dB gain at 28 volts
MRF174	88.00	120 watts out with 11 dB gain at 28 volts
MRF150	92.00	150 watts out with 10 dB gain at 50 volts
Acrian power ISOFETs		
VMIL20FT	33.00	20 watts out with 13 dB gain at 28 volts
VMIL40FT	45.00	40 watts out with 13 dB gain at 28 volts
VMIL60FT	65.00	60 watts out with 13 dB gain at 28 volts
VMIL80FT	77.00	80 watts out with 13 dB gain at 28 volts
VMIL120FT	105.00	120 watts out with 10 dB gain at 28 volts

tion, a loaded Q of about 10 is required. This produces a 1 dB loss for coils of reasonable Q. The double L section allows loaded Qs of about 3 and the two sections produce a loss of about 0.5 dB. Incidentally, because the input and output impedance transformations were very similar at the power level of interest, similar components were used for both networks.

Testing of the amplifier was done at supply voltages of both 13.6 and 16 volts. 16 volts was included for potential base station use because the performance of the DV1260T improved a bit at higher voltages. The amplifier was tested at 146 MHz.

An exploration of the effects of quiescent current was made. If the quiescent current is too high, the device will overheat from static dissipation. If the quiescent current is too low, gain and linearity suffer. **Fig. 2** shows the gain and efficiency of the amplifier as a function of quiescent current. A quiescent current of 3 amperes was used for most of the remainder of the tests.

Fig. 3 shows the gain of the amplifier as a function of the output level. At 16 volts a gain of over 15 dB is achieved at low power levels, dropping to about 10 dB at 75 watts output. At 50 watts the gain was measured at 12.2 dB. The lower curve shows the expected decrease in gain at 13.6 volts.

Fig. 4 demonstrates the effect of output power level on efficiency. At first glance it might appear that the efficiency is greater at 13.6 volts than at 16 volts. However, we must look at the efficiencies at equivalent points with respect to maximum power output. For example, the amplifier operating at 16 volts and 75 watts has about the same gain and linearity as when operating at 13.6 volts and 50 watts and as might be expected, the efficiency at 16 volts and 75 watts is greater than for 13.6 volts and 50 watts.

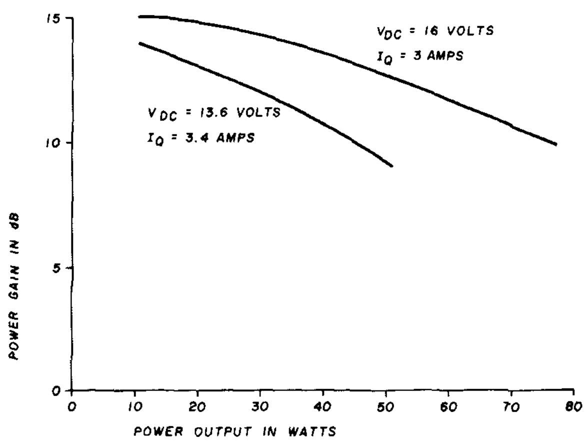

fig. 3. Gain of amplifier as function of output level.

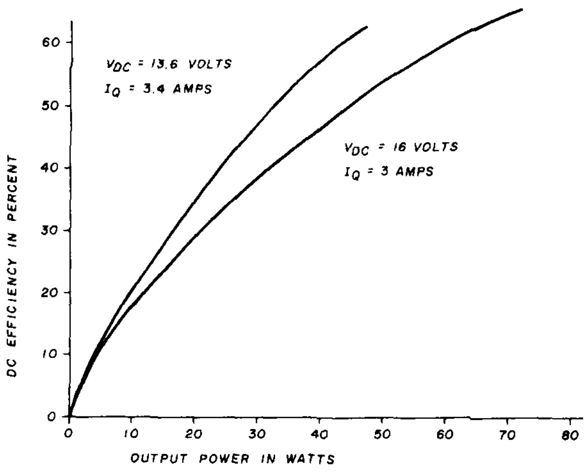

fig. 4. DC efficiency as a function of output power level.

Measured at 25 watts, the test amplifier showed an input VSWR of just under 2. This was with the tuning adjusted for maximum output. This value would seem adequate for working with most Amateur transceivers.

Other tests were run and the following basic conclusions were reached. The DV1260T device performed essentially as claimed by Siliconix. A single device is quite capable of 75 watts when operating at 16 volts and 50 watts when operating at 13.6 volts. Looking forward, a pair of these devices would appear to be suitable for 100 to 150 watts when operating from 16 volts. When operating from 13.6 volts, a capability of 100 watts would seem practical.

a practical amplifier

The next step was to take the test amplifier and turn it into a practical amplifier by adding T/R switching and control circuitry. An amplifier of this power level will be used primarily to boost the power level of the ubiquitous two-meter handheld transceiver (HT) when used in an automobile, so we added a few other features: an adjustable regulated power supply to power the HT and save on batteries, an audio amplifier to boost the HT's sound level, and provision for plugging in a receiver preamplifier. **Fig. 5**, a schematic of the finished unit, represents a complete handheld transceiver (HT) accessory package. Because this is not intended to be a construction article, the schematics are supplied for functional guidance only; in the interest of brevity we will describe the circuit in terms of features rather than in specific detail. We hope it will serve as a source of ideas to those of you who will design their own FET amplifiers.

The unit was built on two PC boards, an RF board,

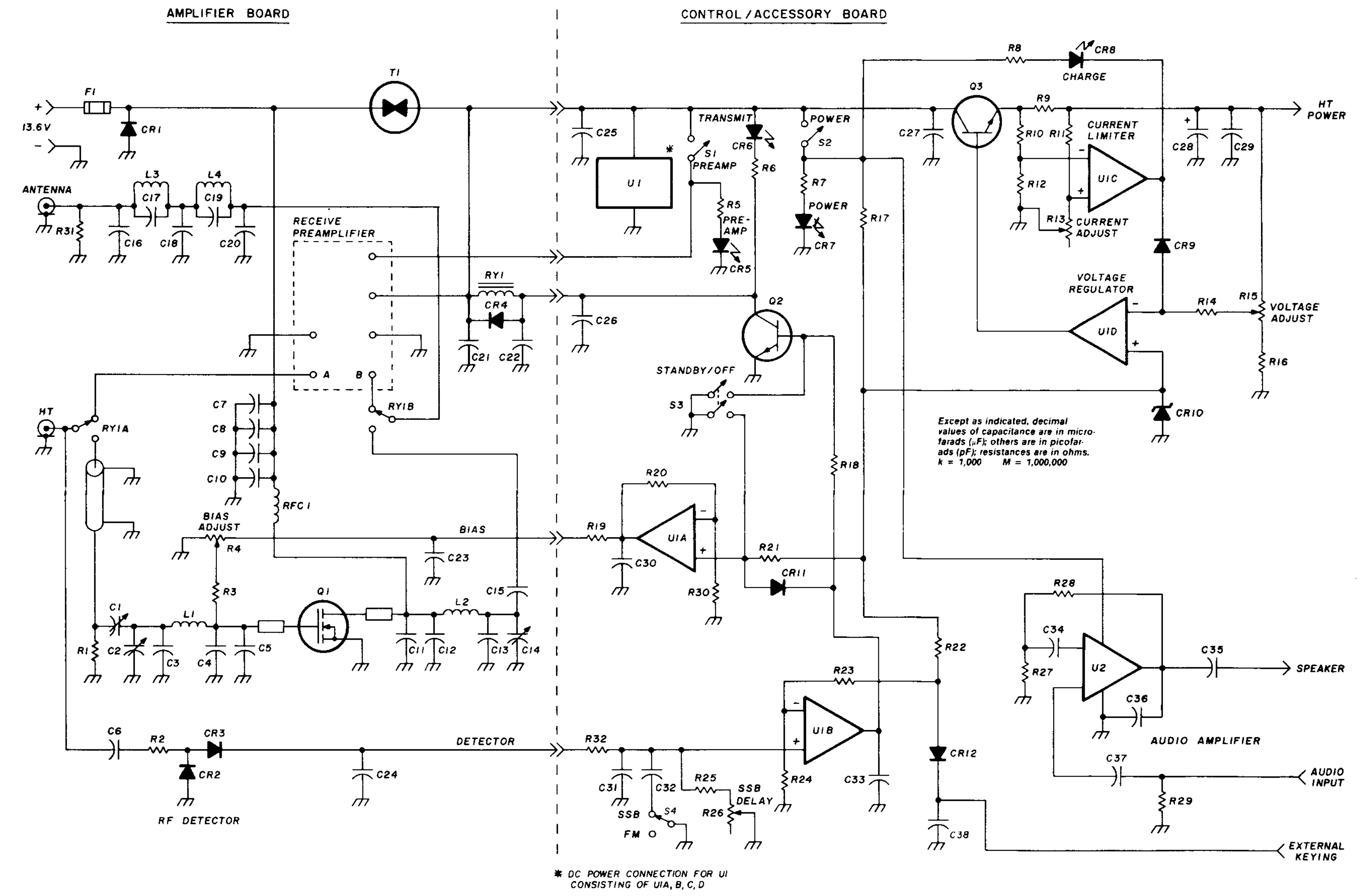

fig. 5. 2-meter HT amplifier and accessory unit schematic.

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parts list for 2-meter amplifier/ accessory package

designation	description
C1,C2	2-20 pF mica trimmer
C3	10 pF disc ceramic NPO
C4,C5	100 pF Unelco
C6	1.5 pF disc ceramic NPO
C7,C8	470 pF disc ceramic
C9	1 μF tantalum
C10	1000 μF 16 volt
C11	100 pF Unelco
C12	22 pF mica
C13	10 pF disc ceramic NPO
C14	2-20 pF mica trimmer
C15	15 pF mica
C16,C17	10 pF disc ceramic NPO
C18	15 pF mica
C19,C20	10 pF disc ceramic NPO
C21,C22, C23,C24,C25	470 pF disc ceramic
C23,C24,C25,C26 C29,C30,C31,C33	470 pF disc ceramic
C27,C28	10 μF/16 volts
C32	22 μF/25 volts
C34	100 μF/16 volts
C35	100 μF/16 volts
C36	0.22 μF
C37	4.7 μF/16 volts
C38	470 pF disc ceramic
CR1	MR750 diode
CR2,CR3	1N4148 diode
CR4	1N4001 diode
CR5,CR6, CR7,CR8	LED indicator
CR9	1N4148 diode
CR10	5.6 volt Zener
CR11,CR12	1N4148 diode
F1	10 amp fuse
L1	3 turns No. 20 wire 5/32 inch diameter
L2	2 turns No. 20 wire 5/32 inch diameter
L3,L4	2½ turns No. 20 wire 5/32 inch diameter
R1	470 ohm, ¼ watt
R2	100 ohm, ¼ watt
R3	10 K, ¼ watt
R4	10 K, trimmer
R5	560 ohm, ¼ watt
R6	470 ohm, ¼ watt
R7	560 ohm, ¼ watt
R8	270 ohm, ¼ watt
R9	0.33 ohm, 1 watt
R10,R11, R12,R13	100 K, ¼ watt
R14	10 K, ¼ watt
R15	10 K trimmer
R16	10 K ¼ watt
R17	560 ohm, ¼ watt
R18	4.7 K, ¼ watt
R19	560 ohm, ¼ watt
R20	82 K, ¼ watt
R21	100 K, ¼ watt
R22	47 K, ¼ watt
R23,R24,R25	10 K, ¼ watt
R26	100 K trimmer
R27	2.7 ohm, ¼ watt
R28	270 ohm, ¼ watt
R29	22 ohm, ¼ watt
R30	10 K, ¼ watt
R31	100 K, ¼ watt
R32	560 ohm, ¼ watt
RFC1	9 turns No. 20 wire 5/32 inch diameter
S1,S2	SPST push-push switch
S3	DPST push-push switch
S4	SPST push-push switch
T1	thermostat, 175° F open
U1	LM324
U2	LM383
RY1	DC DPDT relay

and a control/accessory board. The RF board contains the amplifier and matching networks, a TR relay, a lowpass filter, and a receiver preamplifier. The preamplifier, designed especially for this project by Janel Laboratories, supplies 10 dB of gain for use with those HTs whose receivers need a little bit "extra". It is a plug-in unit and is replaced by a jumper across points A and B when the preamplifier is not needed.

The matching networks perform the same impedance transformations as on the test amplifier. The networks are cascaded L and T sections. Multiple sections are used for the same reasons as explained in the discussion of the test amplifier, above. The inductor for the L sections next to the transistor consists of the transistor leads and a short length of microstripline on the PC board.

The five-pole output lowpass filter has a cut-off frequency of about 200 MHz. Two filter response "zeros" are introduced at about 292 MHz as second harmonic suppressors. The zeros are the result of capacitors C17 and C19. The second harmonic is more than 65 dB below the fundamental. Higher harmonics are further down and not measurable with the equipment used.

Fig. 6 is the PC board pattern for the front and back of the RF board and **fig. 7** is the parts layout.

Fig. 8 shows power output versus power input. It is a little bit less than the output of the test amplifier because of the losses in the relay and lowpass filter.

The amplifier performs smoothly. Its input/output characteristics exhibit none of the discontinuities or hysteresis common to bipolar power transistors. The tuning is very smooth and the tuning characteristics do not vary much with power level, as with bipolar transistors. Varying tuning, power level, and load VSWR while monitoring spectral output revealed no trace of spurious outputs.

The amplifier is well behaved and fully stable in any operating enviroment. It is possible to create oscillations by reactively terminating the input with no load on the output. This condition does not occur in normal operation.

A thermostat that opens at 175 degrees Fahrenheit is mounted on the heatsink near the amplifier transistor. Although you should always use more than adequate heatsinks to prevent overheating, there is always the possibility that even a well-protected unit might be covered by something — a carelessly thrown sweater, for example — that could cut off air flow. In such an event, in which overheating would be possible, the thermostat could prevent expensive damage.

The control/accessory board supplies the necessary switching and control circuitry for the amplifier and accessory circuits to increase the utility of the HT in the mobile environment.

An RF detector on the amplifier board supplies a voltage when the HT is keyed. This is sensed by U1B and turns on Q2 which controls the TR relay. U1B also controls U1A, which supplies a regulated voltage for biasing the amplifier. Without bias the amplifier draws no current. A regulated supply keeps the amplifier specifications more constant as the supply voltage varies.

When S4 is in the "FM" position, the application of bias and the closing of the TR relay is essentially instantaneous, following the sensing of an RF signal. When the HT ceases transmitting, the bias is removed and the TR relay opens, also essentially instantaneously. When S4 is in the "SSB" position, C32 is added to the circuit and while it doesn't slow the turn-on significantly, it does slow the turn-off time. This delay, determined by C32 and, R25 and R26, is

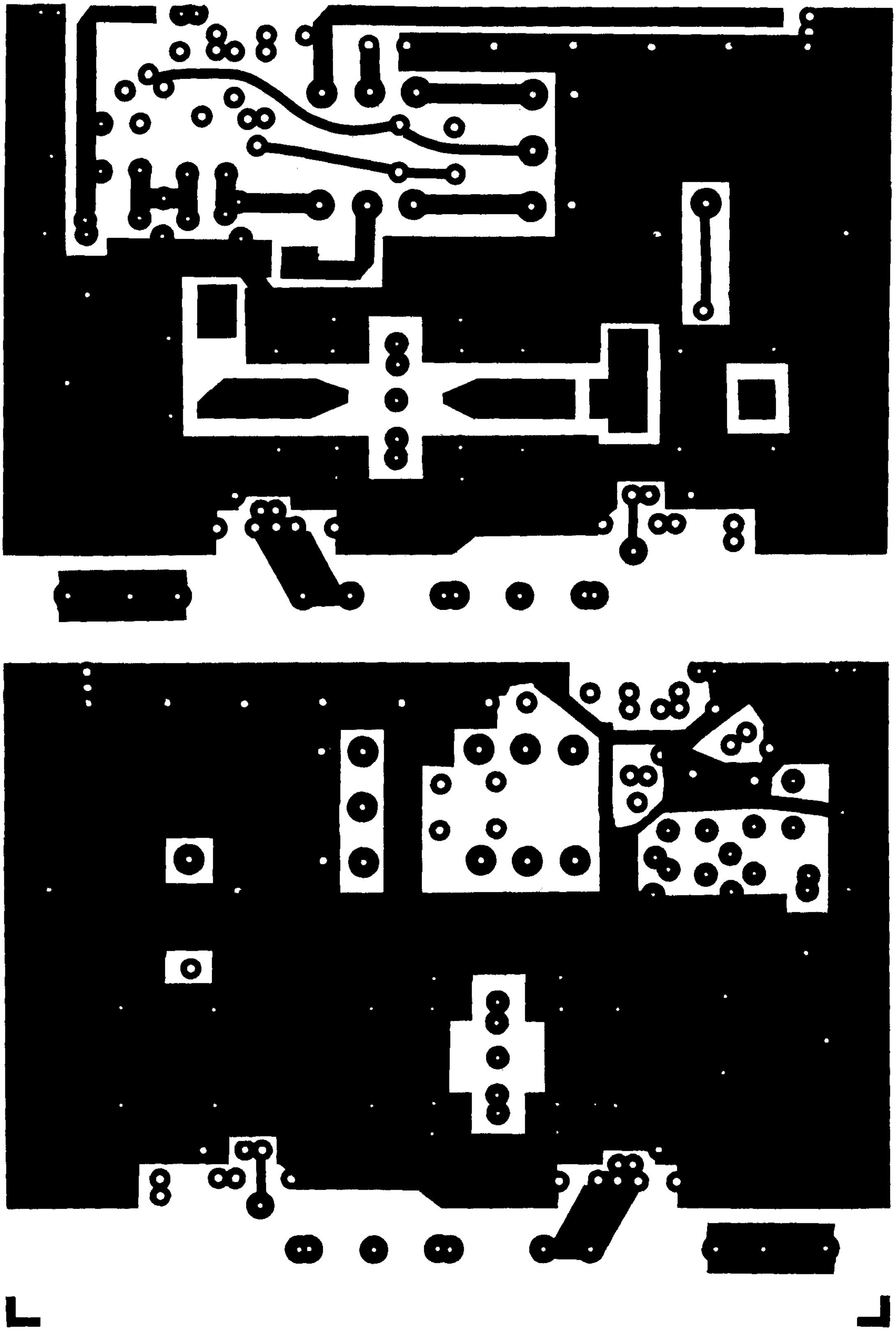

fig. 6. PC board patterns for 50-watt 2-meter amplifier: front (above), back (below).

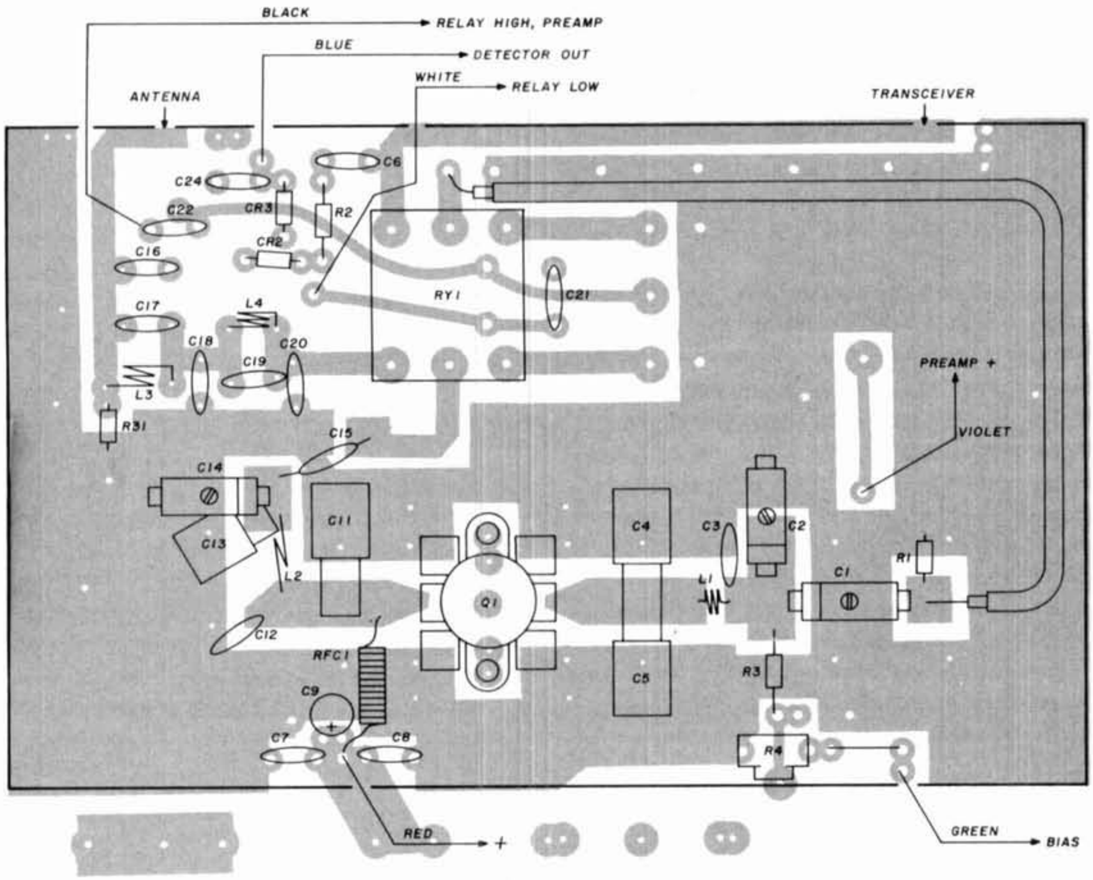

fig. 7. Component layout for 50-watt 2-meter amplifier.

added so that the unit doesn't turn off between words because of the lack of a carrier on SSB.

Most multi-mode amplifiers on the market have this switch. Since the amplifiers are biased for linear operation in both FM and SSB modes, these switches have nothing to do with the linearity of the amplifier and serve only to insert a delay in one RF sensing circuit in the SSB mode to prevent the amplifier from keying in and out between words. The delay is adjustable and a compromise setting must be found. If you set the delay time long enough so that the amplifier doesn't cut in between words, it may take an uncomfortably long time to switch to receive after you let up on the PTT switch.

RF switching is convenient but a better solution is to wire the amplifier for direct keying. An external keying line is supplied on this and most other amplifiers for this purpose.

U1C, U1D, and Q3 form a current-limited voltage regulator to power the HT. This circuit can be used in two different ways. In one, it will power the HT instead of the HT batteries. R15 is adjusted to set the output voltage at the rated voltage of the HT and R13 is adjusted so that the output current limits at a little over the transmit current drain of the HT. The power supply can deliver a little over one ampere.

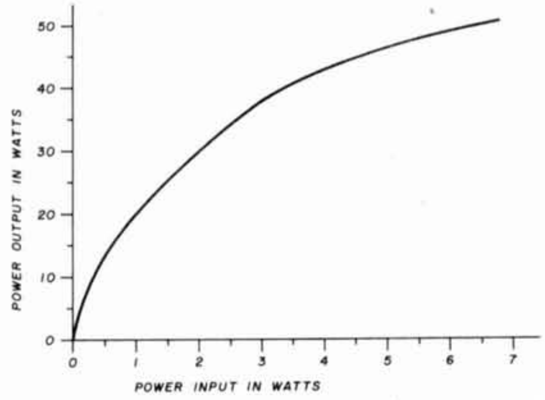

fig. 8. Output power versus input power for 2-meter HT amplifier.

The alternative is to use the power supply as a charger for the HT batteries. For this, adjust R15 to

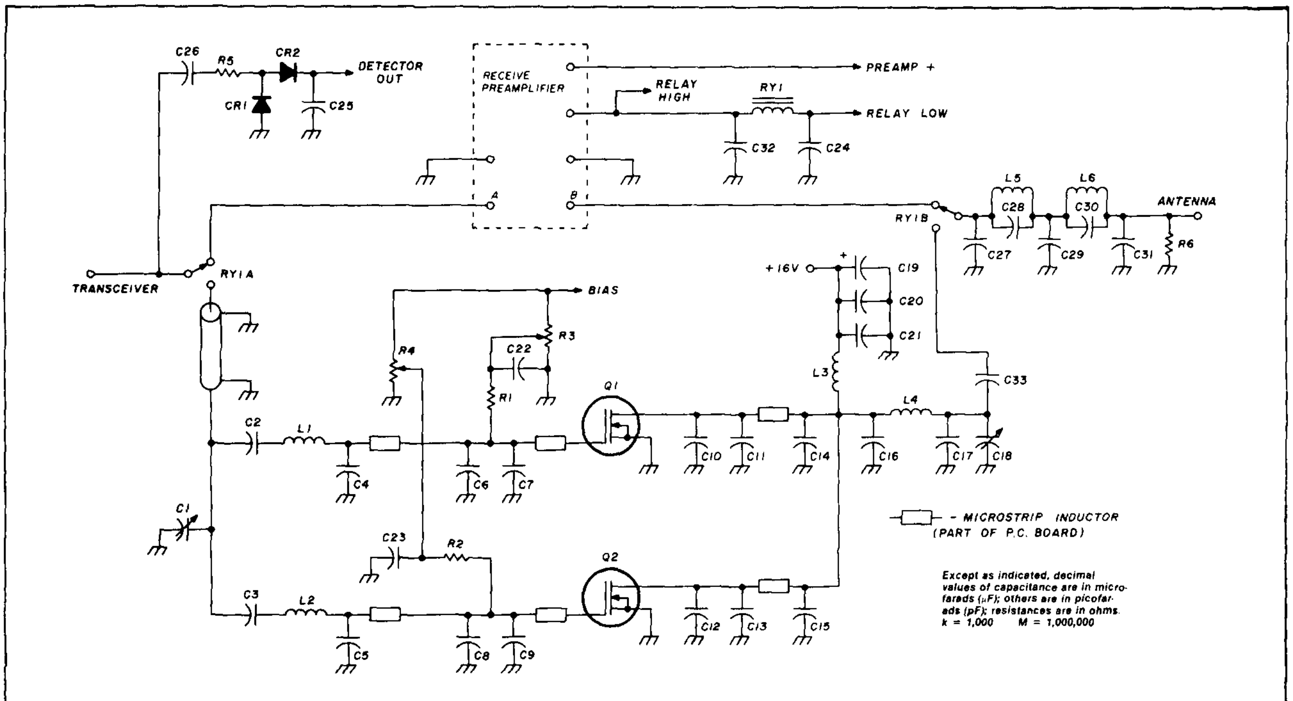

fig. 9. 100-watt 2-meter amplifier schematic.

set the output voltage to the fully charged voltage of the HT batteries and set R13 to the recommended charging current for the batteries. The batteries will be charged at this current until they reach full charge, at which time the power supply automatically switches to constant voltage and reduces the charge rate to whatever is needed to maintain full charge. CR8 will glow when the supply is in the constant current mode, confirming that the batteries are under charge. (See the January, 1983, issue of *ham radio* for an excellent discussion of this subject.)[1] In the first mode, discussed in the previous paragraph, CR8 indicates an overload.

The final major accessory circuit is the one containing U2. This is a speaker amplifier to boost a low HT audio output signal to a level capable of driving a speaker that can deal with the high background noise in a vehicle. The LM383 is capable of supplying sufficient current. However, it is limited to a peak voltage swing of a little less than 1/2 the supply voltage. So use a low impedance loudspeaker if you want to make a lot of noise. The LM383 will typically deliver 4.7 watts to a 4-ohm load with a 13.2 volt supply. It will deliver 7.2 watts to a 2-ohm load, but only 2.4 watts to an 8-ohm load.

Making the control/accessory board separate from the amplifier board provides some flexibility in mounting. When the amplifier is mounted within easy reach of the operator, the control/accessory board mounts in the same cabinet as the amplifier.

parts list for fig. 9

designation	description
C1	2-20 pF mica trimmer, Arco 402
C2,C3	22 pF dipped mica
C4,C5,C6,C7, C8,C9,C10, C11,C12,C13	100 pF Unelco J101 type
C14,C15,C16	47 pF Unelco J101 type
C17	24 pF Unelco J101 type
C18	6-60 pF mica trimmer, Arco 404
C19	1 μF 35-volt tantalum capacitor
C20,C21,C22 C23,C24,C25	470 pF disc ceramic
C26	1.5 pF disc ceramic, NPO
C27,C28	10 pF disc ceramic, NPO
C29	15 pF disc ceramic, NPO
C30,C31	10 pF disc ceramic, NPO
C32	470 pF disc ceramic
C33	560 pF dipped mica
CR1,CR2	1N4148
L1,L2	7 turns No. 20 enamelled wire 5/32-inch ID
L3	5 turns No. 16, 1/4-inch enamelled wire, 5/32-inch ID
L4	2 turns 1/8-inch copper wire, 3/16-inch ID
L5,L6	3 turns No. 20 enamelled wire, 5/32-inch ID
Q1,Q2	Siliconix DV1260T
R1,R2	10K 1/4 watt
R3,R4	10K linear pot
R5	100 ohm, 1/4 watt
R6	100K, 1/4 watt
RY1	DC DPDT relay

When the amplifier is mounted out of reach, such as in the trunk, the control/accessory board is removed from the amplifier chassis, mounted in a small remote control cabinet, and connected by cable.

higher power

The next step was to design a pair of amplifiers using 2 parallel DV1260Ts. The first amplifier was designed for 2 meters and the second for 1-1/4 meters.

As expected, the 2-meter amplifier was similar to the amplifiers just described. At a supply voltage of

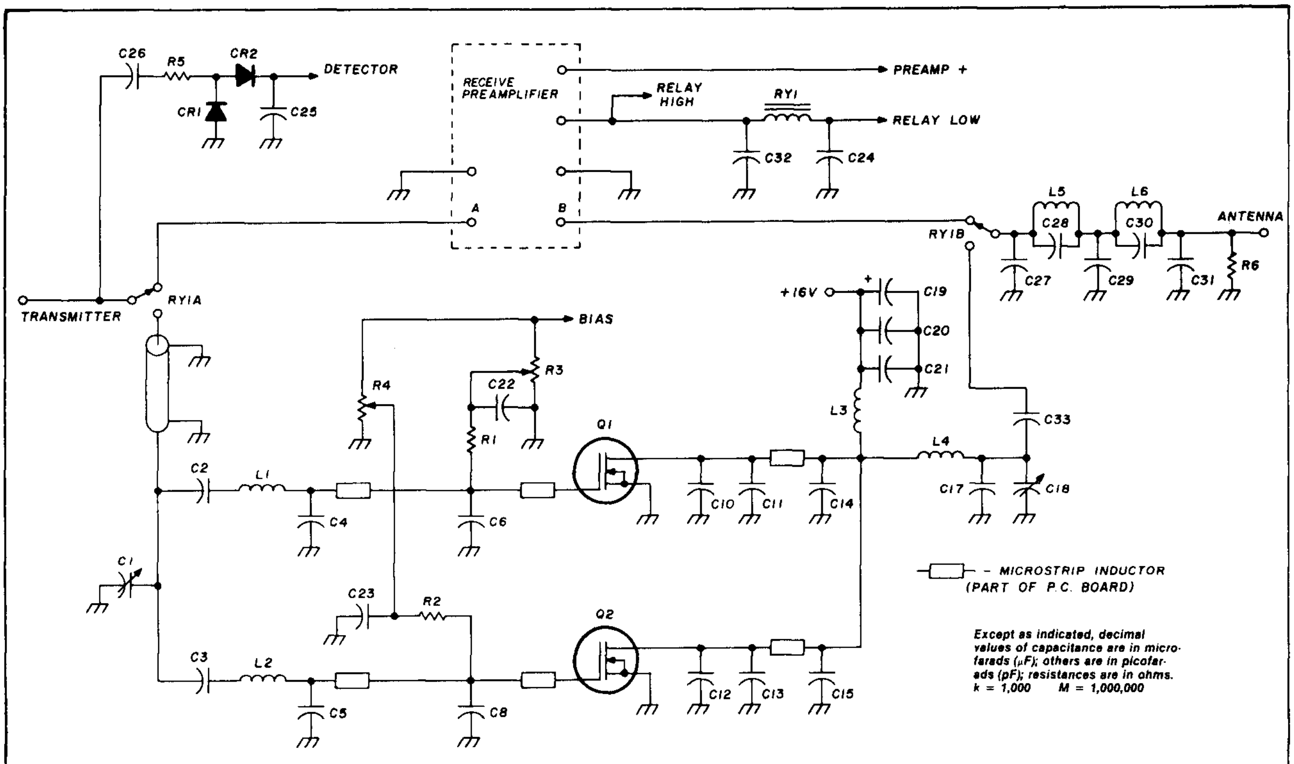

fig. 10. 100-watt 220-MHz amplifier schematic.

16 volts, 100 watts of output was obtained with a little less than 10 watts of input. The gain and efficiency were lower at 13.6 volts. Performance curves are not included because all you have to do is use the single transistor amplifier curves and adapt for the doubling of power.

A single stage amplifier of this gain and power output will most likely be used with a mobile transceiver. A catalog search revealed that most new transceivers have a 25-watt output, so a design which supplied 100 watts output with 25 watts of input was pursued. **Fig. 9** shows the amplifier schematic. Only the amplifier portion is shown because the control board is a simplified version of the one described for the single transistor amplifier, less the audio amplifier and the voltage regulator.

The amplifier consists of two single-device amplifiers connected in parallel. Each single-device amplifier is designed to work in a 100-ohm system. The input and output are both matched by a cascade of three L networks. Multiple L networks increase the bandwidth and reduce the circuit losses over that of single L matching networks. For both the input and the output, the inductors for the two L networks closest to the FETs are made from the transistor leads and the PC board traces.

For the input circuit, the highest impedance L network includes capacitors in series with the inductors (C1, L1 and C3, L2). This arrangement is used to break up a low frequency resonance (about 35 MHz) that can cause oscillations to occur in a push-pull mode. The use of series capacitors is undesirable from the standpoint of loss and bandwidth, but the degradations are not severe. The amplifier outputs are paralleled at less than the 100-ohm point, mainly as a matter of mechanical convenience.

Tuning ease and spectral purity were similar to the

parts list for fig. 10

designation	description
C1	6-60 pF mica trimmer, Arco 404
C2,C3	22 pF dipped mica
C4,C5,C10,C11, C12,C13,C14,C15	47 pF Unelco J101 type
C6,C8	100 pF Unelco J101 type
C17	4.7 pF disc ceramic, NPO
C18	2-20 pF mica trimmer, Arco 402
C19	1 μF 35 volt tantalum capacitor
C20,C21,C22, C23,C24,C25	470 pF disc ceramic
C26	1 pF disc ceramic, NPO
C27,C28	6.8 pF disc ceramic, NPO
C29	10 pF disc ceramic, NPO
C30,C31	6.8 pF disc ceramic, NPO
C32	470 pF disc ceramic
C33	51 pF dipped mica
C7,C9,C16	not used
CR1,CR2	1N4148
L1,L2	5 turns No. 20 enamelled wire, 5/32 inch inside diameter
L3	5 turns No. 16 enamelled wire, ¼ inch inside diameter
L4	copper strap 1/8 inch × ¼ inch
L5,L6	2 turns No. 20 enamelled wire, 5/32 inch inside diameter
Q1,Q2	Siliconix DV1260T
R1,R2	10 K, ¼ watt resistor
R3,R4	10 K linear pot
R5	100 ohm, ¼ watt
R6	100 K, ¼ watt resistor
RY1	DC DPDT relay

single transistor amplifier. The second harmonic is about 75 dB below the fundamental. An imbalance between the two sides was noticed while tuning, probably because of variations in input capacity. It was found that a 30 pF mica capacitor could be moved along the input lines until the output was maximized. This seemed to be adequate compensation for the imbalance, since after the capacitor was installed the two sides seemed to behave very symmetrically.

temperature effects

The amplifier was also tested in a temperature chamber over the range of −40 to +60 degrees C. Quiescent current, power output, gain, power bandwidth, and spectral purity were all examined. The quiescent current was very slightly temperature dependent. As expected, the current is higher at lower temperatures. The total variation was only 0.4 amperes across the entire range. The room temperature current was set at 6.0 amperes. In terms of RF parameters, the variations were so slight as to be difficult to measure. The gain appeared to be a few tenths of a dB higher at the low temperatures. Current drawn at the 100-watt point did not vary significantly with temperature. In all cases the spectrum was clean. In short, temperature effects are not a problem for this amplifier.

1 1/4-meter amplifier

The final amplifier to be discussed is a 1-1/4-meter amplifier using two paralleled devices. A schematic of it is shown in **fig. 10**. Many of its characteristics are quite similar to those of the lower frequency version, but, as might be expected, both the gain and efficiency were lower at this frequency. For example, with a supply voltage of 16 volts, 10 watts input produced 80 watts output, as compared to 100 watts at the lower frequency. An amplifier designed for 25 watts in and 100 watts out ran at 46 percent efficiency at 13.6 volts, as compared to better than 60 percent at the lower frequency. Quiescent current was set at 6 amperes for both the 2-meter and 1-1/4-meter amplifiers.

conclusion

RF power FETs offer a number of significant advantages over bipolar devices; they are easier to handle and allow somewhat simpler circuits. As manufacturers increase the selection and continue to improve specifications, we will see an increasing number of bipolar and vacuum tube designs being replaced with RF power FETs.

reference

1. J.D. Moell, KØOV, "Forget Memory," *ham radio*, January, 1983, pages 62-64.

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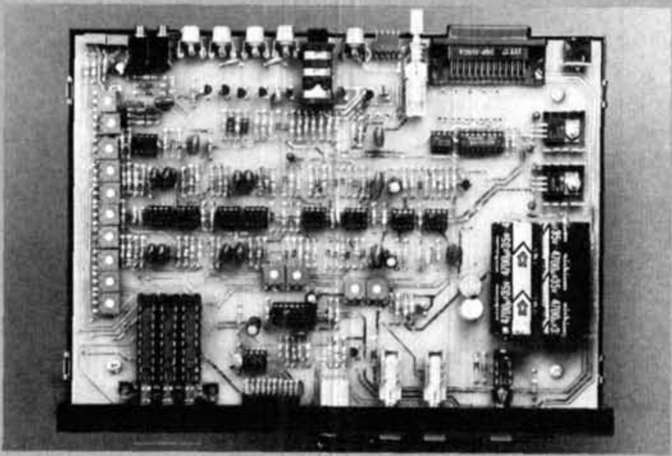

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measuring noise figure

How noise figure, noise factor, ENR, and hot/cold terminations are interrelated

Most Radio Amateurs and electrical engineers learn early in their careers that the ability of a receiving system to respond to weak signals can be improved, not by the addition of gain, but by the reduction of noise.

It is the signal-to-noise ratio that ultimately renders a radio signal useless, and every amplifier or mixer (stage) in a receiver adds to the noise, thus decreasing the signal-to-noise ratio. The amount of noise added by an amplifier or mixer is given quantitatively as a noise factor which is the ratio of the input signal to noise ratio to the output signal-to-noise ratio:

$$noise\,factor = \frac{S_i/N_i}{S_o/N_o} \qquad (1)$$

where S_i = input signal power
N_i = input noise power
S_o = output signal power
N_o = output noise power

If the amplifier frequency response is wide, as compared to the bandwidth of the signal, no amplifier or mixer can improve the signal-to-noise ratio of the input signal. That is, if the input signal-to-noise ratio is 20 dB, the output signal-to-noise ratio will be less than 20 dB. A similar expression, the noise figure, is the "decibel" equivalent of the noise factor and is given by:

$$noise\,figure = 10\log_{10}(noise\,factor) \qquad (2)$$

Thus the signal-to-noise ratio of an input signal is reduced by an amount equal to the noise figure. That is, if a signal with a 20 dB signal-to-noise ratio is passed through an amplifier with a 5 dB noise figure, the output signal-to-noise ratio is 15 dB.

Because the ability of a receiving system is primarily limited by the noise performance of the first RF amplifier, measuring the noise figure is an important part of the receiver evaluation.

noise measurement difficulties

It would appear from the previous equations that measuring the noise figure of an amplifier should be a simple matter of measuring the signal-to-noise ratio of both the input and output of the unit under test. The difficulty in this method arises from the fact that the measuring equipment has noise contributions of its own, and it would be difficult to determine the signal-to-noise ratio of the input signal.

Another problem arises from the fact that the noise power is proportional to the bandwidth used for the measurement. Modulated signals have various relationships between measuring bandwidth and the measured power depending on the form of modulation. Therefore the signal-to-noise ratio can become a rather unpredictable function of the measuring system bandwidths.

This is the electronic equivalent of comparing apples and oranges. The solution lies in making the signal-to-noise measurement using a noise signal, and comparing it to the system noise. Using this method, the measured power is proportional to the measuring bandwidth for *both* signals and noise.

The device used to generate the noise signals is called a noise generator. It is important that the noise power output from a noise generator be greater than the noise power of a resistor at normal room temperature, otherwise the signal-to-noise ratio of the noise generator will be zero dB and of no value for measuring noise figure. The noise power output of any resistor at normal "room" temperature, 290° Kelvin, is:

By Albert Helfrick, K2BLA, RD1, Box 87, Boonton, New Jersey 07005

$$P_n = KT_oB \quad \textbf{(3)}$$

where P_n = the noise power
B = the measuring bandwidth
K = Boltzman's constant
T_o = 290° Kelvin (17° centigrade)

If the noise power of the noise source is higher than a resistor at 290° K, it is equivalent to the noise power from a resistor at some temperature — say, T', which provides a noise power output of:

$$P_s = KT'B \quad \textbf{(4)}$$

where P_s = the noise power of the noise source
T' = the equivalent noise source temperature

The noise power can be generated in several ways. First, a resistor at the higher temperature or some other artificial method such as using the noise current of a solid-state or thermionic diode could be used to generate the equivalent noise power.

A useful expression for the amount of noise power available from a noise source is called the excess noise ratio, *ENR*, and is given by:

$$ENR = \frac{T' - T_o}{T_o} \quad \textbf{(5)}$$

To measure the noise figure of an amplifier or mixer using a noise source, the amplifier is connected to a power measuring instrument and the noise source is connected. The power output from the device under test is measured. A termination, typically 50 ohms, at a temperature of 290° K is connected to the device under test and again the power output is measured. The ratio of the two power outputs, called the Y-factor, is used to calculate the noise figure. The Y factor is:

$$Y = \frac{P_o'}{P_o} \quad \textbf{(6)}$$

where P_o' is the power output of the device under test with the noise source connected, and P_o is the power output with the 290° K termination. The noise figure of the device under test is:

$$NF = 10 \log_{10} \frac{ENR}{(Y-1)} \quad \textbf{(7)}$$

In theory, this technique is simple; however, the difficulty lies in making an accurate power measurement of the output power. A resistive termination at 290° K has a power output of −144 dBm in a 1 kHz bandwidth and even after amplification by the device under test, the output is relatively small.

In order to increase the power to a point at which a convenient power meter such as bolometer type may be used, additional amplification is required. The noise figure of the amplifier used after the unit under test (post amplifier) will affect the noise figure measurement, according to the following relationship:

$$NF = NF_1 + \frac{NF_2 - 1}{G_1} + \frac{NF_3 - 1}{G_1G_2} \quad \textbf{(8)}$$

where NF = noise factor of the cascaded system
NF_1 = noise factor of the first amplifier
NF_2 = noise factor of the second amplifier
NF_3 = noise factor of the third amplifier
G_1, G_2 = gains of the first and second amplifiers, respectively

If the noise figure of the post-amplifiers is low or the gain of the unit under test is relatively high, the effect of the post-amplifier noise figure will be small.

If a signal were a simple sine wave, power could be determined by measuring the voltage with a sensitive voltmeter and determining the power by using the simple relationship $P = E^2/R$, where E is the measured voltage and R is the system resistance usually 50 ohms. *Noise* signals are not simple and require a true power measurement. A bolometer type of power meter provides an accurate true-RMS power measurement for noise figure measurements. A diode-type voltmeter will provide the proper response if the diode is operated in the so-called square-law region. This is the region of the point contact diode characteristics where the rectified output voltage is proportional to the input voltage squared. A crystal detector or diode type voltmeter can be checked for square law response by increasing the RF input by 3 dB and checking for a two-to-one increase in the rectified output or, in the case of a voltmeter, a doubling of the meter deflection.

test set-up

Because the square-law region of a diode does not usually cover a large range of power, it is desirable to include an attenuator between the diode detector and the amplifier under test as shown in **fig. 1**.

To make a noise figure measurement using this set-up, the attenuator is adjusted to give a meter reading in the square-law region of the diode with the amplifier terminated (at its input) with a room temperature termination. This can be checked by increasing the attenuator by 3 dB and observing the meter reading.

The room temperature termination is replaced with the noise source (also called a "hot termination"), and the attenuator is adjusted to provide the same output reading as before. The amount of attenuation added is called the Y factor, in dB, which has to be converted to a pure ratio. This is used with **eq. 7** to calculate the noise figure.

The measurement of noise figure requires a known ENR. Most Amateurs optimize the noise figure of a receiving system using a noise diode by adjusting the

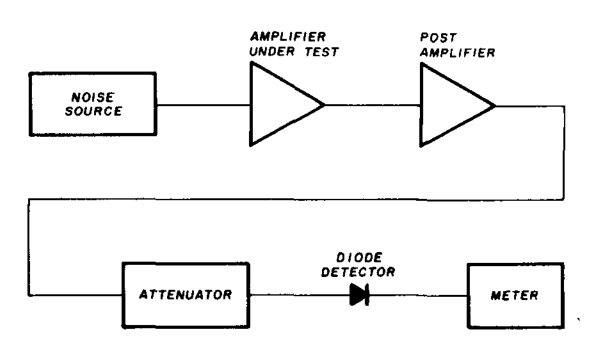

fig. 1. Test set-up for measuring noise figure.

amplifier to give the greatest difference between noise power output with the noise diode on and off. The actual noise figure is not known unless the noise power of the diode is known. Noisy semiconductor diodes do not provide a calculable amount of noise power; commercially available solid-state noise sources are calibrated with a hot-cold noise source.

One very effective method of creating a known ENR is to maintain two identical resistors at a known temperature. Two commonly used temperatures are the temperature of liquid nitrogen at 77° K and the boiling point of water at 100° C or 373° K. The ENR of this system would be:

$$ENR = \frac{T - T_o}{T_o} = \frac{373 - 77}{77} = 3.84$$

or as expressed in decibels: 5.8 dB.

This ENR would be fine for measuring systems with noise figures of a few dB, but it is difficult to maintain the cold termination at 77°K. The cold termination could be at "room temperature" (290°K), and the "hot" termination well above 290°K. One excellent source would be the hot filament of an incandescent lamp. In order to use an incandescent lamp for noise source, the lamp must have a resistance near 50 ohms (hot) and the temperature must be known. Both of these parameters may be determined from the change of resistance versus temperature of tungsten as shown in **fig. 2**.

As an example, assume that a lamp with a cold resistance of 5 ohms is used for a noise source. In order to increase the resistance to 50 ohms, a tenfold increase is required which corresponds to a temperature of 2000° K which produces an ENR of 7.5 dB. This temperature is typical of an incandescent lamp and can be achieved without resorting to special lamps.

A noise source was constructed using two microminiature lamps used for illuminating electronic wristwatches (see **fig. 3**). The lamp is rated for operation at 1.5 volts at 15 mA, which is convenient because this calculates to 100 ohms hot. To determine the temperature of the filament, the cold, 290° K, resistance of the filament was measured and the temperature determined from **fig. 2**. The cold resistance was measured and found to be 16.8 ohms. The hot/cold ratio is 5.9, which corresponds to a temperature of 1300° K.

Two lamps in parallel correspond to a 50 ohm hot source at 1300° K, which is an ENR of:

$$ENR = 10 \log \frac{T - T_o}{T_o}$$

$$= 10 \log \frac{1300 - 290}{290} = 5.42\ dB \qquad (10)$$

Two 1/8 watt 100-ohm resistors were included in the noise source case as the "cold" terminator.

noise source frequency dependence

In order for a noise source to be effective, the impedance must be close to 50 ohms resistive throughout the frequency range of interest. The 100 ohms of the example noise source was determined from the DC operating conditions and does not include the inductive and capacitive components. The complete noise source will have the effects of the coupling

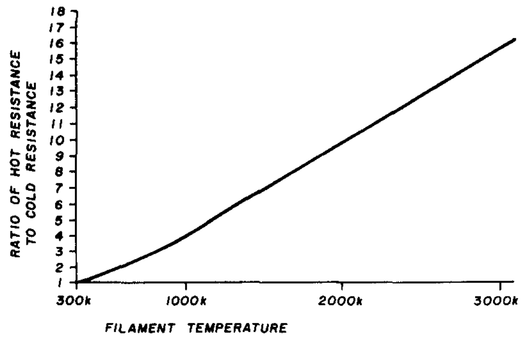

fig. 2. A plot showing the change of resistance with temperature for a tungsten filament.

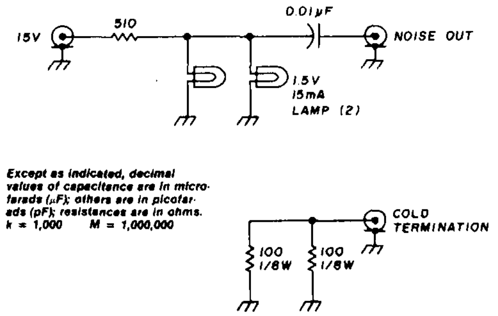

fig. 3. Hot and cold noise sources can consist of 1.5 V incandescent lamps and equivalent 50-ohm resistor, respectively.

More Details? CHECK—OFF Page 116

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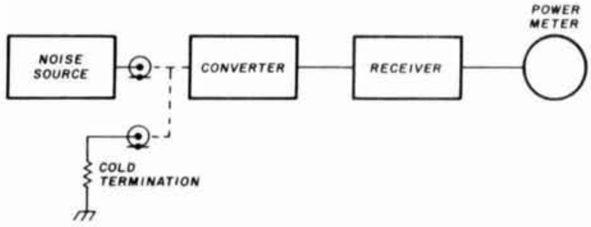

fig. 4. Test set-up for measuring VHF/UHF converter noise figure.

capacitor, the BNC connector and the inductance of the lamp filament. In spite of all of the reactances the return loss as measured on a network analyzer was better than 14 dB up to 1 GHz. Adding a 0.68 pF capacitor improved the return loss to 20 dB to 1 GHz, a very respectable figure for a noise source.

This noise source is suitable for making accurate noise figure measurements to 1 GHz.

The 20 dB return loss of the noise source will allow noise figure measurements to an accuracy better than 0.1 dB.

measuring converter noise

To measure the noise figure of a VHF/UHF converter, the converter is connected to a receiver as shown in **fig. 4**.

An RF probe connected to one of the later IF amplifiers of the receiver is used as a power indicator. Because the noise figure of the system is a function of the setting of the attenuator, the resulting measurement could be distorted. For measuring a noise figure of 2 dB or less with a gain of 20 dB or more, the error will be less than 0.1 dB.

Set the attenuator to 0 dB and terminate the converter with the cold termination. Connecting the converter to the receiver should produce a noticeable increase in background noise. Find a convenient point in the IF amplifier to connect the RF probe. A signal of 100 mW or less is usually in the square law region of the voltmeter. Disconnect the cold termination and connect the hot termination. Adjust the attenuator to provide the same RF voltmeter indications as before; the setting of the attenuator is the Y factor, in dB, and is used in **eq. 7** to calculate the noise factor.

Noise figure measurement determines one of the important operating parameters of receiving systems. The introduction of low-cost GaAs FETs has brought about a reduction of noise figure in many VHF and UHF receiving systems. Using a noise source and the techniques described in this article, it is possible to quantitatively evaluate the improvements effected by the latest technology.

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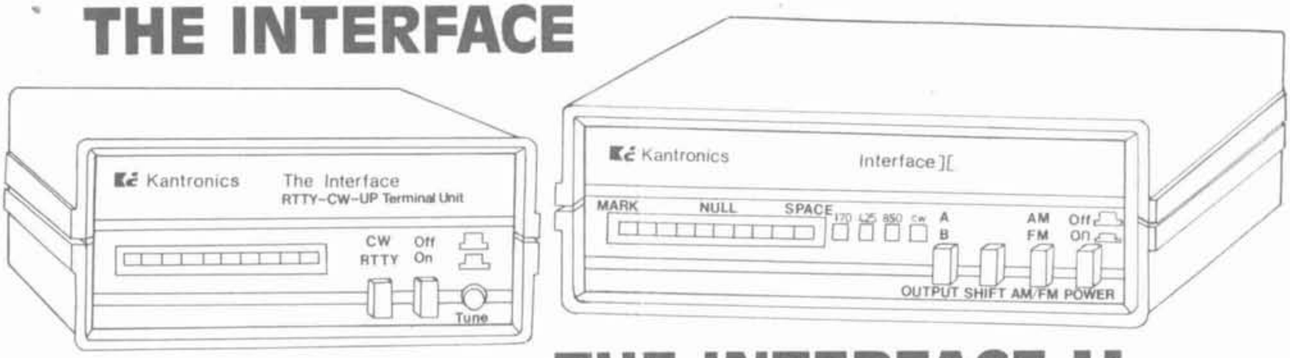

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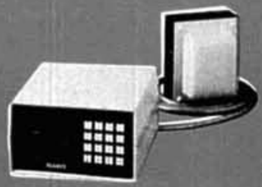

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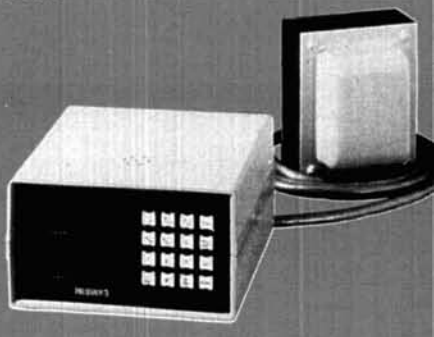

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More Details? CHECK—OFF Page 116

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verticals over *REAL* ground

Ground system geometry and soil conditions determine performance

How does the geometry of a radial system or ground screen affect the radiation pattern of a vertical? How do ground and roof mounting differ? How does gain change with the frequency of operation? And do reflections depend on the dielectric constant and conductivity of the ground? This article — complementing our series on vertical phased arrays by K2BT — addresses these and other questions, in one of the clearest presentations on this important subject ever to appear in the Amateur literature. — **Editor**

Many hams using verticals have wondered how the ground or earth beyond the radial system affects the radiation patterns of their antennas. Much has been written about the need for a good ground screen or radial system to provide a low-loss return path for ground currents. However, not much has been written for Amateurs about how ground reflections affect the performance of a vertical over real ground.

horizontal versus vertical polarization

For dipoles and other antennas putting out predominantly horizontally polarized waves, reflection from a perfectly conducting ground gives a 180 degree phase shift and reflected electric field intensity equal to the incident field. For real grounds the phase shift remains close to 180 degrees and there is little attenuation of the incident wave. That is why reflection from perfect ground is said to indicate what may be expected of a horizontal antenna over real ground.

The situation is quite different with vertically polarized radiation, which is reflected from perfect ground without phase shift or attenuation. However, only salt water is accurately represented by perfect ground. Any other ground, even saturated, fertilized farmland, provides large phase shifts and attenuations of incident radiation which also strongly depend on the angle of incidence and reflection. At grazing angles of incidence and reflection, the phase shift is 180 degrees and there is no attenuation, just as with horizontally polarized radiation. As the reflection angle increases, the phase shift and reflected field intensity both decrease very rapidly, until an angle is reached where the phase shift is 90 degrees and the reflected field intensity is minimum (maximum attenuation). This angle is called the *pseudo-Brewster angle* and ranges from 1 or 2 degrees for salt water to 30 degrees for rocks or dry sand.[1] At this angle, the radiation pattern of a vertical is affected least by ground reflections. Below the pseudo-Brewster angle, the reflected wave of a ground-mounted vertical partially or wholly cancels the direct wave, while above this angle, ground reflections enhance direct radiation. Generally, the better the ground, the smaller the pseudo-Brewster angle, and the greater the gain from ground reflections.

The radiation pattern of a vertical over infinite, perfectly conducting ground is maximum toward the horizon (takeoff angle of 0 degrees). However, a vertical over real ground has no sky wave radiation

By **Mark Bacon, WB9VWA**, 2205 File Drive, Decatur, Illinois 62521

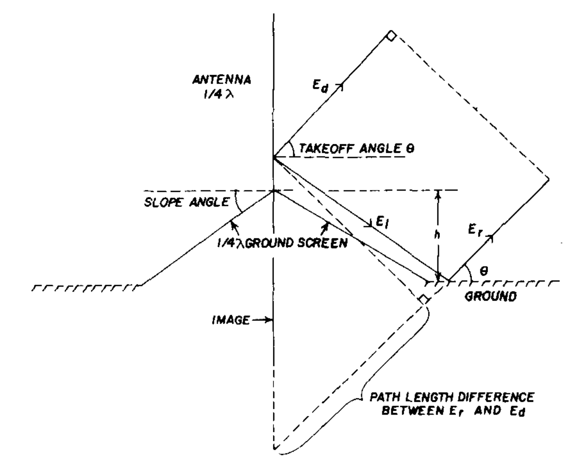

fig. 1. Geometric relationships in a quarter wavelength vertical at height *h* above ground.

toward the horizon and a lobe of maximum radiation varying from 15 degrees, for exceptionally good soil, to 30 degrees, for completely dry rocks and sand. In practice, then, real ground decreases the gain and significantly raises the radiation or takeoff angle of a vertical.

free space patterns and ground reflections

To keep things simple, we will concentrate on a quarter wave, current-fed vertical with a quarter wave, perfectly conducting ground plane, mounted over real ground. The radiation patterns of practical verticals with sixty or more radials will closely approach the patterns presented here.

The overall approach is to combine the results of the optical theory of reflection with the free space pattern of a particular vertical configuration. This composite picture shows a radiation pattern modified by reflections from ground having a particular conductivity and dielectric constant.

The free space pattern is calculated from the standard electric field intensity formula for a quarter wave vertical with an infinite, perfectly conducting ground plane.[2] The ground plane defines a collinear quarter wave image "antenna" below the ground screen (**fig. 1**). In other words, a quarter wave vertical with an infinite ground screen is electrically similar to a half wave vertical dipole except in the feedpoint resistance of the vertical, which at 36 ohms, is just half that of the dipole; its power gain is also 3 dB higher. In our case, the ground screen is a quarter wave in radius instead of infinite. Here the image antenna will be electrically shorter than a quarter wave at takeoff angles θ less than some critical angle defined by the geometry of the system. The progressive shortening of the image as the radiation angle is lowered modifies the free space pattern from what you get with an infinite ground screen, in which the image has the same length as the antenna at all radiation angles.

Ground reflections are determined from the Fresnel equation for the reflection of vertically polarized electromagnetic waves from a plane surface.[3] A set of reflection coefficients, or ratios of reflected to incident field intensities, are calculated for useful takeoff angles in 5 degree increments over ground of a particular conductivity and dielectric constant. If we call the incident-electric field intensity E_i, the reflected field intensity E_r, and the reflection coefficient R, then $E_r = R \cdot E_i$, and E_r is added vectorially to the free space direct field intensity E_d at each takeoff angle to construct a vertical radiation pattern for a vertical over real ground (**fig. 1**).

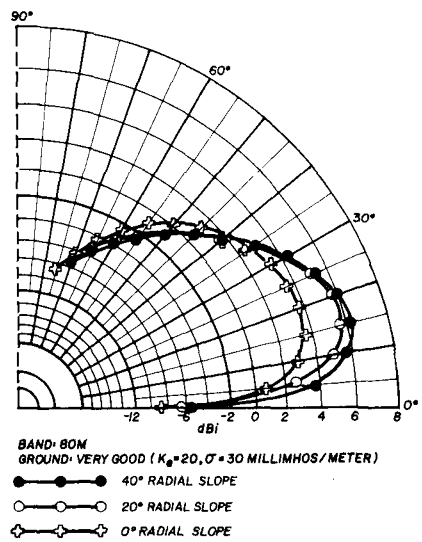

fig. 2. Vertical radiation patterns as a function of the radial slope angle.

ground screen geometry

The radiation pattern of a vertical is strongly influenced by the slope or angle below horizontal of the quarter wave ground screen or radial system. **Fig. 2** shows 80-meter vertical radiation patterns of quarter wave verticals, ground mounted over very good ground (e.g., wet, fertilized farmland). The angles of radial slope are 0 degrees (horizontal radials), 20, and 40 degrees. The configuration with ground systems sloping below horizontal correspond to the antenna mounted atop a mound "carpeted" with a ground screen or dense network of radials. Note that the *verticals with sloping radials have a significant gain advantage over the horizontal or 0 degree radial configuration* — 2.5 dB at a 10 degree fact, about 1 dB at one quarter wavelength high is lost, compared with a ground-mounted vertical (**fig. 4**). Of course, if your ground-mounted antenna is completely boxed in by cars, buildings, or other obstructions, getting the current loop above the lossy surroundings may still pay off. The gain trends with radial slope seen for ground mounted verticals also appear for elevated verticals.

About half a wavelength above ground at the base is a particularly unfortunate height at which to mount a vertical over most grounds. **Fig. 4** shows the 40-meter radiation pattern of a quarter wave vertical

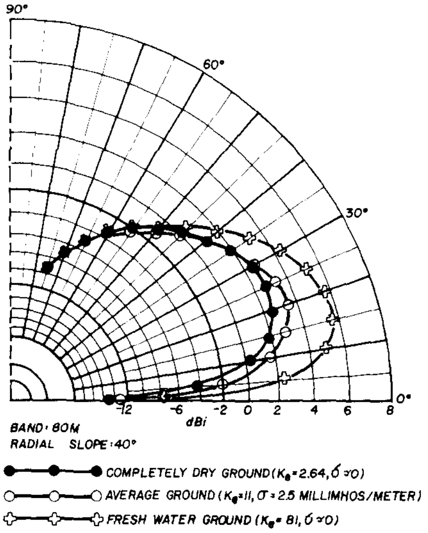

fig. 3. Vertical radiation patterns as a function of ground conditions.

takeoff angle in the case of a 40-degree radial slope. This angle is about the optimum slope. As the slope gets steeper, the gain decreases due to increasing radiation resistance. Other bands besides 80 meters show similar gain increases with sloping radials.

Fig. 3 shows what to expect if you live in a desert or on dry, sandy ground anywhere, or in a city, surrounded by concrete and asphalt. In these settings, the advantage of sloping radials completely disappears. Even over average ground with moderate dielectric constant and conductivity, little is to be gained from a sloping ground screen. Over average or poor ground, the combined phase shift from reflection and from the path length difference between E_i and E_r (**fig. 1**), is between 90 and 180 degrees for useful takeoff angles; this large phase shift leads to substantial cancellation of E_d by E_r.

The advantage of a sloping ground screen is regained over a fresh water ground, even though the conductivity is insignificant (**fig. 3**). Compared to very poor ground, a fresh water ground offers a gain of up to 7 dB and compared to average ground, a gain of 4 dB. This is because the high dielectric constant of water provides a good reflecting plane.

These radiation patterns suggest that it's possible to enjoy a seasonal advantage with sloping radials. Several days of rainy weather can raise both the dielectric constant and the conductivity a great deal, leading to another 2 to 6 dB of reflection gain at takeoff angles below 30 degrees.

roof or tower mounting

Unless a vertical is mounted two to three wavelengths high, putting it up in the air does not increase the gain, as it does with most horizontal antennas. In

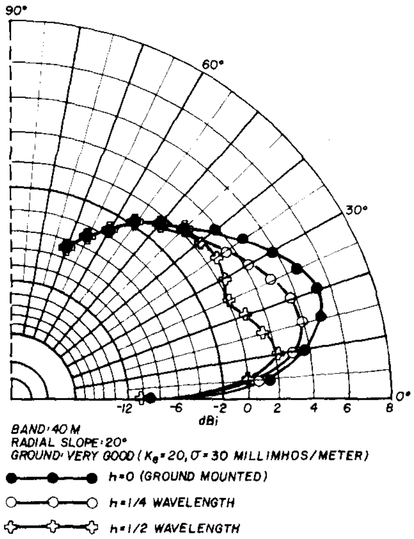

fig. 4. Vertical radiation patterns of a vertical mounted at various heights above ground.

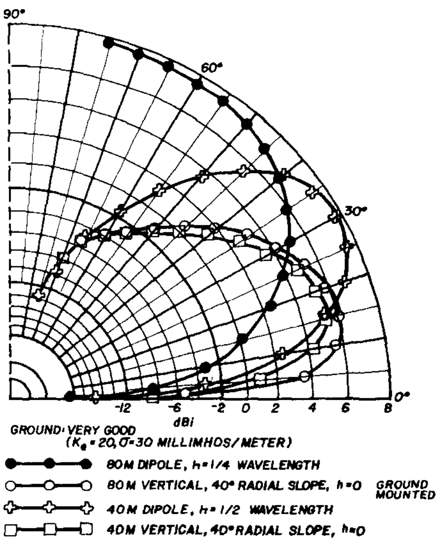

fig. 5. Vertical radiation patterns of 40 and 80-meter verticals and horizontal dipoles.

with 20° radial slope, at one half wavelength high. It has up to 5 dB less gain at the most useful radiation angles than the same antenna, ground-mounted over very good ground. Other radial geometries at one-half wavelength show similar losses. Only a vertical over salt water shines at this height, giving about 7 dBi gain at 5 degrees, which is especially good for the bands above 30 meters.

vertical versus dipole

Recently there has been interest in discussing whether the vertical or dipole works better on the various bands.[4] **Fig. 5** compares the 80-meter radiation pattern of a ground-mounted quarter wave vertical having 40-degree ground screen slope, with the broadside pattern of a half wave dipole one quarter wavelength above very good ground. The dipole at about 65 feet (20 meters) is as high as most Amateurs would mount an 80-meter dipole. The vertical shines at takeoff angles below 30 degrees, while the dipole takes over at higher angles. Undoubtedly some 80-meter DX comes in at angles above 30 degrees, as do most short-skip signals. In that case the broadside dipole looks like the better antenna. However, for most really long-hop circuits, the vertical would be the better choice.

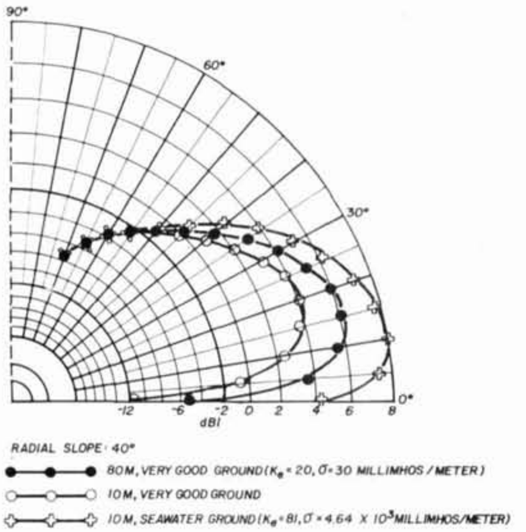

fig. 6. Vertical radiation patterns of 10 and 80-meter verticals over differing grounds.

calculating vertical radiation patterns

To calculate vertical radiation patterns, first define the following terms:

- E_d direct (free space) field intensity
- E_i field intensity incident on the ground
- E_r field intensity reflected from the ground
- R reflection coefficient, equal to E_r/E_i
- K_e dielectric constant of the ground
- σ conductivity of the ground in millimhos/meter
- λ wavelength in meters
- θ takeoff angle of the direct ray. Also equal to the angle of incidence and reflection (**fig. 1**)
- ϕ angle of refraction of the transmitted ray
- ρ phase shift due to reflection
- β phase shift due to the path length difference between direct and reflected rays (**fig. 1**)
- h height of the antenna above ground, in meters
- G_i gain in dBi relative to an isotropic radiator

The electric field intensity E_d or E_r is expressed as a function of the current, which is a standing wave on the antenna (radiator plus image). This current function is integrated over the length of the antenna, including the image, to give the free-space field intensity at a particular θ. If $\theta > 0$, the intensity is E_d and if $\theta < 0$, we call the intensity E_i. E_r corresponds to the ray reflected from the ground.

R is calculated from the Fresnel equation for reflection of vertically polarized radiation from a plane surface:

$$R = \frac{\sqrt{K_e'}\,\sin\theta - \cos\phi}{\sqrt{K_e'}\,\sin\theta + \cos\phi}$$

where $\phi = \sin^{-1} \frac{1}{Re\sqrt{K_e'}} \cos\theta$ from Snell's law, and the complex dielectric constant

$$K_e' = K_e - j(6 \times 10^{-2}) \cdot \sigma \cdot \lambda$$

For each θ, E_d is calculated and for $-\theta$, E_i, the corresponding ray directed downward, is calculated. Then $E_r = R \cdot E_i$ and E_t is determined by adding the E_d and E_r vectors:

$$E_t = \left[E_d^2 + 2E_dE_r \cos(\rho + \beta) + E_r^2 \right]^{1/2}$$

The gain at a particular takeoff angle is $G_i = 20 \log E_t + A$, where A is a normalization factor which gives the correct gain of the vertical being considered at 0 degrees takeoff angle over infinite, perfectly conducting ground. For example, $A = 5.16$ dBi for a quarter wave vertical with 0 degrees radial slope at ground level over infinite, perfect ground. Thus, various combinations of radial slopes and grounds will all give G_i expressed in dBi.

On 40 meters, a half wave dipole one half wavelength above very good ground, pitted against a ground-mounted vertical with 40° radial slope, has a broadside gain advantage above 15 degrees (**fig. 5**). This angle is about the median for New England to western European circuits on 40 meters.[5] Again, the dipole looks better for most medium and short-skip circuits, while the vertical has a slight advantage for very long hops and band conditions favoring very low radiation angles.

On 10 through 30 meters, a vertical is at more of a disadvantage because its reflection gain drops off faster with increasing frequency than the reflection gain of a dipole. As **fig. 6** shows, on 10 meters a ground-mounted vertical with 40 degree radial slope over very good ground has 3 dB less gain at a takeoff angle of 10 degrees and 4 dB less gain at 5 degrees than a similar vertical on 80 meters. A vertical on 10 through 30 meters simply can't compete with a dipole one or more wavelengths high over any ground except salt water. *Between 30 and 40 meters is the point at which the dipole really takes over.*

conclusion

No doubt the long-standing debate will continue over whether a vertical or a dipole is the better antenna. I hope the results presented here will encourage more good A-B comparisons of verticals with other simple antennas. The worldwide system of beacons on 14.100 MHz should aid in these comparisons.

These results also show that ground mounting in the clear is generally the best way to set up a vertical. If the ground beyond the radial system is exceptionally good, the radials can be sloped downward 20 to 40 degrees for another 2 dB or more of reflection gain. Over salt water, a vertical with ground system sloping down to water level and 0.5 miles (0.8 km) of salt water in all directions would be a hard antenna to beat, especially on 10 through 30 meters, where 7 dBi of gain below 5 degrees is what is needed for long hop DX (**fig. 6**). However, for most grounds the ability of the vertical to launch low angle (below 15 degrees) radiation has often been overrated in the Amateur literature.

acknowledgement

I thank Dick Coombe, K9VPK, for his interest and encouragement throughout this project.

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VHF/UHF WORLD

Joe Reisert
W1JR

the VHF/UHF challenge

Although I'm usually branded as a VHF/UHF person, I'm really a DX'er and go where the DX goes, be it 160, 20 meters, or 13 cm. (I'm fully equipped for 13 different Amateur bands and operate them all!) So after I made the sought-after DXCC *Honor Roll* in 1968, I decided that someday I'd probably have every country confirmed on HF (which I did in 1980) and that the best challenges remaining would be on the VHF/UHF bands. I never abandoned the HF bands — as any DX'er will tell you — but I now tend to concentrate my efforts on improving the state-of-the-art on the frequencies above 50 MHz.

a review

It wasn't too many years ago that any Amateur Radio operator venturing above 29.7 MHz had to be ready to "roll his own" rig, so to speak. That's different now. For those so inclined, there has been vast improvement in components and antenna design. You can now purchase commercial equipment for all Amateur frequencies up through 1300 MHz, even to the limits of legal power. This has even been extended to OSCAR and EME (Earth-Moon-Earth). But herein lies the problem: what do you build or buy, how do you hook it up, how do you use it, and more importantly, how do you get the most out of your equipment and keep up with the state-of-the-art?

opportunities

Let's digress briefly and discuss some of the opportunities awaiting us on the VHF/UHF frequencies. This is truly the area for propagation research, and there are records galore just waiting to be made or broken. Disregarding EME and OSCAR for the moment, look at what's happened on 6 meters in the last few years: WAC has been worked by many. Even places like India, Gambia, the Galapagos Islands, Cyprus, and other equally distant places have become workable from North America via F2 propagation.

Then 2 meters opened on the transequatorial path.[1] To our surprise, it wasn't as spotty as expected. In fact, 220 MHz QSOs were finally made and a one-way 70 cm QSO has been verified. Speculation on the existence of a new propagation mode was heard, with hints that FAI (Field Aligned Irregularities) similar to the transequatorial path could possibly exist in the mid-latitudes such as the U.S.A. This was finally confirmed, and QSOs on 2 meters using this mode have been accomplished numerous times; but while it's still possible above 148 MHz, this has yet to be done!

A true Amateur communications satellite, OSCAR 10, is now available to all Amateurs. Then there's EME, the ultimate challenge on Amateur power levels. Worldwide QSOs now take place daily on frequencies from 144 to 2320 MHz. These QSOs are no longer the result of a concerted effort by many individuals pooling their efforts; instead, they're being done by the everyday Amateur who may live on a 60 by 100-foot lot, but is willing to take on the challenge, do the research, and build up a good station. And while this isn't a task for the timid, many non-technical persons are doing it every day.

Let's look beyond operating and propagation. These discoveries weren't made by accident; *they happened and were exploited because the state-of-the-art gear had been improved.*

benefits

So you say, what's in it for me? *PLENTY*. You too can contribute to the state-of-the-art. There is much to be done: some may contribute labor, helping assemble large antenna arrays; others may assist with parts procurement, machining, research, scheduling, antenna design, receiver design, transmitter design and so on. But there's something here for everyone, and the rewards are numerous: records to be broken, propagation modes to be discovered (this takes time and scheduling), new improved antenna systems *(better mechanical designs as well as electrical parameters)*, better receivers with lower noise figure and high dynamic range *at the same time,* and more efficient and cleaner transmitters. (For you HF'ers, have you ever tried to use a frequency adjacent to a station running 100,000 to 1,000,000 watts effective radiated power?) The satisfaction will be enormous. The VHF/UHF frequencies offer a great test bed where you can develop new techniques, circuits, and antennas even if you are restricted to a small or not-so-great location.

summary

Why all the hype? I'm constantly confronted by very competent individuals who are willing to build or buy their own gear to get on the VHF/UHF frequencies but always ask the same questions: "What's the best preamplifier circuit? What's the best antenna for my application? What band should I try?" The answers are not always simple — and often depend on the individual — but there is always one problem common to all the inquiries: where do I find the information I need to put together this gear? The answer is *right here*, because I've been asked by Rich Rosen, the Editor-in-Chief of *ham radio*, to launch this column as a continuing series. Over the coming months I'll try to discuss many of the questions most commonly asked by the newcomer as well as the seasoned VHF/UHF'er. This will be done with concise descriptions, charts, and circuits. After establishing a solid base of factual material over the first few months, I'll then attempt to build on this basis by offering updates, new or state-of-the-art equipment design information, advice on construction of antennas, propagation information and discussion of other subjects that will keep us all up to date. Time and space permitting, we may even include material or ideas expressed by others. Each month I'll also try to list events that are of special interest to VHF/UHF'ers.

Does this seem like the kind of information you're looking for? If so, I'll see you next month.

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1. Joseph H. Reisert, W1JR, and Gene Pfeffer, KØJHH, "A Newly Discovered Mode of VHF Propagation," *QST*, October, 1978, pages 11-14.

VHF/UHF coming events

Quadrantides Meteor Shower: Predicted peak at 0100 UTC on January 4, 1984.
Best EME weekend: January 20, 21, 1984.
ARRL VHF Sweepstakes Contest: January 14-16, 1984. (See December, 1983 *QST* for further information.)

ham radio

meet Joe Reisert . . .

First licensed in 1951 as WN2HQL, Joe Reisert earned his Extra Class license in 1956. He has since held the following call signs: WA6TGY, W6FZJ, W1JAA, and now, W1JR. He attained the DXCC Honor Roll in 1968 and presently has 357/315 confirmed. Joe's interest in UHF began in the late 1960's and he made his first 432 MHz contact in 1970; he has since worked all states on 432 MHz and *nine* other bands: 160 through 2 meters (160, 80, 40, 30, 20, 15, 10, 6, and 2 meters). Active in EME operation on 144 through 1296 MHz, he is the former joint holder of the 2304-MHz tropo record of 330 miles set in February, 1974.

Joe's diversified technical interests are best illustrated by his publication of over thirty articles on subjects as varied as the following: a wide-band, low-noise preamplifier; VHF antenna arrays for high performance; a 432-MHz kW stripline amplifier modification; a low-noise VHF/UHF receiver design; a 2-meter transmitter filter for mode J; new modes of VHF propagation; and the PROMIS Microwave data and video link.

ham radio readers can look forward to reading about these subjects and more as Joe Reisert's column continues over the coming months. Welcome aboard, Joe!

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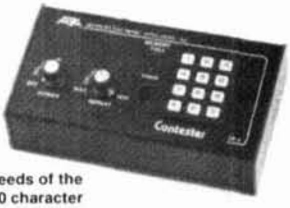

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G.O.E.S. reception: a simple approach

Inexpensive surplus components and scope bring you satellite weather pictures

Too often Amateurs will not attempt a project because it appears, at first glance, to be far too complex; reception of weather images from the geosynchronous satellites is certainly one such project. After reading several excellent articles on the subject,[1-3] I was convinced I'd need at least a four to six-foot dish and a $400 downconverter in order to build the required equipment. But I decided to try to build the system anyway, using whatever surplus materials I could obtain.

antenna

While I did not — and still do not — have a four or six-foot microwave dish antenna, I did have a small 30-inch dish that had been collecting dust for about fifteen years. Now, the gain difference between a six-foot dish and a thirty-inch dish is determined by the ratio of the dish areas. The six-foot dish has an area 5.76 times the thirty-inch antenna. This translates to a gain difference of 7.6 dB. The focal length of the thirty-inch dish was measured to be 10.8 inches. (The focal length of an existing dish is easily found by dividing the diameter squared by sixteen times the depth.[4]) Next, the F number, or focal ratio, was calculated. This is simply the focal length divided by the diameter, just as for photographic lenses. The focal ratio for the thirty-inch dish is 0.36.

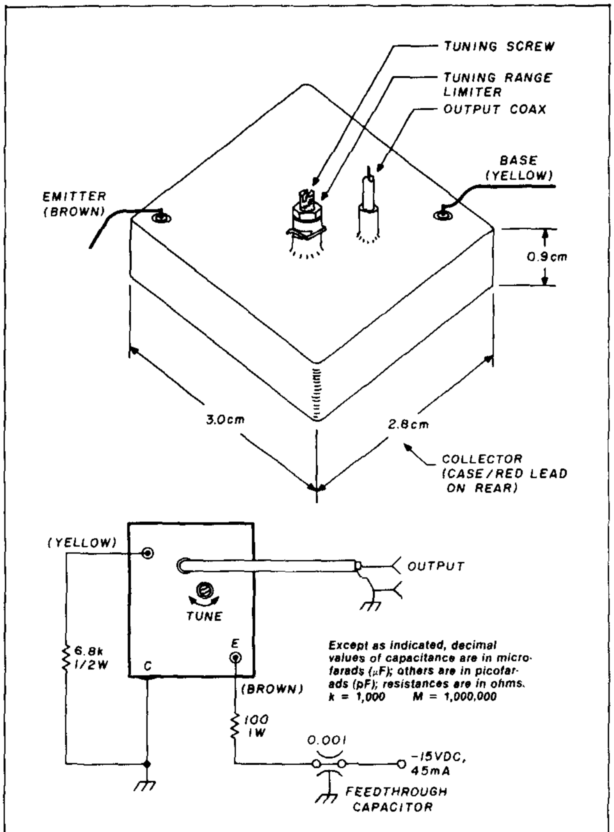

fig. 1. Pictorial views of local oscillator.

By John M. Franke, WA4WDL, 1310 Bolling Avenue, Norfolk, Virginia 23508

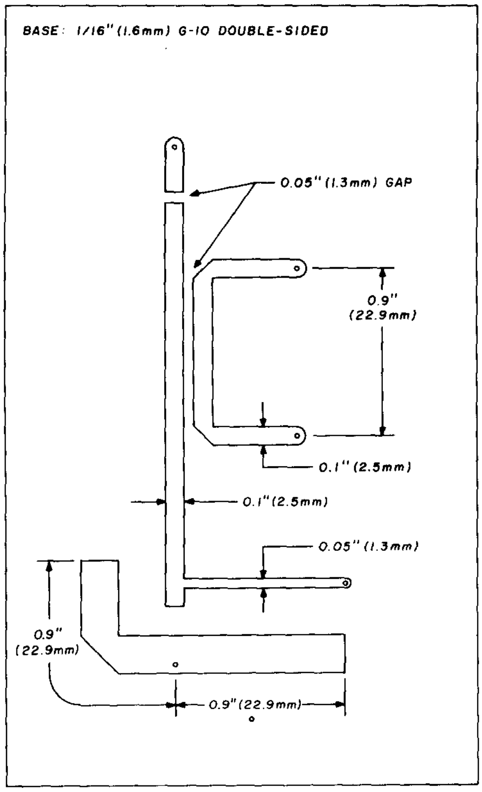

fig. 2A. Mixer printed circuit board.

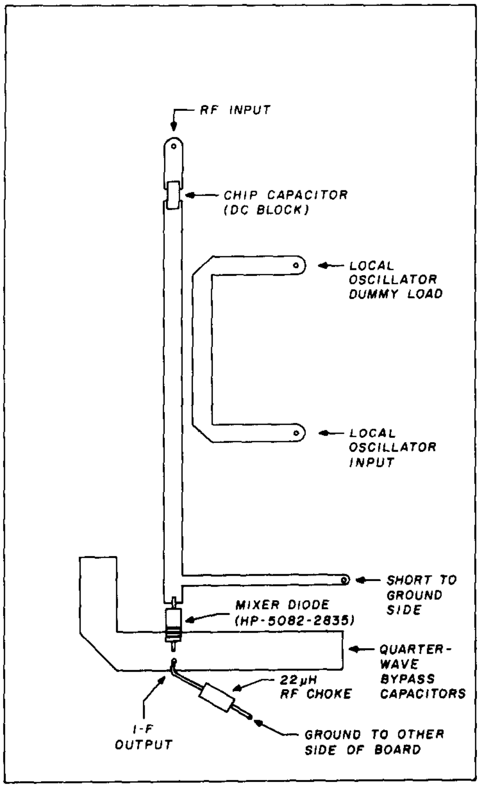

fig. 2B. Mixer components placement.

Once the dish was characterized, I designed the feed, selecting a horn feed because it was the simplest. (After all, this is an Amateur project, not a research program.) I used a piece of five-inch outside diameter aluminum tubing, following an excellent article on waveguide or horn feeds for dish antennas.[5] I chose RG-58 for the feedline from the antenna to the preamp.

antenna mount

The mount consists of a simple frame made from rack panels and aluminum angle supports. The elevation and azimuth angles for the G.O.E.S.-East satellite were calculated for my station latitude and longitude.[6]

The dish is aligned in azimuth by simply turning the entire mount. A simpler, more compact, mount (see photograph) would be hard to devise. The mount was initially aligned with a compass taking magnetic declination into account. The beamwidth of the antenna is about sixteen degrees; hence, alignment is not critical. The feed can be rotated to adjust for optimum polarization. GOES-East and GOES-West satellites are vertically polarized and GOES-Central is horizontally polarized.

downconverter

The downconverter consists of a mixer and a local oscillator. The local oscillator is a solid-state unit from a weather balloon telemetry transmitter and was purchased at a local hamfest for five dollars. The antenna and modulator were removed and an output connector and bias network added (see **fig. 1**). Though the solid-state unit is difficult to obtain, Fair Radio Sales still carries a vacuum tube version for under five dollars. Output power from either source is high: 20 to 100 mW. The output frequency is nominally 1680 MHz ±20 MHz with a manual tuning control.

The mixer uses a single-ended diode with the local oscillator signal inserted using a directional coupler. **Fig. 2** shows the dimensions used with 1/16-inch glass epoxy double-sided printed circuit board material. One side is unetched. The etched side was laid out by first covering the entire copper surface with transparent tape, using a razor blade to trim away the unwanted areas. The areas to be etched away were left covered. (While this is the reverse of most tape techniques, my reasoning will soon become clear.) The board is now sprayed with any color lacquer that is handy; I prefer flat black. The remain-

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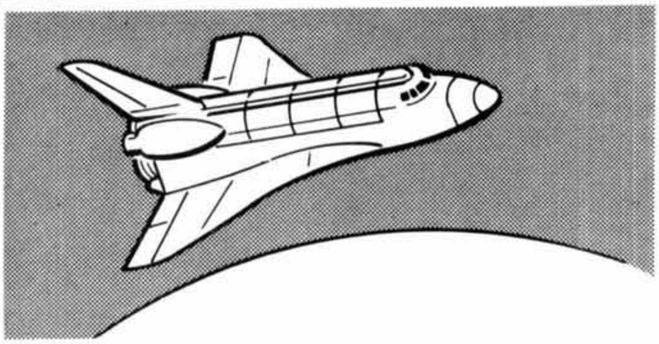

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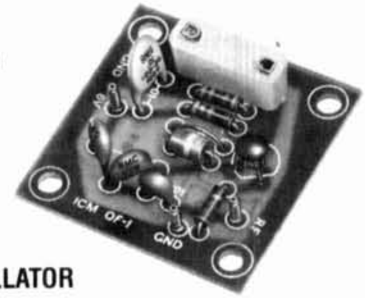

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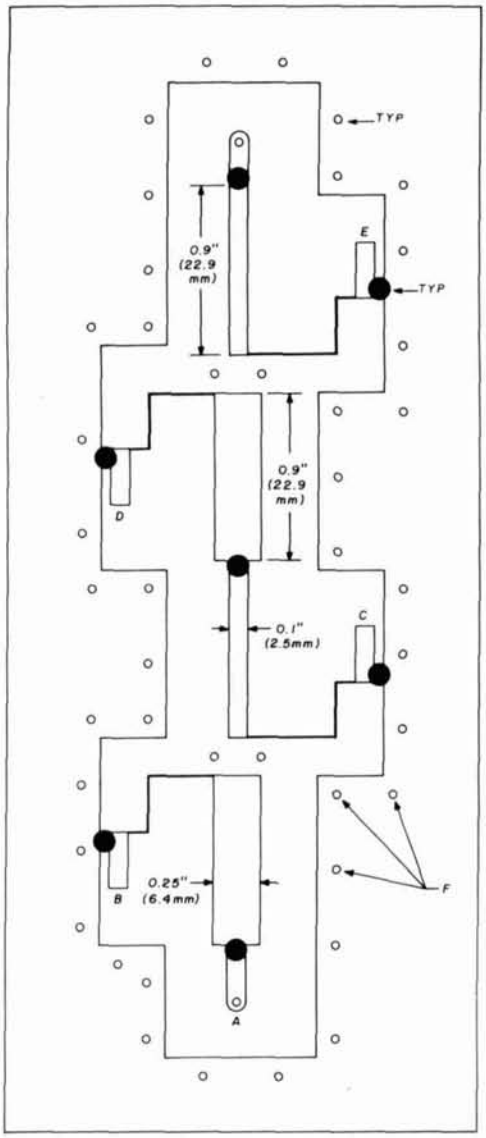

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D BASE OF SECOND STAGE
E COLLECTOR OF SECOND STAGE
F SHORTS TO CONNECT UPPER AND LOWER COPPER PLANES (39 PLACES)

fig. 3. Two-stage preamplifier printed circuit board.

	1st STAGE	2nd STAGE
R1	2.2k	2.2k
R2	4.7k	4.7k
R3	680	560
R4	1k	1k

Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

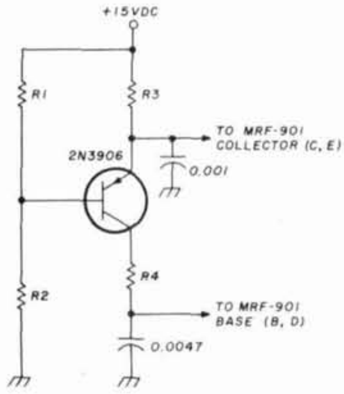

fig. 4. Active bias circuit for MRF-901 preamplifier.

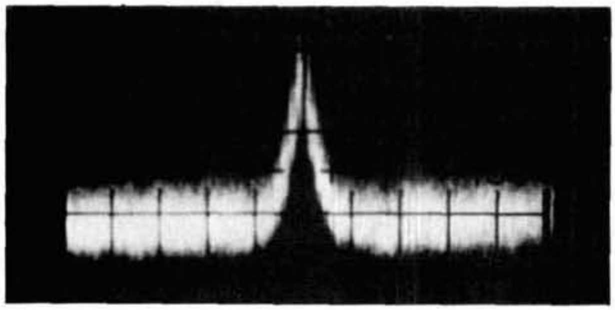

fig. 5. Satellite signal on ART-26 panadapter. Signal-to-noise ratio is approximately 7 dB.

ing tape is peeled off carefully. The unwanted areas are now bare and the desired areas are protected by lacquer. The ground side of the board is painted. After drying, the board is etched with ferric chloride.

The finished board is scrubbed with steel wool to remove the paint and wiring is completed. Care must be taken when installing the connectors to make sure that copper is removed from around the center pin-hole on the groundplane side to prevent shorts. (I used SMA connectors, but BNC connectors would also work.) Connectors are placed at each end of the local oscillator coupling line. The end nearest the mixer is the input; a terminator or dummy load is connected to the most distant connector. About 750 microamperes mixer current is normal. This can be measured by lifting the ground end of the choke and inserting a ten-ohm resistor. Measure the voltage drop across the resistor and calculate the current. Too high a resistance reduces the mixer current, giving a false answer. The noise figure is probably around 12 dB.

intermediate amplifier

The IF frequency I used is 30 MHz. This frequency was chosen for two reasons. First, it fell within the range of the difference between the tunable local oscillator and the 1691 MHz signal. Second, it is the center frequency for my ART-26 panadapter, an invaluable tuning aid. (The panadapter cost only five dollars at the same hamfest where I purchased the local oscillator.) In fact, the panadapter was used as my first demodulator by reducing the scan to zero and using slope detection. The IF amplifier used has

fig. 6. Desktop G.O.E.S. receiver. Window blinds cause no loss.

a gain of 60 dB. Any surplus 30 MHz radar IF could be used. A minimum bandwidth of 30 kHz is needed — more is preferred (2 MHz) if a panadapter is used.

detector

I do not have a 30 MHz FM discriminator, so I up-converted the 30 MHz IF to the FM band and used an FM monitor receiver for detection.

preamplifier

Several excellent articles on low-noise amplifiers are available.[7-9] I decided to build a two-stage amplifier, designing around the MRF-901 transistor. The layout is shown in **fig. 3**. The heavy, wide lines are quarter wave transformers and the narrow lines are quarter wave chokes. The board is laid out using tape and spray paint in a manner similar to that used for preparation of the mixer unit. The dual emitter leads pass through the board and are soldered to the groundplane. Because the emitters are grounded, active baising is used. The circuit in **fig. 4** was wired on a small printed circuit board and mounted in the preamp housing. Short leads prevent oscillation. The PNP biasing transistors are wired as constant current generators. The collector current of the MRF-901 is determined by the bias transistor emitter resistor and the collector voltage of the MRF-901 is determined by the base voltage of the bias transistor.

100 pF chip capacitors are used for coupling and bypassing. The overall gain is about 18 dB and the noise figure is better than that of the converter operated alone.

The total cost of the project at this point is about $18.00.

In the photograph of the panadapter (**fig. 5**), the signal-to-noise ratio can be seen to be about 7 dB. If the antenna were set up outside, the signal-to-noise ratio would be 10 dB.

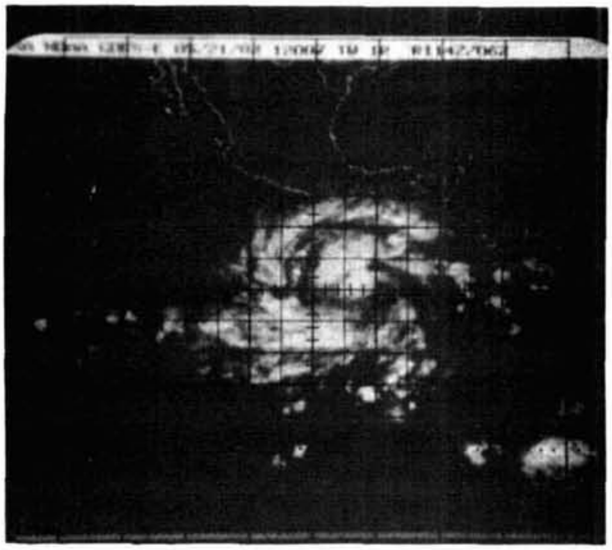

fig. 7. Infrared view of tropical storm "Adolph," May 21, 1983.

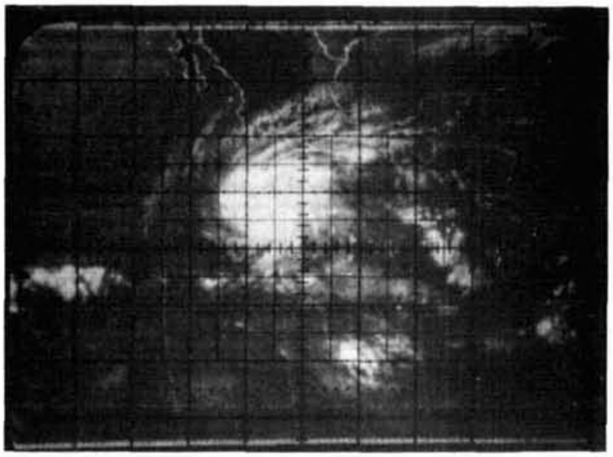

fig. 8. Infrared view of tropical storm "Adolph," May 23, 1983.

display

To photograph the satellite signals, I borrowed a Tektronix oscilloscope and camera (**fig. 6**), using Polaroid type 667 film (ASA 3000). The photographs (see **figs. 7, 8,** and **9**) were recorded in real time. The horizontal sweep was triggered by a 4 Hz signal from a color burst crystal oscillator. A variable divider chain was used for initial phasing. The vertical sweep was generated with a homebrew 10 bit D to A (digital-to-analog) converter (**fig. 10**), connected to a counter that counted horizontal sweep pulses. The video was fed, unfiltered and unrectified, to the oscilloscope Z axis.

conclusion

Future work will include moving the antenna outside, possibly building a four-foot dish, tape recording the signal and replacing the mixer/local oscillator with an interdigital crystal-controlled unit. In my experience, I've found that the best way to get involved with microwave technology is to use what you have and get on with it; don't be put off by high prices or sophisticated equipment. (Please enclose an SASE with any questions.)

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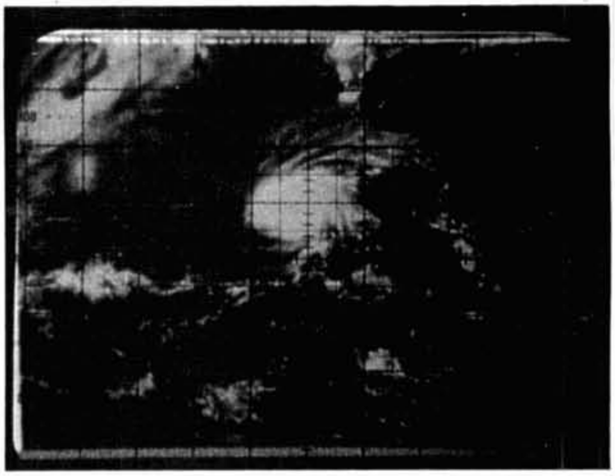

fig. 9. Visible light view of tropical storm "Adolph," May 23, 1983.

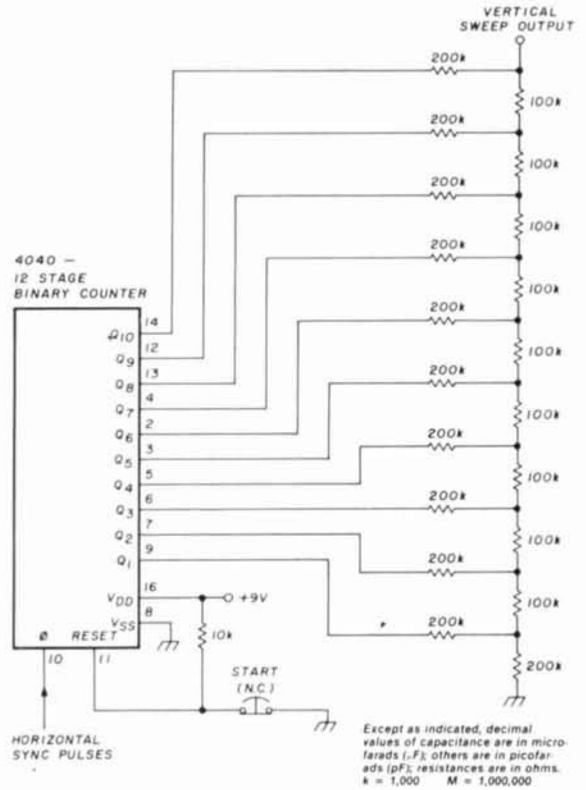

fig. 10. Vertical sweep generator schematic (10-bit Digital to Analog converter).

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Because I needed an ohmmeter with a wider range than the one on my workbench, I decided to design and build one. But wide range would not be enough; my meter would have to be low in cost, provide relatively good accuracy, be easy to read, and offer reliable long-term calibration. Low cost was achieved by developing a simple circuit and using some junk-box components; accuracy, by including an analog instrument; easy reading, by using a single scale on a 4-1/2 inch meter, thus avoiding incorrect readings sometimes made with multiple scales; and long-term calibration, by use of a line-operated power supply instead of batteries.

I wanted an upper limit of 1000 megohms and a lower limit of 0.1 ohms. Although the least significant bit of a 3-1/2 digit DMM displays increments of 0.1 ohms, the actual resistance could be anywhere between 0.06 and 0.14 ohms for a 0.1 ohm display. On some DMMs the LSB will jump up or down one count which, of course, invalidates very low value measurements.

how it works

The circuit shown in **fig. 1** employs a regulated low voltage, 1.22 volts, which is applied to the unknown resistor in series with a switch-selected standard resistor. The voltage drop across the unknown is fed to the input of one section of dual op amp, LF353. This section is connected as a voltage follower. It has the very high input resistance of 10^{12} ohms, which hardly loads down the unknown. Output null is obtained with adjustment of R18. The next stage, the other section of the LF353, provides an adjustable gain of a little more than 1 so that the meter can be calibrated to read full-scale with the unknown terminals open. When an unknown resistor is connected across the terminals, the meter reads down scale, reaching zero when the unknown resistor terminals, $\pm$Rx, are shorted together at the panel.

circuit details

The power supply, using a full-wave bridge rectifier and center-tapped transformer secondary, provides zener-regulated +5 and −5 volts for the LF353. An LM317T voltage regulator supplies the

By John T. Bailey, 86 Great Hills Road, Short Hills, New Jersey 07078

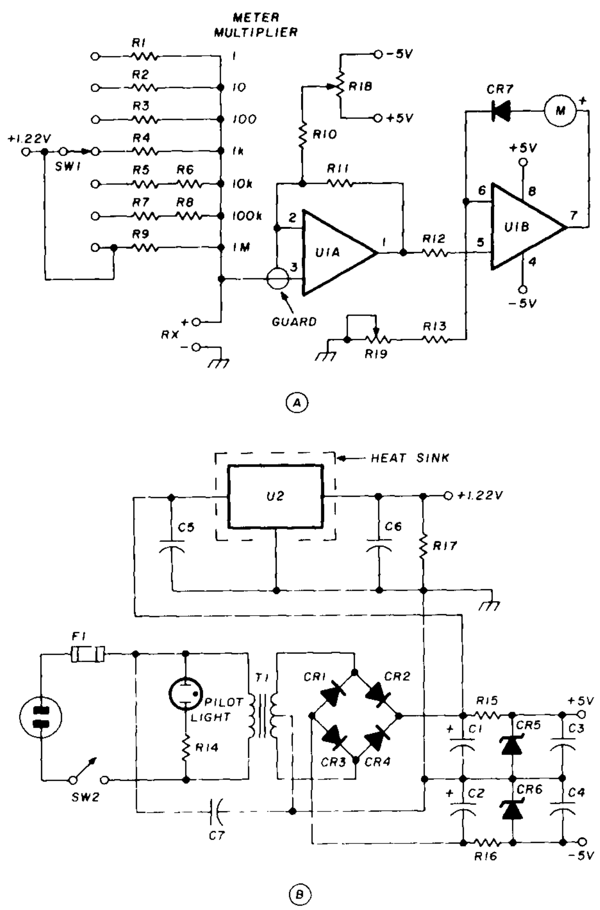


fig. 1. Wide range ohmmeter schematic A) measuring circuit, and B) power supply.

1.22 volts required for the input divider. A heat sink is used on this regulator because of the wattage dissipation on the low range. On this range, with the unknown resistor terminals shorted, 122 mA flow through the 10-ohm standard resistor. Since about 7.5 volts is dropped across the regulator, the worst-case dissipation is 7.5 volts × 122 mA or about 0.9 watts. R17 provides a minimum load of 25 mA for stable operation of the regulator.

The 10-megohm standard is paralleled across the other range standards for all switch positions, which assures an input ground return for the LF353 at all times when switching ranges. Series resistors are added to the × **10k** and × **100k** ranges to compensate for the 10 megohm shunting. The 1N914 diode in series with the meter prevents reverse deflections of the meter. The standard resistors should be metal film type of ± 1 percent tolerance.

The null circuitry is conventional for voltage followers. For the values shown, ± 4 mV maximum is developed across R11. If more null compensation is necessary with the particular LF353 used, simply increase the value of R11. The internal resistance of the meter is not critical since it is in the feedback loop. Mine had a resistance of 1200 ohms.

On the high end of range × **1M**, it is important to minimize any leakage resistance across the unknown terminals, ± Rx, because such leakage would be in parallel with the resistor being measured. The schematic shows only the range resistors and pin 3 of the first LF353 connected to the positive Rx terminal. Since the common ends of the range resistors are not mounted on any terminal strip supports, but rather supported by their leads, only negligible leakage to ground exists. Consequently, pin 3 exhibits a 10^{12} ohm resistance to ground and thereby adds an insignificant shunting effect. Not shown, however, is PC board surface leakage from pin 3 to ground, if pin 3 were soldered (via a socket) to a PC board trace. PC board surface leakage can be minimized by using a guarding technique. This technique consists of a

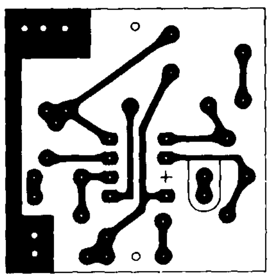


fig. 2. PC board artwork, foil side. Cross indicates drilling location for pin 3 guard terminal. See text.

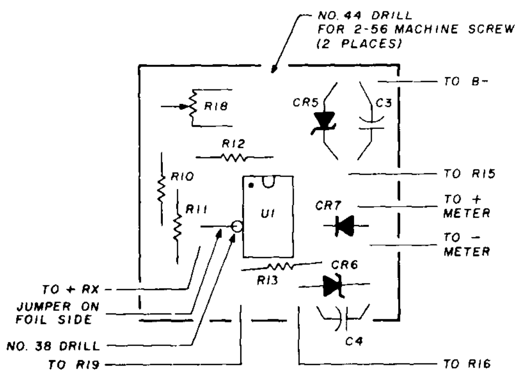
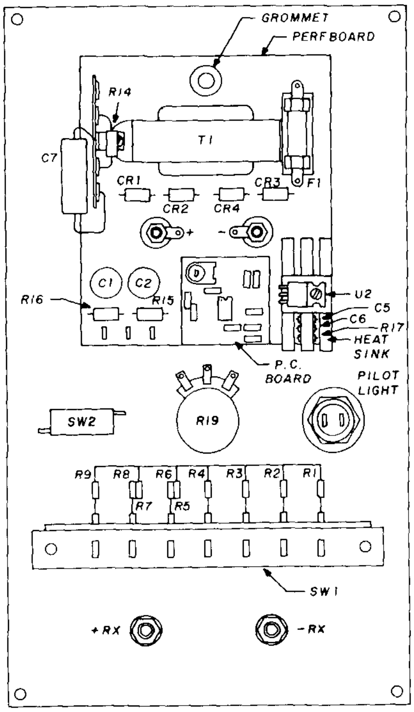


fig. 3. Component side of PC board.

trace ring that completely circles pin 3 and returns it to a low impedance point of voltage — equal to the voltage on pin 3. This must be done without pin 3 (actually pin 3 of the socket) touching the PC board. Isolation is accomplished by drilling a clearance hole in the PC board so that the socket pin 3 protrudes through the board clearance hole and, with a jumper wire, is connected to the trace pad inside the guard ring. The guard ring is connected to pin 2. Purists will be quick to point out that the guard ring should be connected to pin 1 because pin 2 has a higher impedance than pin 1. They are correct; this is only a quasi-guard solution, but for this application, it is sufficient.



parts list

C1,C2	500 μF, 15V aluminum electrolytic P C board terminals
C3,C4,C5,C6	0.1 μF, 50V ceramic, axial leads
C7	0.047 μF, 600V Mylar
CR1,CR2,CR3,CR4	1N4001 50V, 1A rectifiers
CR5,CR6	5.1V zeners, 1N751, 400 mW
CR7	1N914 diode
U1A,B	LF353N dual BiFet op amp, Radio Shack 276-1715
U2	LM317T 1.22v regulator, Radio Shack 276-1778
F1	1A fuse and holder
M	100 μA meter, 4-1/2" square
P.L.	neon pilot light, NE51 with assembly
resistors: 1/4 watt, 1% tolerance metal film	
R1	10 ohms
R2	100 ohms
R3,R6	1 kilohm
R4	10 kilohms
R5	100 kilohms
R7	1 megohm
R8	110 kilohms
R9	10 megohms
resistors: 1/4 watt, 5% tolerance carbon composition	
R10	2.2 megohms
R11	1.8 kilohms
R12	4.7 kilohms
R13	10 kilohms
R14	220 kilohms
R15	390 kilohms
R16	470 kilohms
R17	47 ohms
R18	25 kilohm trimmer potentiometer, single turn
R19	5 kilohm linear potentiometer
SW1	7-station, spst, interlocking pushbutton switch
SW2	SPST toggle switch
T1	transformer, 12.6 Vct, 1.2A Radio Shack 273-1505
misc.	heat sink, 8-pin DIP socket, 2 binding posts, PC board, line cord, perforated, 1/4" standoffs, test leads, etc.

fig. 4. Rear view of ohmmeter.

construction

The power supply components are mounted on a 3-3/4 × 4-1/2 inch (9.53 × 11.4-cm) perfboard which is mounted on the meter studs. The PC board containing the measuring circuit components is mounted on the perfboard with two 1/4-inch standoff spacers. The range switch, mounted on the front panel, is a 7-station push-button type (I prefer this rather than a rotary type switch.) **Fig. 2** shows the foil side of the PC board and **fig. 3** shows the arrangement of parts on the component side of the board. **Fig. 4** shows the placement of all components as seen in the view of the rear of the ohmmeter while **fig. 5** shows the front view.

The meter scale is non-linear, as shown in **fig. 6.** At midscale the readings are equal to the standard resistors for the various ranges. To draw the scale a simple calculation can be made, knowing the meter's full-scale deflection in degrees. (Mine was 101 degrees.) The formula is:

$$\frac{B}{A+B} \times C = \textit{degrees deflection for } R_X = B$$

where A = standard resistor
B = unknown resistor
C = full-scale deflection in degrees

For example, using the × **1k** range $A = 10k$ and $C = 101°$, a 4k unknown will read:

$$\frac{4k}{10k + 4k} \times 101° = 28.86°$$

In building the prototype unit, I decided to mount the gain control on the front panel just in case some slight change in gain would be needed to correct for component value changes with time. So far I haven't found any reason to use it.

I chose to mount the ohmmeter on the back of my workbench in a central position from which four-foot long leads would reach test points where I could read the meter without parallax error.

calibration

Calibration is simple. Adjust the nulling pot for zero output of the voltage follower stage with the input terminals shorted. Then adjust the gain control for full-scale deflection.

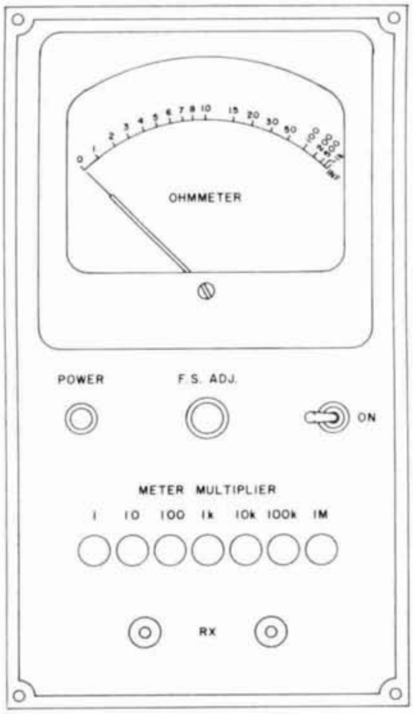


fig. 5. Front panel view of ohmmeter.

fig. 6. Typical meter scale layout.

operation

Switch on the power; the meter should deflect to full-scale. Connect the test leads across the unknown resistor, selecting the range which gives a reading below half-scale because the divisions are larger on the lower part of the meter dial.

If, on the ×**1M** range, jitter occurs at full-scale with the test leads not connected to an unknown, reverse the line plug. When using the ×**1** range the resistance of the test leads introduces a small error which can be measured and subtracted from any fractional ohm measurement. Simply note the reading obtained with the test leads shorted at their tips. Then subtract this reading from the unknown resistor reading.

ham radio

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RG174/U min 50 Ω mil spec	10¢/ft
RG213 noncontaminating 96% shield mil spec	36¢/ft
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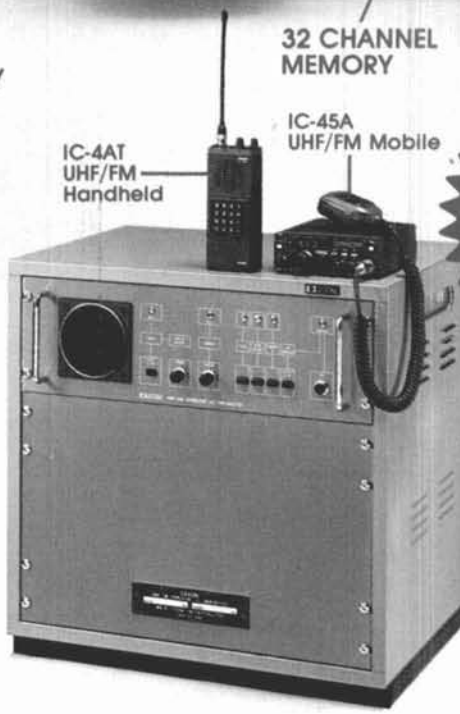

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ham radio TECHNIQUES

Bill Orr W6SAI

antenna "neutralization"

As one cynic put it, "It's hard to be loud on 40 meters when you live on a *city lot.*" Many mini-antennas have been designed for 40 meters (and for 80 meters, too) and some of them seem to work. However, they all pale into insignificance when measured against a full-size beam antenna.

So where does that leave the majority of hams who can't erect a big three-element 40-meter Yagi on a 150-foot tower? The only answer for them is to use a mini-antenna that *works.*

One knowledgeable Amateur who has wrestled with this problem is Les Moxon, G6XN,[1] who concluded that mini-beams constructed with close spacing (to conserve boom length) could never be optimized because the elements were overcoupled. His solution to this problem was to eliminate the excess coupling by means of a neutralization technique (**fig. 1**).

When Les was visiting in the San Francisco Bay area recently, I had the opportunity to speak with him about the technique. By the time he left, my head was abuzz with interesting ideas for mini-beam antennas for the low-frequency bands.

Alas, inertia and lack of free time prevented anything from being done. However, my good friend George Badger, W6TC, grasped the idea, combined it with some original thinking, and developed a mini-quad antenna for 40 meters that provides both good gain and excellent front-to-back ratio.

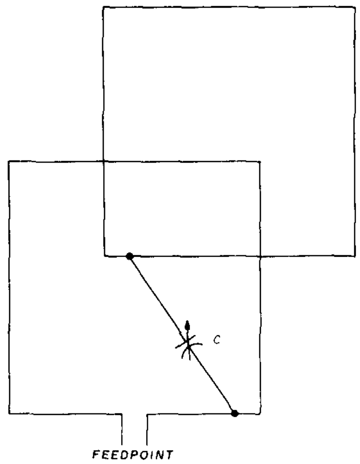

fig. 1. The G6XN neutralizing technique as applied to a 40-meter mini-quad. (Tuning and loading adjustments not shown.) The parasitic element in this case is a reflector. Note that the neutralizing capacitor is connected from one side of the parasitic element to the opposite side of the driven element. A small vacuum variable capacitor is used.

George had built a compact 40-meter quad that worked, after a fashion. Gain over a dipole was questionable, and the array didn't seem to have any front-to-back ratio. Bandwidth was very sharp, and the antenna operated over only a small segment of the 40-meter band before the SWR on the transmission line became too high for proper transmitter operation.

He solved the bandwidth problem with a simple tuning device for the quad loops, but the gain and front-to-back problems remained unsolved until G6XN proposed the antenna neutralization method.

Without going into construction details, the neutralization concept is shown in (**fig. 1**). It can be applied equally well to a close-spaced Yagi array (**fig. 2**). In essence, a capacitor is cross-connected from a driven element to a parasitic element and then adjusted for best front-to-back ratio of the antenna. Maximum forward gain and best front-to-back ratio seem to occur at the same setting of the capacitor. The tap point of the capacitor on the antenna elements seems to be less critical than the value of the capacitor. For W6TC's quad, the capacitance value is optimized for best performance.

Does the neutralization scheme work? W6TC's five-band DXCC proves that you *can* be loud on 40 meters when you live on a city lot! I'll provide more details on this interesting antenna development at a later date. Meanwhile, there's no reason why you can't experiment with antenna neutralization on your mini-beam. I'd be interested in hearing from readers who try this unusual technique.

the coax jungle

Sometimes a little knowledge is worse than none at all. I've heard a lot of plausible stories about coax cables and I know that plenty of junk coax is being sold to unsuspecting buyers. But I didn't realize what a "jungle" exists with regard to the millions of miles of coax cable sold each year to hams, the military, industry, CBers, and others. The military, at least, usually knows what it gets for its money, as flexible coax cables are bought to a strict specification (MIL-17D or E). But how about the rest of us?

This all came to a head when I measured the loss of my coax transmission line running from station to antenna. According to all the published charts, my line loss at 14 MHz should be about 0.8 dB per hundred feet. My measurements, done with laboratory-type instruments, showed a loss of nearly 1.35 dB. What was the problem? Was the cable growing old? Or was it inferior cable to begin with? What should be the expected life of a coax cable? Five years? Twenty years? Forever?

a long phone call

Why not go directly to the coax cable manufacturer? One day, I did just that. I called one of the largest cable manufacturers in the United States and spoke at length to one of the production engineers who was an expert on coax cable manufacture.

I first asked about "military specification" cable. He said that if you want the best cable, that was the type to buy, but that it was also the most expensive because of the exhaustive tests the cable must pass before it gains military approval.

My unseen friend mentioned that there were perhaps a dozen large, top-notch coax cable manufacturers in the United States and about the same number of smaller, but good manufacturers. And finally, there were numerous "garage shop" operators who made up coax on demand to *any* specification. "After all," he said, "a coax cable machine isn't that expensive."

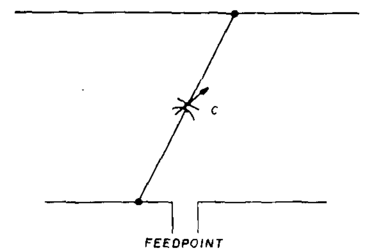

fig. 2. Top view of a compact two-element Yagi beam with neutralization capacitor. (Tuning and loading adjustments not shown.) Value of capacitor and tap points on the elements are adjusted for best front-to-back ratio after beam is adjusted for maximum gain.

Part of the cost of the cable is the exhaustive tests and inspections demanded by the military; sometimes the cost of certification exceeds the cost of manufacturing. If you don't have to meet military specifications, the costs drop sharply...especially if you use second-hand cable machinery.

Consider RG-8/U cable, which is not in military use today. (Military gear is designed for 50-ohm termination, and the old style RG-8/U and newer RG-8A/U cables were 52 ohms.) "Of course, if you want," said the cable company spokesman, "we'll manufacture RG-8/U or RG-8A/U to a military specification, but we've had no call for that."

RG-8/U and RG-8A/U were replaced by RG-213/U (50 ohm) cable made to MIL-C-17D or E specifications. The specifications call for an inner conductor made of seven strands of bare copper wire, each strand 0.0296 inch in diameter. The dielectric is first-grade polyethylene, with no dirt or pinholes in it. One untinned copper braid jacket is used, providing greater than 90 percent coverage. He pointed out proudly that his particular non-military RG-8A/U had 97 percent coverage. The outer jacket was polyvinylchloride IIa, noncontaminating material. And the cable sold for well over 70 cents a foot in small quantities.

"What about coax that sells for about 30 cents a foot?" I asked. Well, that was a long story. Plenty of price-cutting is going on, but it is possible to manufacture an inferior grade of coax that looks pleasing to the casual observer. He had seen cheap cable with less than 60 percent braid coverage for sale. Moreover, the size of the braid wire was reduced from B.S. No. 36 to B.S. No. 36.5 or B.S. No. 37. ("You can buy wire *any* diameter you want," he emphasized.)

The next price-cutting technique is to use a less expensive jacket, such as used on the older RG-8/U cables. These jackets gradually contaminated the copper shield and he classified this old material as PVC-1. He'd seen cable like this one on the market.

Another cost-cutting step in making a cheap cable is to reduce the diameter and number of wires in the center conductor, and to also decrease the twist, or turns-per-inch, of the conductor. And, finally, a low grade of polyethylene insulation can be used. Some cheap cables use *all* these cost-cutting techinques.

During the manufacturing process, costs could be shaved if no attention were paid to the concentricity of the cable. Letting the center conductor "wander" a bit meant that less cable was rejected in final inspection and an older cable-making machine could be used for the job.

When the cable was completed, it might look like the real thing, but losses would be higher and cable life would be shorter than that of high-quality cable, and the impedance would probably wander well away from 50 ohms.

The engineer sighed. "I think much of the cable on the ham and CB market is sub-par quality; as long as price is the determinant, that's the way it's going to be."

To summarize, he rapidly summed up his observations for me:

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SAY YOU SAW IT IN HAM RADIO

1. *Be careful of RG8/U, RG-8A/U, or "RG-8/U type" cable. It has no controlling military specifications. RG-8A/U made by a reputable manufacturer — with its name and type number on it in addition to the RG nomenclature is probably OK...but it is almost as expensive to buy as the premium stuff.*

2. *Look up the specifications for the cable you intend to buy, and examine the cable before you buy it. Does it have the proper number of center strands? Is the inner dielectric uniform with no blemishes or spots? Does it have complete, or nearly-complete, braid coverage? Does it have a noncontaminating jacket? And most important of all, is it made by a known, reputable manufacturer? Be suspicious of underpriced cable because "there ain't no free lunch."*

3. *If you are starting out fresh, buy RG-213/U cable (50 ohms) which also has the manufacturer's name and type number on it instead of RG-8/U type cable (52 ohms). It may be nitpicking, but today's RG-213/U cable standard is 50 ohms. It is a military-approved, properly-manufactured cable. Again, make sure it is made by a reputable manufacturer. You can then be certain the cable is what it is claimed to be and know that it has been tested.*

long life for your coax

Once having bought good cable, how does the owner get maximum life from it?

1. *Keep the cable off the ground and make sure it can dry off after a rain. Because modern outer jackets are slightly hygroscopic, moisture can penetrate the jacket material, reach the outer braid, and cause corrosion.*

2. *Try to keep the cable out of direct sunlight; ultraviolet rays are damaging over time. For prolonged exposure to strong sunlight, the cable outer jacket should be a high molecular weight polyethylene with imbedded carbon black (expensive!).*

3. *Support the cable every ten feet or less. Don't let it sag on a long run.*

4. *Don't let the coax cable whip around in the wind. Repeated flexing is not conducive to long cable life.*

5. *Seal the ends of the cable. Use type-N (waterproof) fittings instead of the cheap, plentiful PL-259 plugs. Coat the terminations with non-acid type silicone rubber sealant. ("If it smells vinegary, that indicates acetic acid in the sealant. Don't use it.")*

6. *Don't step on the cable or otherwise flatten it. And don't bend it around a sharp radius. The minimum recommended bend radius is equal to ten times the outer diameter of the cable. (That's about a 5-inch radius for RG-8A/U and RG-213/U.)*

how long will it last?

I'd heard it said that coax cable should be replaced every few years, so I asked my friend if that was so. He replied that all cables deteriorate at greater or lesser rates depending upon use and abuse. Cable failure occurs when one or more specifications of the cable no longer meets the needs of the user. Sometimes the impedance of the cable changes; sometimes the cable loss becomes intolerable; sometimes the velocity of propagation changes to a degree.

I told the engineer that my RG-213/U, which was about 15 years old, had increased in loss by a measurable amount over the years and asked whether I should scrap it and buy new cable.

"That's up to you," he replied. "Coax cable doesn't fall apart all at once like the One Horse Shay. Deterioration is gradual. If you don't mind the increased loss, why spend the money to replace the cable? If you require every watt, you'd better get rid of it."

"Then this story of a five-year life, or a fifteen-year life for coax is unsubstantiated?" I asked. "That's right," he replied. He said he thought the story had begun because in the past, some branches of the military had routinely junked coax cable after it had been stored for a number of years. He didn't think that was true today.

"Well, if I were operating on 80 meters," he added, "I wouldn't worry too much about the grade of coax I had. Losses are relatively low at that frequency even on old, junky cable. At 20 meters, however, I would start to pay attention to cable loss. And at 2 meters, I would examine the coax I bought very carefully. I would measure the velocity of propagation of each section if I made matching transformers, and I would check cable loss every year or so. As you go higher in frequency, you can't be too careful!"

His parting shot was to remind me that large quantities of imported cable which have recognized U.S. markings but whose manufacturing specifications are unknown are now entering the market. "Have fun when you buy your next length of coax cable," he chided as we hung up.

free brochure

I have reprinted the EIMAC brochure covering the design of Pi and Pi-L networks for linear amplifier service. Write to me at EIMAC, 301 Industrial Way, San Carlos, California 94070 and ask for bulletin AS-30. (Two first-class stamps or two IRCs would be appreciated.) And for full information on the design and construction of linear amplifiers, I recommend the 22nd edition of the *Radio Handbook*, available through Ham Radio's Bookstore, Greenville, New Hampshire 03048 ($21.95 postpaid).

new EIMAC 3CX800A7 power tube

A free data sheet on the new EIMAC 3CX800A7 power tube is available from Varian EIMAC, 301 Industrial Way, San Carlos, California 94070.

reference

1. Les Moxon, G6XN, describes his antenna neutralization technique in his book, *HF Antennas for All Locations*, available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 ($14 postpaid).

ham radio

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Model	Tunable Freq Range	Noise Figure	Gain	Price
LNA 28	20-40	0.9 dB	20 dB	$39
LNA 50	40-70	0.9 dB	20 dB	$39
LNA 144	120-180	1.0 dB	18 dB	$39
LNA 220	180-250	1.0 dB	17 dB	$39
LNA 432	380-470	1.0 dB	18 dB	$45
LNA 800	470-960	1.2dB	15 dB	$45

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- P30K, VHF Kit less case $18
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- P432W, UHF Wired/Tested $36

P432 also available in broadband version to cover 20-650 MHz without tuning. Same price as P432; add "B" to model #.

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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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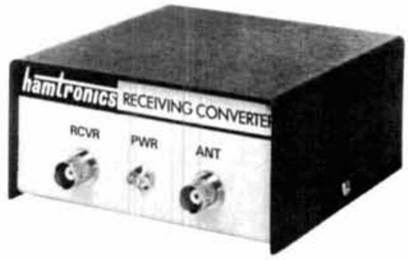

Models to cover every practical rf & if range to listen to SSB, FM, ATV, etc. NF = 2 dB or less.

	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
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	Exciter Input Range	Antenna Output
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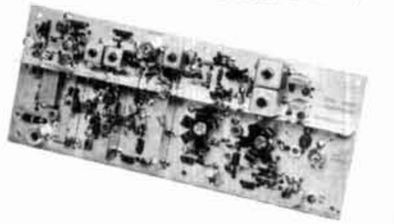
Model XV2	28-29	145-146
Kit $79	28-30	50-52
Wired $149	27-27.4	144-144.4
(Specify band)	28-30	220-222*
	50-54	220-224
	144-146	50-52
	50-54	144-148
	144-146	28-30
For UHF,	28-30	432-434
Model XV4	28-30	435-437
Kit $99	50-54	432-436
Wired $169	61.25	439.25
	144-148	432-436*

*Add $20 for 2M input



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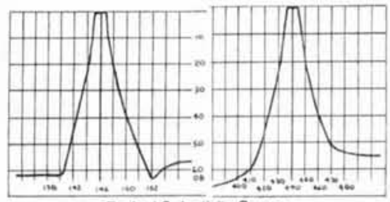

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EMI/RFI shielding: new techniques part 1

Electronic pollution raises new interest in plastic shielding

This two-part primer on plastics discusses their use in suppressing the undesired effects of EMI/RFI (emitted electromagnetic interference and received radio frequency interference). Part 1 examines methods of EMI/RFI suppression; part 2 reviews the various methods of testing shielding effectiveness that employ RF techniques familiar to most Amateurs. Before delving into a discussion of methods of EMI/RFI suppression, let's see just what this interference is, what its adverse effects are, and why there seems to be a sudden surge of interest in this area despite what appeared to be little or no concern in years past.

Intense foreign competition has caused American manufacturers of electronic equipment to cut costs dramatically; as a result, metal cases have often been replaced with less expensive plastic cases. Plastics are basically insulators; consequently they provide virtually no EMI shielding unless they are specially treated.

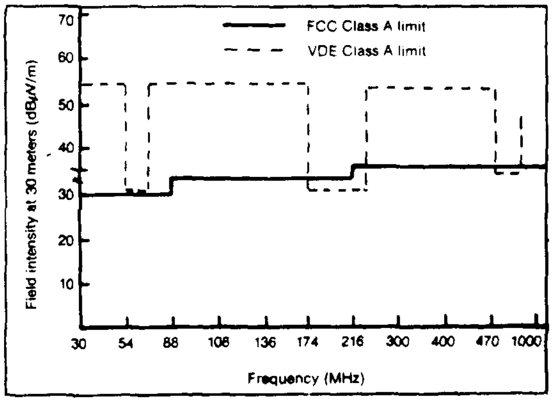

fig. 1. VDE vs. FCC standards for Class A products.

electronic pollution

Ten years ago there was only a small fraction of the number of electronic devices now available to consumers: electronic watches, calculators, home computers, video tape recorders and games, electronic toys, CB radios, microwave ovens, thermostats and home security devices, and a variety of controls on new cars. All of these devices emit electromagnetic radiation. In addition, the emphasis on portability in many of these items means that prolonged battery life through power reduction techniques — such as using switching voltage regulated rather than linear voltage regulated power supplies — has assumed far greater importance. Granted, the switchers are about twice as efficient as the linears, but because of their inherent mode of operation, i.e., switching current into an inductor, they are veritable EMI generators. Consequently, shielding becomes essential.

pollution effects

According to FCC chairman Mark Fowler, the number of electronic interference complaints now exceeds 80,000 per year.[1] For example, communications at an East Coast airport were hampered by interference from a "noisy" cash register in a drug store a mile away. In a western state, police communications at 42 MHz were disrupted by interference from coin-operated video arcade games. A home computer was found to affect its owner's TV as well as sets through-out the neighborhood. A fleet of new passenger buses designed for urban use were delivered, but during a test drive a driver tried to brake as

By Vaughn D. Martin, 114 Lost Meadows, Cibolo, Texas 78108

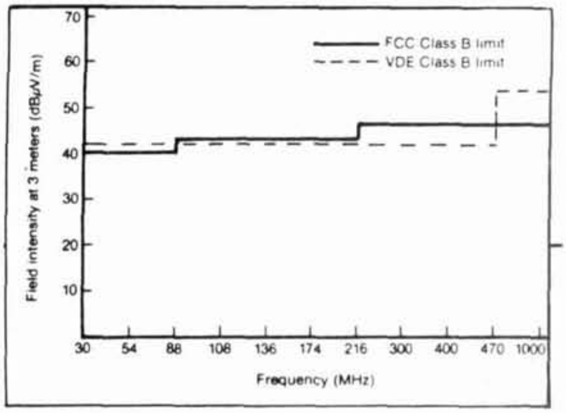

fig. 2. VDE vs. FCC standards for Class B electronic products such as computers and electronic games.

he went downhill and was astonished to discover he had no brakes until he reached bottom. Why? Because the microprocessor-controlled anti-skid devices controlling the brakes had been rendered useless by a commercial TV station's signal lobed in the direction of that particular hill. Once the electronic housings in the buses were shielded, their brakes worked.

background on FCC rule-making

On April 23, 1976, the FCC began a rulemaking proceeding (referred to as Docket 20780, Part 15, Subpart J) for setting realistic limits on VHF and UHF frequency emissions. The law included six categories: class, definitions, emission limits, verification, certification, labeling, and dates of compliance in dealing with radiated EMI/RFI in electronic and electrical industrial devices. In January 1979, a major computer manufacturer petitioned the FCC to relax some of these proposed standards. In response, the FCC relented on a few minor changes and rescheduled the July 1, 1980 compliance date. Other proposals presented are under consideration as well. While class A products (industrial electronic devices) are of interest, most concern seems to be focused on class B products: personal computers, electronic games and similar consumer items. (Certain inexpensive electronic games operating at frequencies less than 495 kHz are exempt from the new FCC ruling.)

Emission limits on class B devices are about three times as stringent as those placed on class A industrial products. Note in **figs. 1** and **2** how class A and B limits compare with the West German or generally accepted European standard, the VDE. The German post office has placed half-page ads in newspapers pointing out that items not meeting the specifications contained in the VDE regulation will not have a government proof number. Purchasers of devices without such numbers are liable to prosecution for electronic pollution; therefore, if an American product is to be marketed in West Germany it must be very EMI-proof. But the FCC *is* tightening up on emissions. For example, as of October 1, 1983, all manufacturers of class A and B products became subject to the FCC's request for random sampling of

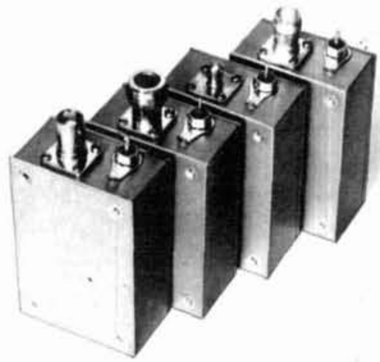

fig. 3. Typical small enclosures designed for EMI shielding.

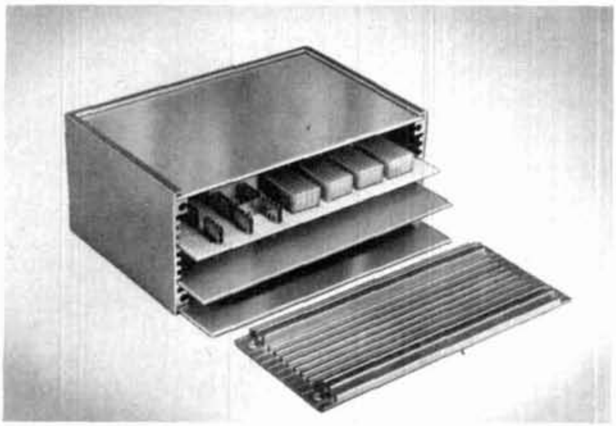

fig. 4. A metal case made with tightly fitting sides and end plates for EMI containment.

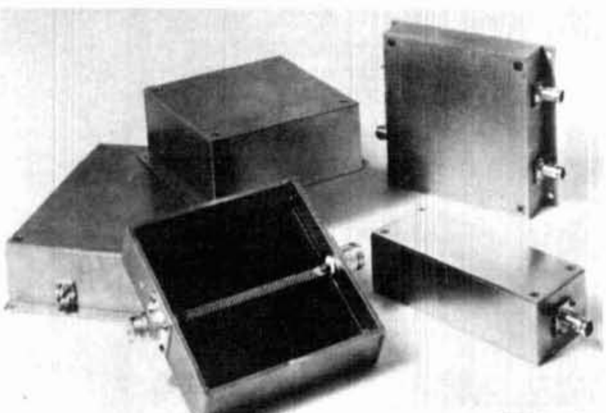

fig. 5. Nickel-plated EMI shielded cases.

table 1. Methods of EMI shielding and/or containment. (A) lists the shielding effectiveness (SE) parameters of various particle coatings, while (B) provides alternate methods of shielding.

(A):

coating*	coating thickness (mils)	sheet resistance ohms/sq.mm at 1 mil)	typical attenuation (dB)
plastic	125.0	0	0
aluminum/panel (for reference)	62.5	0	65-100
silver paint	1.0	0.01	65-70
silver/graphite (two coats)	0.2/1.0	0.01/100	54-77
copper	2.0	2.00	20-65
copper/graphite (two coats)	2.2	8.0/100	27-62
graphite	2.0	20.00	30-60
nickel	2.0	1.00	65

(B) **alternate methods of shielding**

1. Conductive elastometric materials
2. Conductive particle sprays and paints
3. Pressure sensitive adhesive backed tapes
4. Laminated heatsinks with paths for conducted EMI suppression
5. Wire mesh in strips and sheets
6. Zippertubing™ of coverings for cables that suppress conducted EMI and EMP (electromagnetic pulses)
7. *Conductive composite fillers (covered in Part 2 of this article)*

*Information supplied by PacTec Corp., Philadelphia, Pennsylvania

products to check compliance with established standards.*

the consequences of budget cutting

There is a twist to this story: a directive from FCC chairman Mark Fowler to Commissioner Anne Jones directed her to comply with the President's desire to cut their office's budget by 12 percent. In order to

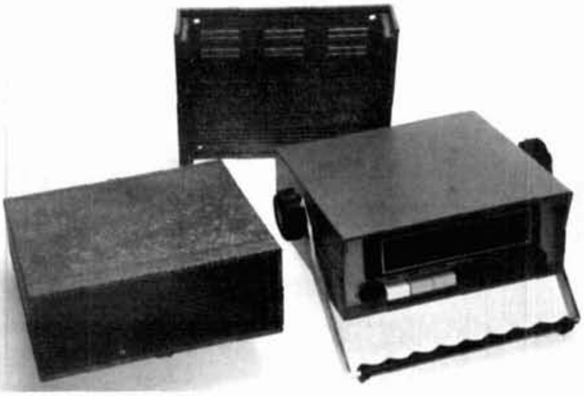

fig. 6. Plastic cases impregnated with conductive fillers to suppress EMI.

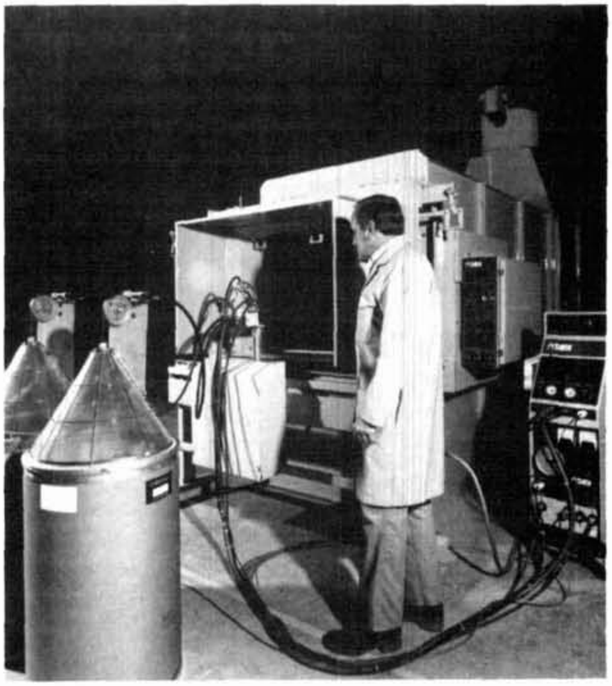

fig. 7. An X-Y axis programmable molten zinc sprayer.

*Any questions should be directed to your local FCC field office or to Art Wall, Office of Science and Technology, Federal Communications Commission, Washington, D.C. 20554.

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comply with the directive, the FCC may decide to close its Laurel, Maryland, test lab. If this happens, will the FCC then contract out its work to an independent laboratory? And if it does, will total impartiality be guaranteed? With the compliance-auditing arm of the FCC eliminated, will manufacturers disregard the new FCC rulings and eliminate metallized plastic cases and power line filters in an effort to produce their products more cheaply?

shielding enclosures

In the absence of effective government regulation, what can Amateurs do on their own?

Surprisingly, the most cost-effective way to solve the electronic pollution problem isn't careful circuit design, but rather the use of well-shielded enclosures. While there are many ways to accomplish this (see **table 1**), all are essentially the same in that they are variations of treating enclosures. (The emissions previously referred to are naturally radiated emissions; conducted emissions are covered later, but suffice it to say for now that conducted emissions are best prevented by adequate filtering of power lines and other lines or cables leaving or entering the "box.")

Metal enclosures were the first to offer efficient EMI shielding. Today many companies still produce metal enclosures: Compac, for example, offers its RFT series, which includes built-in SMA, TNC, N, and BNC interchangeable RF connectors, (see **fig. 3**). Other manufacturers such as Vector Electric produce a series of aluminum Multi-Mod enclosures with tightly overlapping sides and end plates for EMI containment (see **fig. 4**). Like most metal cases, however, these are more expensive than plastic ones and generally offer less decorative, less protective outer finishes than plastic cases.

table 2. Companies specializing in EMI shielding.

	type products manufactured					
shielding manufacturers/ company addresses	metal cases	foil	mesh	applied coatings	magnetic devices	tubing for cables
Adhesives Research Inc. Glen Rock, Pennsylvania 717-235-4860	—	yes	—	—	—	—
Advance Process Supply Chicago, Illinois 312-829-1400	—	—	—	—	yes	—
Compac Deer Park, New York 516-667-3933	yes	—	—	—	—	—
Perfection Mica Co. Magnetic Shield Division Bensenville, Illinois 312-766-7800	—	—	—	—	yes	—
Stackpole Corp., Electronic Components Division St. Marys, Pennsylvania 814-781-1234	—	—	—	—	yes	—
Tafa Metallisation, Inc. Bow, New Hampshire 603-224-9585	—	—	—	yes	—	—
Technit Inc. Cranford, New Jersey 201-272-5500	—	—	yes	yes	—	—
Vector Electronics Co., Inc. Sylmar, California 213-365-9661	yes	—	—	—	—	—
Zippertubing Company Los Angeles, California 213-321-3901	—	yes	yes	—	yes	yes

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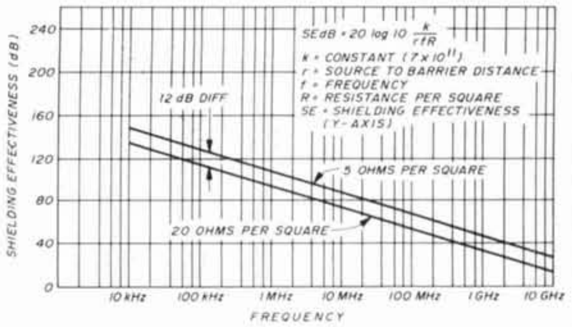

fig. 8. Shielding effectiveness vs. frequency-shielding effectiveness is proportional to the resistivity of thin film coatings, and increases with frequency.

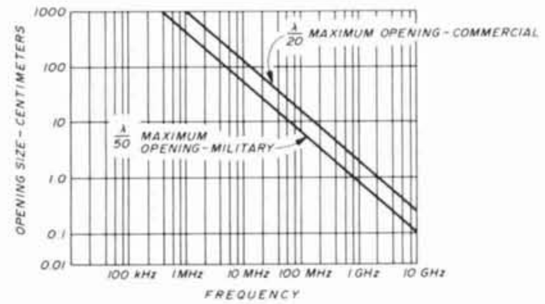

fig. 9. Hole size vs. radiated emissions frequency. Additional shielding materials are not required in a commercial enclosure if hole size is less than 1/20 wavelength, or 1/50 wavelength for military enclosures.

Fortunately, plastic cases can be treated to resist EMI as effectively as metal cases. This treatment process takes one or more of four forms: (1) the cases can be lined with a metal-plated or foil wire mesh screen (see **fig. 5**); (2) the cases can be painted or sprayed with conductive-particle plastic sprays; (3) the cases can be manufactured with conductive fillers impregnated in the plastic itself (see **fig. 6**); or (4), the cases can undergo a treatment process for the direct deposit of metals (see **fig. 7**).

The arc spray coating shown in **fig. 7** is a particularly interesting method used at Tafa Metallisation. Despite the fact that similar methods of using high temperature oxy-fuel plasma may damage some plastic surfaces, this method is so gentle that when molten zinc is applied to the surface of fresh fruit, the fruit will not be scorched. This seemingly impossible task is accomplished with a metal sprayer that looks very much like a paint sprayer but differs in that two small rods of metal stock are fed to the heat source and melted by an arc welding technique. This is accompanied by cool compressed air blowing fine atomized particles of molten metal onto the surface to be treated. This allows the plastic's surface to remain below 125° F (50° C), despite the fact that zinc itself requires a minimum temperature of 770° F (410° C) to even begin to melt. A 0.003 inch (0.0762

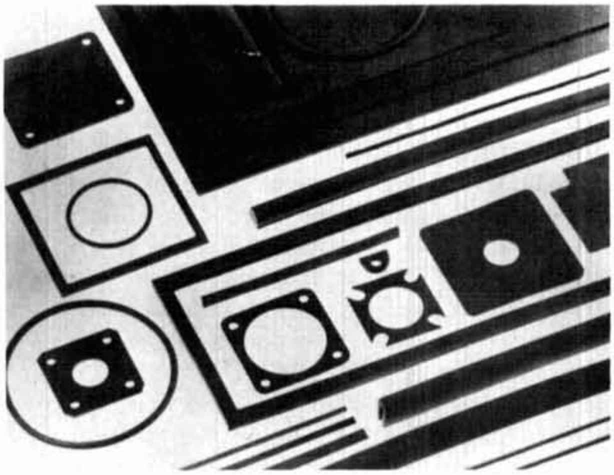

fig. 10A. Gaskets impregnated with conductive materials.

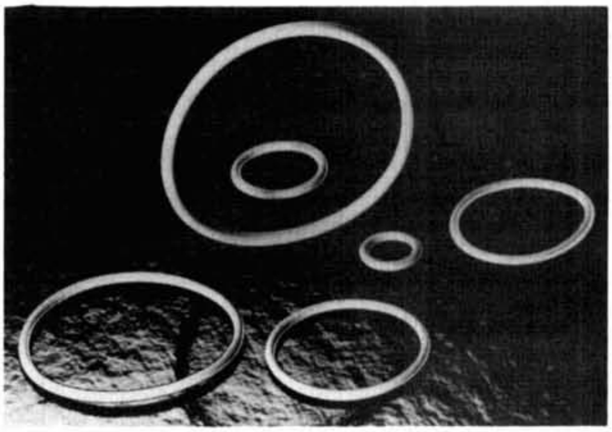

fig. 10B. Rubber grommets containing conductive particles.

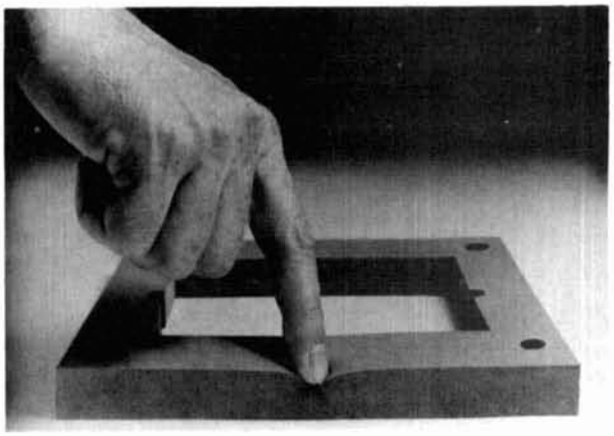

fig. 10C. A foam rubber cushion containing conductive particles.

mm) coating of zinc over a one-square foot surface requires about 3 ounces of zinc at an approximate cost of 19 cents. A 0.002 to 0.005-inch (0.0508 - 0.127 mm) — thick coating of zinc affords a resistivity sufficient for 50 to 90 dB of attenuation to radiation in the sub 100 MHz to 10 GHz range. This is important because EMI problems are essentially broadband in nature, so that shielding methods are devised for effectiveness against the highest potential frequency.

This arc spray coating is classified as either thin film (under 2.5 microns) or thick film (above 2.5 microns in thickness). Thin film coatings work particularly well at higher frequencies (see **fig. 8**) and provide shielding as a function of their resistivity. These resistive thin film coatings contain minute particles of silver, nickel, or carbon. Surface conductivity is therefore "adjustable" according to the type of spray selected, with mixtures using from 20 to 80 percent conductive materials to provide high conductivity. This is much more than commercial applications require (60 dB at 100 MHz). These coatings are quite fragile, though, and require an additional thin dielectric coating to avoid scratching or "fingerprinting" the freshly sprayed plastic surfaces. A scratch can be the "crack" in the box that permits EMI to escape.

specialized EMI problems

So far we have discussed the containment of EMI using various techniques, but have perhaps labored under the inaccurate assumption that any tight box will contain EMI. Generally, a tight box *will* contain EMI, but most pieces of equipment must have openings. These take the form of holes in the front panel through which the control shafts (potentiometers, variable tuning capacitors, and such) protrude. Additionally, LED or LCD displays or even a CRT often prove to be troublesome with their even bigger openings; larger pieces of equipment may have blowers, fans, vents, and louvers open to the outside environment. The cases themselves also often have discontinuities in seams or joints. Covers, gaskets, access ports, display windows, shaft holes, cables, and connectors all make it difficult to achieve optimum EMI/RFI integrity.

There is a relationship between their diameter and the frequency of radiated emissions (see **fig. 9**). The gaskets and rubber grommets that fit around these holes make the gap between the control shaft and the outside world much tighter (see **fig. 10**). In addition, these grommets are also often treated with conductive materials such as nickel, cobalt, iron, silver, or graphite. Many gaskets are made of wire mesh or conductive elastomers (supple, rubberlike plastic sheets — see **fig. 11**). Less supple metallic gaskets

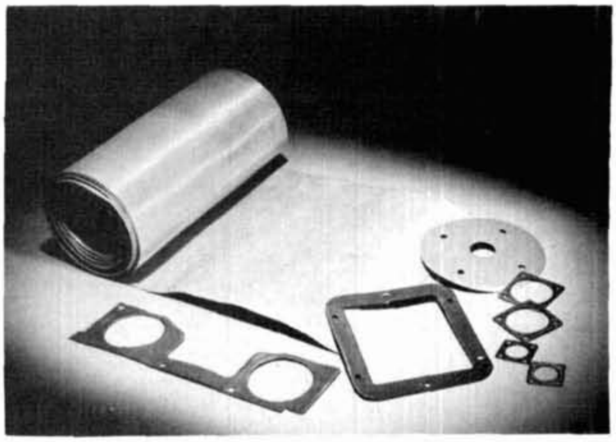

fig. 11. Supple elastomer sheets in roll form.

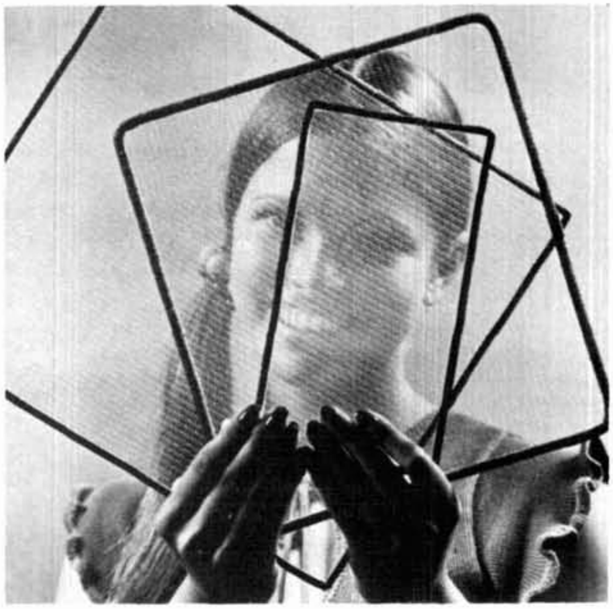

fig. 12. Glass impregnated with screens to contain EMI.

are therefore limited to straight-edge runs or openings with large radii. **Table 2** lists companies and products offered in this general area of EMI shielding. There are mechanical fittings made of wire mesh combined with silicone rubber or neoprene for cores that are both water- and gas-tight. There are also metallic tapes made with sticky or adhesive backs that can be applied to seams in an enclosure from which EMI might radiate. Glass that is relatively clear but has nonetheless been impregnated with conductive EMI constraining particles, (**fig. 12**), would be ideal in any application using a CRT.

references

1. Dr. Theodore J. Cohen, N4XX, "CQ Interviews: Mark S. Fowler, Chairman, FCC," *CQ*, March 1982, page 18.

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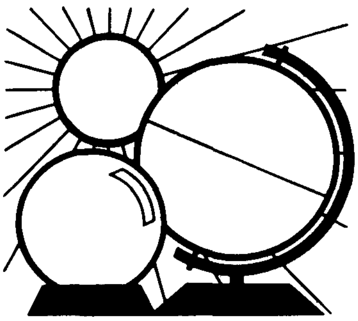

DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

Midwinter DX conditions are expected to be very good this first month of 1984. The higher frequency bands (10-30 meters) are expected to provide long skip and transequatorial openings on the 7th and possibly on the 20th. The lower bands (30-160 meters) are expected to provide excellent conditions throughout the month, with short skip during the daytime, between the above dates, and longer skip openings at night when the geomagnetic field is quiet. Geomagnetic ionospheric disturbances can be expected about the 1st, 10th, 18th, and 27th; the 5th, 13th, and 23rd are also possible disturbance dates, though with somewhat lower probability.

For EME and meteor burst communicators, the lunar perigee is on the 19th and a full moon appears on the 18th.

updating the foF2 formula

In the September, 1983, *DX Forecaster*, formulas were given for determining a mid-latitude local-noon foF2 (F2 layer critical frequency) from solar radio flux or sunspot numbers. The foF2 is the most variable of the propagation parameters that help define the maximum usable frequency (MUF) for a path between you and the DX QTH (MUF ≅ 2.5 foF2). Keep in mind that the MUF is about the optimum frequency for working that DX. These formulas are meant to be used for predicting "long term" (base) values of foF2 (for a few weeks or a month).

Changes in foF2 correlate with the daily solar flux changes over the previous three days. Delay in correlation (onset of foF2 change) depends on the magnitude of the flux change. Consequently these daily flux values can be used to update or "fine tune" the "long term" foF2 values discussed before. Furthermore, the rate of change of foF2 is only 30 percent the rate of change in solar flux and is used to alter the "long term (base) value."

but what about today?

To determine today's foF2, use your recorded values of the flux over the previous few days, noting how much it has varied. This variation, when multiplied by 0.3, equals the incremental increase (or decrease) in the long term value or base value of foF2. If you want a forecast of the foF2 that may be expected to occur several days ahead, use the last days' flux change. Small flux changes (up to 5 or 10 units) do not cause the ionosphere to change very much, so do not work too far back in time. The cause of the delay is the time the electrons take to drift or diffuse upward into the F2 region after being produced below 180 km by the solar flux (ultraviolet).

The flux — foF2 correlation is quite good in winter and equinoxal months. For lower latitudes the correlation is even better; for higher latitudes and summer months, correlation is poorer. The solar flux correlation with lowest usable frequency or absorption of the signal (signal strength) is *immediate*, with no delay experienced. Remember this correlation when using the lower frequencies in or near daytime.

band-by-band summary

Ten meters will occasionally be open, providing F2 long skip by the transequatorial one-long hop propagation mode (TEM). The openings will follow the sun during the day and into late evening. Geomagnetic disturbances will *enhance* this mode, as will high solar flux. Openings may favor southern Africa, South America, and Australia.

Fifteen meters can experience the same TEM modes as 10 meters with the openings being more frequent. World-wide DX is prevalent from after sunrise until well after sunset during the periods of high solar flux (listen to WWV at 18 minutes after the hour for reports on solar and geomagnetic conditions).

Twenty and thirty meters will be open most days and into the night to some areas of the globe with 1000-2500 mile long skip and some short-skip of 1200 miles near midday. Both propagation modes follow the sun across the sky; east, south, then west.

Thirty and forty meters are the transition bands, providing all-night propagation as well as some short-skip conditions during the daytime. Most areas of the world can be worked from darkness hours till just before sunrise. Hops shorten on these bands to about 2000 miles, but the number of hops can increase since signal absorption is low during the night.

Eighty meters offers ample opportunity for much DX work. Several stations have worked over 300 countries on this band. The band operates much like 40 meters except that the hop distances shorten to about 1500 miles. Noise from distant thunderstorms is low enough to make these bands a joy to work this time of year. The path direction follows darkness across the earth (east, south, then west).

One-sixty meters, similar to 80 meters, will provide multihop opportunities, though each hop shortens to 1000 miles.

ham radio

JANUARY

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	30	30	30	30	40	40	40	40	40	30	30	30	30	30	20	20	20	20	20	20	20	20	20	20	N
EUROPE	30	20	20	20	20	20	20	20	20	30	30	40	40	40	30	30	30	30	30	30	30	30	20	20	NE
S. AFRICA	15	15	10	10	10	10	15	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	15	15	E
S. AMERICA	15	15	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	10	10	10	10	10	10	10	SE
ANTARCTICA	15	15	15	15	15	15	15	15	20	20	20	20	20	20	20	15	15	15	15	15	15	15	15	15	S
NEW ZEALAND	10	10	10	10	15	15	15	15	20	20	20	20	20	20	15	15	15	10	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	10	10	10	10	10	10	W
JAPAN	20	20	20	20	20	20	30	40	40	40	40	40	30	30	30	30	20	20	20	20	20	20	20	20	NW

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	40	40	30	30	30	30	30	30	20	20	20	20	20	20	30	30	30	30	30	30	30	30	30	30	N
EUROPE	30	20	20	20	20	20	20	20	20	30	30	30	40	40	40	30	30	30	30	30	30	30	20	20	NE
S. AFRICA	15	15	10	10	10	10	10	15	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	15	E
S. AMERICA	10	10	10	10	10	10	15	15	15	15	20	20	20	20	20	20	15	15	15	15	10	10	10	10	SE
ANTARCTICA	15	15	15	15	15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	15	15	15	15	S
NEW ZEALAND	10	10	10	10	10	15	15	15	20	20	20	20	20	20	20	15	15	15*	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	15	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	10	10	10	10	10	W
JAPAN	20	20	20	20	20	20	30	40	40	40	40	40	30	30	30	30	30	20	20	20	20	20	20	20	NW
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	40	30	30	20	20	20	20	20	20	20	20	20	20	30	30	30	30	30	30	30	30	30	30	30	N
EUROPE	20	20	20	20	20	20	20	20	20	30	30	30	40	40	40	40	30	30	30	30	30	30	30	20	NE
S. AFRICA	15	15	10	10	10	10	10	10	15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	E
CARIBBEAN S. AMERICA	10	10	10	10	15	15	15	20*	20	15	20	20	20	20	20	20	20	20	20	20	15	15	15	15	SE
ANTARCTICA	15	15	15	15	15	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	15	15	15	15	S
NEW ZEALAND	10	10	10	10	10	15	15	15	15	20	20	20	20	20	20	20	15	15	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	10	15	15	15	20	20	20	20	20	20	20	20	20	20	15	15	15	10	10	10	10	W
JAPAN	20	20	20	20	20	30	30	40	40	40	40	40	30	30	30	30	30	20	20	20	20	20	20	20	NW

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.

short circuit

optical FM receiver

In the article by Poon and Pieper, "Construct an Optical FM Receiver," on page 53 of the November, 1983, issue, error was inadvertently introduced in editing. The text should read as follows:

"The deflection angle ϕ_d (measured outside the cell) between the incident beam of light and the first order light (beam) equals

$\lambda_0/\Lambda = \lambda_0 \cdot f/V_s$ where f is the frequency and V_s is the velocity of sound.

Incident light is most efficiently diffracted when the incident angle equals

$\lambda_0/2\Lambda_c$ where Λ_c refers to the center of the band."

the weekender

the 2-meter V-antenna

I am always on the lookout for new antennas for HF and VHF applications because they represent projects that can be assembled on a weekend at minimum cost, with maximum enjoyment. Recently, the V antenna came to my attention as a possible 2-meter portable radiator.

The V antenna (see **fig. 1**) consists of two long wires spreading apart from one end in an angle of less than 90 degrees at the apex (known as the apex angle). The maximum direction of radiation bisects the angle, requiring careful placement for best results. The leg length determines the overall gain and directivity of the system as well as the apex angle. I chose a leg length of 2.25 wavelengths and a 65-degree apex angle resulting in a 15-foot long wire antenna for 2 meters. (Charts are available if you wish to use a different leg length.)[1]

To determine the length in feet for a frequency of 146.9 MHz, I used the following expression:

$$L = 984\,(N - 0.025)/F$$

where L = length in feet
N = number of wavelengths
F = frequency (MHz)

Solving for:

$$L = 984(2.25 - 0.025)/146.9$$
$$L = 14.9\,feet = 14\,feet\ 11\,inches$$

construction

I used No. 22 gauge stranded insulated hookup wire for the antenna for several reasons. The wire is very flexible and does not end up in a tangle during storage. More importantly, the wire is available at any electronic supply store and is not expensive.

By Thomas M. Hart, AD1B, 32 Westwood Terrace, Westwood, Massachusetts 02026

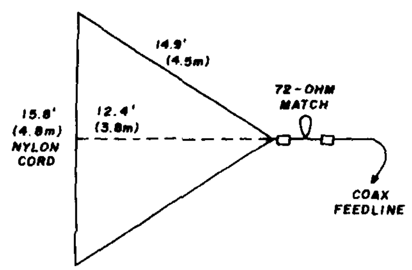

fig. 1. V antenna for 2 meters.

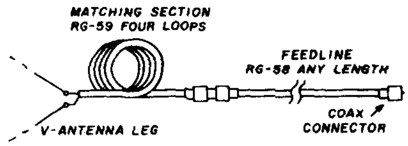

fig. 2. V antenna feedline details.

A recent article by Bill Orr[2] discussed the problem of feeding V antennas. I found his solution quite satisfactory for 2 meters. A 50-ohm coax line services the system, matched by a 1/4-wavelength section of 75-ohm coax.

The length can be found using the following:

$$L = 246(V)/F$$

where V = velocity factor
F = frequency (MHz)
L = length (feet)

$$L = 246\,(0.66)/146.9$$
$$= 1\,foot\ 1\,inch\,for\ RG\text{-}59\ (73\ ohm)$$

The Orr article recommends forming the matching section into four loops to "decouple the outside of the line from the antenna currents."

The completed antenna, run as a horizontal V, loaded well (SWR 1.1:1) and enabled me to easily access the desired repeaters. So, if you are interested in a different solution to the perennial antenna problem, try this conversation piece. In terms of efficiency, the reference texts indicate that a V with 2.25 wavelength legs has a theoretical gain of 4.5 dB over a halfwave dipole. The V antenna will provide a substantially better signal than the usual 1/4-wave coat-hanger vertical.

references

1. *The Radio Amateur's Handbook*, ARRL, 1980, pages 20-7 to 20-9.
2. William I. Orr, W6SAI, "Ham Radio Techniques," *ham radio*, July, 1983, page 42.

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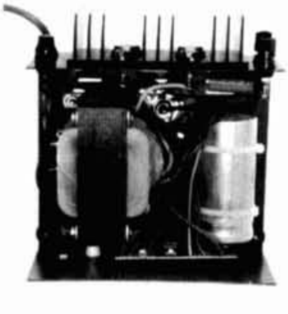

INSIDE VIEW – RS-12A

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RS and VS SERIES SPECIAL FEATURES

- SOLID STATE ELECTRONICALLY REGULATED
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- OUTPUT VOLTAGE: 13.8 VDC ± 0.05 volts (Internally Adjustable: 11-15 VDC)
- RIPPLE: Less than 5mv peak to peak (full load & low line)

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MODEL RS-50M

MODEL VS-50M

RM-A Series

MODEL RM-35A

19" X 5¼ RACK MOUNT POWER SUPPLIES

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

RS-A SERIES

MODEL RS-7A

MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H x W X D	Shipping Wt (lbs)
RS-4A	3	4	3¾ x 6½ x 9	5
RS-7A	5	7	3¾ x 6½ x 9	9
RS-7B	5	7	4 × 7½ × 10¾	10
RS-10A	7.5	10	4 x 7½ x 10¾	11
RS-12A	9	12	4½ x 8 x 9	13
RS-20A	16	20	5 x 9 x 10½	18
RS-35A	25	35	5 x 11 x 11	27
RS-50A	37	50	6 x 13¾ x 11	46

RS-M SERIES

MODEL RS-35M

- Switchable volt and Amp meter

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

VS-M SERIES

MODEL VS-20M

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

MODEL	Continuous Duty (Amps) @13.8VDC	@10VDC	@5VDC	ICS* (Amps) @13.8V	Size (IN) H x W x D	Shipping Wt (lbs)
VS-20M	16	9	4	20	5 x 9 x 10½	20
VS-35M	25	15	7	35	5 x 11 x 11	29
VS-50M	37	22	10	50	6 x 13¾ x 11	46

RS-S SERIES

MODEL RS-12S

- Built in speaker

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

More Details? CHECK—OFF Page 116

✓ 111

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Clock with 10 min. ID timer, 12/24 hour, DC-10 **$29.95**

For wired and tested clocks add $10.00 to kit price.
SPECIFY 12 OR 24 HOUR FORMAT

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Transmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.

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THE POPULAR SAT-TEC RECEIVER IN KIT-FORM!

NEW, LOWER PRICES!

Featured in a Radio Electronics magazine cover story (May 82), the reliable R2B Sat-tec TV receiver is now operating in thousands of locations. The R2B is easy to build; pre-etched, plated boards with screened component layout assures accurate component placement and the critical IF section and local oscillator are pre-assembled and aligned! All parts are included for the R2B, attractive case, power supply, descriptive operating manual as well as complete assembly instructions. Features of the receiver include: dual conversion design for best image rejection, fully tunable audio to recover 'hidden' subcarriers, divide by two PLL demodulator for excellent threshold performance, tight tracking AFC to assure drift free reception, and of course, full 24 channel tunable coverage.

Build your satellite TV system around the R2B, close to ten thousand others already have and now it's available in kit form at a new low price. Order yours today.

A complete Satellite TV System requires a dish antenna, LNA (low noise amplifier), Receiver and Modulator.

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Prices include domestic UPS shipping and insurance.

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Provides the basic parts and PC board required to provide a source of precision timing and pulse generation. Uses 555 timer IC and includes a range of parts for most timing needs.

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Produces LOUD ear shattering and attention getting siren like sound. Can supply up to 15 watts of obnoxious audio. Runs on 6-15 VDC.

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Produces upward and downward wail characteristic of a police siren. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.

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Runs on 5-15 VDC. Low current (2.5ma), 1 min./month accuracy. TB-7 Kit **$5.50**
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380	$1.50
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556	$1.00
565	$1.00
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3900	$ .50
3914	$2.95
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7447	$ .65
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7216D	$21.00
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14 Pin	10/$2.00
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24 Pin	4/$2.00
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2N3904 NPN C+F	15/$1.00
2N3906 PNP C+F	15/$1.00
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2N4410 NPN C+F	15/$1.00
2N4916 FET C+F	4/$1.00
2N5401 PNP C+F	5/$1.00
2N6028 C+F	4/$1.00
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MPF 102/2N5484	$.50
NPN 3904 Type T+R	50/$2.50
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1N914 Type	50/$1.00
1KV 2Amp	8/$1.00
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25 AMP 100V Bridge
$1.50 each

Mini-Bridge 50V 1 AMP
2 for $1.00

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3" leads, 8 ohm, good for small tone speakers, alarm clocks, etc.
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Mini 8 ohm Speaker

Approx 2¼" diam. Round type for radios, mike etc.
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+5 vdc input prod. -9 vdc @ 30ma
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SOLD OUT

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10 ft. for $1.00

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Nice quality clips **5 for $1.00**
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sm. bag (100 pc) **$1.00** lg. bag (300 pc) **$2.50**

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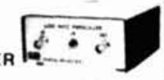
PS-2 wired **$39.95**

600 MHz PRESCALER



Extend the range of your counter to 600 MHz. Works with all counters. Less than 150 mv sensitivity, specify - 10 or -100.

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Kit, PS-1B **$44.95**

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PA-1, 30 W pwr amp kit **$22.95**
TR-1, RF sensed T-R relay kit **6.95**

MRF-238 transistor as used in PA-1
8-10db gain 150 mhz **$11.95**

RF actuated relay senses RF (1W) and closes DPDT relay. For RF sensed T-R relay
TR-1 Kit **$6.95**

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Complete triple regulated power supply provides variable 6 to 18 volts at 200 ma and +5 at 1 Amp. Excellent load regulation, good filtering and small size. Less transformers, requires 6.3 V @ 1 A and 24 VCT.

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OP-AMP Special

BI-FET LF 13741 - Direct pin for pin 741 co... but 500,000 MEG input z, super low 50 pa input curr... power drain
SOLD OUT
50 for only $9.00 **10 for $2.00**

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79MG	$1.25	7815	$1.00
723	$.50	7905	$1.25
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7805	$1.00	7915	$1.25

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Thermalloy Brand **5 for $1.00**
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CDS Photocells

Resistance varies with light. 250 ohms to over 3 meg **3 for $1.00**

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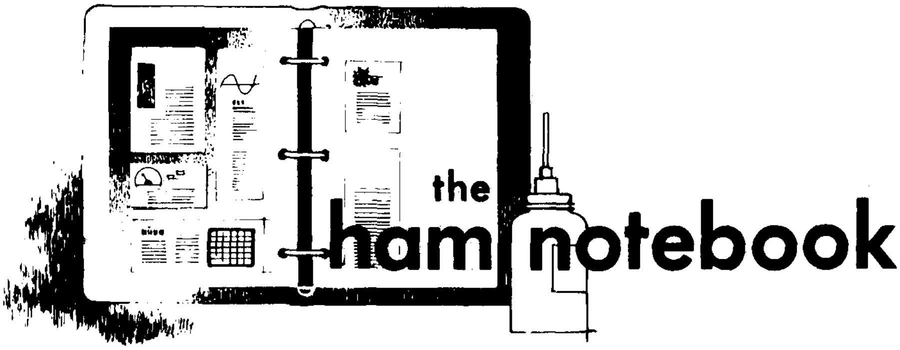

three circuits for repeaters

Unmanned repeater operation requires the use of remote control circuits. **Figs. 1, 2,** and **3** illustrate three popular circuits that enhance repeater operation: the autopatch phone line interface, the phone auto answer and ring indicator, and the TouchTone™ sequence decoder. All three are constructed of easy-to-find components.

autopatch phone line interface

Fig. 1 is a schematic diagram of a repeater-to-phone line interface for use as an autopatch. Its function is to provide for the receiver-to-phone line and phone line-to-transmitter link, with both using an opamp for gain. Q1 and Q2 control which audio path is active; when the receiver squelch sense line goes above 1 volt, Q1 conducts. This enables the receiver audio to pass the phone line. At the same time, Q2 turns off and the phone-to-transmitter audio is disabled. The receiver squelch input, therefore, must provide a high (above 1 volt) when an input is present. When the receiver squelch sense input goes below 0.5 volts, Q1 turns off and Q2 conducts, passing phone-to-transmitter audio and disabling the receiver audio path.

R1 adjusts the receiver-to-phone line audio and R2 adjusts the phone-to-transmitter audio level. R3 is an optional adjustment to allow for passing phone audio to a TouchTone™ decoder.

Transformer T1 isolates the electronics from the phone line and thereby maintains a balanced phone line. Relay RL1 acts as the on/off hook interface for the patch. When RL1 is energized, the phone line will be seized and audio can be passed to and from the phone line to the repeater receiver/transmitter. A low on the "line seize" will energize RL1. Make sure that diode CR2 is in place as shown; otherwise damage to the circuit that energizes RL1 could occur when the relay is turned off.

Diode CR3 and the 100k resistor force the audio circuits to pass receiver-to-phone audio and disable the phone-to-transmitter audio when the autopatch is not in use. This prevents any audio which might be produced from the autopatch circuit from going to the repeater transmitter. Several different types of op amps can be used. In this case, LF353 is used. In choosing a different op amp, the primary consideration should be one of stability.

This circuit has been used by many repeater groups with much success. Problems which might be encountered are primarily with dialing phone numbers. This autopatch circuit will provide for a very flat audio response with low noise and distortion. However, with the typical HT or mobile rig, it is often found that the rolloff characteristics will produce imbalance in the high to low group levels in the TouchTone™ audio. The phone company is becoming more and more

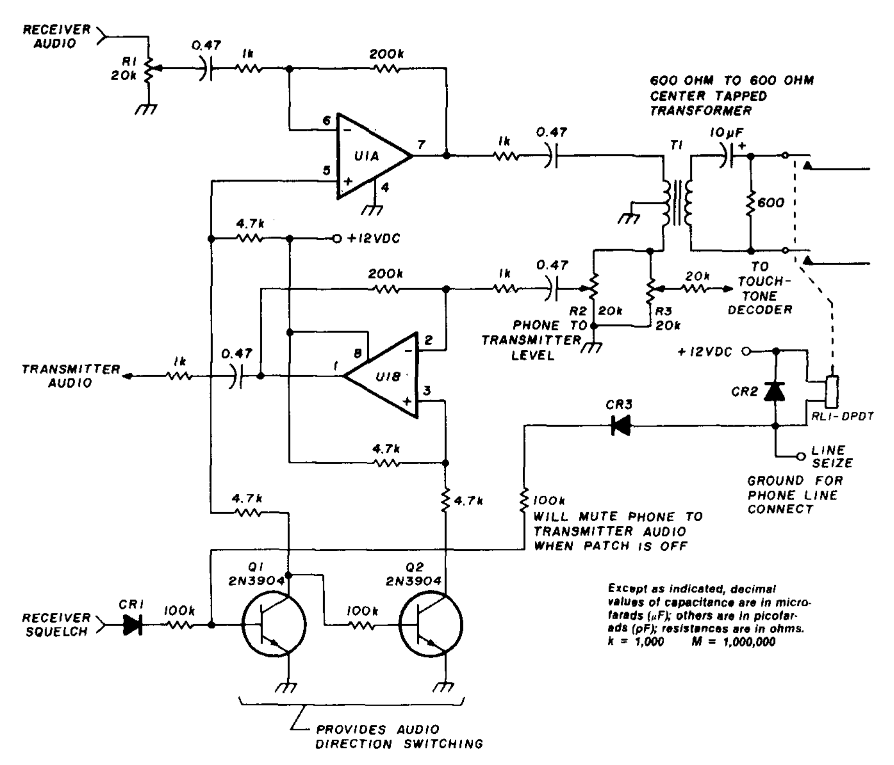

fig. 1. Autopatch (repeater-to-phone line) interface schematic diagram.

sensitive about this and is using equipment which is fussier about what it will accept than previous equipment. Thus, even though one may have plenty of level, the tones will often be rejected by phone company equipment. I assume this is done to provide for a greater degree of falsing prevention of their TouchTone™ decoders. The solution is solved by providing equalization that emphasizes the high response with about a 6 dB per octave rolloff. That is to say, a two-to-one ratio between the 697 Hz tone (lowest low group TouchTone™) and the 1209 Hz tone (lowest high group TouchTone™).

If you need an autopatch — and most repeater users do — this is a good and reliable circuit.

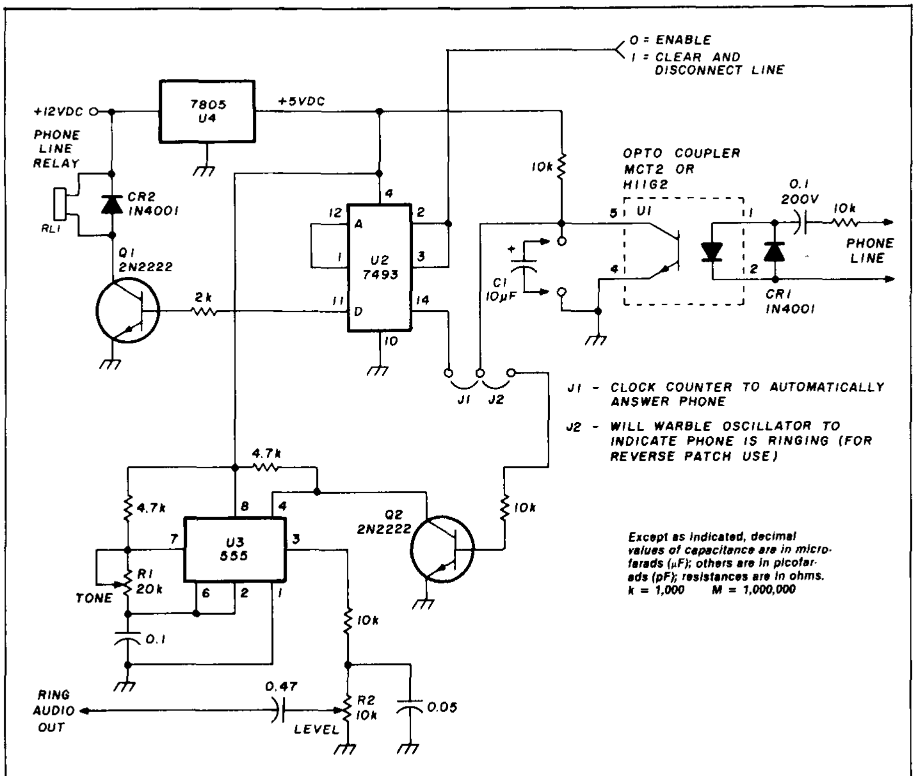

fig. 2. Auto answer or ring indicator schematic diagram.

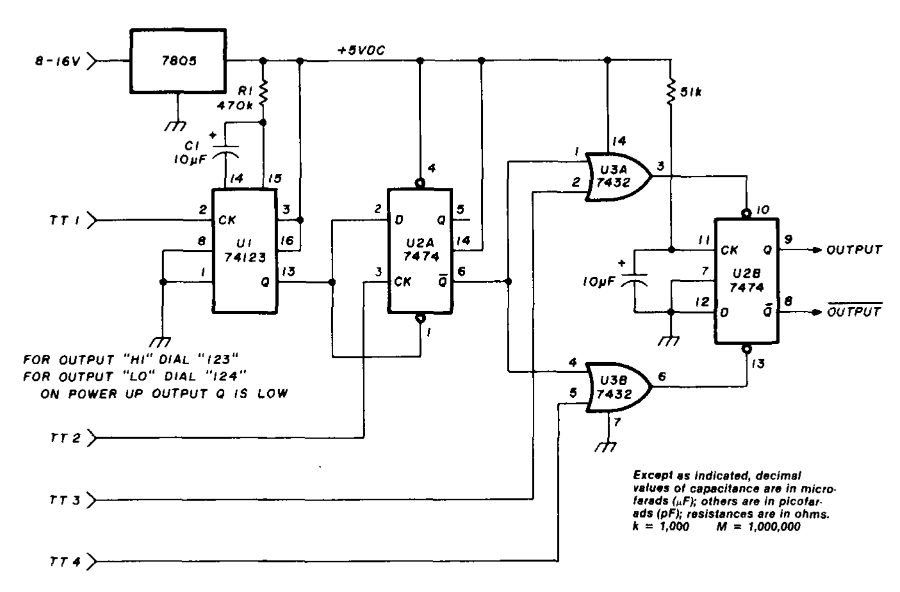

fig. 3. TouchTone™ sequence decoder schematic diagram.

phone auto answer and ring indicator

Fig. 2 is a schematic diagram of a ring detect circuit for automatic phone answering or tone generation for reverse autopatch use.

U1 is an opto-isolator consisting of an LED and phototransistor. When the LED lights, the phototransistor conducts. The diode is connected across the phone line through a 10K resistor and a 0.1 μF capacitor. This combination is transparent to the phone line, which is a must as far as the phone company is concerned. When the phone starts ringing, the ring signal produces pulses which force U1 to conduct and generate pulses in turn. This output is coupled to U2 and the pulses are counted. When the count reaches 8, U2's output goes to a logic high and forces Q1 to conduct closing the line seize relay, RL1.

The output of U1 is also coupled to U3 which is a 555 timer IC operating in the oscillator mode. When pin 4 goes high the oscillator will produce a tone at a frequency determined by R1. R2 is the level adjustment for this tone. This tone can be used to signal a repeater listener when the phone is ringing for use in a reverse autopatch. In the reverse patch mode, jumper J1 should not be connected in order to prevent U2 from answering the phone, stopping the ringing of the phone.

Jumper J1 determines whether the phone is answered automatically and J2 forces the tone generator to produce a tone on each ring of the phone. If capacitor C1 is not used, the output pulses from U1 will be at the phone ring rate (20 or 30 Hz depending on the phone system). This will force the phone to be answered almost immediately and the tone generator to give a warbling tone. However, if C1 is inserted, a single pulse will be given for each ring. Thus, the phone will be answered on the eighth ring and the tone generated will be constant while the ring is taking place.

The "clear" input to U2 clears the ring counter when a logic high is present on this line. This input should be connected to the decoder logic, enabling a caller or repeater user to force the disconnect of the phone when desired.

TouchTone™ sequence decoder

Fig. 3 is a schematic diagram of a TouchTone™ sequence decoder circuit. Its purpose is to take active low inputs from a TouchTone™ decoder and react to a proper sequence of digits. The proper sequence is determined by which TouchTone™ digits the user connects to the sequence decoder inputs TT1, TT2, TT3, and TT4. The function of this circuit is most useful for repeater builders that require some sort of logic control such as enabling and disabling functions on the repeater.

The circuit operates on the principle of requiring the digits to arrive in a proper sequence, preventing a function from being activated should a random sequence be entered. For example, if TT1 = TouchTone™ digit 1, TT2 = digit 2, TT3 = digit 3 and TT4 = digit 4, then the code for forcing the output to a logic high is *123*. To force the output low the code is *124*. If the sequence is dialed in any other order, the sequence decoder will not react to it (for example, dialing *213* will do nothing).

U1 is a "one-shot" which reacts to a pulse from the TT1 input by forcing its Q output, pin 13, to a high for a time determined by R1 and C1. Larger values keep high longer. Using the given values Q remains high for 4 seconds. If TT1 is strobed again during this period the 4-second period will restart. However, if TT1 is not strobed again, Q will revert back to a logic low. When the Q output is in the low state, no sequence decoding can take place. U1 acts as both a timer and a first digit seeker. After the first digit is dialed the remaining digits of the code must be dialed within 4 seconds. U2A decodes the second digit of the sequence. Upon dialing the second digit, the Q ($\overline{Q}$ not) goes low, enabling the TT3 and TT4 inputs of U3. If TT3 is dialed next, pin 3 of U3 will go low, producing a latched output on U2Bs Q output, pin 9. If TT4 is dialed as the third digit, the Q output will be forced low.

Pin 9 of U2B is a latched output and will remain in its state as long as power is maintained or until the proper sequence is dialed forcing Q to another state. Of course if an "ON" code is dialed and the state of the decoder is ON, no change will take place.

C2 and R2 force the Q output of U2B to a low on power up. This feature is most desirable in cases where power may be lost and no one is around to reset the circuit to the desired state, which is the case in most unmanned repeater sites. However, if the desired output state is a high on power up, the user should use the $\overline{Q}$ output. In this case the ON/OFF codes are reversed from the above description.

As shown, the ON/OFF codes are three digits each. However, if only a two-digit code is desired, removing the A part of U2 and connecting U1's $\overline{Q}$ pin 4 output to pins 1 and 4 of U3 will produce a two-digit decoder with the ON code being TT1 and TT3.

The OFF code becomes TT1 and TT4. If more than three digit codes are desired, all one must do is add D-type flip-flops after U2A and before U3 connecting U2As Q (not $\overline{Q}$) to the added flip-flops D input and its $\overline{Q}$ output to U3. For each added flip-flop the code is increased by one digit.

The suggested digits for setting up the codes is determined primarily by how the decoder is to be used. In the case where TouchTone™ might be used for other functions such as dialing numbers on an autopatch, it is most desirable to make sure that a telephone number will not produce the same sequence of digits as a controlling code. Thus, if a controlling code were *123* and a phone number of *844-1235* is dialed, the sequence decoder would react. This can be prevented by making sure that at least one of the digits in a code is not a 0 through 9. Thus, one should use a # or a *, or A, B, C, or D, if 16 digit TouchTone™ pads are desired, for at least one digit of a code.

Ron Wright, N9EE

John J. Meshna Jr., Inc.

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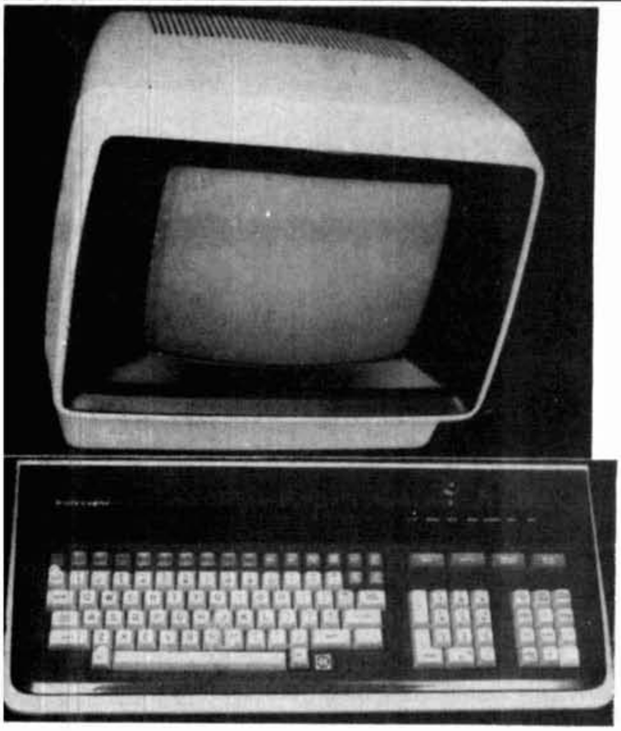
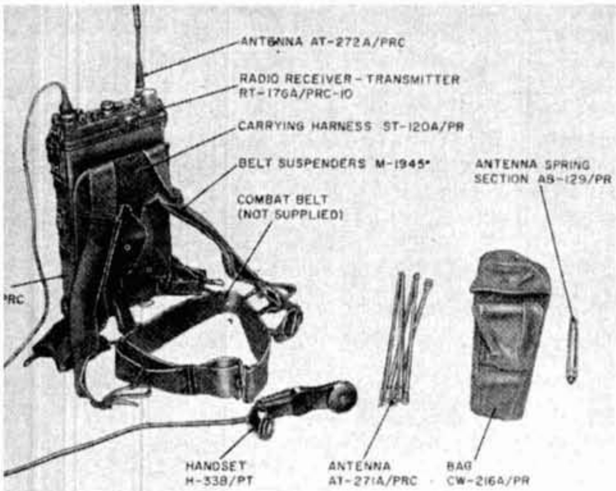


SELF STANDING COMPUTER TERMINALS

We acquired a small number of these beautifully made computer terminals which were made by a major U. S. computer manufacturer. We do not know all the details about them at press time but we can tell you that these terminals cost someone at least $2,000.00 each. They lose, you win ! The terminals feature the following: 3 seperate microprocessors for powerful capabilities, 106 key ASCII keyboard for changing the parameters of the installed EAROMs, 16K RAM, 48K ROM, serial RS-232 asynchronous data communications (synchronous optional), selectable baud rates of 75-38.4K BPS, high rsolution, 12" green screen, composite video monitor, 80 x 25 line dispaly with expandable character font (40 x 25), scrolling display, built in reverse video option, light weight, self contained, tightly regulated, switching power supply and much more than can be fit in this space. The terminals can configured in daisy chain format around a central host computer. All units are new or are in like new condition & are checked for completeness prior to shipping. The terminals are sold untested. Each one comes with operator's manual.
UPS shpg. wt. 55 lb. Stock no. MT-686 $289.00

We offer the following as options: schematic pac. 3 lb. $10.00
USRT for synchronous data comm. w/ installation data $10.00
25' RS232 cable 1 male & 1 female DB25 connector $20.00

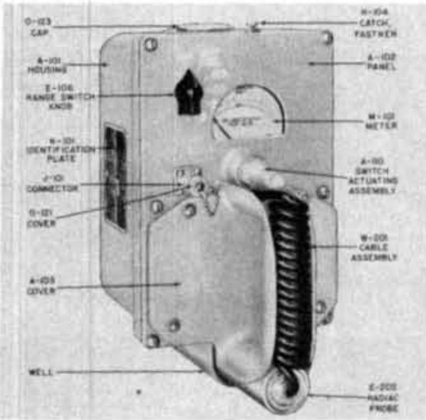
For further info. send $3.00 for a brochure on this terminal which is applicable to your order for and MT 686.



U. S. RECEIVER TRANSMITTER RT 176/PRC 10 RADIOS

Thru a very lucky purchase, we just bot a small quantity of new, unused PRC 10 radios. They are just beautiful. Any collector would be proud to have one of these babies in his possession. These radios came bulk packed to us just the way they were shipped from the factory to Uncle Sam. They were never released into the field. We are selling these as complete sets. The picture below shows all accessories that will be shipped with each unit.

RT 176/PRC 10 feature: *voice communication, tuneable range of 38-55 MC, super heterodyne FM front end, .9 watt xmtr., range of 5 miles (may vary depending on antenna used & siting conditions), & total wt. w/ accessories of only 16 lb.. Each set will include at no extra cost operators manual, schematic, & 4300 KHz. calibration xtal. They do not come w/ batteries, but they are available commercially. We are selling these as complete sets as shown below for $100.00 / set. Shpg. wt. 18 lb. The quantity is limited, so act fast.*



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Just released by the US Navy. They appear to be in excellent condition and include the fitted aluminum transit case. Batteries not furnished but are available in most electronic supply houses. 4 ranges 0.5 to 500 mr/hr. Removeable hand probe, detection of Beta and Gamma radiation. With todays world conditions and perhaps proximity to a nuke power station, it might provide a little insurance to own one of these instruments. With no facilities to check or test, we offer AS IS, visually OK Schematic provided with each. We have some accessories and offer as an option although not required for operation.
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PDR-27 phones $7.00 — Approx. 100 page Instr. Book $10.00
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The above listed tubes are already installed in the meter.
We are offering these as spares if desired.

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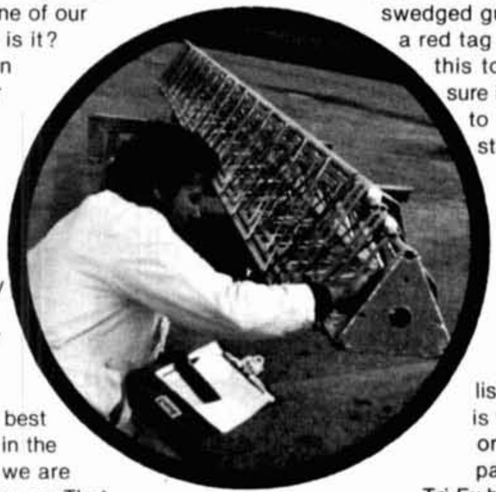

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VLF-LF preamps, coupler, Loran-C boards. SASE. Burhans Electronics, 161 Grosvenor St., Athens, Ohio 45701.

QSL CARDS: $17.50/500 ppd. Free catalog. Bowman Printing, 743 Harvard, St. Louis, MO 63130.

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RECLAIM SILVER from electronics scrap. Write RALTEC, 25884F Highland, Cleveland, OH 44143.

WANTED: Manual for Lavoie oscilloscope model LA-265A. Original or photocopy. State cost. WE4O, 4257 Via Alta Drive, Mobile, Alabama 36609.

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FOR SALE: TI Silent 700 model baudot printers. KSR's and RO's. New and used, working. Schematics and tech info available. Freight COD. KSR's $150.00. RO's $100.00. D. Regan, PO Drawer R, College Park, MD 20740.

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WANTED: Pre-1950 bugs and spark keys for my collection. Vibroplex, Martin, McElroy, Marconi, DeForest, etc. K5RS, Neal McEwen, 1128 Midway, Richardson, TX 75081.

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FOR SALE: Swan 500C with five accessories $400; Icom 211 $300; Galaxy Comm 1C with p/s $150; Collins R390A PTO unit $30. D. Johanson, 431 Jupiter Lakes Blvd. #2127A, Jupiter, Florida 33458.

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.

SELL: Kenwood Twins. E. Alline, NE5S, 773 Rosa, Metairie, LA 70005.

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COLLECTORS: Have Radio Craft/Radio Electronic Magazines from 1937 through 1955. Almost consecutive. Make offer. W6RFM, 1241 West 13 Ave., Escondido, CA 92025.

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Coming Events

ACTIVITIES

"Places to go..."

South Bend, INDIANA: Hamfest Swap & Shop, January 8, first Sunday after New Year's Day at Century Center downtown or U.S. 33 Oneway North between St. Joseph Bank Building and river. Industrial history Museum in same building. Carpeted hal acre room. Tables $3 each. *Four lane highways to door from al* directions. Talk in freq: 52-52, 99-39, 93-33, 78-18, 69-09, 145.43 145.29.

MICHIGAN: The Cherryland Amateur Radio Club's 10th annua Swap and Shop, February 11, 8 AM to 1 PM, Immaculate Con ception School Gym, Traverse City. Register at door. Talk in or 146.25/85. For information call K8YVU, Jerry Cermak at (616 947-4848.

NEW YORK: Yonkers Electronics Auction sponsored by the Yonkers ARC, Sunday, January 22, 9 AM to 3 PM, Lempko Hall 556 Yonkers Avenue. Admission $3.00 each. Children under free. Auction starts 10 AM. New and used equipment. Club com mission on successful sales 10% on first $100, 5% on remainder Unlimited free coffee all day.

OHIO: Mansfield Mid-Winter Hamfest/Auction, Sunday, Febru ary 12, Richland County Fairgrounds, Mansfield. Doors open t public 8 AM. Tickets $2.00 advance; $3.00 at door. Tables $5.0 advance and $6.00 at door. Half tables available. Talk in o 146.34/94. For information, tickets/tables SASE to Dean Wrass KB8MG, 1094 Beal Road, Mansfield, Ohio 44905. (41 589-2415.

OHIO: Cincinnati ARRL '84 State Convention and Flea Marke February 25 and 26. Registration $5. Flea market $4 per spac both days. Forums, meetings, vendors, Wouff Hong, banque *Hospitality suite Friday and Saturday nights.* Write: Cincinna ARRL '84, POB11300, Cincinnati, OH 45211 or call (51 825-8234.

VIRGINIA: Frostfest '84, Winter Amateur Radio and Comput Show, Sunday, January 15, Better Living Building, Virginia Sta Fairgrounds, Richmond, 8 AM to 4 PM. General admissic $4.00. Flea market space $3.00, tables $3.50 additional. Boot for commercial exhibitors. Contact N4DDM (804) 272-8206 Richmond Frostfest, Box 1070, Richmond, Virginia 23208.

OPERATING EVENTS

"Things to do..."

JANUARY 8-9: Rats Nest and Crooked Stick IV, an antenna experimenter's sprint contest. 2100Z January 8 to 0100Z January 9. Frequencies: CW 21.060 to 21.200 MHz. SSB 21.350 to 21.450 MHz. Rats Nest & Crooked Stick Antenna: 100 ft. max. of single conductor wire. Feedline will not count if it is coaxial cable. Antenna is limited to 20 ft. high. Transmitter Power: 250 watts or less (DC input). Exchange: Name, QTH, type of antenna, I.A.R.C. member or not. Contest entries must be submitted by February 1, 1984. For more information: SASE to Issaquah ARC, Bob Farnworth, KB7NV, 6822 - 131st Avenue S.E., Bellevue, WA 98006.

FEBRUARY 2-8: The Michigan Technological University ARC and the Copper Country Radio Amateur Association announces a radio celebration of our Winter Carnival festivities in the northernmost part of Michigan's Upper Peninsula. A certificate will be issued to all Amateurs who make contact with any participating ham in the Copper Country between 0000 February 2 through 0000 February 8. Frequencies: RTTY - 3.630, 7090, 14.095. CW 3.705, 7.085, 14.085, 21.085, 21.185. Phone - 3.930, 7.285, 14.305, 21.385, 28.685. On CW listen for CQ Winter Carnival. Send your QSL with 3-20¢ stamps for p&h to: Howard Junkin, N8FHF, 106 W. South Avenue, Houghton, MI 49931.

FEBRUARY 4-5: Vermont QSO Party sponsored by the Central Vermont ARC (W1BD), 2100Z Feb. 4 to 0700Z Feb. 5 and 1100Z to 2400Z Feb. 5. Frequencies: Phone - 3910, 7230, 14260, 14320, 21360, 28570, 50110, 144.2. CW - 3530, 3730, 7030, 7130, 14060, 21060, 21160, 28060. RTTY - 3620 & 090 other RTTY sub-bands. Exchange: VT stations send QSO number, 2 letter county designator. Others send QSO number and state or province. Scoring: VT 1 point per phone contact, 2 points per CW or RTTY. Times states plus provinces plus ARRL countries. Others 1 point per phone contact, 2 points per CW or RTTY times number of VT counties. A station may be worked 3 times per band, once each on phone, CW or RTTY. Separate awards to Vermont and non-Vermont stations. Send logs/facsimiles, name, address, Vermont county NLT March 1, 1984 to: D. Nevin, KK1U, W. Hill, Northfield, VT 05663.

FEBRUARY 4-6: New Hampshire QSO Party, sponsored by the NH ARA, 1900Z Feb. 4 to 0700Z Feb. 5 and 1400Z Feb. 5 to 0200Z Feb. 6. Exchange signal report and QTH. Suggested frequencies: Phone 3.935, 3.975, 7.235, 14.280, 21.380, 28.575, 50.115, 145.015. CW 1.810, 3.555, 3.730, 7.055, 7.130, 14.055, 21.055, 21.130, 28.055, 28.130. RTTY 3.625, 7.085, 14.085, 21.085, 28.085. Logs must be postmarked by March 15, 1984. Include large SASE for results. Mail to: Pete Cantara, KI1M, 19 Haverhill Street, Hudson, NH 03051.

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

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

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

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

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

So imagine how good I felt to find the "Micro-Office" Work Center! These are fine pieces of computer system furniture that make my office-at-home as pleasant a place to work as it ought to be. And the biggest and best surprise is the low, low price for such good quality.

Here is what you get—all for only $249.50 plus shipping.

- Mar-resistant work surface. Your choice of oak or walnut grained. Work surface height is adjustable to your keyboard, your chair, your height.
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book and product REVIEWS

ASTI

TI, Terrestrial Interference, is one of the most important problems facing users of the satellite service. Commercial and home TVRO owners have found that because of the relative newness of the technology they are using, there is little available in the way of information on terrestrial interference and how to avoid it.

Recognizing TI as a major problem, the folks at Microwave Filter set about the task of putting together a how-to book that would help identify and define problems and then set about the task of eliminating them. This book — *The Avoidance/Suppression Approach to Eliminating Terrestrial Interference of TVRO Earth Stations*, by Glyn Bostick, Tom Fannetti and William Johnson, is based upon the actual experience of the authors in their efforts to reduce the problems caused by TI. The authors also obtained a significant amount of input from the fledgling TVRO industry through symposiums and technical meetings held around the country.

During the early days of the TVRO industry, the common solution for a TI problem was to change the location of the system. But, now due to the explosive growth of the industry and high costs, this is not always a practical solution to the TI problem. Because of siting or budgetary limitations, it is often necessary to locate systems in less than optimal sites. Thus was born the ASTI project. The answers on how to reduce or eliminate TI and maximize system performance are found in ASTI.

Chapter 1 lays the ground work for TI avoidance and provides a brief summary of the rest of the book. Chapter 2 provides the reader with an illustrated summary of TVRO operation as it applies to the distribution of TV programming. Chapter 3 is a soup-to-nuts description of how TVRO works, starting with the uplink, transponder operation, and TVRO installation. This is most important because a complete understanding of the system is necessary to recognize how and where susceptibility will come. With that information in mind, chapter 4 details and describes potential TI sources by function and frequency. Chapter 5 deals in the symptoms of TI. Plenty of photos are provided so the reader can relate his unknown problem to known and quantified problems.

Chapters 6 through 11 deal with the actual site selection, antenna/LNA and other components in the system. Complete coverage is given to ensuring that the system is engineered properly, the first time through, to reduce TI problems to an absolute minimum. Some of the methods of TI suppression discussed are a bit severe, such as pits, fences, and other forms of artificial microwave barriers. However, some are absolutely necessary to eliminate the really thorny TI problems. The authors have gone to a great deal of trouble to discuss and eliminate some misconceptions that exist about TI shielding. In some cases, microwave shields are more expensive than they should be because of a lack of solid technical information. The authors give a complete description of the optical principles that control microwave radiation. And upon this framework, how innovative solutions can be derived to solve TI problems. Chapters 12 and 13 deal with how to eliminate unavoidable TI; Chapter 12 discusses what filters are available, their ability to counter TI, and their application at critical points in the system. Chapter 13 deals with "worst case" situations and takes full advantage of the authors' practical field experience in TI reduction.

Finally, chapter 14 deals with SMATV techniques for satellite and master TV systems. Techniques are outlined for avoiding and suppressing the interference that often comes from this kind of system hybridization.

This book is an absolute *must* for the professional TVRO and satellite earth station community. I would also recommend ASTI to home TVRO owners as an invaluable resource book. Even for those who do not now have a TI problem, construction of TI-producing systems continues daily. A trouble-free system today could become an unusable system tomorrow. The retail price for *ASTI*, $125.00, may sound a bit high but is quite reasonable in light of the wealth of information found within the book. (Besides, when you've spent more than $4,000 to install a TVRO system, the price of *ASTI* seems inexpensive, compared to a microwave technician's time in troubleshooting a TI-plagued system. MFC also provides an ASTI update service for $60/year that will keep you fully informed on all the latest TI problems and solutions.

For more information on *ASTI*, contact MFC at 6743 Kinne Street, East Syracuse, New York 13057.

N1ACH

Circle #301 on Reader Service Card.

Keithley Model 130-A digital multimeter

The latest addition to Keithley's product line, the Model 130-A Digitial Multimeter, reached my desk the other day for review. I have been looking over quite a few multimeters over the last several months for *ham radio* and I must admit that upon opening the box, I found the Model 130-A to be the most aesthetically pleasing that I have seen. Functionwise, color has

little to do with performance. Ergonomically, however, a well designed, color-coordinated piece of test equipment will eliminate eye strain and fatigue that can reduce a test technician's overall performance.

Another interesting ergonomic feature is that the unit is designed to comfortably fit into your hand. Should the need arise to change scales or units to be measured, when the unit is in your left hand, it can be done easily and conveniently with the left thumb. This allows the user to hold the probes in position while the scales are being changed. Keithley also provides a handy carrying case with a belt loop. The small size means that you can stow the Model 130-A into your tool box without displacing too many tools.

The display for the Model 130-A uses an easy-to-read, 3/5 inch VCD readout. The large readout combined with work stand makes the 130-A digital multimeter right at home in your workshop, as well as being an invaluable tool for field service.

Keithley also has a full line of accessories for the Model 130-A that includes a temperature probe that will measure from −55 to 150 degrees C, high voltage probe that is rated up to 40 kV, a 50 ampere shunt, a clamp-on AC current probe, and of particular interest to Radio Amateurs and other RF people an RF voltage probe for measuring voltages from 100 kHz to 250 MHz.

The Model 130-A is rated at a maximum common mode voltage of 500 volts and is designed and operated from 0 to 50 degrees C. It is powered by a single 9 volt battery which is rated at 100 hours usage with carbon zinc cells and 200 hours usage with an alkaline cell. The unit is 7.1 × 3.1 × 1.5 inches (178 × 78 × 38 mm) and weighs a mere 10 ounces (283 grams). It is priced at $145 and comes with battery, test leads, and instructions.

specifications

DC volts	200 mV to 1000 V (±0.25% + 1d)
AC volts	200 mV to 750 V (±1% + 3d) 45 - 500 Hz
Resistance	100 n ohms to 20 M ohms (±Avg. 275%)
DC amps	2 mA to 10 A (±Avg. 75%)
AC amps	2 mA to 10 A (±Avg. 2.4%)

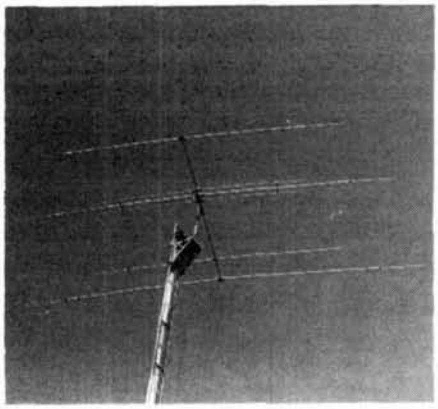
This is an excellent product and will be right at home in either your ham shack or on-the-job. For more information, contact Keithley Instruments, 28775 Aurora Road, Cleveland, Ohio 44139.

Circle #302 on Reader Service Card.

de KA1JWF

Explorer 14

The Explorer 14 is a three-band (10, 15, and 20 meters), four-element (two parasitics), Yagi antenna that provides complete band coverage *without* retuning. Telex/Hy-Gain, the manufacturer, was able to achieve this performance by incorporating a multi-section driven element and separate reflectors for 10 and 15/20 meters. (The single director uses 15



and 20 meter traps). It is relatively light (45 pounds, 20.4 kg), can be installed by one person (see **installation**), does not require any length/spacing readjustments after initial preset and is fed directly by 50-ohm coaxial cable — there's no gamma match to adjust. Its small size (14-foot boom) is an attractive feature for those who must be concerned with neighborhood aesthetics, while mechanically it accounts for only 7.5 square feet of wind surface area. Important specifications include a maximum gain of 8.8, 8.0, and 7.5 dBi for 10, 15, and 20 meters, respectively; a worst-case VSWR of less than 2.0:1 from band edge to band edge; and an average F/B ratio of 16 dB on 10/20 meters and 19 dB on 15 meters. It handles maximum legal power and is at DC ground potential including coaxial inner conductor.

para-sleeve system

The driven element consists of three sections: a center element and a closely spaced front and rear sleeve. The para-sleeve system (patent pending), basically an open-sleeve dipole, uses a trapped 15 and 20 meter driven element and *two* parallel elements for 10 meters. A Hy-Gain balun provides the balanced-to-unbalanced transformation while maintaining DC continuity between the antenna and cable inner and outer conductors.

construction

I enjoy assembling kits that are complete, have a well-written and diagrammed manual, and have been engineered for trouble-free assembly. In designing this kit, the staff at Hy-Gain must have carefully thought through each step, anticipated problem areas, and corrected for them as needed. Construction is simple; I have to admit that my two children (ages 7 and 9) built most of the antenna — and were usually one step ahead of me. All parts fit as described and were of good quality (stainless steel for the brackets and hardware).

Of course, the usual common-sense techniques are called for. Read through the manual carefully; clear a space in which to work; read the manual; unpack, count, and identify parts; read the manual, and proceed. You might have noticed that I've said "read the manual" three times; Hy-Gain recommends this as a good number. (I have personally seen "experts" assemble antennas incorrectly because they "knew" what to do.)

At one point in construction I was ready to pick up the phone and call Hy-Gain for two missing aluminum sections until I discovered that the manufacturer conserves packing space by telescoping some sections within others. In one particular case, the ID/OD dimensions were so close as to make the inner piece "disappear."

There are quite a few repetitive steps in constructing this antenna that lend themselves to production line procedures: compression clamp assembly, element-to-boom bracket assembly, etc. This is where my young workers excelled. The manufacturer suggests that at least five hours be allowed for assembly, and though we weren't in a race, I believe we beat that figure by at least half an hour. One of my children remarked, "Don't worry, Dad, we'll have you on the air by tonight." (Visions of climbing towers by moonlight had overtaken me.)

Final assembly is simpler if you drive a temporary 5-foot length of mast into the ground and attach the boom and boom-to-mast brackets to it. This permits eye-level installation of parts and easy alignment of elements after assembly. This, naturally, is the best time to check and double-check all dimensions, (not when it's 100 feet in the air and 20° below zero).

I felt that there was a little too much play in the sleeve spacer clamping arrangement due to the use of 5/8-inch clamps — the next size smaller might have been better. Also, since no ·eadjustment of element lengths and spacings s ever called for, assembly would have pro- ceeded even faster if the manufacturer had narked the boom and color-coded the element sections. But then again this additional step is easily done, and by leaving it to the assembler, the manufacturer probably keeps cost down.

installation

I had remarked earlier that the antenna was relatively light. To prove it, I mounted the Ex- plorer 14 to a fifty-foot push-up TV mast. It withstood high winds and remained intact until disassembled several months later. I don't recommend TV mast installation to the timid — t takes some resolve and a bit of muscle. Mine settled at the 42-foot level with only a few feet overlap of mast sections and four sets of polypropylene guys. The manufacturer recom- nends that it be mounted at least 30 feet above roofs or metallic structures if a low VSWR is to be achieved. I agree completely. Normal tower nounting procedures and precautions are imply described in the manual.

performance

The antenna test "range" at K2RR in Milford, New Hampshire, consisted of at least one completely open acre with no other anten- nas or structures (metal or otherwise) closer than 1½ wavelengths at the lowest operating frequency — 14.0 MHz. The Explorer 14 was mounted at 42 feet above a low conductivity ground (New Hampshire isn't called the Gran- ite State for nothing). The antenna used for A-B comparison exhibited at least 1 dBd gain toward Europe at a fairly low angle (estimate between 20 and 30 degree takeoff angle). A sim- ple coaxial relay allowed for rapid comparison.

Initial tests involved verification of the manufacturer's VSWR specifications for the entire three bands. The test setup included a Bird wattmeter and a SWR bridge (used separ- tely). At the input to a 100-foot run of new 52- ohm coaxial cable (Belden 8214), a VSWR of .0:1 was not exceeded at any frequency on 0, 15, or 20 meters and at many points was elow 1.5:1.

Both the gain and front-to-back evaluations were qualitative, unfortunately, but in all for- ward gain tests the received signal strength was greater from the Explorer 14 than from the reference antenna when both were aligned in the preferred direction. Since a bi-directional reference antenna was used, a rapid qualitative front-to-back evaluation was possible. Signals were weaker from off the back of the beam than from the standard antenna, as was ex- pected. To provide accurate gain and F/B figures, a calibrated test setup and better knowledge of the reference antenna and site are required.

30 and 40-meter add-on

The Explorer 14 can be operated on 30 or 40 meters as well with the addition of the Hy-Gain QK-710 conversion kit. The add-on kit includes a 20-meter trap, additional tubing, stainless steel hardware, and another well-illustrated and written manual. Depending on which of the two kits you choose, the driven element assembly resonates on either 30 or 40 meters (besides 10, 15, and 20 meters). It adds 3.5 or 6 pounds, to the overall weight of the Explorer 14 using the 30 or 40 meter kit, respectively. It provides rotary dipole performance with the advantage of a single coaxial feed still only required for *four* band operation. (The add-on kit was not available at time of testing.)

field testing

In "field testing" the Explorer 14, I established a one-month goal to contact at least 100 countries during *non*-contest periods. It actually took only three weeks (June 18 - July 9) to accomplish this. An abbreviated list of some of the "catches" is listed below. (A complete list is available; send SASE).

5H3SG	5Z4PR	UI80AA
UF6FER	UK8BAA(UH8)	UL7VBA
UK5OAA(U0)	YI1BGD	AP2ZA
C30LAB	A92F	VU2GI
UD6BR	SV1NA	3B8DB
J28DN	XT2AW	UJ8AP
A4XHZ	TU2AZ	

conclusion

The Explorer 14, model number EX-14, provides low VSWR broadband Yagi performance on 10, 15, and 20 meters. It allows the constructor to build it once, on the ground, without need of laborious readjustments for different mode operation. It is light enough for one-man installation, though an additional helping hand or two would be highly welcomed. Upon dismantling, no hardware showed any signs of corrosion — all the more surprising considering the acidic pH of New Hampshire rain. If you enjoy putting kits together and want a good performing no-tune Yagi, this definitely is one way to go.

For further information contact Telex/Hy-Gain, 9600 Aldrich Avenue, South, Minneapolis, Minnesota 55420.

K2RR

NEW products

new Hamtronics® catalog

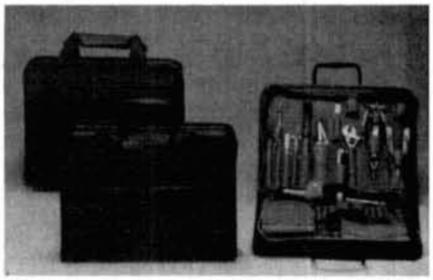
The new 1984 Hamtronics mail order catalog of supplies for VHF/UHF/OSCAR enthusiasts and two-way radio shops is now available. This 36-page, two-color catalog features many new products, including an expanded line of FM repeaters and accessories such as power amplifiers, DTMF tone decoder/controllers, and autopatches. Also included are the popular lines of FM and AM receivers, FM transmitters, VHF and UHF transmitting and receiving converters, space shuttle receivers, 800 MHz scanner converters, preamps, and other products.

For a free copy, contact Hamtronics, Inc., 65F Moul Road, Hilton, New York 14468. (For overseas mailing, please send $2.00 or 4 IRCs.)

Circle #303 on Reader Service Card.

technician's tool kit

The JTK-86 "Premier," new from Jensen Tools, is a full-service technician's tool kit in a compact zipper case. It includes a selection of tools rarely found in zipper case kits, such as a complete 13-piece 1/4 inch drive socket set with ratchet, spinner handle and extensions; a Vise-Grip locking plier; a 9-blade fold-up hex key set, and an 11-blade feeler gauge.



The JTK-86 is available in a vinyl or leather case with handles or in a case of rugged Cordura nylon with three roomy outside pockets for meters, test leads, or service manuals. Two pockets measure 5-1/2 × 9 × 2-1/4 inches, and the third measures 10-1/2 × 9 × 2-1/4 inches.

The JTK-86 "Premier" Jensen's finest zipper case kit, is available with or without a Fluke 8021 Digital Meter or a Triplett 310 VOM.

For more information or a free catalog of other Jensen kits and cases, write Jensen Tools, Inc., 7815 S. 46th Street, Phoenix, Arizona 85040.

Circle #305 on Reader Service Card.

720-channel handheld receiver

FDK International Corporation has begun to market what is said to be the world's first PLL-synthesized 720 channel hand-held AM airband receivers, the ATC-720/SP series. Designed for air traffic control and Amateur purposes, the series ATC-720/SP series employs PLL-synthesized circuitry for accurate frequency selection of 720 channels between 118-136 MHz in 25 kHz steps. The light weight (11 ounces; 315 gr.) and small size (6-5/8 × 2-1/4 × 1-3/4 inches; 169 × 58 × 43 mm) of the ATC-720/SP allows the user maximum portability in operating fields. Supplied with flex rubber antenna, Ni-Cd battery pack, and AC-charger, the ATC-720/SP features an adjustable squelch level to eliminate background noise on the AM mode. Low battery consumption allows 6 hours of continuous operation. A BNC aerial connector DC-charger and shoulder case are available as optional accessories.

For information, contact FDK International Corporation, 10-2, Kaji-cho 2-chome, Chiyoda-ku, Tokyo 101, Japan.

Circle #304 on Reader Service Card.

new handhelds

The new IC-02A and the IC-02AT two-meter handhelds are now available from ICOM. These compact multifeatured handhelds are the same compact size as the IC-2A series, but have features found on no other Amateur handheld.

The IC-02A and the IC-02AT are designed to be compatible with all existing IC-2A accessories plus new accessories that will make them unique. An important feature of the IC-02A series is that it features *32 PL* tones built into the unit as *standard*. These tones are programmable from the front panel pad, and may be used with any frequency selected, or may be stored in memory and recalled along with the frequency at any time.

Any frequency on 5 kHz spacing in the 2-meter ham band may be called up in the IC-02A. All frequency entries as well as control functions for memory, scanning, etc., are selected by the 16-button pad on the face of the radio. Included are priority watch, scanning *of both memories and programmable band* scan, and DTMF on the IC-02AT model. The unit features ten memories which store frequency, PL tone, offset and offset direction, and an internal lithium battery backup. The *priority channel is a unique feature to the IC-*02A and IC-02AT, as well as the custom LCD readout with an S-meter function, unique to the ham industry.

The IC-02A series will run at 3 watts with the standard BP3 battery pack, or at 5 watts with an optional high power battery pack. A long-life battery, 8.4 volts at 800 mA, will be available to double the working time of the standard 3-watt output unit. Batteries may be charged a variety of ways.

The IC-02A series has an environmentally sealed case with "O" ring seals to protect it

NEW products

against dirt and moisture. A heavy-duty aluminum back provides heatsinking for the 2 watts of power. A power connector is supplied on the top of the unit. Twelve volts applied there will power the unit as well as charge the battery pack.

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

Circle #306 on Reader Service Card.

WARC bands kit for Yaesu FT-101

A new kit which provides receive/transmit capability on all three WARC bands for all models of the FT-101 except the ZD is now available from Fox Tango Corporation. While only the 10 MHz band has been authorized for use to date, little additional effort or expense will be needed to add all the bands while the circuit changes for 10 MHz are being made. In addition to making the old 101 ready when the new bands become available, the added capability increases the trade-in value of the set. Based on a tried and tested design by G3LLL, the WARC bands kit is complete with all needed crystals, relay, switch, and detailed instructions for moderately easy installation.

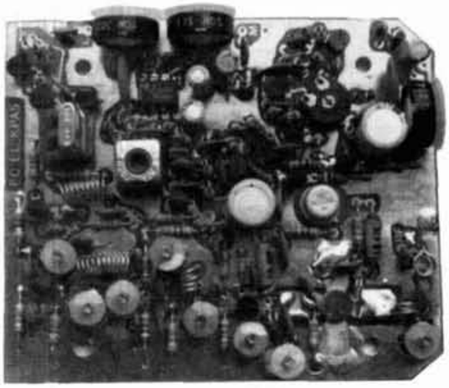
For further information, contact the Fox Tango Corporation, Box 15944H, West Palm Beach, Florida 33416.

Circle #307 on Reader Service Card.

mobile ATV module

P.C. Electronics has released a 1-watt AM UHF ATV transmitter module board (Model KP5A) which, when mounted in an aluminum box atop a portable color camera, allows the camera operator to move freely. Coverage of up to a mile is typical under most conditions; 50 miles has been done from an airplane. Applications include video from radio-controlled model airplanes or robots, computer video, base station remotes, weather radar video, or any application in which cables would be impractical.

The KP5A is a wired and tested board capable of full color and sound. It comes standard with one crystal on either 439.25 (east) 434.0 (west), or 426.25 MHz. Its power requirement is 13.8 VDC at 280 mA. The board size is only 4 × 3.25 inches (10.16 × 8.26 cm); its price is $159. Additional crystals are $15 each. Buyers must hold an Amateur license of Technician class or higher.

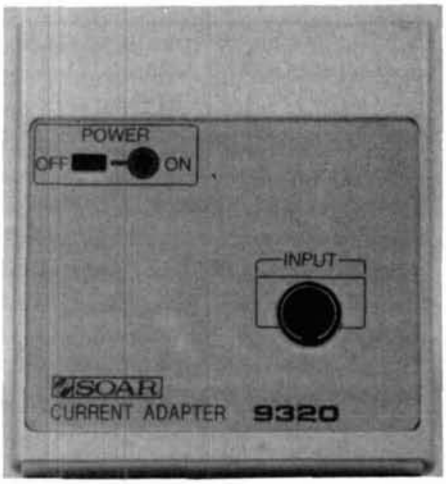


For further information, contact P.C. Electronics, 2522 Paxson Lane, Arcadia, California 91006.

Circle #308 on Reader Service Card.

three new adapters

Three new adapters designed to work with all DMM's having a 10 megohm or better DC input resistance and a 200 mV DC range are available from North American Soar. *Model 9320*, shown above, is a combination AC and DC current adapter complete with a clamp-



around Hall effect sensor. It can measure AC current to 150 amperes and DC current to 200 amperes without breaking into the line; it's priced at $79.00, with battery.

Model 9310 is a temperature adapter priced at $79.00, battery included. Switch-settable to read degrees in centigrade or Fahrenheit, it will work with all "K" type bimetal sensor probes.

NEW products

Model 9330 is a capacitance measuring adapter with two sets of input connectors, banana jacks for large or in-circuit devices, and pin-insert jacks for direct device capacitor tests. Priced at $44.00 with battery, this device can measure capacitance from 2 nF through 200 μF on six ranges.

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

Circle #309 on Reader Service Card.

solar systems

Photowatt International, Inc., a leading manufacturer of "total" solar electric systems, offers a laminated solar panel module rated at 55 watts, 16.5 volts at 3.4 amps that features 5-inch silicon cells. Other modules ranging in power from 7 watts to 35 watts are available. The Solar Eclipse Series modules have a power output of 7, 12, and 25 watts and are laminated in a durable bronzed frame with charcoal gray Tedlar backing. Modules are wired for either 6 or 12-volt applications.

Photowatt also manufactures a photovoltaic regulator used for system control. These power control units are the only regulators that offer current and voltage meters, low-battery indicator, lightning protection, and additional components to protect the PV systems. The PCU's are in NEMA 3R, rain-tight, lockable enclosures. Ground and pole mount support frames are available for one to ten modules per structure. Batteries, wires, hardware, J-boxes, accessories and installation instructions are also supplied. Customized photovoltaic systems are available for immediate shipment. Computer sizing quotations are available upon request to match customer's specific PV power requirements.

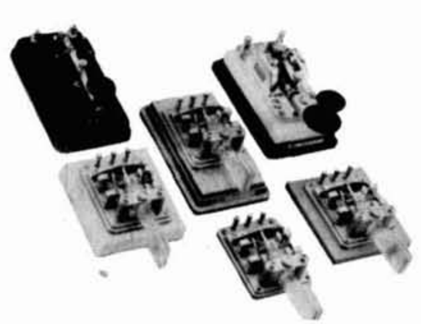
For details, contact Photowatt International, Inc., 2414 West 14th Street, Tempe, Arizona 85281.

Circle #310 on Reader Service Card.

hand keys and keyer paddles

Guild, one of the most respected names in musical instruments and related electronics, recently became the sole distributor for the Hi-Mound line of iambic keyer paddles and hand keys.

Hi-Mound paddles feature silvered contacts with full spacing and tension adjustments on all models. Three of the iambic paddles have *heavy, slip-resistant bases (one of solid marble)*, while the fourth is a paddle assembly which can be mounted on the base of your choice or built into an existing keyer. The hand keys, in addition to retaining the classic look, also have silvered contacts and a unique tension adjusting system.



A clear plastic dust cover is included with each key, and all are protected by Hi-Mound's *one-year warranty, backed by Guild*.

For more information, contact Guild at 225 West Grand Street, Elizabeth, New Jersey 07202.

Circle #311 on Reader Service Card.

SSB/FM microphones

A new cardioid unidirectional microphone especially built for SSB and FM communications is available from Heil, Ltd.

Two models are available. The HM-5 features a die-cast metal base and heavy-duty flexible goose-neck stand. The MM-5 is a comfortable hand-held unit for use in mobile or fixed operations.

Both feature Heil's new HC-3 cartridge and offer enhanced intelligibility and articulation and clean, natural reproduction of voice transmissions. Sensitivity is measured to −70 dB; response, 300-4000 Hz; impedance, 2000 ohms.

For more information, contact Heil, Ltd., Marissa, Illinois 62257.

Circle #312 on Reader Service Card.

count on these

Two new series of turns-counting dials for panel control of precision potentiometers are *now available from Beckman Electronic Technologies Group (BET)*. Ten new analog dials, series 2650 and 2660 Duodial® are available in the popular 1/8″, 1/4″, and 6 mm shaft sizes in either a black housing with white numerals or in an anodized case with black numerals. The 7/8″ dials count up to 15 turns.

The eight new digitals, series 2100 and 2200 Digidial® are available in either the popular 1/4″ or 6 mm shaft size and are available with a clear or black anodized housing. They count up to ten turns and are available in eight three- or four-digit models.

NEW products

Both series feature a positive locking mecha nism that prevents accidental changes due t shock or vibration. They mount directly on th potentiometer shaft to prevent backlash an are designed to compliment the Beckman Heli pot® potentiometer.

For complete information, contact Beckma Instruments, Inc., Beckman Technologie Group, 2500 Harbor Boulevard, Fullerton, Cali fornia 92634.

Circle #313 on Reader Service Card.

new cable

Nemal Electronics has just introduced a ne cable for both the home and commercial sate lite TV market. This new cable eliminates a the separate control and RF cables and bundle them together into a single easy-to-handl covered package. Nemal's new SCC-921859 cable is covered with a high-strength, non-cor taminating vinyl outer jacket suitable for eithe direct burial or laying on the ground. Insid there is one Mil-Spec RG-59 RF cable with a 9 percent copper braided shield. There are fiv No. 22 copper strand wires and two No. 2 wires that are shielded with drain for sensitiv signal activator circuits. Finally, two heavy- du ty No. 18 wires are included for motor control By eliminating the number of separate wires the chances of accidental system damage ar reduced. Installation time is also reduce because of the ease and convenience of run ning one cable rather than several. The price i tentatively set at 75 cents per foot and $495.0 per thousand feet.

For more information, contact Nemal Elec tronics, 12240 NE 14th Avenue, North Miami Florida 33161.

Circle #314 on Reader Service Card.

new MOS for 150 MHz power amplifiers

Motorola has introduced an extensive new line of RF Power MOSFETs offering output power in the range of 5 watts to 125 watts at 150 MHz. Manufactured with TMOS technology, these devices are designed for 28 volts operation in VHF amplifiers, with a range of 9 to 13 dB minimum gain. The devices are designated MRF134, MRF136, MRF171, MRF172, and MRF174.

These new TMOS devices exhibit higher gain, high input impedance, lower noise figure and lower intermodulation distortion than bipolars. This helps improve the performance of amplifying circuits and, in some cases, lowers the overall cost by requiring fewer stages of amplification.

specifications

device	output power (watts)	minimum gain (dB)
MRF134	5	11
MRF136	15	13
MRF171	45	12
MRF172	80	10
MRF174	125	9

For more information, contact Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, Arizona 85036.

Circle #315 on Reader Service Card.

6-meter amplifier

Mirage Communications has recently been granted FCC type acceptance on their new 6-meter amplifier, the A1015. The solid-state unit is rated at 150 watts out for 10 watts in and comes with a list of features that includes a built-in receiver pre-amp, "all mode operation" (FM, SSB, and CW) and antenna changeover capabilities.

Designed to fill the growing demand for a 6-meter amplifier compatible with a variety of different 10-watt radios now in use, the unit sells for $279.95.

For more information, contact Everett Gracey, Mirage Communications, P.O. Box 1393, Gilroy, California 95020.

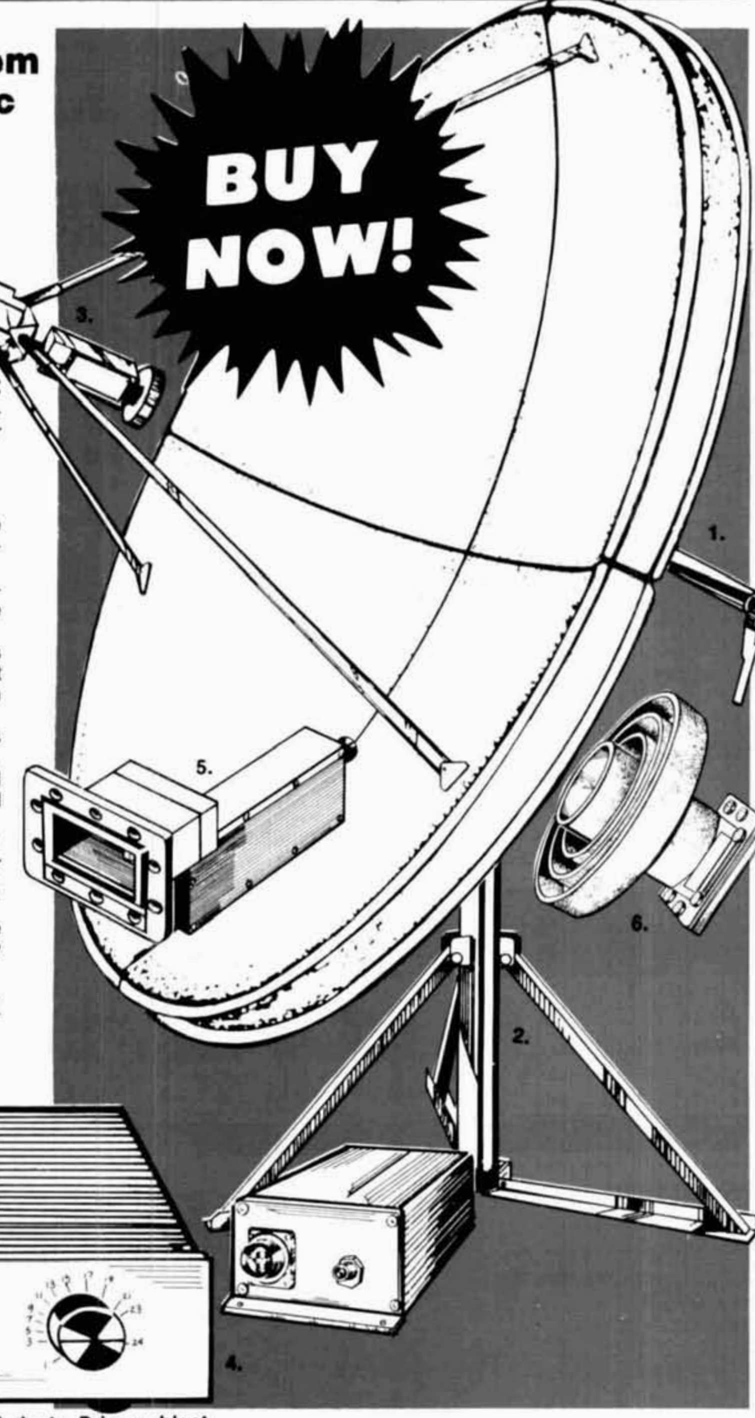
Circle #316 on Reader Service Card.

ENJOY TV FROM SPACE!

Complete TVRO System With 10 foot Parabolic Antenna

$1395

Item No. SAT44311
Shipped Motor Freight Collect



What the system will do:
Receives up to 60 satellite TV channels including movies, sporting events, news, other TV stations and much more!

What the system includes:

1. 10 ft. parabolic antenna made of reflective metal bonded with fiberglass. Breaks down into 4 sections for compact shipment.
2. Polar mount. Features azimuth and elevation adjustments for precise tracking. Available with earth or slab mounts.
3. LNA mount complete with rotor. Enables LNA to be remotely positioned for correct polarity. Control console included. Extension tubes extra.
4. KLM Sky Eye V satellite receiver. Features the latest in single conversion electronics, large signal strength meter, video invert and variable audio tuning. Downconverter and built-in RF modulator included.
5. Amplica low noise amplifier. Rated at 120° K, uncooled. Uses GaAs FET transistors for maximum performance. Cast aluminum, weatherproof housing.
6. Scalor feed horn. Provides 0.5 dB more gain than conventional types. Virtually eliminates system noise.
NOTE: LNA-to-downconverter cable included. Other interconnecting cables between components sold separately.

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