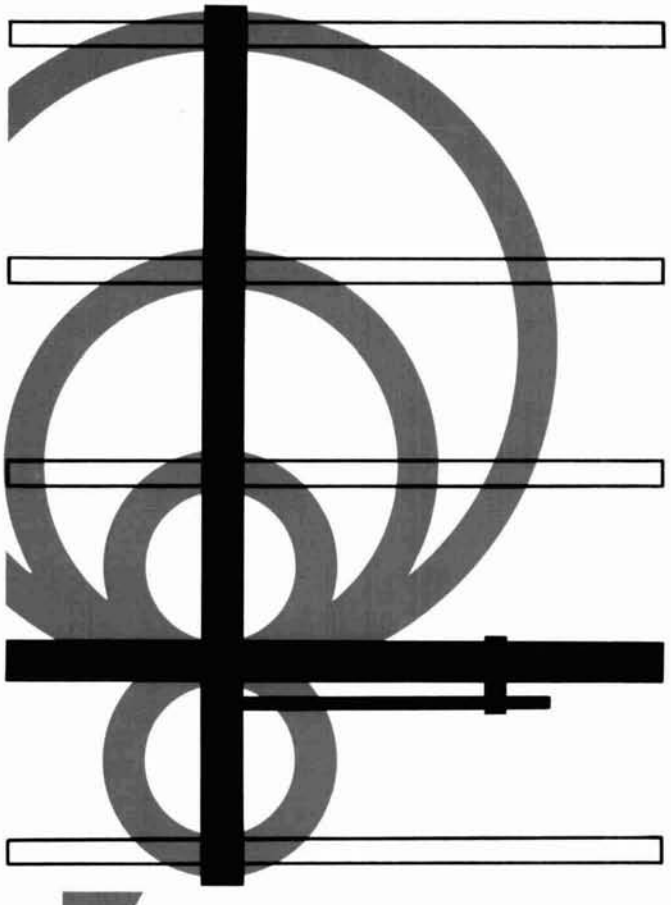
one dollar

ham radio

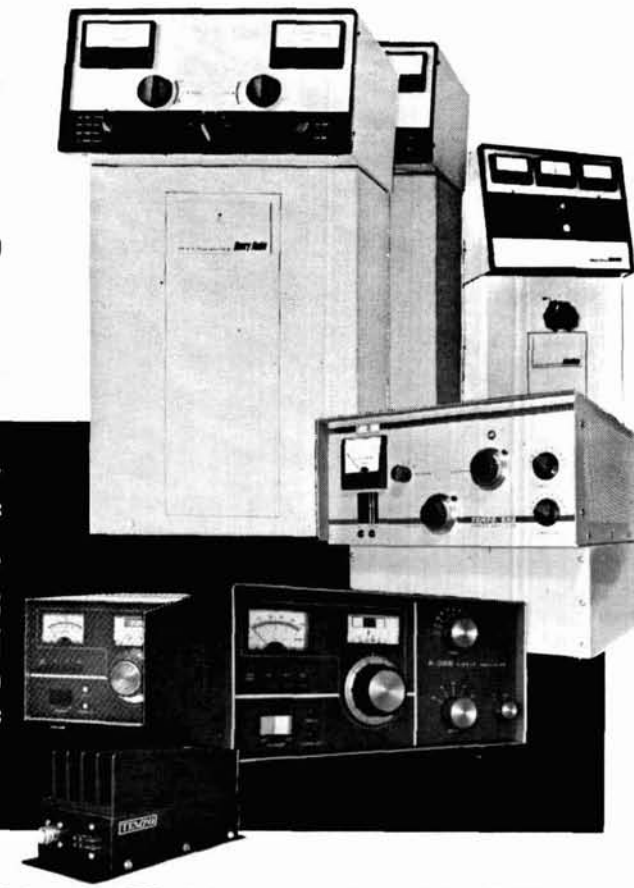
magazine

MAY 1976



7th annual ANTENNA issue

Henry Radio has the amplifier you want



Never before has one company manufactured such a broad line of amateur amplifiers, both vacuum tube and solid state, for HF, VHF and UHF; fixed station and mobile; low power and high power. Take your pick from 20 models...the world's finest line of amateur amplifiers.

2K-4. . .
THE "WORKHORSE"
The 2K-4 linear amplifier offers engineering, construction and features second to none, and at a price that makes it the best amplifier value ever offered to the amateur. Constructed with a ruggedness guaranteed to provide a long life of reliable service, its heavy duty components allow it to loaf along even at full legal power. If you want to put that strong clear signal on the air that you've probably heard from other 2K users, now is the time. Move up to the 2K-4. Floor console or desk model ..$995.00

3K-A COMMERCIAL/MILITARY AMPLIFIER
A high quality linear amplifier designed for commercial and military uses. The 3K-A employs two rugged Eimac 3-500Z grounded grid triodes for superior linearity and provides a conservative three kilowatts PEP input on SSB with efficiencies in the range of 60%. This results in PEP output in excess of 2000 watts. In addition, the 3K-A provides a heavy duty power supply capable of furnishing 2000 watts of continous duty input for either RTTY or CW with 1200 watts output. Price...$1250.00

4K-ULTRA
The 4K-ULTRA is specifically designed for the most demanding commercial and military operation for SSB, CW, FSK or AM. The amplifier features general coverage operation from 3.0 to 30 MHz. Using the magnificent new Eimac 8877 grounded grid triodes, vacuum tune and load condensers, and a vacuum antenna relay, the 4K-ULTRA represents the last word in rugged, reliable, linear high power RF amplification. 100 watts drive delivers 4000 watts PEP input. This amplifier can be supplied modified for operation on frequencies up to about 100MHz. Price...$2950.00

TEMPO 6N2
The Tempo 6N2 brings the same high standards of performance and reliability to the 6 meter and 2 meter bands. Using a pair of advanced design Eimac 8874 tubes, it provides 2,000 watts PEP input on SSB or 1,000 watts input on FM or CW. The 6N2 is complete in one compact cabinet with a self-contained solid state power supply, built-in blower and RF relative power indicator. Price...$795

TEMPO 2002
The same fine specs and festures as the 6N2, but for 2 meter operation only. ...$695.00

TEMPO 2006
Like the 2002, but for 6 meter operation. ..$695.00

TEMPO T-2000 LINEAR AMPLIFIER
The brand new T-2000 linear is the perfect companion for the Tempo ONE. It is compact, reliable, and priced right. Uses two Eimac 8873 grounded grid triodes cooled through a large heat sink. The T-2000 offers a full 2 KW PEP input for SSB operation and provides amateur band coverage from 80–10 meters. Provides a built-in solid state power supply, built-in antenna relay, a relative RF power indicator, and built-in quality to match much more expensive amplifiers. $795.00

K-2000 LINEAR AMPLIFIER
The new K-2000 is the perfect companion for Kenwood's TS-520...matched for style and circuitry. The same specifications as the T-2000...$795.00

TEMPO VHF/UHF AMPLIFIERS
Solid state power amplifiers for use in most land mobile applications. Increases the range, clarity, reliability and speed of two-way communicatios. FCC type accepted also.

TEMPO 100AL10 VHF LINEAR AMPLIFIER
Completely solid state, 144-148 MHz. Power output of 100 watts (nom.) with only 10 watts (nom.) in. Reliable and compact.

please call or write for complete information.

Henry Radio

11240 W. Olympic Blvd., Los Angeles, Calif. 90064 213/477-6701
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Butler, Missouri 64730 816/679-3127

Prices subject to change without notice.

The Drake MN-2000 Antenna Matching Network

A study in operator convenience

(or—how not to hang upside down behind your operating desk in order to disconnect your tuner from the line.)

FRONT PANEL SELECTION of key operating functions. No need to manually connect and disconnect the unit from the line for bypass applications.

FRONT PANEL SELECTION of up to three different antennas, or two antennas and a dummy load. The two may be selected in the matched or bypassed mode in each circuit with the flip of a switch.

FRONT PANEL SELECTION of forward or reflected rf power with a built-in precision wattmeter — not just a relative indicator.

This coax to coax 2kW tuner will tame VSWR up to 5:1 at any phase angle. If your 75 meter antenna is flat on ssb, but has high VSWR on cw, this could be just the answer.

Excellent for beams that exhibit a high VSWR on the opposite end of the band from where you set the elements.

The MN-2000 provides an additional 25 to 35 dB second harmonic attenuation which can help reduce TVI.

Covers 80-10 meter ham bands. Considering the built-in coax antenna switch, by-pass switch and rf wattmeter/VSWR bridge, the MN-2000 is a real value at $220.00.

The Drake MN-4
does basically the same thing as the MN-2000 but is rated at 300 watts.

For details on these and other fine Drake Radio Communications Equipment, please contact:

R. L. DRAKE COMPANY

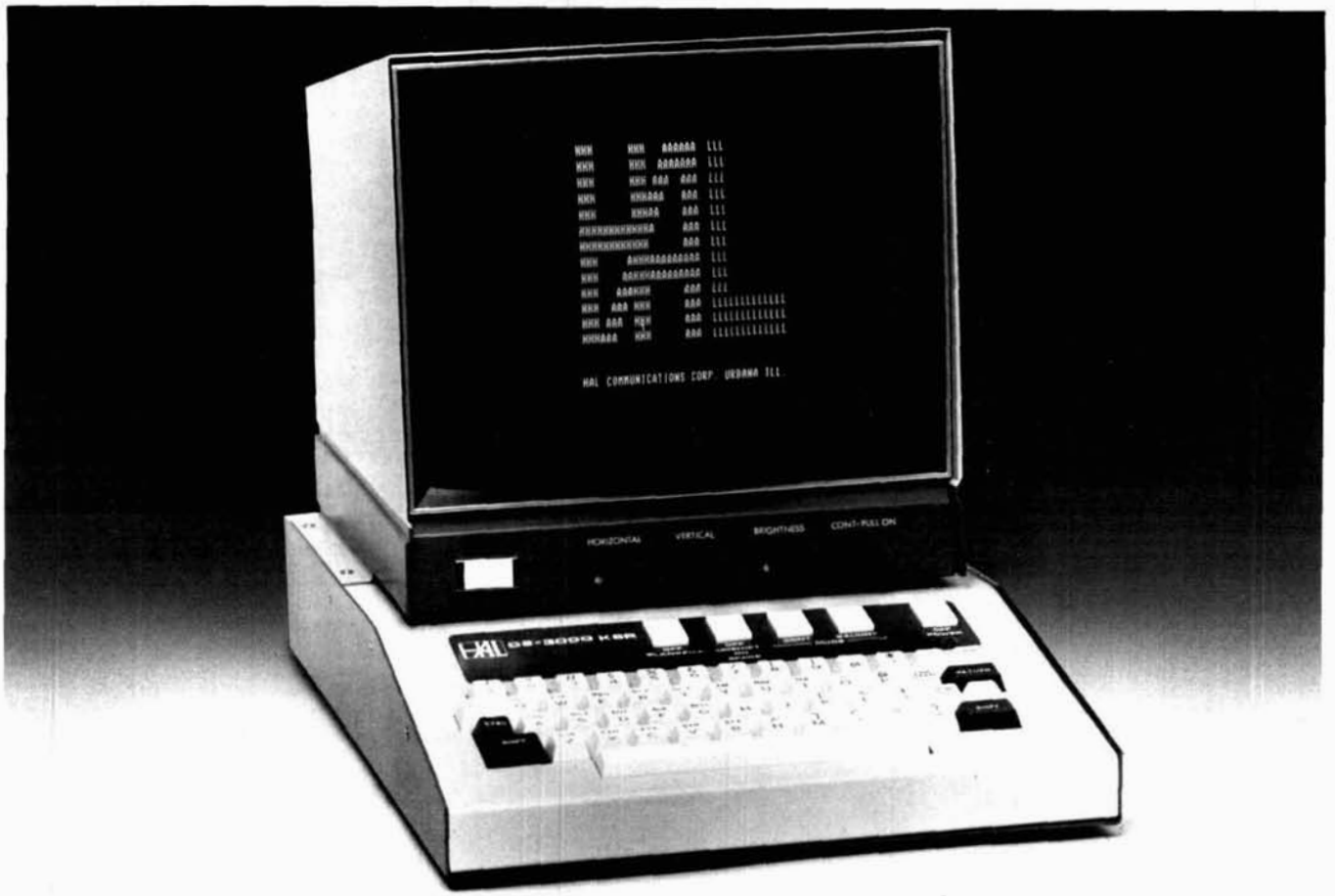
DRAKE®

540 Richard St., Miamisburg, Ohio 45342
Phone: (513) 866-2421 • Telex: 288-017

See us at ARRL National in Denver

More Details? CHECK–OFF Page 118

Stay tuned for future programs.



The HAL ST-6000 demodulator /keyer and the DS-3000 and DS-4000 KSR/RO series of communications terminals are designed to give you superlative TTY performance today —and in the future. DS series terminals, for example, are re-programmable, assuring you freedom from obsolescence. Sophisticated systems all, these HAL products are attractively priced—for industry, government and serious amateur radio operators.

The HAL ST-6000 operates at standard shifts of 850, 425, and 170 Hz. The tone keyer is crystal-controlled. Loop supply is internal. Active filters allow flexibility in establishing different tone pairs. You can select AM or hard-limiting FM modes of operation to accommodate different operating conditions. An internal monitor scope (shown on model above) allows fast, accurate tuning. The ST-6000 has an outstandingly high dynamic range of operation. Data I/O can be RS-232C, MIL-188C or current loop.

The DS-3000 and DS-4000 series of KSR and RO terminals provide silent, reliable, all-electronic TTY transmission and reception, or read-only (RO) operation of different combinations of codes, including Baudot, ASCII and Morse. The powerful, programmable 8080A microprocessor is included in the circuitry to assure maximum flexibility for your present needs —and for the future. The KSR models offer you full editing capability. The video display is a convenient 16-line format, of 72 characters per line.

These are some of the highlights. The full range of features and specifications for the ST-6000 and the DS series of KSR and RO terminals is covered in comprehensive data sheets available on request. Write for them now—and tune in to the most sophisticated TTY operation you can have today... or in the future.

HAL Communications Corp., Box 365, 807 E. Green Street
Urbana, Illinois 61801 • Telephone: (217) 367-7373

More Details? CHECK–OFF Page 118

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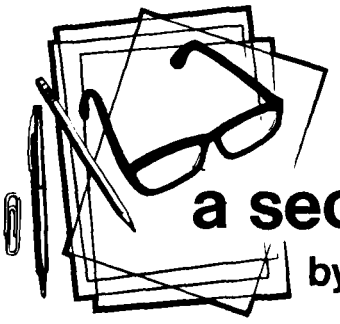


a second look

by Jim Fisk

Although many amateurs still look on the citizens band with a certain amount of scorn, attitudes are changing, and I think it's time that we all took a second look at the CB service and what its tremendous growth in recent months means to amateur radio. There's little doubt that many of the early CB operators were frustrated amateurs, unable (or unwilling) to spend the time and effort to pass the amateur exam. The CB ticket provided a painless way to get on the air, to play with radio, to work skip DX, to exchange QSL cards—radio was as much a hobby to them as it is to amateurs, and perhaps it was the CBer's free ride that was so irritating. That, and the fact that they were operating on frequencies which had been expropriated from the amateur service.

This all began to change in early 1974 when the truckers started using citizens band in their much publicized revolt against the 55-mph speed limit. The truckers soon discovered that citizens band offered them a chance to keep track of their pals, to avoid road hazards and traffic snarls, and to relieve the boredom of long hours in the cab of an 18-wheeler. The idea caught on quickly, and it wasn't too long before many travelers started installing CB sets in their cars before they started on a long trip.

The CB service, which had taken sixteen years to grow to a million licensees, quickly doubled, then tripled, as license applications poured into the FCC offices at the rate of 500,000 per month. The new CBer, now the vast majority, wasn't interested in radio as a hobby, but as a medium of communications. The old CBer, crowded out of the band by six-million new users, is still interested in radio as a hobby, and there is growing evidence that many are turning to amateur radio as an outlet. This is a huge potential resource for amateur radio, one that can no longer be ignored.

While many CB operators have been expecting some relief in the form of more channels in the 27-MHz band, the FCC recently announced that CB expansion will be delayed until new technical specifications for CB equipment can be developed. This means that there will be no expansion of the class-D service (or inauguration of the proposed class-E service) until at least early 1977. License applications are still pouring into the FCC at an unprecedented rate, so band crowding is going to get much worse than it is now. There's little doubt that there will *eventually* have to be some sort of relief in the form of expanded CB bands, but that may be more than a year away. This action promises to hasten the immigration of CB hobbyists into the amateur ranks.

As most amateurs know, our bands will come under close scrutiny at the World Administrative Radio Conference (WARC) in Geneva, in 1979. The size of the amateur service has remained practically static for the past ten years or so, and insiders who should know have repeatedly stressed the need for substantial growth between now and 1979. Without growth we're liable to be facing the complete demise of amateur radio as we now know it. The citizens band is a readily available source for that needed growth. The displaced CB hobbyists have already displayed an interest in radio communications and a willingness to equip their stations with top-quality equipment; it's our job to sell them on the idea of becoming radio amateurs. With the present crowded conditions on the CB channels, it shouldn't take much more than a nudge. And when a CBer expresses interest in amateur radio, don't turn your back on him -- he and his friends may hold the key to the whole future of amateur radio.

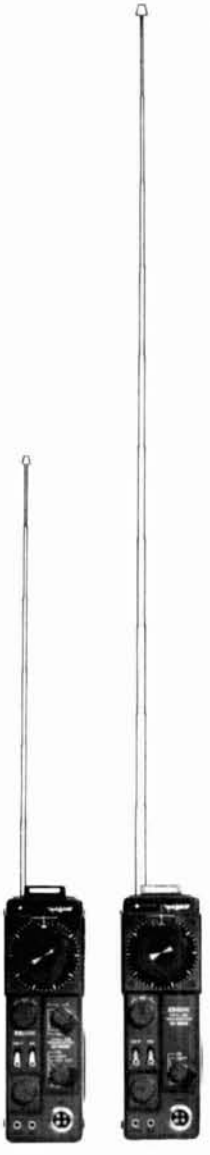
Jim Fisk, W1DTY
editor-in-chief

Hold it!

Take hold of SSB with these two low cost twins. ICOM'S new portable **IC-202** and **IC-502** put it within your reach wherever you are. You can take it with you to the hill top, the highways, or the beach. Three portable watts PEP on two meters or six!

Hello, DX! The ICOM quality and excellent receiver characteristics of this pair make bulky converters and low band rigs unnecessary for getting started in SSB-VHF. You just add your linear amp, if you wish, connect to the antenna, and DX! With the **202** you may talk through OSCAR VI and VII! Even transceive with an "up" receiving converter! The **IC-502,** similarly, makes use of six meters in ways that you would have always liked but could never have before. In fact, there are so many things to try, it's like opening a new band.

Take hold of Single Side Band. Take hold of some excitement. Take two.



IC-202
2 Meter SSB • 3 Watts PEP • True IF Noise Blanker
Switched Dial Lights • Internal Batteries • 200KHz
VXO Tuning • 144.0, 144.2 + 2 More! • RIT!

IC-502
6 Meter SSB • 3 Watts PEP • True IF Noise Blanker
Switched Dial Lights • Internal Batteries • 800KHz
VFO • RIT!

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More Details? CHECK–OFF Page 118

presstop

SIGNIFICANT CONFLICTS FOR FREQUENCIES appear in the FCC's first tabulation of the various services WARC Working Group proposals. In a 128-page Public Notice Number 62477 released on March 22, the commission carefully pointed out that at this point no attempt had been made to reconcile conflicts nor were comments on the compilation being sought from the public.

Other Than A 5 kHz Slice off the bottom of the present 160 band, the only challenge to present Amateur Radio allocations below two meters was the Broadcast Service's bid for 3.9-4 MHz. However, all of the proposed new bands and extensions of the present bands are frequencies that other services are also after.

Two Meters Presents a more serious problem, with Aeronautical Mobile looking to pick up 146-148 MHz — a change that would make Region II conform with the two meter allocation in the rest of the world! 220 MHz is being chased by the General Radio Service (CB), but 420-450 MHz was not challenged.

Still Higher In The Spectrum we have several competitors for the 900 MHz segment the Amateur Radio Working Group had proposed, while several of the proposed or present microwave Amateur allocations may also have to be fought for. In view of the rapid upward move of technology, these may become far more important to us in the next decade or so than will be apparent in 1979.

CB EXPANSION DELAYED UNTIL at least early 1977. In a surprise move on March 19th the Commissioners agreed to postpone action on both Class-D (27 MHz) expansion, Docket 20120, and the proposed Class-E (220 MHz) service, Docket 19759, until new technical specifications for CB equipment can be developed. These technical specs will be the subject of a new Notice of Proposed Rule Making which will propose tight limits on both receiver incidental radiation and transmitter spurious and harmonic outputs. The Commissioners set the end of this year as the deadline for action on this as yet unwritten NPRM, and said that until it is acted on no further action will be taken on either CB expansion docket. At the same time they also said they plan to include the recently announced study to be conducted by FCC's Office of Plans and Policy on the "Long Term Needs of the General Public for Personal Radio Communications" in their future deliberations on possible CB expansion.

The Delay Certainly came as a shock to the CB industry, whose insiders had predicted the Class-D expansion to 40 or 50 channels would be announced at the FCC Forum at PC '76 in late March.

"POINT OF MAIL" CB LICENSING was also approved by the FCC and is supposed to have been implemented by late April. Under the new plan the buyer of a CB radio will receive a license application form from either the dealer or packed with the radio. He fills out the form, which he then takes to his Post Office where it will be receipted and mailed for a nominal charge. He can then go on the air immediately with his self-generated call using the Post Office receipt as his Special Temporary Authority to operate.

WRITTEN CW REQUIREMENT for Amateur Radio license examination has been dropped from Part 97 of the Rules in an FCC order released March 12th. The change, which deletes need for "at least 1 minute" of error-free copy became effective March 24, and opens the way for substitution of questions on content as an alternative method of determining CW competence. It won't really change things for most Amateurs for some time to come, however — a few selected FCC Offices will probably start administering "no write" exams on an experimental basis almost immediately, but the rest will continue giving exams with a written code test until a final procedure worked around the new approach can be developed.

RFI ELIMINATION EFFORT IN CONGRESS has received a valuable boost with Senator Barry Goldwater's introduction of his Senate version of Representative Vanik's bill (HR7052). Goldwater's Senate bill, S3033, deserves our strongest support — write your Senators today asking them to help push it and send a copy of your letter to K7UGA at the Senate Office Building.

AMATEUR FAST-SCAN TV REPEATERS will be permitted to operate in the 420-450 MHz Amateur band under a waiver authorized by the Chief of the FCC's Safety and Special Services Bureau. The waiver suspends Section 97.61 (c) of the Commission's Rules, which limits repeaters to 442-450 MHz, for a period of one year — to February 27, 1977 — to permit any licensed Amateur repeater station to conduct fast-scan TV experimentation on the band without having to request prior FCC approval.

HIRAN HAS BEEN APPROVED for operation in the entire 420-450 MHz Amateur band in a Report and Order that became effective April 22. HIRAN, the high accuracy radio location system that was developed for the off-shore oil drilling industry, will use the 70-cm band on a secondary, non-interfering basis to the Amateur service. We also share the band with government Direction Finders.

Dentron Amplifies America

We took the most desirable and important features and engineered them into the all new Dentron **Continuous Duty** 160-10 meter amplifier.

160-10L Specifications

Size: 7¼"Hx14½"Wx14"D
Weight: 43 lbs.
Frequency Range: 1.8 MHz (1.8-2.5) 3.5 MHz (3.4-4.6)
7 MHz (6.0-9.0) 14 MHz (11.0-16.0)
21 MHz (16.0-22.0) 28 MHz (28.0-30.0)
Power Input: SSB 1200 P.E.P. Continuous
CW 1000 watt DC Continuous
SSTV 1000 watt DC input 25 minute continuous
RTTY 1000 watt DC input 25 minute continuous
TUNE 1000 watt DC input 15 minute continuous
Output impedance: 50-75 ohms Pi network wide range
VSWR not to exceed 2 to 1
Third-order Distortion: Down at least 30 db

Meter Selector Switch-plate, voltage, Plate Current
Built-in Antenna change over relay
Dual-speed Cooling System
AC Input Source 110V or 220V AC, 50-60 Hz
Automatic Circuit Breaker Protection

160-10L Features

- **160 thru 10 meters**
- **1200 watts P.E.P. on SSB continuous**
- **1000 watts DC on CW, RTTY or SSTV**
- **"On demand" Variable forced air cooling system**
- **Self contained continuous duty power supply**
- **4-811A Triodes in Grounded Grid mounted in cooling chamber**
- **Compact, low profile, solid, one-piece cabinet, tube cooling chamber eliminates need for perforated cabinet.**
- **Covers MARS Frequencies without modifications**
- **Broadbanded input and output circuit**
- **70 watt drive for maximum legal input**

DenTron Radio Co., Inc.
2100 Enterprise Parkway
Twinsburg, Ohio 44087
(216)425-3173

Another surprise from Dentron, but the biggest surprise of all is the price.
Just $499.50 Post paid USA from Dentron Radio Co., Inc.
Also available from your favorite dealer.

All Dentron products are made in U.S.A.

More Details? CHECK—OFF Page 118

KENWOOD'S TS-520

...worth waiting for!

Why wait any longer for a rig that offers top performance, dependability and versatility . . . the TS-520 has proven itself in the shacks of thousands of discriminating amateurs, in field day sites, in DX and contest stations, and in countless mobile installations.

Superb craftsmanship is evident throughout . . . in its engineering concepts as well as its construction and styling . . . craftsmanship that is a Kenwood hallmark.

Maybe the Kenwood TS-520 is the one you have been waiting for.

Kenwood offers accessories guaranteed to add to the pleasure of owning the TS-520. The TV-502 transverter puts you on 2-meters the easy way. (It's completely compatible with the TS-520.) Simply plug it in and you're on the air. Two more units designed to match the TS-520 are the VFO-520 external VFO and the model SP-520 external speaker. All with Kenwood quality built in.

Specifications TS-520

MODES: USB, LSB, CW
POWER: 200 watts PEP input on SSB, 160 watts DC input on CW
ANTENNA IMPEDANCE: 50-75 Ohms, unbalanced
CARRIER SUPPRESSION: Better than -45 dB
UNWANTED SIDEBAND SUPPRESSION: Better than -40 dB
HARMONIC RADIATION: Better than -40 dB
AF RESPONSE: 400 to 2600 Hz (-6 dB)
AUDIO INPUT SENSITIVITY: 0.25μV for 10 dB (S+N)/N
SELECTIVITY: SSB 2.4 kHz (-6 dB), 4.4 kHz (-60 dB); CW 0.5 kHz (-6 dB), 1.5 kHz (-60 dB) (with accessory filter)
FREQUENCY STABILITY: 100 Hz per 30 minutes after warmup
IMAGE RATIO: Better than 50 dB
IF REJECTION: Better than 50 dB
TUBE & SEMICONDUCTOR COMPLEMENT: 3 tubes (2 x 6146B, 12BY7A), 1 IC, 18 FET, 44 transistors, 84 diodes
DIMENSIONS: 13.1" W x 5.9" H x 13.2" D
WEIGHT: 35.2 lbs.
SUGGESTED PRICE: $629.00

VFO-520

Provides high stability with precision gearing. Function switch provides any combination with the TS-520. Both are equipped with VFO indicators showing at a glance which VFO is being used. Connects with a single cable and obtains its power from the TS-520. Suggested price: $115.00.

SP-520

Although the TS-520 has a built in speaker, the addition of the SP-520 provides improved tonal quality. A perfect match in both design and performance. Suggested price: $22.95.

TV-502

TRANSMITTING/RECEIVING FREQUENCY: 144-145.7 MHz, 145.0-146.0 MHz (option)
INPUT/OUTPUT IF FREQUENCY: 28.0-29.7 MHz
TYPE OF EMISSION: SSB (A3J), CW (A1)
RATED OUTPUT: 8W (AC operation)
ANTENNA INPUT/OUTPUT IMPEDANCE: 50Ω
UNWANTED RADIATION: Less than -60 dB
RECEIVING SENSITIVITY: More than 1μV at S/N 10 dB
IMAGE RATIO: More than 60 dB
IF REJECTION: More than 60 dB
FREQUENCY STABILITY: Less than ±2.5 kHz during 1-60 min after power switch is ON and within 150 Hz (per 30 min) thereafter.
POWER CONSUMPTION: AC 220/120V, Transmission 50W max., Reception 12W max. DC 13.8V, Transmission 2A max., Reception 0.4A max.
POWER REQUIREMENT: AC 220/120V, DC 12-16V (standard voltage 13.8V)
SEMI CONDUCTOR: FET 5, Transistor 15, Diode 10.
DIMENSIONS: 6⅝" W x 6" H x 13¼" D
WEIGHT: 11.5 lbs.
SUGGESTED PRICE: $249.00

CW-520
500 Hz CW Crystal Filter: $45.00.

Prices subject to change without notice

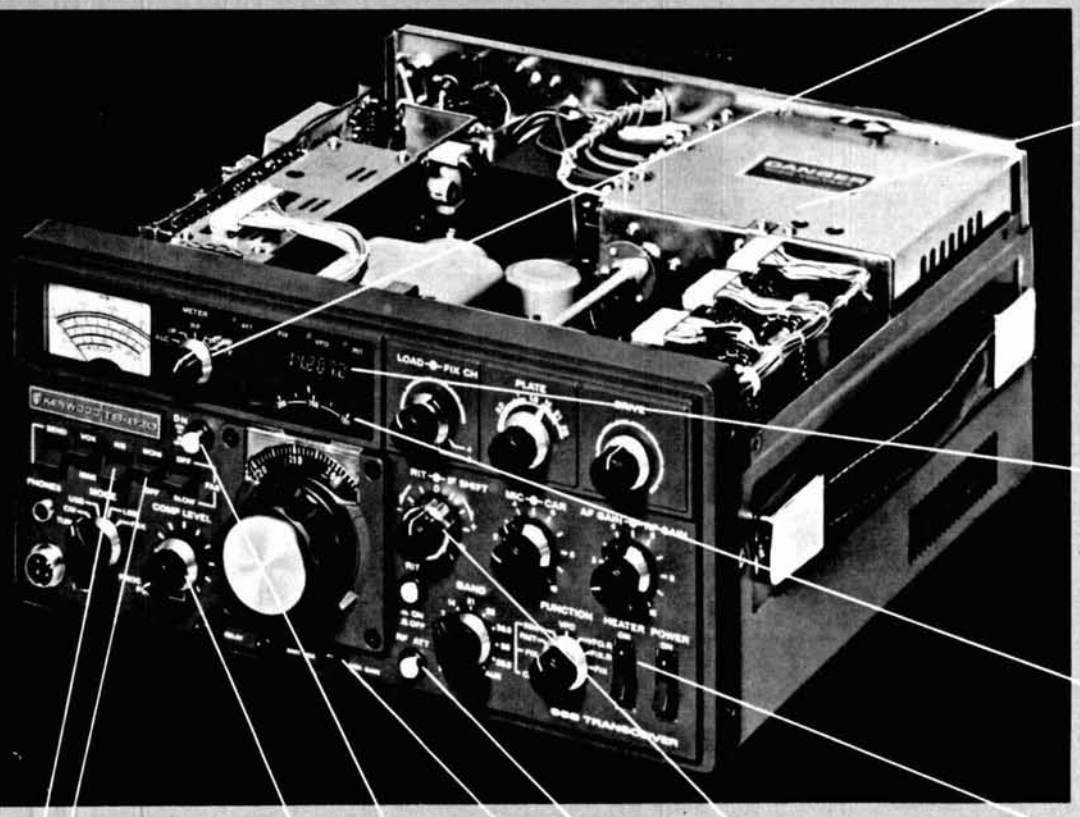
KENWOOD'S TS-820

the Pacesetter

LIMITED QUANTITIES AVAILABLE IN JULY

Kenwood's well deserved reputation for fine craftsmanship and superb performance has never been more evident than in the TS-820. As a result of a host of innovative features being brought together, the 820 offers a degree of versatility, performance and pleasure second to none.

The Kenwood TS-820 is destined to be the world's new standard of excellence in amateur radio for years to come . . . a true "Pacesetter".



Features

PLL • The TS-820 employs the latest phase lock loop circuitry. The single conversion receiver section performance offers superb protection against unwanted cross-modulation. And now, PLL allows the frequency to remain the same when switching sidebands (USB, LSB, CW) and eliminates having to recalibrate each time.

FULL METERING • During receive, an easy to read meter functions as an S-meter. The same meter displays ALC level, plate current, RF output, and plate voltage during transmit. Includes COMP setting for adjusting the compression level of the built-in speech processor.

FINAL AMPLIFIER • The TS-820 is completely solid state except for the driver (12BY7A) and the final tubes. Rather than substitute TV sweep tubes as final amplifier tubes in a state of the art amateur transceiver, Kenwood has employed two husky S-2001A (equivalent to 6146B) tubes. These rugged, time-proven tubes are known for their long life and superb linearity. The input power of the TS-820 is conservatively rated at 160 W DC, 200 W PEP. Tubes run cool with the aid of a noiseless fan (standard) mounted on the rear panel. The above tube and power combination minimizes the possibilities of TVI and helps to maintain the Kenwood reputation for excellent audio quality.

DIGITAL READOUT DG-1 • (optional) A digital counter display can be employed as an integral part of the VFO readout system. Counter mixes the carrier, VFO, and first heterodyne frequencies to give *exact* frequency. Figures the frequency down to 10 Hz and digital display reads out to 100 Hz. Both receive and transmit frequencies are displayed in easy to read, Kenwood Blue digits.

DRS DIAL • Includes the same satin-smooth planetary drive found on other fine Kenwood models plus special, high-precision gears to add a new "monoscale" feature for easier frequency readout. LSB, USB, and CW operating frequencies can be accurately read from the same pointer.

HEATER SWITCH • The filaments of the three vacuum tubes may be turned off during periods of "receive only".

CW AUDIO CHARACTERISTICS • During CW reception, a special filter is used to alter the audio frequency response to provide a more comfortable, easy to copy tone.

Other features include:
- Built-in 25 kHz calibrator*
- Built-in speaker*
- CW Sidetone and semi-break in*
- Rear panel terminals for linear amplifier, IF OUT, RTTY, and XVTR.
- Handy phone patch IN and OUT terminals*

*Also available, the VFO-820 . . . the perfect companion to the TS-820.

NOISE BLANKER • The TS-820 uses an efficient noise blanker circuit, another Kenwood exclusive. A special crystal filter assures unsurpassed efficiency in eliminating unwanted pulse noises.

RF MONITOR • Built-in monitor circuit allows you to hear your own voice by sampling the RF signal. Especially useful for adjusting the RF Processor.

HIGH STABILITY VFO • The VFO, heart of any SSB transceiver, is an exclusive Kenwood design using FET technology.

DIGITAL HOLD • A single pushbutton switch offers the operator unprecedented versatility. The digital hold circuit will lock the counter and display at any frequency, but will allow the VFO to tune normally. Ever wanted to return to a certain spot on the band and forgotten the frequency? That won't happen again with the new digital hold feature on the Kenwood TS-820.

SPEECH PROCESSOR • An HF circuit provides quick time constant compression using a true RF compressor as opposed to an IF clipper. Amount of compression is adjustable to the desired level by a convenient front panel control.

IF SHIFT • The IF SHIFT control varies the IF passband without changing the receive frequency. Enables the operator to eliminate unwanted signals by moving them out of the passband of the receiver. This feature alone makes the TS-820 the pacesetter that it is.

RF ATTENUATOR • Easy, one touch activation of the attenuator supplies 20 dB of padding on receive.

VOX • A voice-activated microphone circuit is built into the TS-820 with VOX GAIN, ANTIVOX, and VOX DELAY controls placed on the front panel for convenient adjustment any time.

TRIO-KENWOOD COMMUNICATIONS INC.
116 EAST ALONDRA/GARDENA, CA 90248

KENWOOD
. . . pacesetter in amateur radio

PIN diode transmit/receive switch for 80-10 meters

Need a fast, dependable break-in system? This design handles up to 100 watts output with keying speeds as high as desired

Popular break-in methods include the vacuum-relay and saturated-amplifier systems. The vacuum relay, actuated by a keyer circuit, switches the antenna between receiver and transmitter in accordance with keying commands. This system is effective but is limited to keying speeds of 55-60 wpm. The saturated-amplifier system consists of an rf amplifier loosely coupled to the antenna. The amplifier has enough gain to overcome the loss caused by loose coupling to the antenna. When the transmitter is keyed rf saturates the amplifier, decreasing its gain, which provides receiver-transmitter isolation from the antenna during key-down conditions. This system has a number of shortcomings, which are discussed later.

A solid-state TR switch that operates at very high speeds and provides the advantages of the vacuum relay keying system would be a worthwhile addition to the station of the amateur who enjoys working DX and high-speed CW. Such a switch would also be satisfactory for phone work.

design objectives

My objective was to design a low-power, solid-state switch that would transfer the antenna between receiver and transmitter in accordance with transmitter keying commands at the highest speed desired. This TR switch would overcome saturating-amplifier TR switch limitations, which include:

1. Receiving system sensitivity degradation caused by antenna-to-receiver coupling loss.

2. Receiver desensitization caused by noise in the transmitter power amplifier stages.

3. Receiver sensitivity limitations between dots and dashes caused by TR switch saturation during key-down conditions (amplifier recovery time).

4. Sensitivity, isolation, and transmitter loading variations with frequency caused by the mismatch introduced by paralleling the TR switch with transmitter output.

5. Harmonic generation and TVI in extreme cases.

An additional objective was to obtain a TR switching system with losses and isolation approaching a vacuum-relay system but with higher speed capability.

PIN diode basics

The PIN diode is the heart of this TR switch. Its key parameters are illustrated in **figs. 1 to 3**, which show the impedance characteristics of a typical Unitrode UM4000-series device versus forward-bias current and reverse-bias voltage. With a forward dc bias current of about 35 mA, (**figs. 1** and **3**) the diode looks like a 1-ohm resistor below 500 MHz. With a reverse bias voltage of, say, 100 volts dc, (**fig. 2**) the diode looks like a 2.5 pF capacitor in parallel with a 60k resistor at 100 MHz and an even higher resistance at lower frequencies.

These characteristics mean that a single PIN diode can be made to provide 0.1 to 0.2 dB insertion loss when forward biased and about 25 to 30 dB isolation when reversed biased. A PIN diode also looks like a relatively high impedance without reverse bias and no forward direct current.

PIN diodes have sometimes been considered microwave devices, unusable at hf. However, the lowest frequency at which a PIN diode exhibits the characteristics of **figs. 1 to 3** is related to "carrier lifetime," which is usually expressed in fractions of a second. Long-carrier-lifetime diodes will exhibit these impedance/bias characteristics at lower frequencies than short-carrier-lifetime (microwave) devices, which behave like regular diodes at lower frequencies. The PIN diodes illustrated have typical carrier lifetimes of 7 microseconds, which makes them useful in this application below 1 MHz to over 3 GHz.

In a TR switch application the diode peak inverse voltage (PIV) rating limits the reverse bias that can be applied to isolate a source from a load, and the maximum junction temperature limits the amount of rf power that can be connected between source and load.

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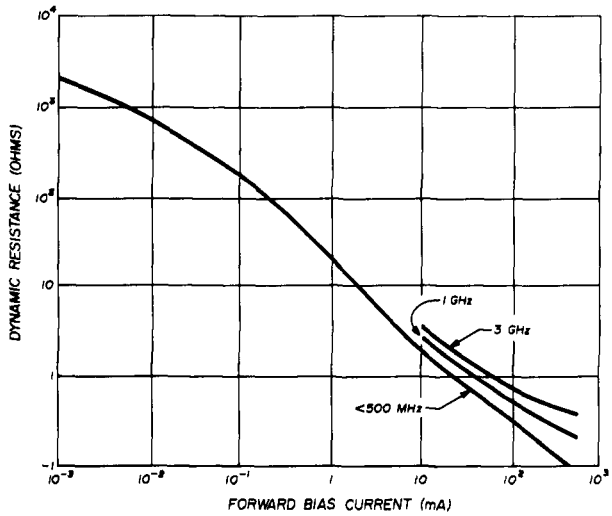

fig. 1. Typical forward resistance characteristic, UM4000-series PIN diode.

The Unitrode UM4000-series diodes have PIV ratings to 1 kV (UM4310) and maximum junction temperature ratings of 347°F (175°C).

functional description

During key down CR1 (**fig. 4**) is forward biased, connecting the transmitter to the antenna. CR2, CR4 are reverse biased and CR3 is forward biased, isolating the receiver from antenna and transmitter. For best operation CR2 reverse dc bias should be at least as large as transmitter peak rf output voltage, which prevents distortion or rectification in CR2 during key-down operation.

During key up CR1 is zero biased (or reverse biased if desired) to isolate the transmitter tank circuit and noise generated in the transmitter from the antenna and receiver, thereby preventing receiver desensitization. The receiving-system impedance match is also preserved. CR2, CR4 are forward biased and CR3 is reverse biased, thereby connecting the receiver to the antenna.

The three diodes in the receive path provide a theoretical isolation of 75 to 90 dB between receiver and antenna terminal during transmit. This isolation corresponds to about 6 mV applied to the receiver with a 50-watt output transmitter, assuming a 50-ohm system, or about 8.5 mV open-circuit voltage at 100-watts transmitter output. These key-down receive signals are well within the dynamic range of most amateur receivers. Fewer or more diodes may be used in the receive leg, depending on desired receiver isolation.

circuit description

Fig. 5 is a schematic of the TR switch, which is designed for power levels to 100 watts. Normal (nominal) dc voltages are listed on the diagram. CR1 is forward biased for about 45 mA dc in transmit and CR2 is reverse biased by 124 volts in transmit. These two conditions ensure minimum loss in CR1 and maximum isolation in CR2 during transmit.

CR3, CR4, shown as UM4004s, could probably be replaced by less-expensive 1N5767s or possibly even high-grade computer switching (high-conductance, low-capacitance) diodes. The 1N5767s, which are also PIN diodes, will give equivalent isolation whereas the computer diodes may not, because of their possible larger capacitance.

Fig. 5 is designed to operate from the collector of the Q3 keying-circuit transistor of the Touchcoder II,[1] which is shown in dotted lines. However, any source providing the T (transmit) and R (receive) voltages shown will key the circuit.

transmit operation

The voltage to R4, Q1's base resistor, is low (0.2 volt), causing Q1 to be off, which results in a high voltage at Q1's collector. This, in turn, turns on Q3, Q2, allowing CR1 to conduct about 45 mA of forward current, permitting transmitter power to flow to the antenna. In additon it causes CR3 to conduct, thereby presenting a low rf impedance (CR3 conducting in conjunction with bypass capacitor C9). The current through CR3 causes sufficient voltage drop across R2 to reverse

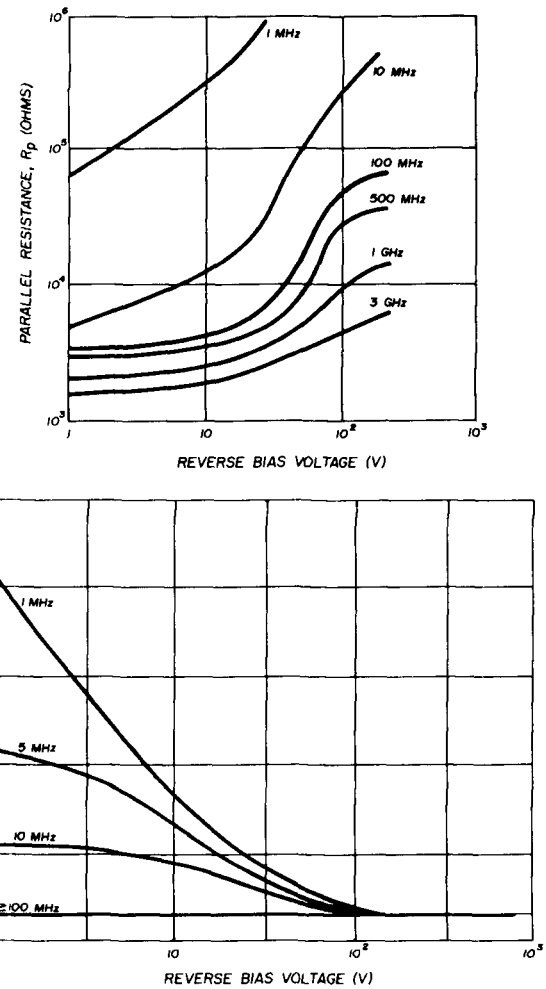

fig. 2. Typical parallel resistance characteristic, A, and capacitance characteristic, B, UM4000-series PIN diode.

bias CR4 (voltage at CR3, CR4 junction is less than the fixed bias provided by CR5, CR6). This, in turn, causes CR4 to present a high rf impedance.

receive operation

The voltage to Q1's base resistor, R4, is high (2 volts) causing Q1 to be on (saturated), which results in a low voltage at Q1's collector. This, in turn, causes Q2 to be

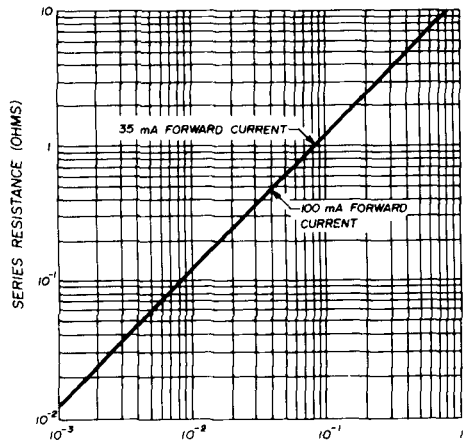

fig. 3. Insertion loss versus series resistance (one diode in series with 50-ohm load).

off, resulting in a high voltage at Q2's collector. This condition allows CR2 to conduct through R1, Q1, thereby presenting a low rf impedance.

The low voltage at Q1's collector also causes Q3 to be off, which renders CR1 essentially zero biased and CR3 reverse biased, resulting in high rf impedances in the two diodes. The absence of current in CR3 removes this component of voltage from R2, permitting current to flow through R2, CR4 and CR5, CR6. Thus CR4 looks like a low rf impedance. Diode CR7 ensures that Q3 will be off when Q1 is on.

component selection

The rf chokes must have no series resonances in the bands of interest. Standard pi-wound 2.5-mH units usually look like about 50k-100k ohms resistance in parallel with 1-2 pF between 3.5 and 28 MHz. In other words, all rf chokes must look like high impedances in the frequency range of interest otherwise they will absorb rf power and cause losses in receive and possibly burn up in transmit. It's well to measure the rf impedance of these chokes on an rf impedance meter. Also, L1, L2 should be rated for at least 50 mA for the circuit in **fig. 5.**

Capacitors C1-C9 should be good-quality, low-inductance ceramics. Note that C1 and C2 carry the transmitter rf output current. Transistor Q1 must have sufficient voltage rating to switch up to 124 volts dc. Q2 need not be a high-voltage unit (I used 2N5550s, which I had in the junk box). Q2 could be a low-voltage switching transistor (high beta and low leakage are preferred to ensure good switching characteristics).

The power supply shown in **fig. 5** has minimum acceptable filtering (the junk box was almost empty); thus additional filtering may be desired. Listen for ripple on received signals and add capacitance to suit yourself.

The TR line that switches Q1 could also be used to activate additional logic to reduce receiver rf gain if a better monitoring note is desired. However, the unit shown gives a reasonably good monitoring note with my DX-60A transmitter output level.

keying time constants

The circuit shown works well with my transmitter, which has a hard keying characteristic; however, keying time constants are mentioned briefly for completeness.

When the key is depressed the circuit will switch to transmit instantaneously, and in any reasonably shaped transmitter keying system, the circuit should be in the transmit mode before the transmitter rf output appears at J1. When the key is released, the circuit will also return to receive instantaneously, because no "deliberate" time constants are built in except for the inherent time required for Q1 collector to change from 124 to 0.8 volts dc.

A transmit-to-receive delay can be easily obtained by adding capacitance on the TR input line (line feeding

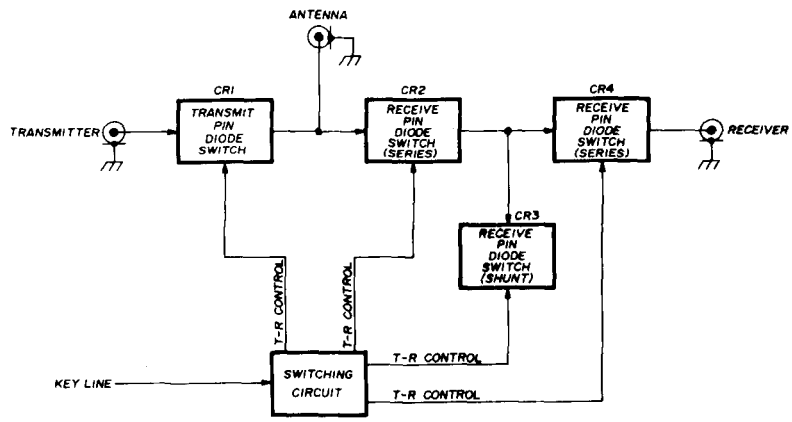

fig. 4. Simplified functional diagram.

R4). This added capacitance will have virtually no effect on receive-to-transmit transition time, because the keying transistor (shown as Q3 in **fig. 5**) will instantaneously discharge the capacitance when driven into conduction with key down. However, when the key is released the keying transistor base current will cease instantaneously,

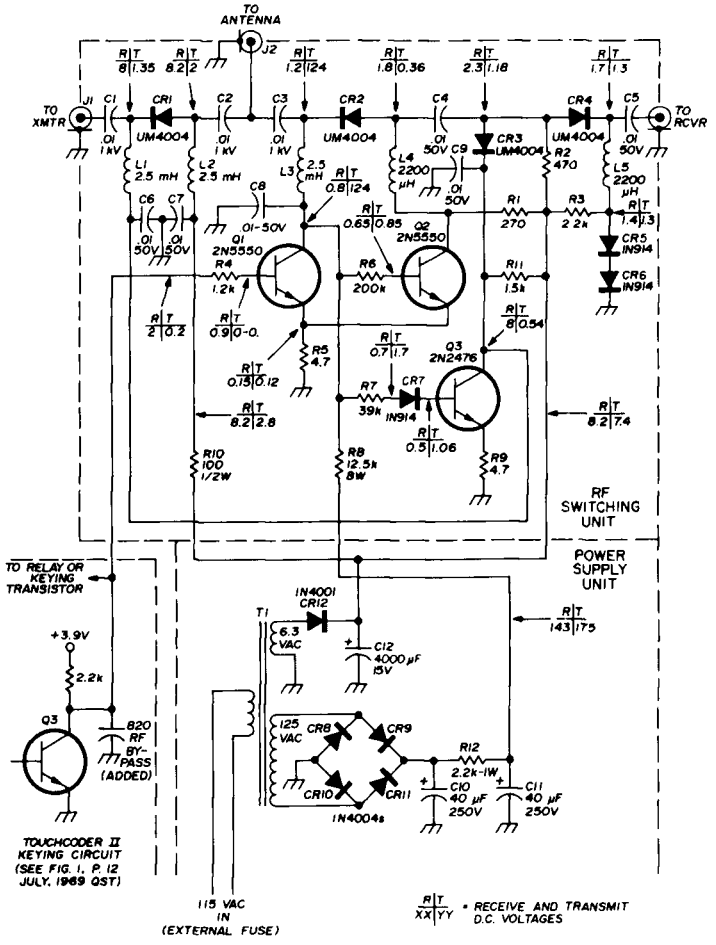

fig. 5. PIN diode TR switch schematic.

but the collector voltage rise to receive level will be delayed by the time constant of the 2.2k resistor in Q3's collector and the added capacitance on the TR switch input line.

construction

The photos show the completed 100-watt TR switch, which is mounted in a 3- by 4- by 5-inch (7.6- by 10.2- by 12.7-cm) Minibox. What looks like extra parts, compared with the schematic, are components that were paralleled to obtain desired values. For example, the power supply contains some paralleled capacitors to obtain the power-supply output capacitance, and two resistors were paralleled in two cases in the rf switching unit to obtain desired values.

A full-size drawing of the rf switching unit PC board is shown in **fig. 6**. This figure is included primarily to illustrate the general layout of CR1-CR4, L1-L5, and C1-C9. Note that these components are laid out essentially as shown in the schematic. Chokes L1-L5 should be oriented at right angles to each other to minimize mutual stray coupling (although I didn't do this). Note the ground plane strip extending the length of the board in the drawing, which provides a low-impedance grounding strap for C6-C9. The layout shown is only a guide — it was made to fit the parts on hand and can be modified to suit your preference, providing the guidelines mentioned above are followed. I used a low-cost Vector board kit as a source of board and fabrication materials.

All capacitor and PIN diode leads should be as short as possible to ensure proper rf impedance characteristics. Take care not to overheat the diodes and other semiconductors when soldering them to the board. The ARRL handbook is a good reference for PC-board construction.

final assembly

Ground lugs are placed under the rf connector retaining nuts (on the inside of the box), and are positioned and bent to permit soldering the rf switching unit PC board ground plane edge strips to them, thereby fastening the rf switching unit into the box. The rf connector center pins are then soldered directly to the pads on the rf switching unit board. These center pins can also be connected to the board by short lengths of large bus wire. AWG 18 or 16 (1.0 or 1.3mm) may be used, depending on the rf connectors chosen.

The power supply can be mounted as shown or mounted underneath the rf switching unit on the main part of the Minibox. Power and TR switching interconnections could be made through a connector and cable (cable mounted at the front of the Minibox). In this case, the rear cover would not contain the power supply but would be just a simple cover.

checkout and operation

Inspect the unit for wiring errors and solder splashes or other solder bridges between PC-board pads, and check all solder joints for quality. Apply ac power and check all voltages against the values shown in the schematic (receive and transmit). These are nominal values and may vary slightly. The important voltages are the voltage drops through CR1-CR4 rather than absolute values at each diode terminal. The cover can now be attached and the unit connected to the transmitter, receiver and antenna.

I used my Touchcoder II keying circuit to activate the TR switch. Other acceptable methods for applying transmit and receive control signals for Q1 include a) a set of contacts on a keying relay that will supply the required voltages, and b) a transistor-level converter from an existing keying circuit. In operation, the TR switch will switch the antenna between transmitter and receiver in accordance with keying commands. The receiver is connected to the antenna between dots, dashes, and words allowing full receiver sensitivity during these periods (limited only by receiver recovery time).

Keying time constants can be checked by using a dual-trace scope, with one trace monitoring transmitter rf output and the other individually monitoring voltages

at the junctions of L2, C7 and L3, C8 (and elsewhere if desired).

TR switch performance was measured on 80 through 10 meters with the following general results:

1. Loss between transmitter and antenna in transmit was about 0.2 dB.

4. Isolation between antenna and receiver in transmit was greater then 78 dB on 80 meters to 71.5 dB on 10 meters.

I have made a preliminary analysis and developed a concept for a high-power, 1-kW output solid state TR switch; however, no circuits have been built to date.

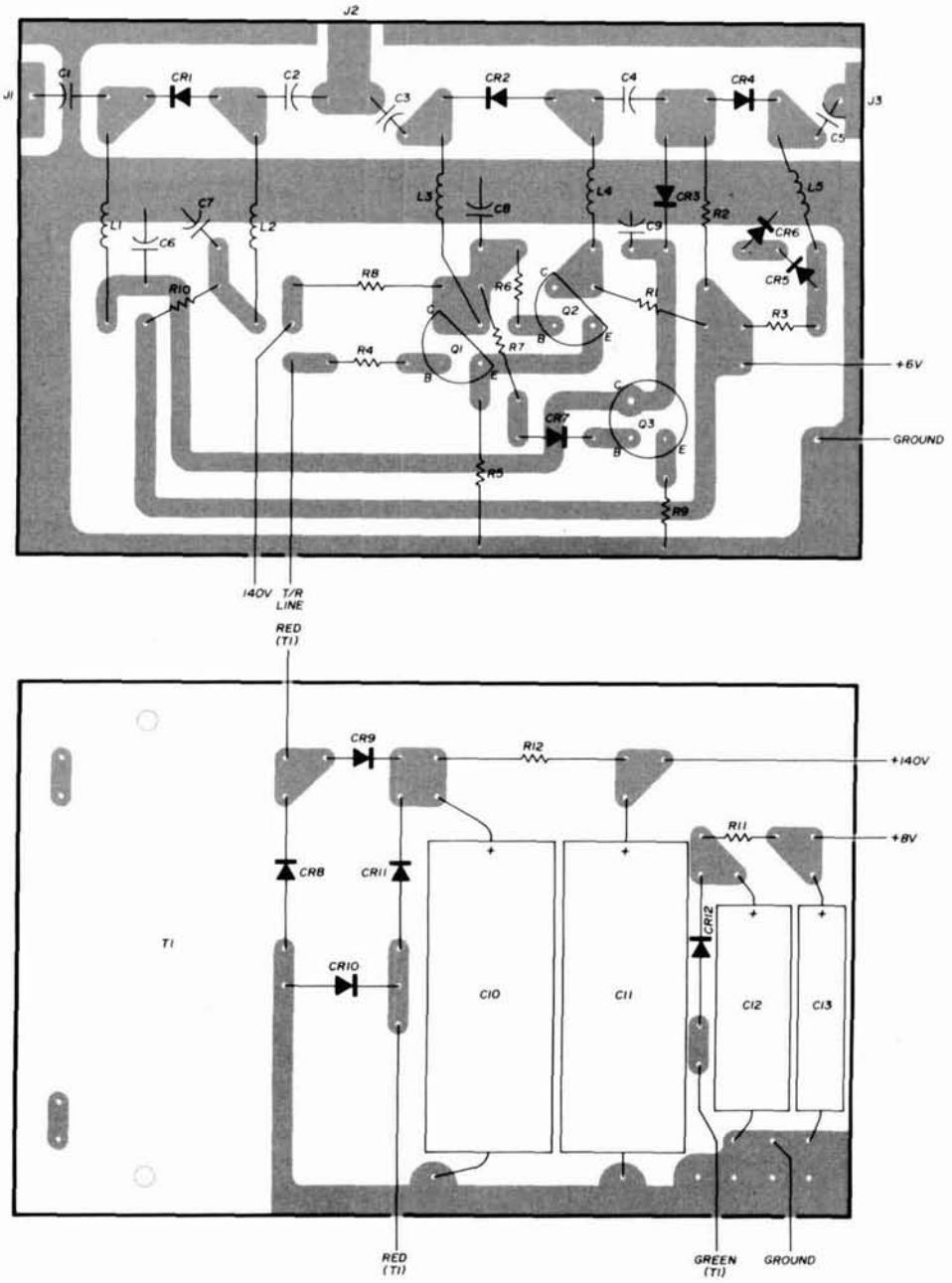

fig. 6. Suggested layout for the rf switching unit, above, and power supply, below.

2. Loss between antenna and receiver in the receive mode was 0.8 dB.

3. Isolation between transmitter and receiver in receive mode was 22 to 12.5 dB. The lower isolation occurred on 10 meters, as expected, but no transmitter noise or loading were noted on 10 meters.

Some critical components and ratings that must be considered in such a TR switch (see **fig. 5**) are the voltage and current ratings of C1, C2; voltage rating of C3; power rating of CR1; PIV rating of CR2; voltage rating of Q1; and quality and ratings of L1-L3.

For high power, it's almost imperative that a design be used that doesn't require capacitors C1 and C2, be-

cause low-reactance, high-current, high voltage capacitors are very scarce, if available at all. At 1-kW output the rms rf current is about 4.5 amperes at a 50-ohm impedance level. For a 1-kW output TR switch, C4 must be a good-quality ceramic capacitor with at least a 1-kV rating. PIN diode CR1 must be capable of passing the 4.5 amperes of rf current with the lowest possible loss.

Referring to **figs. 2** and **3**, it is seen that CR1 will look like an rf impedance of about 0.5 ohm with a forward current of 100 mA below 500 MHz, which will result in a CR1 insertion loss of about 0.04 dB in a 50-ohm system. This means that the diode will dissipate about 10 watts at 1-kW output level.

Unitrode makes a stud-mounted series of diodes (UM4000D series) that will dissipate 20 watts at room temperature, which provides adequate margin. The devices will also handle 4.5 amperes of rf (the UM4001D or UM4004D are probably good choices). The stud on these diodes is insulated from the signal leads; thus they can be directly mounted to a good heat sink to provide safe thermal performance.

As noted earlier, best performance is obtained if CR2 is reverse dc biased by an amount at least equal to the transmitter peak rf output voltage. This corresponds to about 316 volts dc in a 1-kW output, 50-ohm system. In systems with high transmission-line swr, the peak rf voltage and current at the TR switch antenna terminal can be higher or lower than its 50-ohm value, depending on swr, line length and operating frequency. For example, if a 2:1 swr exists on the transmission line, the peak rf voltage at the antenna terminal could be as high as 450 volts instead of the previously noted 317 volts. Thus CR2 should have a PIV of at least 350 volts; preferably greater than 500 volts if it is to be reverse biased up to 450 volts during transmit.

Switching transistor Q1 must have voltage ratings compatible with the reverse bias to be applied to CR2 during transmit. Rf chokes L1-L3 should exhibit a high rf impedance over the frequency range of interest (preferably greater than 100k in parallel with 1-2 pF). If these chokes exhibit a low rf impedance at any operating frequency, a high current will flow in them causing possible burnout. L1 and L2 must also have dc ratings of at least 125 mA for 1-kW operation (CR1 forward current assumed to be 100 mA).

transceiver application

This TR switch could be incorporated into transceivers, depending on their design. The design should afford protection of the receiver front end during transmit. The major consideration would be the method of B+ switching incorporated in the transceiver and the degree of commonality of transmitter and receiver circuits; i.e., the degree to which receiver amplifiers are used in transmit and vice versa.

I would like to thank C. H. Glenn for his assistance in selecting PIN diodes for this project.

reference

1. L.Bryant, W4UX, "Touchcoder II," *QST*, July, 1969, page 11.

ham radio

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tips on soldering tips

Until a better method than soldering comes along, we're stuck with soldering guns. Here's how to make a wire-bending jig that can be used to make professional-looking, soldering-gun tips that will fit Weller models 8100B, 8200N, D440, and 8100.

You'll need the following items: one new soldering-gun tip; a block of wood approximately 3.5 inches wide by 4.5 inches long by 1 inch thick (9 by 11 by 2.5cm); three 2-inch-long (5cm) finishing nails; five 1-inch-long (2.5cm) brads; and six pieces of no. 12 AWG (2mm) bare copper wire, each piece cut to just 5 inches (12.7cm) long (straight; no bends).

Step 1: Place the new tip on the center of the block with the two tip ends level of flush with the right side of the block. Trace the complete outline of the soldering-gun tip onto the block (see **fig. 1**). Set the new tip aside.

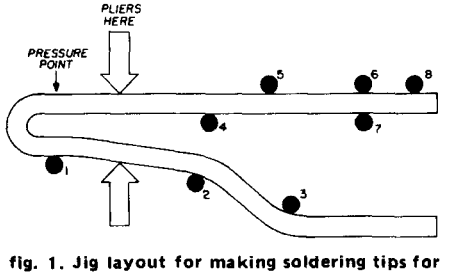


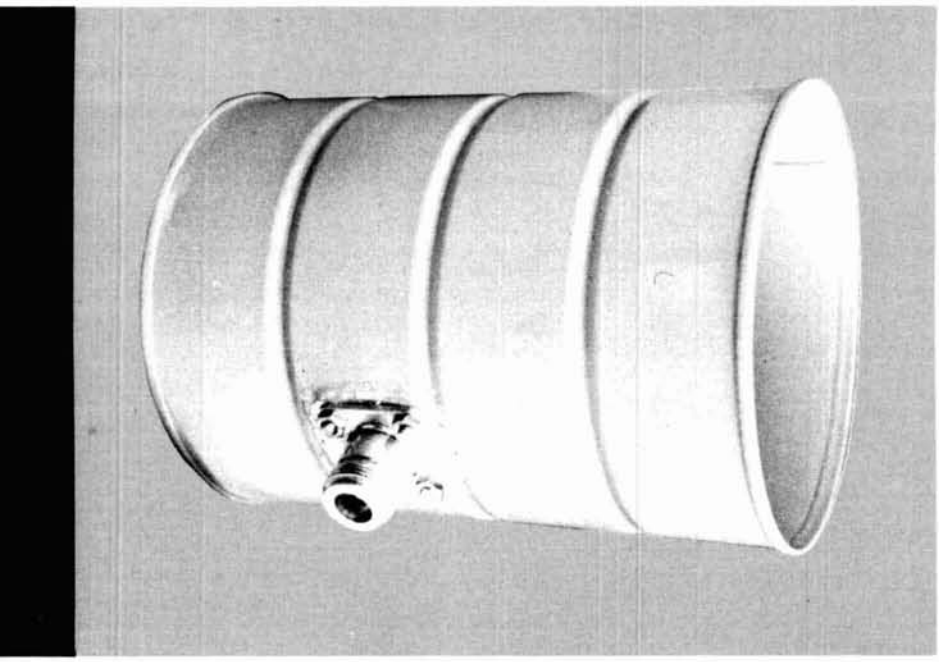
fig. 1. Jig layout for making soldering tips for Weller soldering guns.

Step 2: With a 3/32-inch (2.4mm) drill, bore three holes each 3/4 inch (20mm) deep at points 1, 2, and 3 (**fig. 1**). These holes will be for the finishing nails to provide bending points on the jig. (A nail is inserted into each hole individually each time a bend is made, then all three nails are removed when the new tip is completed.) Next, drive a brad into the block at points 4, 5, 6, 7, and 8 so that ½ inch (13mm) is straight above the block surface. These brads form a channel for the straight portion of the tip.

Step 3: Lay a piece of the copper wire into the channel with the end of the wire flush with the right side of the jig. Insert one of the finishing nails into hole 1. Hold finger at the pressure point and firmly bend the wire downward around the nail at hole 1 to form a U-shape. Use pliers to make the U tight, keeping the legs of the U parallel but not touching. Next insert the second finishing nail into hole 2 and bend the wire downward toward the bottom right corner. Insert the third finishing nail into hole 3 and bend the wire upward until parallel with the length of wire in the channel.

You now have a soldering-gun tip, however imperfect. Use the remaining wire to improve your skill.

Howard J. Stark, WA4MTH



cylindrical feed horn for parabolic reflectors

Design data with complete construction and tune-up instructions take the guesswork out of building your own feed system

This article provides a simple step-by-step procedure for the design and construction of a feed horn that will work with any parabolic reflector. The objective is to optimize the overall performance of the parabolic antenna system using readily available materials and simple test equipment.

The horn feed has for many years been considered the standard means of illuminating parabolic reflectors.[1] While the rectangular horn has been most often used, more recently circular horns have been used for amateur work.[2] This article explains why the circular horn is a good choice in terms of performance; besides, cans of appropriate sizes and shapes are readily available.

Some pitfalls await the experimenter not familiar with waveguide theory. First, there's an optimum location for the probe that excites the horn. Second, a distinct cutoff frequency is related to horn diameter below which performance rapidly deteriorates. Finally, the choice of feed-horn diameter is important in terms of the focal length/diameter (F/d) ratio of the parabola, because the feed horn radiation pattern depends on feed-horn diameter. It's important that the horn illuminate the parabola effectively.

general considerations

Sometimes relationships that appear to be relatively simple are in fact quite complex. This is certainly the case for the horn antenna. The horns discussed here are relatively short lengths of cylindrical waveguides, shorted on one end. For one thing, what goes on inside a waveguide is unreal compared with the unguided or free-space situation. To put it in Maxwellian terms, the boundary conditions are entirely different. While most amateurs have developed a fairly good mental picture of electromagnetic waves propagating in free space, guided waves are a much more complex matter.

Instead of propagating in straight lines, rf energy moves through a waveguide by bouncing off the walls in a zig-zag manner. Because of interference set up in the guide due to these multiple reflections, the phase of the wave appears to travel faster than the speed of light. As a result, the wavelength in the guide is greater than in free

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space.[3] This startling revelation simply means that the wavelength inside the guide is a stretched-out version of the free-space wavelength. The reasons for the stretchout have to do with the so-called phase and group velocities within the guide. For those who wish to pursue this matter further, an excellent and easy-to-comprehend account is given in reference 3.

probe location

If you wanted to transmit two signals of exactly the same frequency down the same waveguide, you would adjust their phase so that the signals would reinforce each other. In a horn antenna, the wave reflected off the closed end of the horn should be in phase with the direct wave traveling out the open end of the horn. The way to accomplish this is to locate the probe one quarter of a guide wavelength from the short. (Note the terminology "guide wavelength.") Under these conditions, it takes exactly one half an rf period for the reflected wave to return to the probe. In the meantime, the driving voltage at the probe has reversed its polarity, but so has the reflected wave in the reflection process. Therefore, the direct and reflected waves are in phase and will reinforce each other. Any other arrangement will provide results that are less than desirable.*

Fig. 1 shows the probe location in a 1296-MHz circular waveguide horn with respect to the horn diameter. The probe location varies with horn diameter because phase velocity depends on the diameter. The graph shows the quarter-wave spacing of the probe from the shorted end of the guide.

Unpainted feed horn made from a 1-pound (.45kg) coffee can

The equation for the guide wavelength is included on the graph of probe location for reference. The curve is based on this equation, using $\lambda_c = 3.42r$, where r is the horn radius and λ_c is the horn cutoff wavelength.

Note that in **fig. 1**, the smaller the horn diameter, the further the probe should be from the shorted end of the guide. The probe spacing increases rapidly for horn diameters less than about 6 inches (15cm) because the waveguide cutoff frequency is being approached. For

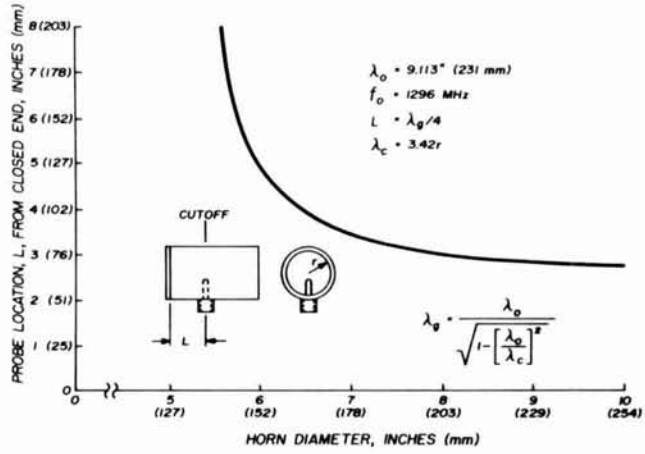


fig. 1. Probe location for a 1296-MHz circular waveguide horn with respect to horn diameter. The equation for the curve is also shown, where λ_o and f_o are respectively wavelength and operating frequency; L is probe location from the closed end in inches (mm); λ_c is horn cutoff wavelength; and r is horn radius.

1296 MHz the cutoff horn diameter is 5.37 inches (13.6cm). At cutoff, rf power does not propagate in the guide. For example, a 2-pound (0.9kg) coffee can with a diameter of 5 inches (12.7cm) will give very unsatisfactory performance at 1296 MHz.

Fig. 1 can be used for 432 MHz simply by multiplying the horn diameter and probe location numbers by 3. **Fig. 2** shows probe locations for 2304-MHz horns. The curves can be scaled for use at other frequencies by multiplying the diameter and probe locations by the ratio of the two frequencies. For example, a 6-inch-diameter (15.2cm) 1296-MHz horn scales to 3.375 inches (86mm) at 2304 MHz by multiplying the diameter by 1296/2304. Using the same multiplication factor, the probe (which is 4.9 inches [124mm] from the short on 1296 MHz) should be 2.76 inches (70mm) from the short at 2304 MHz. The overall length of the horn antenna can be any reasonable value so long as the probe is not located immediately at the open end of the horn. A good rule of thumb is to make the horn length between $2L$ and $3L$.

The radiation from an open-ended waveguide has a pattern whose beamwidth varies with the waveguide diameter. It's important to select a horn-feed diameter whose radiation pattern will illuminate the parabola

*Other conditions will provide an in-phase reflected wave; namely, when the probe is located $\frac{n}{4}\lambda$ from the short, where n is any odd integer such as 1, 3, 5 . . . etc. Only the case of $n = 1$ is considered here.

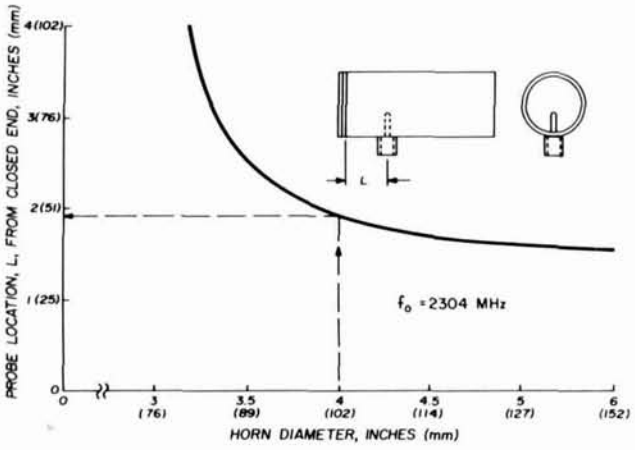


fig. 2. Probe locations for 2304-MHz horns. Curves can be scaled for use at other frequencies by multiplying horn diameter and probe locations by the ratio of the two frequencies.

most effectively. Because of the geometry involved, a parabola with a small F/d ratio should be illuminated with a feed horn of small diameter. To illustrate the relationship, a polar diagram of the radiation pattern of a typical horn is shown in **fig. 3**. The relative amount of power being radiated in any given direction is proportional to the length of the radius vector from the focus to a point on the curve.

A cross section of a typical parabola has been superimposed on the polar diagram. Note that less power is directed toward the rim of the dish than toward the center. Furthermore, some of the energy misses the dish entirely, resulting in spillover. If a feed horn having a very narrow radiation pattern is used to reduce spillover, most of the energy will be directed toward the center of the dish with the result that the outer part of the parabola is not used effectively. A condition somewhere between these two extremes represents good design. According to reference 1, overall efficiency peaks out when the illumination at the reflector edge is about 10

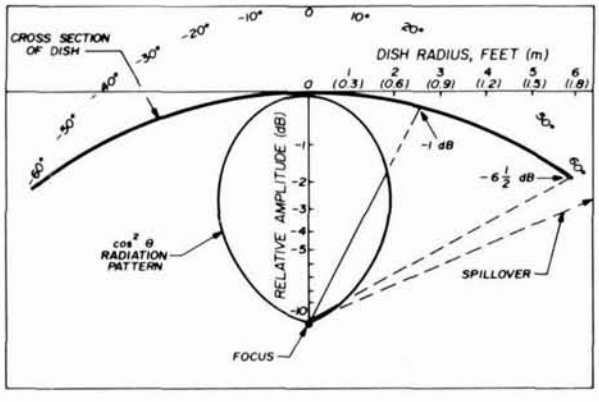


fig. 3. Cross section of a parabolic reflector superimposed on a typical feed-horn radiation pattern. This graph illustrates the importance of selecting a horn-feed diameter whose radiation pattern will illuminate the dish most effectively. Focal length/diameter ratio, F/d, is 0.417; horn diameter is 6.3 inches (16cm), and illumination taper is 6.5 dB. Note that the illumination taper is not ideal.

to 12 dB down from that at the center. Note that the illumination taper in **fig. 3** is not ideal.

The manner in which the beamwidth of a 1296-MHz circular horn antenna varies with horn diameter is illustrated in **fig. 4**. Since the beamwidth of the horn depends on its diameter, it's possible to select a horn diameter to match the particular parabolic reflector to be illuminated.

Fig. 5 is a curve from which the feed-horn diameter can be selected to match the parabola F/d ratio. For example, if your dish has a 6-foot (1.8m) focal length and a 16-foot (4.9m) diameter, the F/d ratio is 6/16 = 0.375, and the proper horn diameter from **fig. 5** is 7 inches (17.8cm). **Fig. 5** is based on a dish illumination

Plastic coffee-can lid makes an effective rf-transparent radome that's bird and weatherproof.

with a 10-dB taper. According to **fig. 1**, the probe for this horn should be located 3.6 inches (9.1cm) from the shorted end. A reasonable overall horn length would be 7.5 inches (19.1cm).

Fig. 4 is based on average values of vertical and horizontal beamwidths. In practice, assuming horizontal polarization, the illumination will taper more rapidly at the top and bottom of the parabolic reflector than at the sides, because the horn vertical beamwidth is less than the horizontal beamwidth. This situation might be rectified by using a sectoral or elliptical horn. In the latter

case, a circular horn such as described here might be slightly flattened at the open end so that its diameter is increased in the horizontal direction. This will tend to produce a radiation pattern more nearly circular.

feed-horn probe

One of the pertinent factors involved in feed-horn design is the probe for exciting the waveguide. The photographs show a 2304-MHz probe designed for use with a 4-inch (10.2cm) diameter horn made from a 1-pound (0.45kg) coffee can. A 15/16 inch (24mm) length of 0.157-inch (4mm) diameter brass tubing is soldered to the lug of a UG-58A/U type N connector. A 3/4-inch (19mm) length of 0.185-inch (5mm) diameter brass tubing slips over the probe for length adjustment. A 3/8-inch (9.5mm) diameter, 1/4-inch (6.5mm) long brass washer slides over the adjustable sleeve to tune out reactance introduced at the connector.

The connector is attached to the horn at the probe location with brass screws. After the connector holes have been drilled, and before mounting the probe assembly, the paint around the connector flange area should be cleaned off and the flange area tinned with solder.

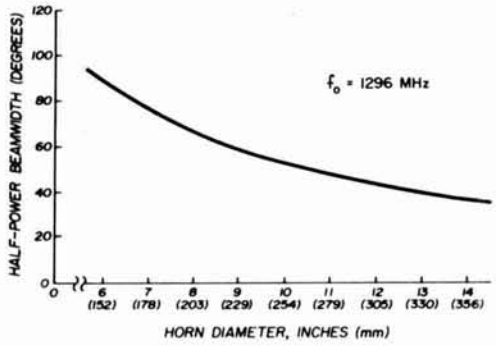


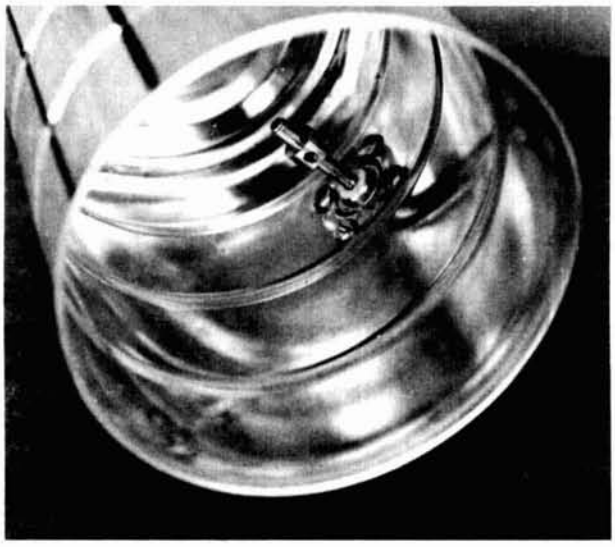
fig. 4. Relationship of beamwidth and 1296-MHz feed-horn diameter. Average values of vertical and horizontal beamwidths are shown.

Once the feed horn has been made, it's only necessary to adjust the probe to put it in operating condition. This can best be done with the aid of a directional coupler and a detector, together with the other components illustrated in **fig. 6**. Use a directional coupler with a coupling value consistent with transmitter power level. For example, a 60-dB coupler should be used with a 300-watt transmitter; a 20-dB coupler will do the job if the transmitter power is 0.1 watt. In any case, it's desirable that power to the crystal detector be less than about ten milliwatts. The 3- or 6-dB rf pad should be used to ensure a good power match at the coupled arm output.

Orient the feed horn so that energy is not reflected back into the horn while the probe adjustments are being made. **Caution**: Do not look into the horn when the transmitter is energized, otherwise eye damage can result, particularly if high power is being used. It is far better to power down the transmitter and use a lower value of directional coupling.

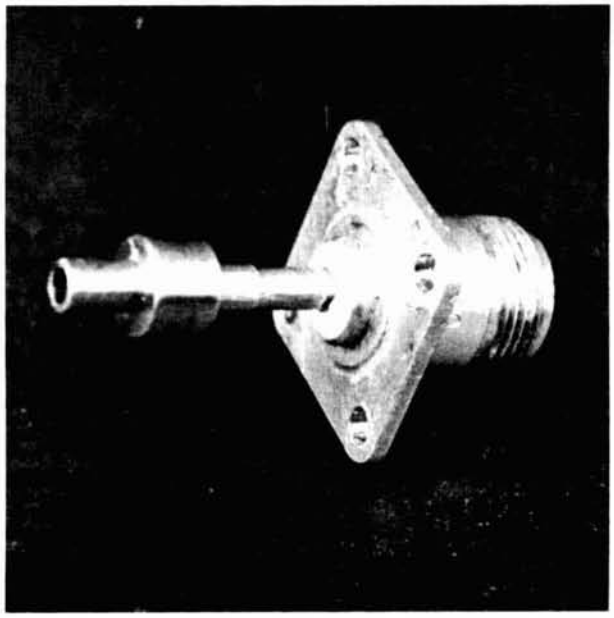
Start with the directional coupler in the forward direction (opposite to that shown in **fig. 6**), and adjust the voltohmmeter range and the variable resistor so that the meter reading is full scale. Next, turn off the transmitter and reverse the directional coupler; then turn the transmitter on again and observe the vom reading. Adjust the probe length (with transmitter off) for minimum vom reading. Adjust the probe length so that the reflected power is as close to zero as possible. This condition corresponds to minimum vswr.

At this point, switch the vom to a more sensitive scale and adjust the position of the brass washer for minimum vom reading. It should now be possible to reduce the vom reading essentially to zero.



Inside view of unpainted horn showing rf-probe installation.

Details of the probe assembly, consisting of a length of brass tubing soldered to a UG-58A/U type N connector. Probe length adjustment and reactance tuning are also provided (see text).



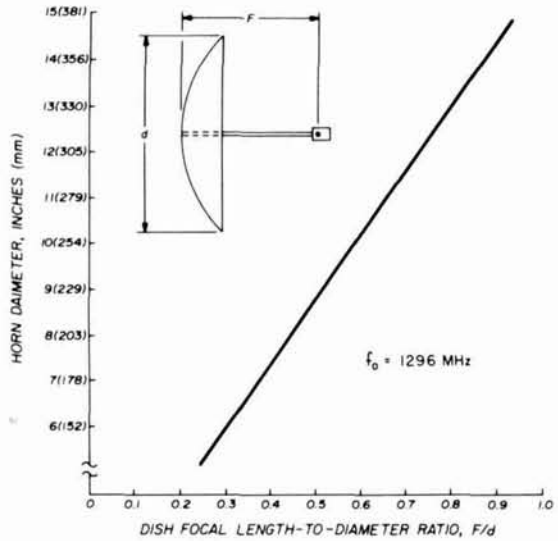


fig. 5. Feed-horn diameter as a function of focal length/diameter ratio, F/d, of the parabolic reflector, for a 1296-MHz system. According to fig. 1, the probe for this horn should be 3.6 inches (91mm) from the shortened end.

An interesting experiment is to hold a metal reflecting plate close to the open end of the horn and note variations in the meter reading. Even at considerable distances from the horn, indications of power being reflected back into the horn can be demonstrated.

The feed horn vswr may change slightly after the feed horn has been mounted on the dish. The reason for this is that a small amount of rf energy reflected from the dish or supporting boom will intercept the horn. Therefore, it's a good idea to use the setup of **fig. 6** to check the reflected power after the horn has been mounted on the dish. This is particularly important for EME installations where even the smallest misadjustments may have serious consequences.

radome

The plastic covers that come with coffee cans make excellent radomes with low loss even at 2304 MHz. These covers fit tight enough to keep the snow and the birds out. As an alternative, a one- or two-inch-thick (25 or 50mm) disc of styrofoam pressed into the open end of the horn also makes a good radome, having a loss about the same as the plastic cover. Unfortunately, birds are attracted to the white styrofoam and chip away at the radome with their bills. A means to solve this problem is to apply coarse fiberglass cloth to the outside of the styrofoam radome with epoxy cement. Don't use polyester resins which react with and dissolve the polyfoam.

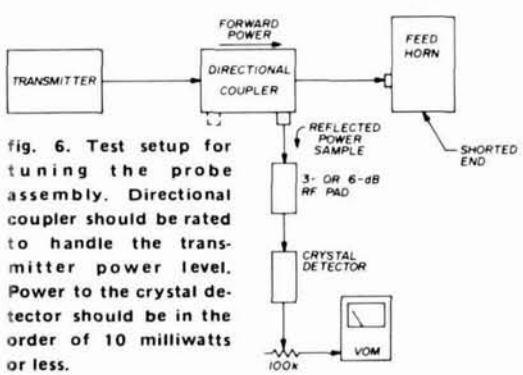


fig. 6. Test setup for tuning the probe assembly. Directional coupler should be rated to handle the transmitter power level. Power to the crystal detector should be in the order of 10 milliwatts or less.

summary

Probably the most important part of the parabolic antenna system design is the feed horn, where small compromises can result in sizeable reductions in overall performance. You can achieve satisfying and rewarding results (and take the guesswork out) by carefully following the design, construction, and tuneup instructions given here. Your parabolic antenna should then operate at relatively high efficiency, an important factor in any antenna system, particularly when conditions are marginal, such as long-haul tropospheric contacts and EME work.

Completed 2304-MHz feed horn ready for installation on dish.

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More Details? CHECK–OFF Page 118

six-element collinear antenna for 20 meters

A fixed-azimuth wire array for point-to-point communications

A couple of years ago I had a requirement for a fixed-azimuth array for reception and transmission on 20 meters between Boulder, Colorado, and Europe. A narrow beam was required for receiving European stations at azimuths of 15 to 55 degrees because of strong U.S. East-Coast interference at azimuths near 80 degrees. I was impressed with the narrow-beam characteristics of the collinear array, sometimes called the Franklin antenna.[1-5] The simple collinear, as originally conceived and still described in all the amateur handbooks, is a horizontal wire array. The collinear was later adapted to vhf omnidirectional broadcasting by positioning it vertically and using cylindrical conductors.

antenna description

The array described here consists of two or more horizontal doublets in series. The currents are in phase in each doublet. Ordinarily if half wavelengths of wire are connected directly, the current shifts phase 180 degrees from one wire to the next, so a phase-reversing circuit is used between each doublet. The circuit traditionally used is a quarter-wave open-wire line. Alternatively, a high-Q resonant L-C trap could be used and would have the advantages of small size and light weight. However, it would require high-voltage capacitors and weather protection and might not be as stable in adjustment as an open-wire line.

beamwidth and feed impedance

Reference 6 gives the horizontal beamwidths of collinear arrays. A two-element array has a beamwidth at the half-power points of about 48 degrees; a three-element array has a beamwidth of about 36 degrees. An average three-element Yagi has a horizontal beamwidth on the order of 60 degrees at its optimum vertical angle of radiation. The collinear array is bidirectional. The three-element collinear array has the advantage of symmetrical center feed at a current maximum, so this was my first serious starting point after some poor luck with a two-element array. To feed two elements or any even number of elements symmetrically, one must enter at a high-impedance point. Unbalanced coupling and losses may occur if a metal mast is used to support the feed point.

By Dick Silberstein, WØYBF, 3915 Pleasant Ridge Road, Boulder, Colorado 80301

A three-element 20-meter collinear array was constructed with no. 10 AWG (2.6mm) copperweld wire, and the elements were cut to the usual 95 per cent of a half wavelength in free space. The phasing lines were a full quarter wavelength long but were adjustable from a maximum of about 18 feet (5.5m). The impedance of such antennas, two to six elements in length, is said to be about 100 ohms times the number of elements.[7] I decided to match the antenna to 50 ohms by using a quarter-wave matching section according to the well-known relationship

$$Z_o = \sqrt{Z_a Z_b} \qquad (1)$$

where Z_o is the characteristic impedance of the matching section, Z_a is the input impedance, and Z_b is the output impedance.

I found experimentally that with an output impedance of 50 ohms, the characteristic impedance of the matching section had to be 140 ohms to match the input impedance. From **eq. 1**, the antenna resonant impedance was about 392 ohms. By the rule given in reference 7 stated above, I'd expected something nearer 300 ohms.

The matching section was made from two quarter-wave sections of old Belden no. 8275 twinlead connected in parallel, but almost any good 300-ohm twinlead would have been satisfactory. The actual impedance of this particular transmission line was 280 ohms. Two sections in parallel obviously gave 140 ohms. The velocity factor came out by test to be 86 per cent instead of the usual 82 per cent, making the correct length 15 feet (4.6m). The antenna swr was near unity between 13900 to 14350 kHz.

During test, this antenna produced slightly stronger signals from Europe than my three-element tribander. However, to eliminate bidirectionality, increase gain, and narrow the beam a little bit more I decided to proceed further.

The most obvious approach was to make the collinear a driven element of a two-element parasitic array. The only place I've seen anything like this is in reference 6, where mention is made of a reflector with a collinear array. However, from a mechanical standpoint, a row of three parasitic reflectors would be difficult to construct since it would have to be longer than the driven array,

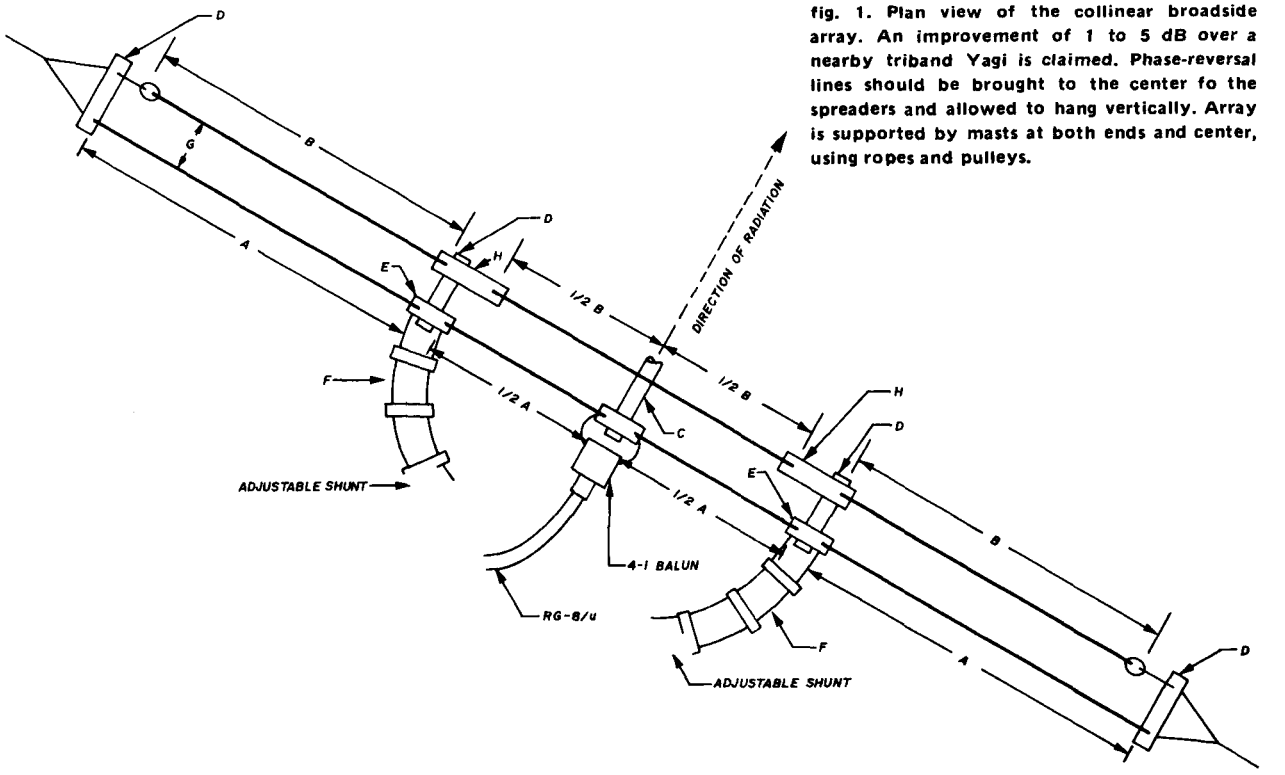

fig. 1. Plan view of the collinear broadside array. An improvement of 1 to 5 dB over a nearby triband Yagi is claimed. Phase-reversal lines should be brought to the center fo the spreaders and allowed to hang vertically. Array is supported by masts at both ends and center, using ropes and pulleys.

A. Driven elements	no. 10 AWG (2.6mm) copperweld wire
B. Directors	no. 10 AWG (2.6mm) copperweld wire
C. Center spreader	1-1/8 inch (29mm) diameter oak pole (8 feet or 2.4m long in 20-meter array)
D. Spreaders (4 required)	1 inch (25mm) PVC tubing (8 feet or 2.4m long in 20-meter array)
E. Insulators	½ inch (12.5mm) nylon or 1 inch (25mm) diameter PVC tubing 6 inch (15.2cm) long
F. Phase-reversal lines	see text
G. Separation distance	0.1 wavelength
H. Insulators	1 inch (25mm) diameter PVC tubing (2 feet or 61 cm long in 20-meter array)

requiring short stubs to make it fit parallel to the driven array. I chose instead a row of three directors, which would be shorter than the driven-array assembly. Each director was separated from its neighbor by a section of plastic tubing.

The theoretical lengths for a two-element parasitic antenna were used for each driven element and its corresponding director, according to reference 6 for two-element arrays and reference 8 for the driven element and director of a three-element array:

$$\text{Driven element (ft)} \cong \frac{475}{f}$$

$$\text{Driven element (m)} = \frac{144.8}{f} \qquad (2)$$

$$\text{Director (ft)} \approx \frac{455}{f}$$

$$\text{Driven element (m)} = \frac{138.7}{f} \qquad (3)$$

where f = frequency (MHz)

Construction details are shown in **fig. 1**. Note the generous use of rigid PVC water pipe, which provides good mechanical strength and rf insulation in a lightweight material yet doesn't warp enough to affect spacing appreciably. The antenna was built for 20 meters. Nominal values of length for 14.2 MHz are

driven elements 33 ft, 5 in (10.2m)
directors 32 ft (9.8m)
separation 7 ft (2.1m)
phase-reversal stubs 17 ft 4 in. (5.3m)

The phase-reversal stubs were actually 18 feet (5.5m) long with adjustable shunts. These shunts are needed for correcting minor errors in element lengths, compensating for height differences in different installations, and making final swr adjustments.

The antenna is driven through a 4:1 balun at the end of an RG-8/U feedline for the following reasons: The resonant impedance of a simple three-element collinear measured experimentally in the same location was almost 400 ohms. From experiments with parasitic antennas I reasoned that good gain was possible with element adjustments, which would reduce the normal resonant impedance of an antenna having no parasitic elements by a factor of about one-third. This means that the 400-ohm impedance of three collinear elements alone would be reduced to about 133 ohms with directors under certain adjustment conditions. A 4:1 balun would make the input impedance about 33 ohms, for an swr of approximately 1.5.

swr measurements

Swr was adjusted for a minimum at the desired operating frequency by moving the shunts on the phase-reversal stubs. The swr varied between 1.5 and 2.0 over most of the 20-meter band. Improved results might have been obtained with a gamma match, but I didn't use one because the match might not have held over a wide enough frequency range. Certainly it isn't good to push stub lengths too far beyond their theoretical values in optimizing swr alone. This is especially true in view of information in reference 8, which shows only 14 ohms impedance for a two-element parasitic array at 0.1 wavelength spacing, adjusted for optimum gain. The free-space impedance of the driven element alone would be 72 ohms (at resonance), giving an impedance reduction of about 5:1 due to the presence of the parasitic element, rather than the 3:1 ratio assumed above. So it would be a worthwhile experiment to start with theoretical values of element and stub length, adjust swr on a gamma match, and make corrections of driven-element length by moving the shorting stubs.

The antenna as built had some characteristics of an inverted vee. The antenna center was suspended 25 feet (7.6m) above ground, but the ends were only about 10 feet (3m) above ground on one side and 15 feet (4.6m) on the other. Proximity to ground increases losses but doesn't affect horizontal beamwidth.

results

Performance tests over about 18 months showed that the six-element array in reception gave S-meter readings on most European signals 1 to 5 dB stronger than those received on an adjacent triband Yagi. Interference from East-Coast U.S. stations was about 8 dB below that noted on the tribander, yielding even greater net signal-to-interference ratios; the advantage frequently was two S-units or more.

final remarks

The main disadvantage of this antenna is the same as any other antenna system using resonant phasing stubs or feedlines: the antenna impedance changes greatly under icing conditions. However, here in Colorado, such conditions exist only for a few hours each winter. The six-element broadside wire array should provide excellent narrow-beam, fixed-azimuth reception and transmission even at low heights. The 20-meter version is fairly long, yet it should fit into a half acre (2024m^2) of land. It is an easy-to-erect, high-performance antenna for those wishing point-to-point communication with a distant station.

references

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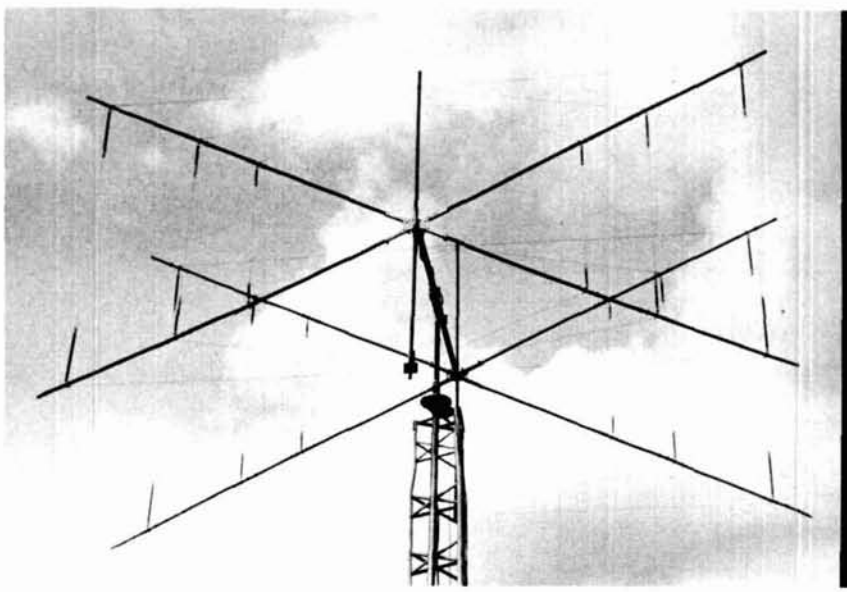


improved low-profile three-band quad

An updated version of this compact antenna which features higher structural strength and a different tuning method

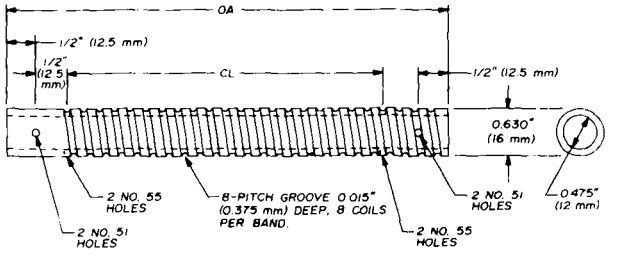
My previous article on the low-profile quad[1] ended with a statement about a new model with better structural rigidity. The version described here has been designed with hexagonal-shaped 10- and 15-meter elements, providing such improvement. Another innovation has been added which consists of loading coils in place of the folded three-wire section and its shorting bars. This doesn't imply that the loading-coil version is better; it's merely another method resulting in easier element assembly. The biggest problem is making 24 loading coils, 8 for each band. I've provided instructions for making these coils using simple shop equipment.

The low-profile quad is unique[2] because the basic quarter-wavelength radiator sections have been retained and compactness achieved by tampering with the "no-good" quarter-wavelength vertical antenna. It's surprising to find that many quad users are unaware that only 50 per cent of a full-wavelength quad is being used effectively. The vertical sections are out of phase, and radiation fields cancel. The primary purpose of the ver-

By John P. Tyskewicz, W1HXU, 77 West Euclid Street, Hartford, Connecticut 06112

tical sections is to complete the full-wave loop. If a small loss occurs because of the closer spacing, such loss is compensated by a smaller and stronger structure.

The loading-coil shape factor isn't critical. I used ½ inch (25mm) (nominal) PVC plastic tubing because of its low wind resistance. Some builders may be tempted to use one large coil at the center of each vertical leg; however, this wasn't tried because the high rf voltage at this



BAND	OA in. (cm)	CL in. (cm)	TURNS
10	6.5 (16.5)	4.5 (11.3)	36
15	9 (22.5)	7 (17.5)	56
20	15 (37.5)	13 (32.5)	104

MATERIAL: 1/2" (12.5 mm) RIGID PVC TUBING
NO. 16 (1.3 mm) COPPER WIRE (See Text)

LOADING COIL FORM

point could be a trouble spot. Wire size isn't critical because the coils are located 1/8 wavelength or more from the high-current points. I used no. 16 AWG (1.3mm) copper wire salvaged from a discarded electric motor. Coils are exposed to the elements, but no serious detuning occured during rain or snow. **Fig. 1** shows the sets of coils required. To avoid any mixup, driven-element and reflector coils are identical.

The coil forms are made by machining a groove on the PVC tube. This was done on a lathe set up for an 8-pitch thread. A steel mandrel was made to fit the inside diameter of the PVC tube. One-half inch (25mm) of the tube was held by the lathe chuck. The cutting tool was ground to a radius slightly larger than the wire diameter. The cut was made in two passes: the first was 0.010 inch (0.25mm) deep, followed by a second cut 0.005 inch (0.13mm) deep.

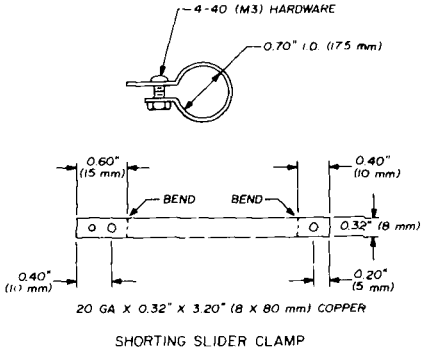
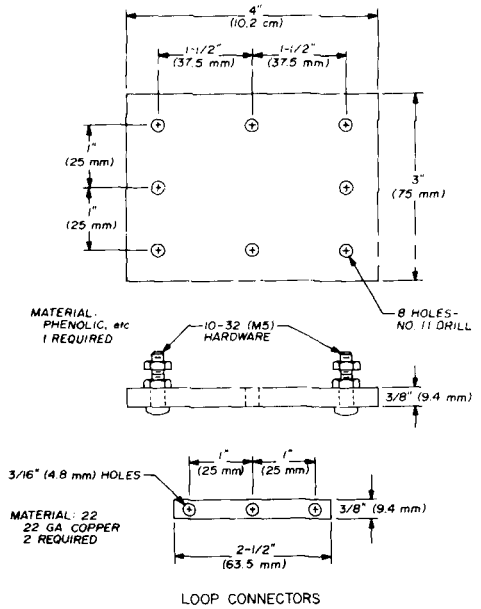


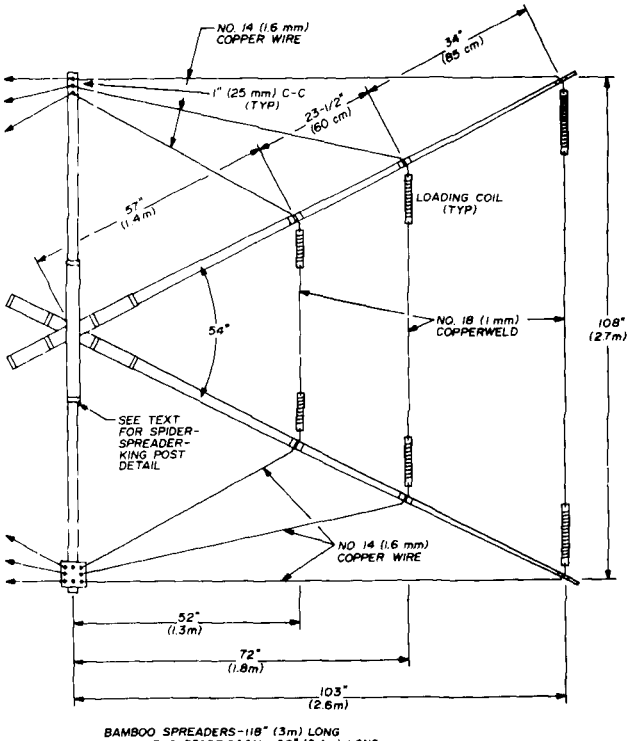
fig. 1. Construction details for the coil forms and shorting clamp.

The coils are wound by stretching a length of wire held in a bench vise and rotating the coil form by hand to accept the wire. Gloves are a must. Wrap two layers of masking tape around the end of the coil, cut the wire to allow a 6-inch (15cm) lead, and pull the wire through the holes in the form. Insulation should be cleaned from the bottom end of each coil for several turns (see **fig. 3**) so that an adjustable clamp can be moved over the coil



LOOP CONNECTORS

fig. 2. Details for constructing driven element and terminal block (1 required).



BAMBOO SPREADERS-118" (3m) LONG
ELEMENT SUPPORT BOOM - 96" (2.4m) LONG

for tuning. Only one set of upper and lower coils per element need be tuned.

element assembly

Construction of spiders, spreaders, wire anchors and boom was covered in reference 1. **Figs. 2** and **3** show the radial dimensions necessary to give the proper spans. The final dimensions can vary a bit, preferably on the long

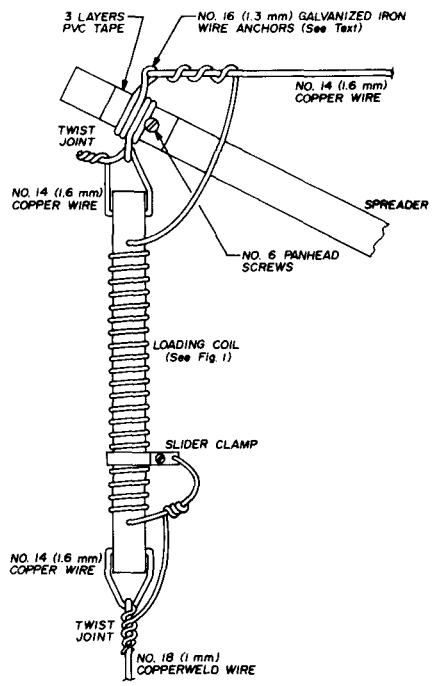


fig. 3. Reflector-element construction and loading-coil installation.

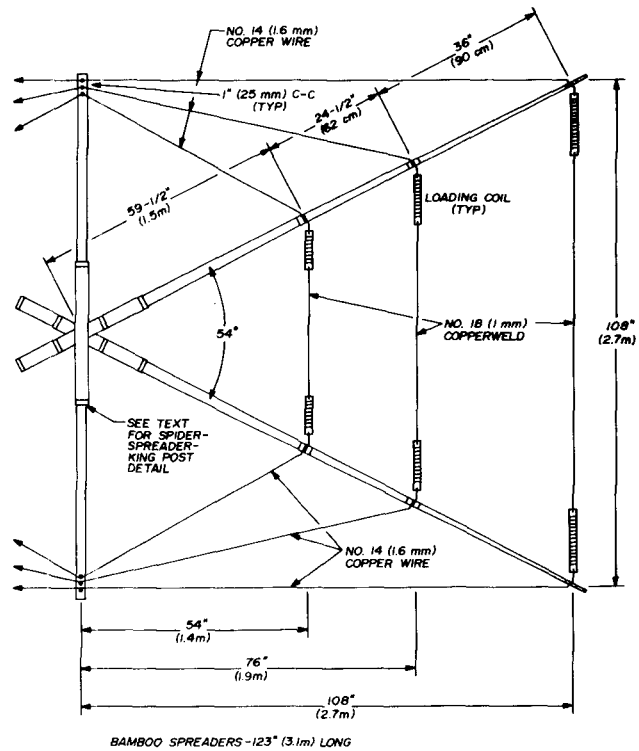
side, to ensure sufficient tuning range. Fastened to the bottom of the driver element king post is an insulated terminal block, **fig. 2**.

Wire stringing is started with the 20-meter loading coils and wire pieces, followed by the upper and lower horizontal wires. Next, the 15- and 10-meter sloping wires are added, and finally the remaining coils and wire parts. The coil leads are connected to the driver and reflector wires. *Do not* rely on continuity through the wire anchors!

tuning and adjustment

Initial tuneup can be done near ground level with a grid-dip meter monitored by a calibrated receiver. At the driven element terminal block, close the element loops with an insulated wire jumper having a one-turn loop to which the gdo can be coupled. Scanning will reveal a multitude of dips because of mutual coupling between three resonant elements. The trick is to isolate the correct dip by its second harmonic. With full-turn loading coils the resonant frequency should be at the low end or perhaps out of the band. The frequency is now increased by shorting turns from the two lower or upper coils. If more than half of the two coils must be shorted, then the respective opposite coils should be partially shorted. Do not remove any turns at this time.

The reflector coils can now be adjusted to the same settings as those of the driven-element coils, providing the reflector-element span is approximately 5 per cent longer; otherwise make an educated guess. Recheck the driven-element loops with the gdo. Remove the loop jumpers from the terminal block and install the vertical



strap jumpers, connecting the three loops in parallel. A homemade balun[3] was used with the RG-8/U, 50-ohm coax.

Direct feed with a single coax cable is not the best method; nevertheless, it works out quite well. Because of some reactance, the swr is sensitive to line length — a case of conjugate tuning. The resonant frequency of the elevated antenna can be quickly determined with an antenna noise bridge. A simple field-strength meter was used for front-to-back ratio and forward-gain adjustments. Current expert opinion[4] is not to lose any sleep if the swr can't be decreased to less than 2:1. The low-profile quad with loading coils and the three-wire version seem to be equally good; each has its merits.

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ham radio

selective antenna system

for minimizing unwanted signals

An approach to the interference problem using matched vertical antennas and a novel phase-control method

Evening operation on 40-meter phone has long been complicated by a wall-to-wall array of foreign broadcasters whose power levels present a formidable barrier. The result, too frequently, is amateur inactivity or a mass migration to the already over-crowded 75-meter band.

Isn't it about time to do something more objective? A favorable outcome of the 1979 World Administrative Radio Conference is not assured, so perhaps we should reexamine our techniques and serve notice that we don't intend to be dislodged. Increased power would be barking up the wrong tree, as we are faced with a receiving problem. "You can't work 'em if you can't hear 'em!" A compact, highly directional receiving antenna is required, which is inexpensive and easy to erect.

The best receiving antenna is one giving the best signal-to-noise ratio, not merely the strongest signal. Below 30 MHz, weaker signal pickup can usually be improved by amplification without penalty. The following account is not presented as a solution to the problem, but as a possible starting point for those sufficiently interested in doing something about it.

background

The first effort[1] used two widely spaced verticals in a steerable phased system. Because of the wide spacing between antennas and lack of amplitude-balance control, this system did not produce the deep null required for this application.

In a second effort the phasing system of reference 1 was retained but a pair of very small whip antennas, 2 feet (61cm) high were substituted, each with its own transistor preamplifier. In addition to providing necessary gain, these preamplifiers isolated the antennas from effects resulting from phasing-control adjustments. This allowed closer antenna spacing to reduce diversity reception differences between signals obtained from the two antennas. Initial spacing of a quarter wavelength was nonproductive, so a reduction was made to about 6 feet (2 meters).

To control preamplifier gain for amplitude balance, one unit used an npn transistor, while the other was a pnp type. The method of controlling the applied voltage to each unit is apparent from **fig. 1**, where a potentiometer bridges the dc power supply, with the movable arm grounded to the coaxial cable outer conductors.

The null depth first obtained left much to be desired until I found that the coils in the phasor were picking up the signals directly. When these coils were rewound on toroid forms, the situation was greatly improved. Shielding the original coils should have been equally effective.

By **Henry S. Keen, W5TRS**, Fox, Arkansas 72051

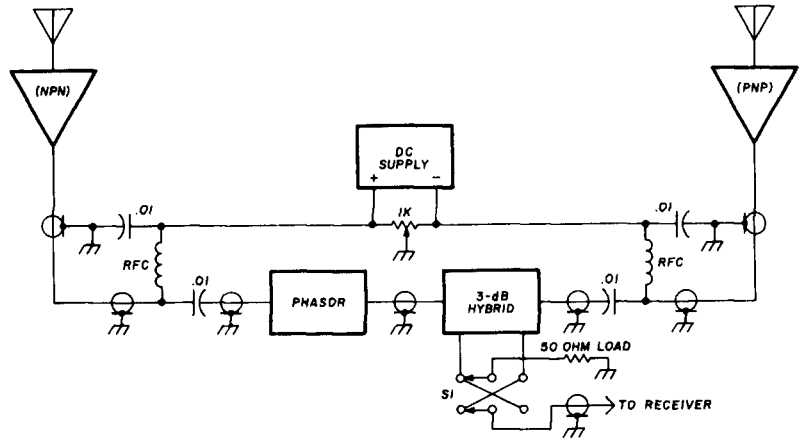

fig. 1. Setup used for receiving tests with foreign broadcast signals on the 40-meter band. Antennas are 2 feet (61cm) long spaced about 6 feet (2m). The hybrid coupling system, described in reference 1, was used to control received signals.

receiving tests

Tests made on the signal of Radio Moscow, in late March, 1975, showed a 50 to 55 dB difference between the in-phase and out-of-phase condition. These numbers, in the absence of calibrated test equipment, were based on an assumed 6-dB per S-meter division reading. This degree of improvement was not all "gravy," however, as the close spacing of the antennas reduced all signals 10 to 15 dB from the in-phase signal level. However there were happy occasions when an otherwise completely smothered signal could be dug out for solid copy.

Later in the year, and through the early summer of 1975, when conditions were particularly poor, the gain achieved over the broadcaster was degraded appreciably, but noticeable and worthwhile improvement was still there. It seemed ironic to find that the very conditions of selective fading and other multipath propagation effects, which degrade normal reception of the broadcast signals, were the same conditions that limited the effectiveness of the phase-out.

The tiny antennas used in this experiment were chosen to approximate the voltage probe antenna,[2] with the hope of making the system less sensitive to the polarization of the incoming wave. The input amplifier mentioned in reference 2, however, used fet elements instead of bipolar transistors, which required a tuned network input circuit. As this investigation was aimed only at the 40-meter band, this point was not considered critical.

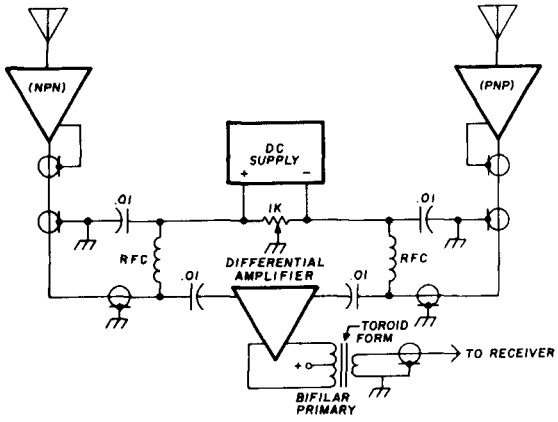

fig. 2. Suggested system using a differential amplifier to replace hybrid couplers of fig. 1. Antennas and preamplifiers would be on a rotatable boom, which could be oriented to minimize interfering signals.

simplified system

A suggested simplified system, which does not require the phasor and hybrid but should be equally effective, is shown in **fig. 2**. Identical lengths of coaxial cable would bring the signals from the antennas to a differential amplifier, such as the CA3028, with a balanced output. A transformer with a bifilar-wound primary on a toroid core would cancel in-phase signals. The antennas and preamplifiers would be mounted on a rotatable boom oriented to minimize the interfering signal. Amplitude balance of the antenna preamp outputs would be accomplished as before.

With this system multiband operation should be feasible if the preamplifiers as described are replaced with untuned fet input amplifiers as in the voltage probe antenna. This would seem to be an excellent area for further investigation.

Considerable time and experimentation were directed toward different methods of detection that might discriminate against the a-m signal of the broadcaster in favor of the ssb amateur signal. Success in this area was quite limited, however, as multipath propagation problems complicated matters and severely limited benefits that otherwise might have been obtained.

conclusions

The conclusions drawn from the study are that the receiving antenna is by far the most likely candidate for improvement, and that the general concept of using the same antenna for both transmitter and receiver severely limits the ability of the amateur station to compete under conditions of heavy interference.

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ham radio

loop-yagi antennas

Comparative data based on recent literature is presented on loop-Yagis versus conventional designs

The elements of a Yagi antenna can take a variety of shapes. The most common are linear designs, with elements arranged as in **fig. 1**; the square loop, as in the quad; or triangular loop, as in the delta loop. Less often seen are circular loops. Yagis having an element formed into a loop, usually of one-wavelength circumference, are called loop-Yagis.

The controversy of loop-Yagis versus linear, or conventional Yagis, has raged for many years. Feeding the controversy have been a number of articles making technical comparisons on a practical basis.[1,2] Usually, however, the choice is made on the basis of mechanical convenience, appearance, or plain dollars and cents. I'd like to draw attention to two recent papers that detail design methods for optimum-gain arrays: one for Yagis of conventional design;[3] the other for loop-Yagis.[4]

conventional yagi optimization

"Optimum Element Lengths for Yagi-Uda Arrays," by C. A. Chen and D. K. Cheng,[3] appeared in the January, 1975, issue of the IEEE journal, *Transactions on Antennas and Propagation,* and is the first paper of interest. (See also reference 5). An analytical method is described that begins with a given design; element lengths and spacings are then shuffled several times until the gain is optimized. Chen and Cheng refer to these adjustments as "length-spacing perturbation," The mathematics of the method are somewhat involved but are amenable to computer solution. Perhaps someone with the time and experience could write a program and oblige the amateur fraternity with published data.

Chen and Cheng[3] illustrated their technique by applying it to a six-element Yagi. This antenna consisted of a one-half-wavelength-long driven element, a reflector about 4% longer spaced a quarter-wave behind the driven element, and four directors spaced 0.31 wavelength apart, all 0.43 wavelength long. The gain of this initial array was 8.8 dBd (gain in dB referred to a dipole). The array parameters were then adjusted for maximum gain, using Chen and Cheng's procedures, ending with a gain of 11.25 dBd. In the process, the length increased from 1.49 to 1.69 wavelengths. (But this alone does not fully account for the gain increase of nearly 2.5 dB). That final figure puts the array in the same ballpark as loop Yagis of similar length, according to references 1 and 2. It also exceeds measured gains of published Yagi designs having more elements. The final design and its parameters are illustrated in **fig. 1**. Element lengths and spacings for various frequencies, which I computed are given in **tables 1** and **2**. I haven't tried the numbers in practice;

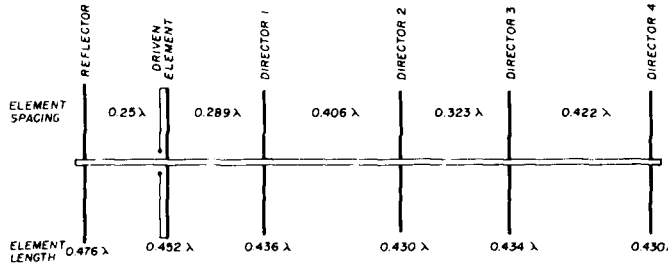

fig. 1. Optimized design of Yagi-Uda array by Chen and Cheng. Drawing is to scale: 1.75 inch (44.5mm) equals 1 wavelength. Element diameter is given as 6.738×10^{-3} wavelength.

By Roger Harrison, VK2ZTB, 47 Ballast Point Road, Birchgrove, New South Wales 2041, Australia

they are intended as a starting point for amateur experimentation.

Added benefits gained by the design method of Chen and Cheng are decreased sidelobe amplitude and slightly improved front-to-back ratio (with reference to the initial array). The frontal lobe is narrower as a result of the increased gain. Unfortunately, they make no comment on bandwidth, but bandwidth would be expected to be around 1% or less.

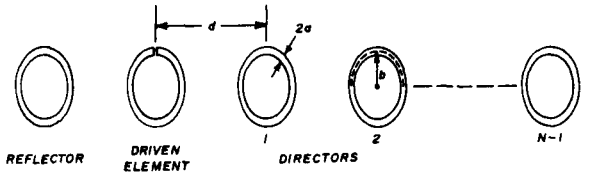

fig. 2. Loop-Yagi antenna (after Shen and Raffoul). Dimensions are loop thickness ($2a$), loop radius (b), and loop spacing (d).

table 1. Element lengths and diameters for selected frequencies based on the optimized Yagi-Uda antenna of fig. 1.

element	element length (λ)	element spacing (mm except as noted) frequency (MHz) 28.5	50.1	52.1	144.1	146.0	432.1	435.0
reflector	0.476	4.852m	2.760m	2.654m	960	947	320	318
dipole	0.452	4.607m	2.621m	2.520m	911	899	304	302
director 1	0.436	4.444m	2.528m	2.431m	879	868	293	291
director 2	0.430	4.383m	2.493m	2.398m	867	856	289	287
director 3	0.434	4.424m	2.517m	2.420m	875	864	292	290
director 4	0.430	4.383m	2.493m	2.398m	867	856	289	287
element diameter (mm)		69	39	38	14	14	5	5

loop-yagi design

The second paper of interest is "Optimum Design of an Yagi Array of Loops," by L. C. Shen and G. W. Raffoul.[4] They describe a quite simple design procedure. Equal element spacing and element diameter are used throughout. The reflector spacing could be made larger to improve front-to-back ratio (see reference 6).

The general form of the array is shown in **fig. 2**, and one proceeds as follows. The first parameter chosen is usually gain or array size. The curves in **fig. 3** (after Shen and Raffoul[4]) give bandwidth versus array size and gain (in dBd). Select an appropriate d/b (loop spacing/loop radius) ratio or an appropriate bandwidth for the array length chosen. **Table 3** (again after Shen and Raffoul) gives the L/λ and b/λ ratios for the d/b ratio just selected. Knowing the wavelength, you can then find b, followed by $2a$ (loop thickness), and thus the distance, d, between the loops. The number of elements (including the reflector) can be found by dividing the approximate boom length by d. The bandwidth decreases with array size (as expected); but even with a large array, the bandwidth is quite substantial.

example

To illustrate the procedure, here's an example. Calculate the wavelength from

$$\lambda = \frac{29050}{f}$$

where λ is wavelength (mm)
f is frequency (MHz)

If f = 433 MHz, wavelength = 671 mm

table 2. Element spacing and array length for selected frequencies based on the optimized Yagi-Uda antenna of fig. 1.

element	element spacing (λ)	element length (mm except as noted) frequency (MHz) 28.5	50.1	42.1	144.1	146.0	432.1	435.0
reflector-dipole	0.250	2.548m	1.450m	1.394m	504	498	168	167
dipole — D1	0.289	2.946m	1.676m	1.611m	583	575	194	193
D1 — D2	0.406	4.138m	2.354m	2.264m	819	808	273	272
D2 — D3	0.323	3.292m	1.873m	1.801m	651	643	217	216
D3 — D4	0.422	4.302m	2.447m	2.353m	851	840	284	283
array length (m)		17.23	9.8	9.43	3.41	3.4	1.14	1.14

From **fig. 3**, choosing an array length of three wavelengths (3λ), the bandwidth is 13%, or 56 MHz, and the gain is 15 dBd. The a/b ratio is fixed at 0.01. Now, for a d/b ratio of 1.0, proceed as follows.

From **table 3**, b/λ = 0.142, and

loop radius = 0.142 X 671 = 95mm
loop circumference = 2π X radius = 600 mm
loop thickness = $2a$ = 0.02 X 95 = 2mm
loop spacing = 95mm (as d/b = 1.0)
number of elements = $N = \frac{\text{array length}}{d}$ = 21

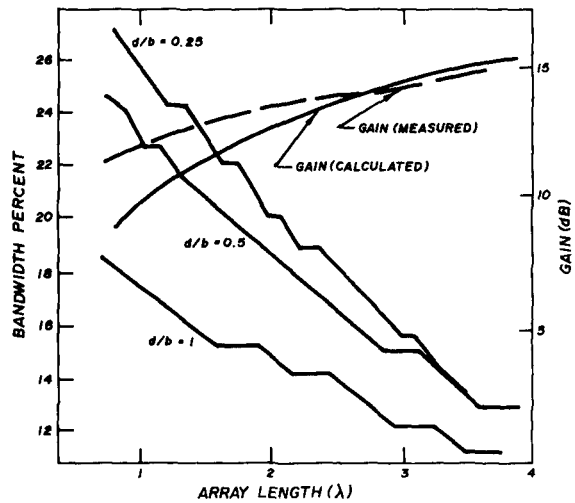

fig. 3. Design curves for loop-Yagi antennas (after Shen and Raffoul). Loop spacing/loop radius values (d/b) are used with table 3 data to obtain array length/wavelength ratio (L/λ) and loop radius/wavelength ratio (b/λ).

Thus the boom length is 2.02 meters. Summarizing,

frequency	=	433 MHz
array length	=	2.02m
gain	=	15 dBd
bandwidth	=	56MHz
loop diameter	=	190 mm
loop circumference	=	600 mm
loop thickness	=	2 mm
loop spacing	=	95 mm

comparisons

From an examination of **fig. 3**, a loop-Yagi 1.7 wavelengths long has a calculated gain of 11 to 12 dBd, which compares with the six-element Yagi by Chen and Cheng.[3] But the measured gain of the loop-Yagi is higher than the calculated gain by about 1 dB. Do loop-Yagis still hold the edge in performance? Maybe 1 dB is splitting hairs; a few practical comparison measurements may prove interesting.

table 3. Loop-Yagi antenna design data (after Shen and Raffoul). Ratio a/b is 0.01; L is array length.

d/b = 1.0		d/b = 0.5		d/b = 0.25	
L/λ	b/λ	L/λ	b/λ	L/λ	b/λ
0.73-0.87	0.146	0.78-0.98	0.142	0.81-1.00	0.140
0.88-1.44	0.145	0.99-1.45	0.140	1.01-1.40	0.138
1.45-2.55	0.143	1.41-1.99	0.138	1.41-1.80	0.137
2.56-3.36	0.142	2.00-2.51	0.137	1.81-2.18	0.135
3.37-4.03	0.140	2.52-3.28	0.135	2.19-2.55	0.135
		3.29-3.92	0.134	2.56-3.17	0.132
				3.18-3.65	0.131
				3.66-3.84	0.129

A loop-Yagi 1.7 wavelengths long, designed by Shen and Raffoul's method, has 12 elements. The obvious disadvantage is more hardware than an equivalent-size conventional Yagi; but the wide bandwidth is an advantage, and construction tolerances are relaxed. It would be an interesting exercise to adopt the length-spacing perturbation techniques of Chen and Cheng[3] to the loop Yagi designs of Shen and Raffoul.[4]

table 4. Representative data for an amateur-band loop-Yagi antenna. Dimensions may be used as a starting point for experimentation.

parameter	6 meters		2 meters		70 cm	
gain (dB)	>10	>11	>11	15	>11	14
loop radius (mm)	795	797	288	279	96	95
loop thickness (mm)	16	16	6	6	2	2
element spacing (mm)	795	797	288	279	96	95
number of elements	7	12	12	29	12	21
bandwidth (MHz)	9	7.8	22	16	65	56
loop circumference (mm except as noted)	5m	5.008m	1.81m	1.79m	604	600
physical length (mm except as noted)	5.6m	8.8m	3.2m	7.8m	1056	2013
array length (λ)	1	1.7	1.7	4	1.7	3

construction notes

Dimensions of a representative series of loop Yagi antennas appear in **table 4** for various amateur bands. Elements could be made from sheet metal, rod, or tubing providing the loop thickness is maintained; i.e., cross section equal to calculated loop thickness. The elements can be supported by a metal boom through the center of the loops, using insulated arms to support the elements. Alternatively, the elements can be supported at voltage nodes (current maxima); i.e. at the feedpoint. Etching the loops on fiberglass PC board would be an ingenious method of construction, although the effect of the fiberglass on the resonant frequency would have to be determined. Insulated boom material, such as PVC conduit, allows elements to be cemented in place using epoxy resin. For further information on loop-Yagis, see references 6, 7, and 8.

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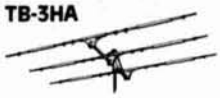

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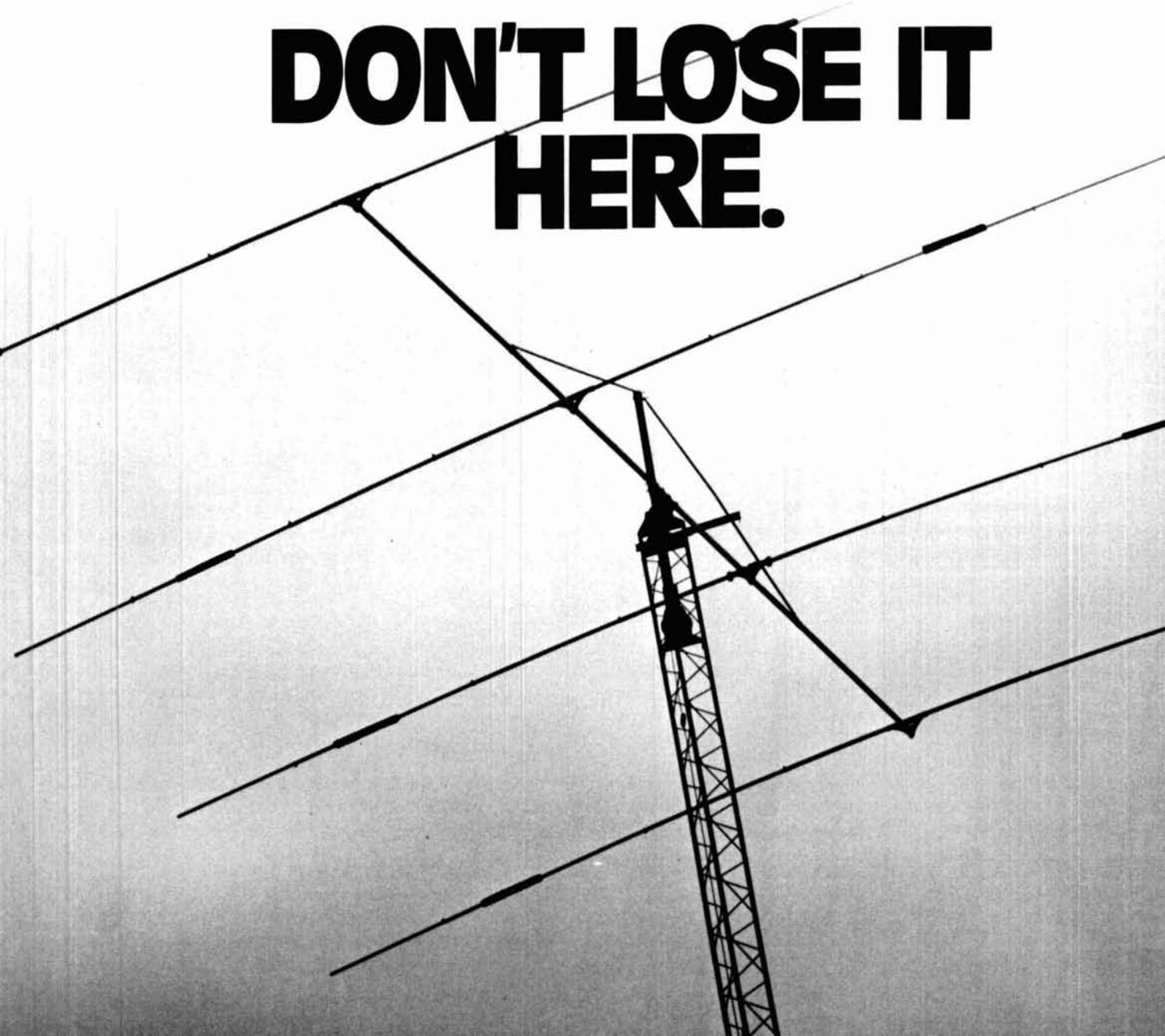

towers and rotators

Helpful ideas you can use in planning your rotary beam antenna installation

By E. H. Conklin, K6KA, Box 1, La Canada, California 91011

This article contains some information, not available in current handbooks, that should prove useful in planning your antenna and tower installation, selecting your tower and associated equipment, and raising and lowering the tower. Obviously every situation can't be covered; however, I've tried to include solutions to most problems encountered. Suggestions for preventive maintenance are also provided.

site selection

The average amateur tower is confined to a city lot, so site selection is pretty much determined by nearby structures and available clearance for guys, assuming a guyed tower is contemplated. Much disappointment can be avoided by choosing the safest tower height and antenna load for your location. An excellent treatment on the effect of wind loading on antenna towers in terms of overturning moment appears in reference 1, which is recommended reading for anyone planning a tower installation.

Many cases are on record of antenna towers that had to be removed because of deed restrictions, zoning ordinances and building codes.[2] Check your local ordinances to find out just what restrictions prevail. Assuming there are no problems in this area, the next thing to check is insurance coverage. What can you expect if your tower and antenna end up in the living room of the house next door during a storm?

maintenance considerations

A little planning pays off when you must work on the tower and antenna. It's desirable to perform all maintenance work unassisted, including removal and reinstallation of the rotator. In most installations the antenna is mounted on a mast, which extends several feet above and below the top of the tower and which is mounted in thrust bearings. This mast is driven by a rotator, which is usually mounted inside the tower. A thrust bearing is necessary at the top of the tower to relieve antenna weight and to facilitate certain types of work without having to lower the antenna to the top of the tower. Although a bottom line bearing isn't absolutely necessary, it limits lateral motion at the bottom of the mast, which puts an unequal strain on rotator bearings. When planning the rotator installation, consider the fact that it may be necessary to lift the mast out of the rotator to provide sufficient clearance to tilt the rotator so that it can be passed between the tower braces.

limit switches

After experiencing a tower lift-motor burnout, I installed some limit switches that are activated by the raising and lowering cables. The limits were established by

Crosby clamps, which consist of a U-shaped bolt, a yoke, and two nuts. These clamps were designed to fasten two cables together; installed on one cable, they can operate limit switches.

The switches are standard mercury household types selected with a square-shaped actuating lever to which the clamps and a V-shaped trip wire are mounted (see **fig. 1**). *Leviton* switches have the least taper.

The switches are mounted in standard household metal outlet boxes with cover plates. The boxes are held in place by steel straps. One switch is mounted at the bottom of the downhaul cable (near the tower center), and the other is mounted at the uphaul cable near the cable winch. A bolt at the point of the trip wire secures the cable. A spring between the top of the switch box and the clamp assembly provides tension to keep the switch lever in the *on* position except when it's pushed down by the clamp. Ordinary spring-type clothes pins, clipped on the downhaul cable, can operate the limit switches at intermediate points if desired.

To get the tower out of the limit-switch cutoff position, an interlock override switch is mounted on the motor connection box. This switch shorts the two series limit switches with a momentary contact lever or push-button. Because of heavy motor-starting current, which caused a switch failure after some years of operation, I usually push this button before placing the motor switch in the up or down position and hold it closed until the tower moves out of limit-switch range. I then secure the motor up-down switch to a convenient point to hold it

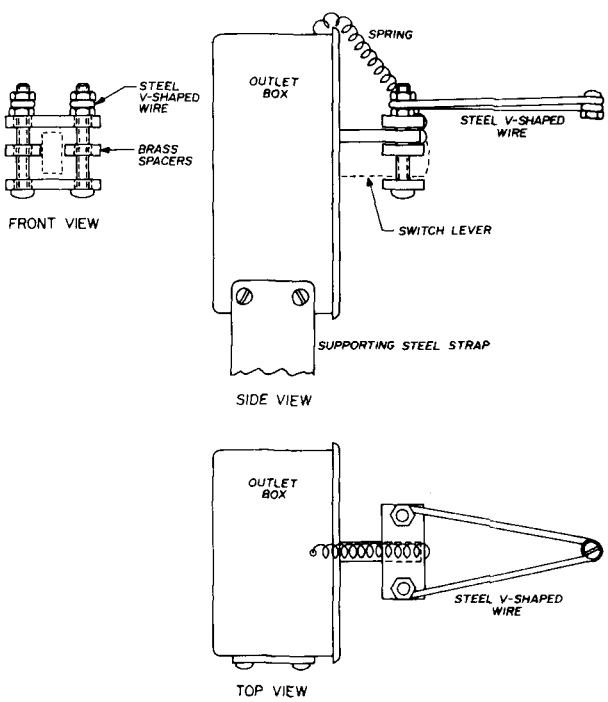

fig. 1. Details of home-made limit switches for an up-down tower. Switches are Leviton household mercury types mounted in standard outlet boxes supported by steel straps. The V-shaped wire trips the limit switches at selected points during tower travel.

on without further attention. Be sure you move the tower in the correct direction to get it out of the limit-switch range to avoid breaking a switch.

guy wires

Guy-wire failure is one of the greatest causes of tower catastrophes. Compromises here will surely result in a mass of twisted metal on yours or your neighbor's

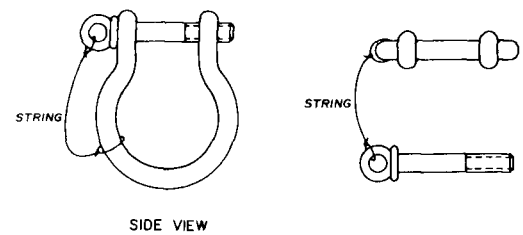

fig. 2. Clevis used to attach snatch blocks to tower braces or heavy eye bolts. These devices are available from marine-equipment supply houses and large hardware stores.

property after a storm. Use the best guy material you can find, with appropriate turnbuckles and locknuts. Check marine hardware suppliers for guywire hardware, such as thimbles and turnbuckles. Never pass an unsupported guy wire through and around a tower brace. Metal thimbles are available for this kind of rigging; they should always be used to relieve friction and eliminate metal fatigue. Crosby clamps should be used in sets of three on each side of strain insulators. Guy-wire anchors should be able to take the tension load of the guys attached to them. Again, reference 1 supplies the geometry and structural information for resolving this problem of antenna-tower installation.

climbing belts

Before you attempt any tower climbing, obtain a new "construction belt." The belt should have a 6-foot (1.8m) tether. Good belts, made of nylon, are available from supply houses serving the construction industry.* Don't buy an old leather belt from second-hand outlets.

The tether might seem a bit long, but it can be snapped around the tower, then tested to determine optimum working length.

antenna assembly and raising

Quads and Yagis seem to be the most popular beam antennas mounted on towers, so we'll discuss these. A quad antenna element can usually be assembled on a driveway or roof. If the quad is completely assembled, it can be placed with its boom next to the tower with the elements straddling the tower. My first quad was mounted on a 20-foot (6m) length of thick-wall aluminum tubing, guyed near the top, and resting on a fitting on top of a chimney. I used a tackle with double-sheave pulleys to lower and raise the mast. I assembled the

*Irving Air Chute Company, Industrial Products Division, Lexington, Kentucky 40500. Ask for model THOR-18.

antenna by standing on top of the chimney, with the quad boom within reach. The boom was slid to one end and an element was attached. I then secured the boom at its center, dressed the cables, and raised the mast without help. A similar approach was used on the tower, assembling one element at a time, with the top mast lowered.

The quad was later replaced by a large Telrex Yagi,

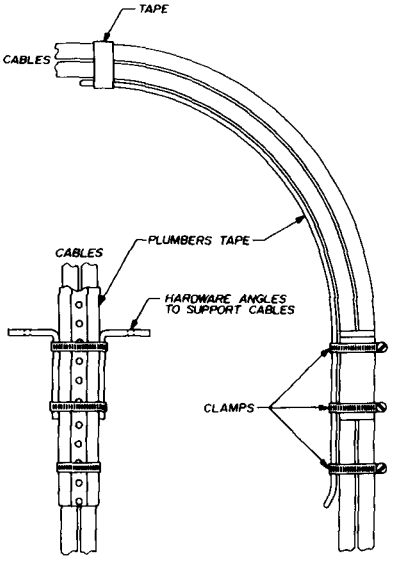

fig. 3. Support assembly for securing coax cable and rotator power lines to the tower. Plumber's tape limits minimum-radius bend for the transmission line, which is important to avoid breakage or short circuits. Clamps are ordinary stainless-steel hose clamps assembled with plastic electrical tape between clamp and cable bundle.

which was assembled on the roof. After assembling the antenna, I raised it to the tower top mast with the antenna elements oriented horizontally. An assembled antenna can be raised using a block and tackle suspended from an S-hook at the top of the top mast. Two lines, each twice the height of the mast, passed over a long boom and back to ground, can be held by assistants to keep the boom level while raising the antenna. Thus the rope can be released at one end and the other end pulled down.

rigging

The block and tackle were moved to the inside of the tower after the antenna was raised. A heavy eye bolt was mounted at the lower part of the top mast so that the mast could be raised to final position with the block and tackle. This assembly is also used to lift the top mast out of the rotator and top thrust bearing when rotator removal is necessary.

Except when used with the S-hook at the top of the top mast, the blocks were secured with a clevis, which is a U-shaped device with a threaded pin closing the open end (**fig. 2**). The pin has a hole in its head to which a light line may be attached. The other end of the line is attached to the U so that the pin will be there when you need it. Two such clevises are used; one is on a cross brace at the top of the tower, and the other secures the lower block to the heavy eyebolt mounted near the bottom of the top mast. With this arrangement, the entire antenna and top mast can be lowered to the top of the tower when the thrust bearing is released, or mast and antenna can be lifted a few inches out of the thrust bearing.

rotators

Rotator information is summarized for Telrex, WØMLY, and Cornell-Dublier, which produces the TR-44 and HAM-M. Little data is available at this writing on the Hy-Gain design since they no longer market a rotator for amateur use.

Telrex rotators feature worm and chain-link drive, antenna locking, and rotation limit switches. Two minutes are required for full rotation. A mast clamp permits rotator removal, but its size and shape aren't compatible for use with small towers. Rotating torques are available between 6000 and 18000 inch-pounds (69 to 207 kg-meters). Weight ranges between 52 and 145 pounds (23.6 - 65.8kg). Prices are in the $450 to $1100 range. A special 12-conductor cable is required.

The WØMLY rotator requires a 9½-inch (24cm)

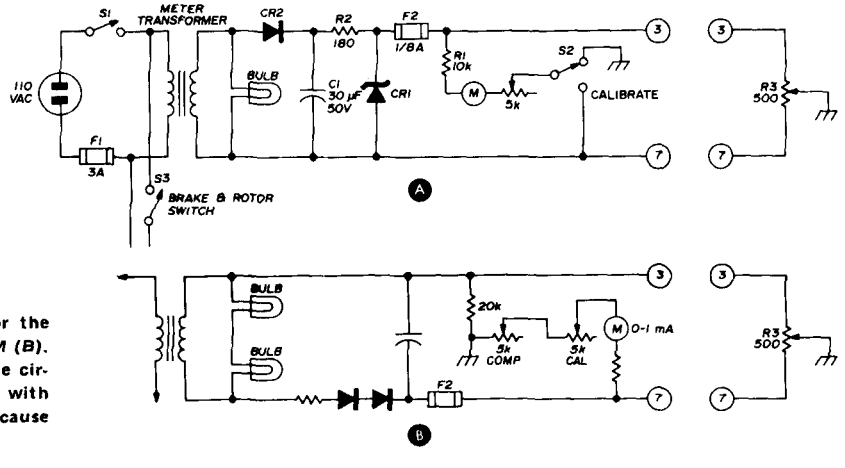

fig. 4. Rotator control circuits for the HAM-2 rotator (A) and the HAM-M (B). The HAM-M can be modified to the circuit of the HAM-2 for installations with varying line voltage, which will cause antenna-bearing errors.

mounting hole. It has a short steel mast to fit inside a 2-inch (5cm) mast diameter. The vertical length of the rotator assembly is about 24 inches (60cm), so it probably won't pass through the side of most amateur towers. It weighs 70 pounds (32kg), rotates in one minute, has high torque, promises 2-degree accuracy from its selsyn system, and its control unit is provided with a

New HAM-2 rotator and control box. Latest model of the popular Cornell-Dubilier HAM series, this antenna rotator system features a new break release control, separate directional control switches, and stainless-steel gears and hardware. The system is designed for up to 7 square feet (0.65m^2) of antenna wind load area.

world map (centered on mid USA). Price class is $425.00. A 10-wire cable is required.

Because of extensive experience with the HAM-M at my station, this rotator is covered in more detail below. The TR-44 uses the same control unit as the HAM-M and HAM-2. However, the TR-44 doesn't have a brake solenoid and has a lower rating in terms of antenna wind-area loading, turning torque, and brake torque. The TR-44 has a disc brake, whereas the HAM-type rotators use a steel wedge. The HAM types require not more than one ohm in two of the cables. Rotation time is 48 seconds. These rotators take mast sizes up to 2 inches (5cm) and are 8 inches (20cm) in diameter.

cable support

Cable installation will be determined by your particular situation. However, I'd like to offer some suggestions based on my experience. Coax cable should be dressed so that the radius of curvature is as large as possible. The rotator power cable and coax can be in one bundle. Make sure that adequate strain relief and slack are used to avoid problems when rotating the antenna or when raising or lowering an up-down tower. I use the method shown in **fig. 3** to support coax and rotator power cables on my tower. A piece of plumber's tape bent into a large radius supports the cable bundle. Two galvanized steel angles keep the assembly from sliding through the hanger on the cable outrigger. Stainless-steel hose clamps tie the assembly together. Small wooden dowels inserted into the cable bundle fill space between cables.

On the lower outriggers, the cable bundle should be tied to one side, which forces the loops to fall beyond the ends of the outriggers when the tower is fully extended. This precaution will prevent a loop of cable from catching around the end of a lower outrigger, which will break either the outrigger or a coax cable. Nylon rope is recommended for cable ties.

control unit mod

A slight modification can be made to the HAM-M rotator control unit that will benefit those with variable line voltage, which can cause considerable error in bearing indication. The HAM-M rotator may be modified by a slight rearrangement of the control-circuit resistors and by installing a 13-volt zener (part no. 50153-00 in the HAM-2 owner's manual). These devices can be obtained from other sources. The zener furnishes 13 volts in the HAM-2 compared with 21 volts in the HAM-M, so the fixed resistors in the HAM-M must be reduced in value and the ground connections changed. Both circuits are shown in **fig. 4**. The HAM-M circuit is a bridge, whereas that for the HAM-2 uses a simple variable shunt resistance across the meter and multiplier resistors. Either circuit will work with protective 100-ohm resistors installed at the ends of the rotator potentiometer, if the meter zero is reset below zero with current off and the calibration pot is then set for maximum meter reading.

It's well to enter information in your maintenance log such as all resistances between control unit and rotator, wire color code and connections, and circuit mods as described above. This might help to isolate problems in case of trouble without having to remove the rotator.

If the antenna doesn't rotate when you activate the control unit, check the ac electrolytic capacitor. In addition to the test suggested in the manual, try using two ordinary electrolytics about twice the value of the ac capacitor, connected back-to-back.

factory repair

The HAM-2 owner's manual mentions factory overhaul of a rotator for $15, a control unit for $12, or both for $25. If you need pinion gears or other expensive parts, this is quite a bargain. At this writing, a replacement rotator can be purchased for $82.95 directly from the manufacturer.*

As a final note, I suggest you list in your antenna maintenance log every bolt, nut, and other part used in the installation. Another item to include is the wrench sizes for every piece of hardware and where used so you won't be missing some tool when you climb the tower for maintenance.

*Cornell-Dubilier, Rotator Service Department, Fuquay-Varina, North Carolina 27526.

references

1. John J. Nagle, K4KJ, "How to Calculate Wind Loading on Towers and Antenna Structures, "*ham radio*, August, 1974, page 16.

2. Harry R. Hyder, W7IV, "Antenna and Tower Restrictions," *ham radio*, January, 1976, page 24.

ham radio

understanding the ZL Special antenna

One answer to the problem of building small, lightweight directional antennas on small parcels of real estate is the ZL Special, a close-spaced version of the two-element driven array. The ZL Special has been around for a long time, but not much has been published about it except for empirically derived data. The ZL Special offers light weight and compact physical size with little compromise in forward gain, front-to-back ratio, or sidelobe levels.

description

The ZL Special basic configuration is shown in **fig. 1**. Two folded dipoles spaced one-quarter wavelength apart are driven 90 degrees out of phase. Typical characteristics are: forward gain, about 3 dB and front-to-back ratio, about 20 dB. Several sidelobes appear when the antenna is placed at heights greater than one-half wavelength above ground. Approximate dimensions are given below, in which F is frequency in MHz, L is element in length, S is element spacing, and P is the phasing-line length for 90 electrical degrees of phase difference between elements:

$$L, \text{ element length (feet)} = \frac{468}{F}$$

$$\text{(meters)} = \frac{143}{F} \qquad (1)$$

$$S, \text{ element spacing (feet)} = \frac{245}{F}$$

$$\text{(meters)} = \frac{74}{F} \qquad (2)$$

$$P, \text{ phasing line length (feet)} = \frac{196}{F}$$

$$\text{(meters)} = \frac{60}{F} \qquad (3)$$

In previous descriptions[1] the ZL Special is shown as six tubular pieces comprising two radiating elements driven 135 degrees out of phase. Spacing between elements is on the order of 1/8 wavelength, and a transposed 300-ohm line is used as a phasing section, **fig. 2**. Claims have been made that the feedpoint impedance is about 70 ohms with this arrangement and that the antenna can be fed with 72-ohm line, although this is probably true only in special cases. The design will work, however, and the dimensions usually given are:

fig. 2 dimension, feet	(meters)
A = $438/F$	$134/F$
B = $447/F$	$136/F$
C = $101/F$	$31/F$
D = $122/F$	$37/F$
E = $110/F$	$34/F$

design for optimum performance

A more modern design would use 300-ohm line throughout, with bamboo or fiberglas supports and a simple aluminum boom. However, in this case the phasing line will be physically a bit shorter than the desired element spacing. As shown in **fig. 3** maximum gain for a parasitic element will occur at about 0.11 wavelength for a director and 0.15 wavelength for a reflector. Since the ZL Special has a "driven director-reflector," you might expect that optimum forward gain would occur between 0.11 and 0.15-wavelength spacing. This is indeed the case, and maximum gain occurs at about 0.123 wavelength spacing. In no event should less than 0.1-wavelength spacing be used, because not only does gain drop rapidly but the characteristic (feed) impedance changes drastically.

Empirical designs using 300-ohm line have shown that director lengths of $447.3/F$ in feet ($136.3/F$ in meters) and reflector lengths of $475.7/F$ in feet ($145.0/F$ in meters) are nearly optimum. These dimensions are somewhat longer than those given for the tubing version, primarily due to the much narrower width dimension of

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the 300-ohm elements. For example, in free space one-half wavelength in feet is $492/F$ ($150/F$ in meters), whereas in practice a folded dipole at ordinary heights will resonate at $468/F$ in feet ($143/F$ in meters).

Using 14.2 MHz as a design example, a free-space half wavelength is $492/F$ = 34.65 feet, or $150/F$ = 10.6 meters, which is 5.19 electrical degrees/foot (17 degrees/meter). The ZL Special dimensions are then:

director $447.3/F$ = 31.5 feet
($136.3/F$ = 9.6 meters)
reflector $475.7/F$ = 33.5 feet
($145.0/F$ = 10.2 meters)

element spacing 0.12 wavelength
= 8.5 feet (2.6 meters)

Compared to a resonant dipole, the director is shortened by (468 - 447.3)/468 = 0.044 or about 4.4%. Similarly, the reflector is lengthened over the dipole by (475.7 -

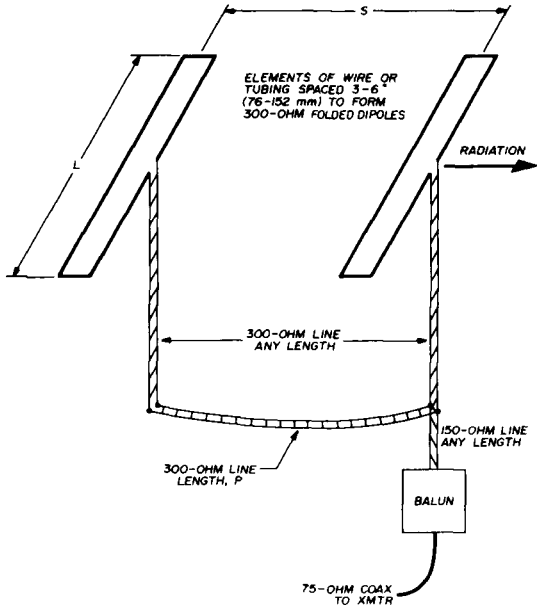


fig. 1. Basic arrangement of the ZL Special, a unidirectional quadraphased two-element array. (Essentially two half-wave antennas phased at 180 degrees.)

468)/468 = 0.0165 or about 1.7%. While these numbers aren't sacred, the difference between them is very close to optimum at (475.7 - 447.3)/447.3, or about 6.3%.

Similarly, for 20 meters a phasing-line length of 7.75 feet (2.4 meters) nearly always proves to be optimum. Making the assumption that the velocity factor of typical 300-ohm line will approximate 0.7, a half wavelength of 300-ohm line is $(492/F)(0.7)$ = 24.3 feet, or $(150/F)(0.7)$ = 7.4 meters. Then 180 degrees divided by 24.3 yields 7.4 electrical degrees per foot (24.3 degrees per meter) in 300-ohm line. Also, 7.75 feet (2.4 meters) of phasing line yields 57.5 degrees of phase shift.

Since the phasing line transposition adds 180 degrees in phase, the difference in phase between director and reflector is 360 - (180 + 57.5) = 122.5 degrees. Thus in

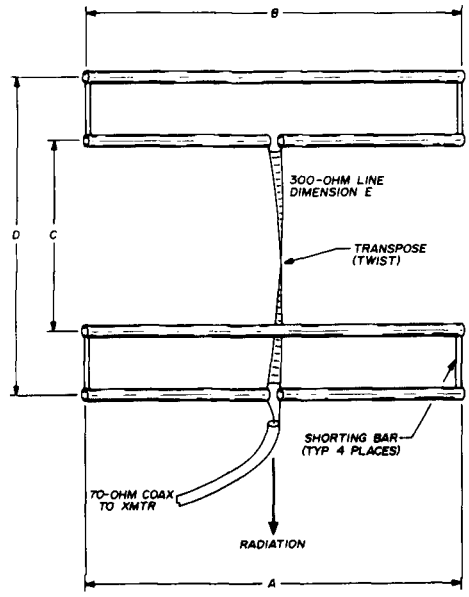


fig. 2. ZL Special using tubular elements. The two radiating elements are said to be driven 135 degrees out of phase; however this value is more like 115-125 degrees (see text).

truth, most ZL Special antennas don't employ 135-degree phasing but rather something between 115 and 125 degrees, depending on phasing-line velocity factor and empirical pruning.

construction

Construction may be as previously described, or as I prefer, using ordinary plastic plumbing pipe (known as PVC tubing). Placing the 300-ohm line into the pipe (no twists allowed) is easy, and T connectors provide additional rigidity for guying (**fig. 4**). **Fig. 5** shows a successful design at 14.2 MHz using the desired phasing line, but with the rear element bowed somewhat to allow for correct element spacing. You may think that the "delta" of the rear element aids in a smooth phase transition (as

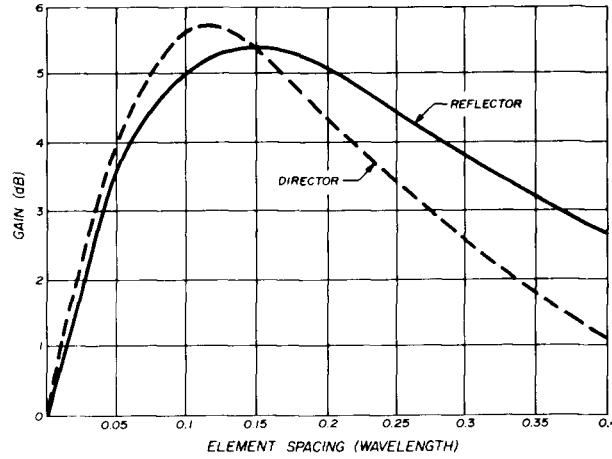


fig. 3. Maximum gain obtainable with a parasitic element over a ½-wavelength antenna alone, assuming parasitic element tuned for maximum gain at each spacing.

with a delta match), but this is a pure speculation. Construction is easy enough with bamboo or fiberglas supports, and still not too difficult with plastic plumbing pipe into which slots are cut to allow the rear element to pass forward to the phasing line.

Rather than simply feeding this balanced antenna with unbalanced coaxial cable, a balanced feed should be used. One method (other than using a balun transformer) is to make a 1/4-wave bazooka line as shown in **fig. 6.** Simply wrap aluminum foil around the last 1/4 wavelength of feed line, using plenty of overlap, then use masking tape to cover the foil. Apply several coats of

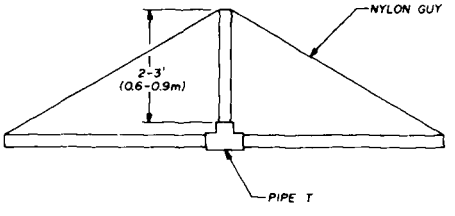


fig. 4. Suggested construction for a single element using PVC tubing and T connector (end view). The 300-ohm line feeds easily into the tubing (no twists permitted).

weatherproof compound to the tape. The foil may be secured to the coax shield by wrapping it tightly with a number of turns of wire.

performance

Performance should be quite broadband compared with a true parasitic beam, and the turning radius for the 20-meter example here will be only 17.3 feet (5.3m). Weight may be less than 10 pounds (4.5kg). Gain over a reference dipole should be 6 to 7 dB, with a front-to-back ratio of at least 15 to 18 dB. Don't forget to take into account the velocity factor of the coax when constructing the bazooka. The 1/4-wave bazooka length is about 11 feet 5 inches (3.5m) at 14.2 MHz. For those amateurs with more space, additional true parasitic elements may be added as in **fig. 7**, although the feedpoint

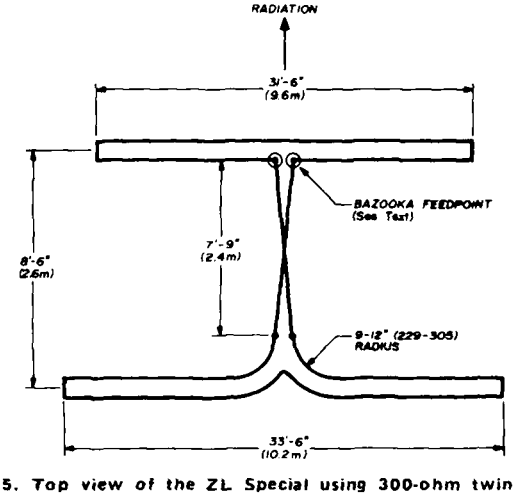


fig. 5. Top view of the ZL Special using 300-ohm twin lead. Design is for 14.2 MHz. Rear element is bowed slightly to allow for the desired element spacing.

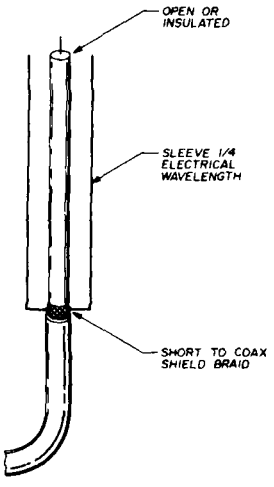


fig. 6. One-quarter wavelength balanced-to-unbalanced transformer for feeding the ZL Special with coax transmission line. Transformer is recommended for keeping antenna currents off coax, which degrade antenna pattern and may cause difficulty in transmitter tuning.

impedance will be lowered. For the basic ZL Special, feeding with 52-ohm line may require that the bazooka be made of 72-ohm line, which will yield a transformation of $(75)^2/52 = 108$ ohms to the antenna. This may be very useful, as the nominal 60 to 80-ohm feed-point

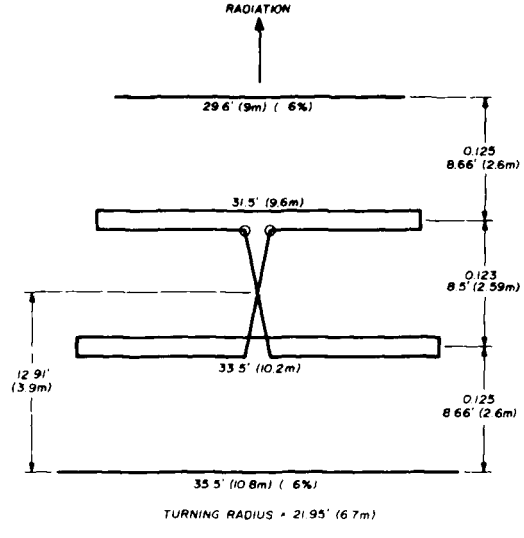


fig. 7. ZL Special antenna with parasitic elements. Typical parameters: input impedance approximately 40 ohms; gain referenced to a dipole at the same height about 13.6 dB; front-to-back ratio 28 to 35 dB. Space for slightly more turning radius is required for this version.

impedance might increase* for small heights (less than one wavelength) above ground. A 52-ohm line plus bazooka will match the ZL Special with parasitic elements reasonably well without further transformation.

The addition of true parasitic elements, when carefully tuned (not an easy chore), can yield gain and front-to-back ratios comparable with parasitic beams which have a greater number of elements.

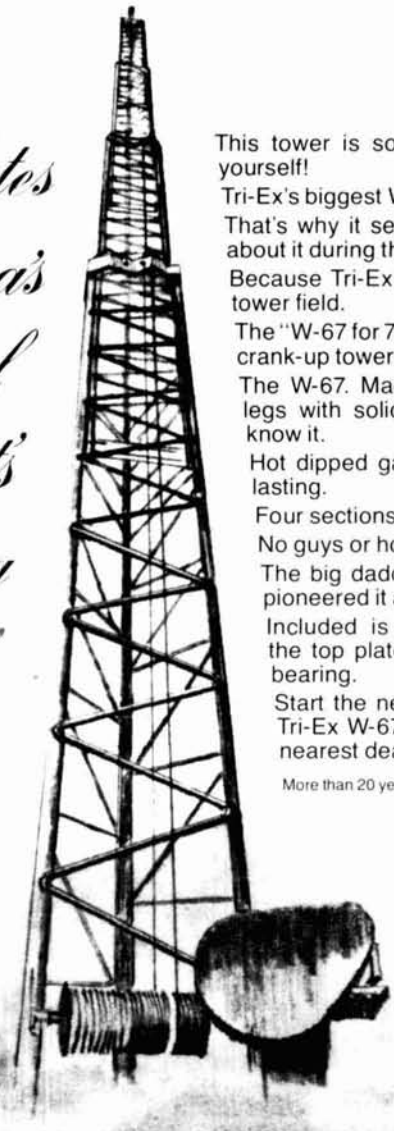
*On the other hand, the reverse may be true.

reference

1. *The ARRL Antenna Book*, ARRL, Newington, Connecticut, ninth edition, 1960, page 214.

ham radio

Tri-Ex Salutes America's Bicentennial Year with its Freestanding "W-67 for 76"



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Spirit of '76

5/8-wavelength vertical antenna for mobile work

Problems with loading coils are eliminated with this design — the coax feedline also acts as a matching stub

Most published 5/8-wavelength vertical antennas have used a base loading coil.[1,2,3] I built several of these but difficulty in obtaining components, weatherproofing, and adjusting the antenna for low vswr led me to seek a better design. This design[4] is mechanically simple, uses readily available components, and best of all is easy to adjust for a low vswr over the entire 2-meter band.

The antenna consists of a 5/8-wavelength radiator fed with a length of coax that also is the matching stub. A diagram appears in **fig. 1**. The mechanical components are simple. A short length of RG-58/U coax cable with the outer insulation removed and one end shorted, is slipped inside a piece of 1/4-inch (6mm) diameter tubing. The stub is connected electrically in series between the radiator and coax center conductor. The tubing is mounted in an insulator that attaches to a PL-259 coax plug. The feasibility of this design can be demonstrated by making an "emergency" antenna from a 48-inch (122cm) length of RG-58/U or RG-8/U cable, as shown in **fig. 2**.

electrical performance

A 5/8-wavelength radiator above a ground plane exhibits an impedance of approximately 50-j185 ohms[5] (see **fig. 3** or **table 1**). Thus its resistive component closely matches 50-ohm coax, but it's highly capacitive. To resonate this 5/8-wavelength radiator and provide a purely resistive load, an inductive reactance of approximately 185 ohms is needed, and a loading coil is usually used. A length of coax cable shorted at one end and less than 1/4-wavelength long also appears as an inductive reactance. If a 0.21-wavelength shorted coaxial stub is connected in series with the 5/8-wavelength radiator, capacitive reactance will be cancelled and a 50-ohm resistive load will be presented to the transmission line.

This coaxial matching scheme can be used with many vertical antennas. In the form presented, it can only compensate for an inductive or capacitive reactance.

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table 1. Impedance of radiators mounted above a ground plane with 50-ohm coax feed (calculated from reference 5).

radiator length (λ)	impedance (ohms) 1/4 in. (6mm) diameter	1/4 in. (13mm) diameter
9/16	111-j310	86-j240
19/32	71-j244	58-j195
5/8	50-j185	44-j147
21/32	39-j133	37-j105

Fortunately, radiator lengths between 9/16 to 5/8 wavelength have 40 to 65-ohm resistive components, depending on diameter, and can be easily matched by this technique. I've used this method of "hiding" the matching stub on collinear arrays using four 5/8-wavelength radiators[6] and also with collinear 1/2-wavelength radiators, rather than using conventional 1/4-wavelength open-wire stubs. The advantages of the coaxial design include no radiation from the phasing stubs and ease of constructing weatherproof arrays from available materials.

construction

Detailed dimensions of the components for a 5/8-wavelength whip are shown in **fig. 4.** The components are assembled as follows. Slip the 36-inch (91cm) long, 1/8-inch (3mm) diameter rod 1-1/2 inches (38mm) into the tubing and solder. You'll probably have to insert a soft copper or brass shim or crimp the tubing to make a tight fit. After joining, the radiator should be 47-1/2 inches (121cm) long overall, and the tubing should be unobstructed for at least 11-1/2 inches (29cm). Next, slip the modified PL-259 connector into the insulator. Epoxy-bond the sleeve, center portion and insulator into a single unit. Be sure to seal between the sleeve and insulator so water can't enter that joint.

The antenna can be made of stainless steel. Stainless-steel welding rods as well as stainless-steel tubing are easily obtainable at low cost. A special soldering flux* is necessary for soldering stainless steel. Use care to clean joints and the inside of tubing to prevent corrosion and to ensure a good solder job. An advantage of stainless steel is that its ductility is good. After several mishaps (garage door, bridges, vandals, trees) it was easy to straighten out an S-shaped whip with no degradation in performance.

At this point, you'll have three components: plug and insulator assembly, radiator, and the coaxial matching section. The coax should be carefully soldered at the short circuit so the coax will slide easily into the tubing. Tin the center conductor, cut the end of the braid, and slide the coax into the tubing until the end of the braid is flush with the tubing end. If you wish, the edge of the braid may be carefully soldered to the end of the tubing to ensure better mechanical and electrical stability, although it may also be simply tinned and wedged for a snug mechanical fit. Solder must be kept off the outside of the tubing so that the tubing will slide into the insulator. The coax may be loose inside the tubing with no adverse effects so long as it makes electrical contact near the unshorted end of the braid and can't slip in or out to change its effective length.

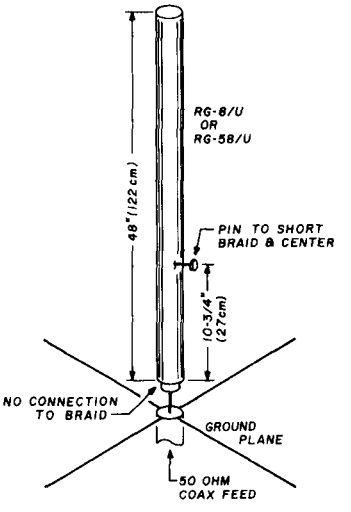

fig. 2. Example of an "emergency" 5/8-wavelength radiator made from coax cable. Outer braid is the radiating element.

When the coax has been inserted into the tubing, measure the distance from the tip of the PL-259 to the top of the insulator. Measure this same distance from the tip of the coax center conductor along the tubing, and scribe the tubing. The radiator tubing should now be inserted into the insulator to the scribe mark and the coax center connector soldered temporarily to check the vswr before applying the epoxy for the final assembly. The assembly shows less than 1.1:1 vswr over the entire 2-meter band. If not, check the dimensions of the coax and radiator carefully, and be sure braid and tubing are flush in the insulator. A 1/4-inch (6mm) error in the coax length will make a difference in vswr. If you wish to make the overall whip length somewhat shorter, say 42 or 43 inches (107 or 109cm), it will be necessary to

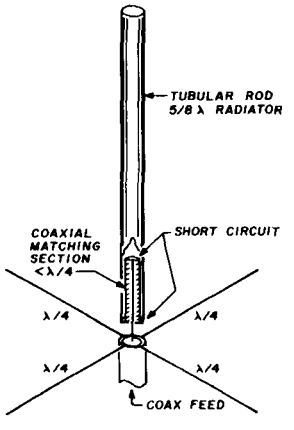

fig. 1. The 5/8-wavelength 2-meter antenna showing series-connected coax matching system. Increasing number of radials will decrease system ohmic resistance and increase radiation resistance.

*"Stay Clean" brand flux and "Stay Brite" solder are good for this purpose.

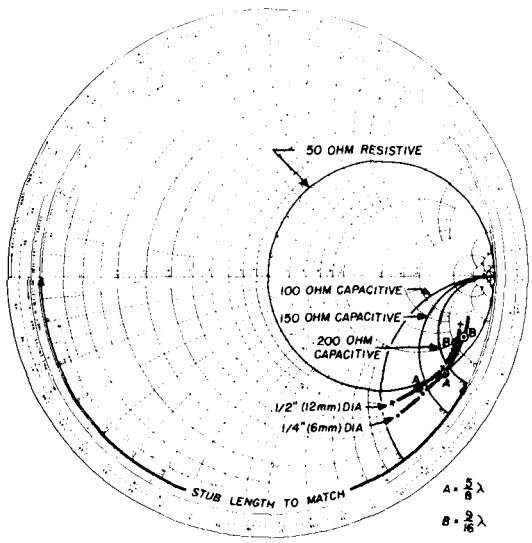

fig. 3. Smith chart showing impedance of 5/8-wavelength radiator mounted above a ground plane and fed with 50-ohm coax cable.

lengthen the coax matching section about 1 inch (25mm).

If the vswr is not very low, check at two frequencies, about 2 MHz apart if possible, and determine which vswr is lower. If the lower frequency shows a lower vswr, shorten the coax or shorten the radiator. If the higher frequency shows the lower vswr, the reverse applies.

vswr measurement notes

Most reflectometers and swr bridges don't appear as a purely resistive 50-ohm length of coax. When inserted into a flat (matched) line they may show an swr *not* representative of the true line swr, depending on the line length between bridge and load. When the "impedance" of the vswr meter is placed a multiple of one-half wavelength from the load to be measured, both appear effectively in parallel, sometimes causing questionable results. This is particularly true when very low (less than 2:1) vswr is being measured.

After much frustrating experimentation, I found that the *best* distance to place a vswr meter from the measured load is an odd multiple of one-quarter wavelength at the measuring frequency. Vswr measurements may be checked by adding short 1/8 to 1/4 wavelength lengths of coax to the line between reflectometer and load. For impedance measurements as well as vswr, I use a carefully constructed slotted line.[8] However, such a device is rather impractical to use on a roof or tower.

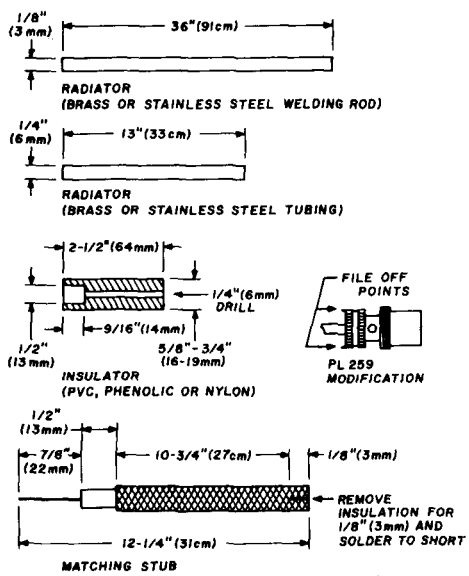

fig. 4. Dimensions of components used in the 5/8-wavelength vertical antenna. Brass or stainless steel may be used for the radiator; the latter is recommended (see text).

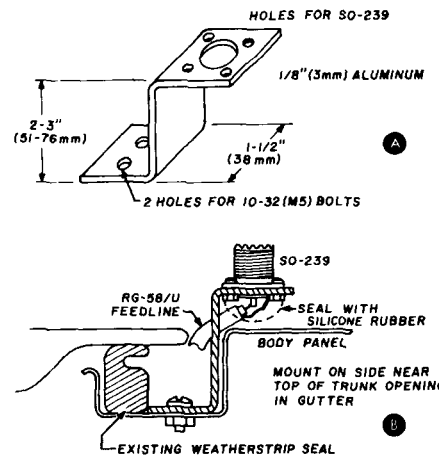

fig. 5. Mounting bracket (A) and suggested mounting details for an automobile trunk lid (B).

For best performance the whip should be mounted on a good ground plane. A mounting for a trunk-lid lip, which requires only two holes (invisible and easily patched), is shown in fig. 5. This antenna design can also be used on mounts that use the equivalent of an SO-239 fitting.

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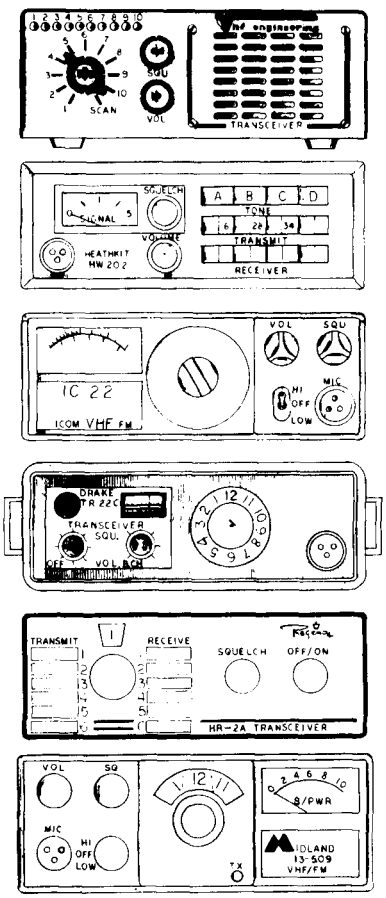

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More Details? CHECK–OFF Page 118

test data on 1/4- and 5/8-wavelength vertical antennas for two-meter mobile

Measurement results made under practical conditions to help you decide which antenna is best

Controversy still persists on the merits of 1/4- and 5/8-wavelength vertical antennas for two-meter mobile service. Measurements are difficult to make under conditions of multipath transmission between automobile and receiver. The elegant (but impractical) way to make a comparison is to drive over a prescribed route, with each antenna *in turn continuously emitting* constant power, while recording the instantaneous intensity of the signal.

Lacking such means, we decided to make a number of measurements at many fixed points on the road. At each point the 1/4-wavelength and 5/8-wavelength antenna was plugged into the bulkhead fitting on the top of my car. Intensity measurements were made by W2CQH using a precision attenuator on the i-f of his receiver to obtain constant S-meter values.

test conditions

The vehicle was a 1965 Plymouth Fury station wagon. Vehicle overall dimensions are 17.5 feet (5.3m) by 6 feet (1.8m). The roof is 9.5 feet (3m) by 4.6 feet (1.4m). The antenna bulkhead fitting was mounted in a hole drilled through the roof centerline 2.75 feet (0.8m) behind the windshield.

The 5/8-wavelength antenna was 3.96 feet (1.2m) long, fed through a 5½-turn coil, 1 inch (25mm) long and 1/2 inch (12.5mm) inside diameter, made with no. 14 AWG (1.6mm) copper wire. The top part of the antenna was a chrome-plated segmented whip 1/4 inch (7.5mm) in diameter, tapering to 1/16 inch (1.5mm). The reflected power was -19.5 dB.

The 1/4-wavelength antenna was 1.4 feet (0.4m) from the top of the PL-259 connector, which was 1.5 inches (38mm) high. Material was 1/16-inch (1.5mm) diameter stainless steel. Reflected power was -20.5 dB.

Equipment used for the mobile tests was a Midland 13-500 operating at 147.63 MHz. The transmitter delivered 13.4 watts to the bulkhead fitting through a 4-foot (1.2m) length of coax cable.

Transmitting points were 1.2 and 7.7 miles (2 and 12km) from the receiver. At each location the vehicle was moved 3 to 20 feet (0.9 to 6m) in a random fashion.

By Bill King, W2LTJ, and Reed Fisher, W2CQH, 5 Midwood Drive, Florham Park, New Jersey 07932

table 1. Attenuator settings for a constant S-meter reading, test point 1 (1.2 miles or 2 km from receiver).

attenuator setting (dB)		
1/4 λ antenna	5/8 λ antenna	Δ dB
22	27	5
24	26	2
17	20	3
17	23	6
11	16	5
20	22	2
14	20	6
24	26	2
23	26	3
22	24	2

average gain, 5/8 λ over 1/4 λ antenna = 3.6 dB. one standard deviation = 1.7 dB.

Tables 1 and **2** show the attenuator settings at the receiver and the differences between each antenna at each transmitting point. Note that the statistical term "one standard deviation" is used in these tables. In **table 1**, for example, one standard deviation is shown as 1.7 dB. A standard deviation of 1.7 means that the average is estimated to lie between 3.6 + 1.7 and 3.6 - 1.7 with 67% confidence.*

Remarks from contacts with amateurs who heard about these experiments led to further experiments to compare a stainless-steel and a copper 1/4-wavelength

table 2. Attenuator settings for a constant S-meter reading, test point 2 (7.7 miles or 12 km from receiver).

attenuator setting (dB)		
1/4 λ antenna	5/8 λ antenna	Δ dB
12	15	3
11	11	0
10	10	0
-3	4	7
9	15	6
16	18	2
18	18	0
19	20	1
17	17	0
12	13	1

average gain, 5/8 λ over 1/4 λ antenna = 2.0 dB. one standard deviation = 2.6 dB.

whip under the same conditions. These tests were conducted with no difference in gain noted between the two antennas.

concluding remarks

The purpose of this experiment was to compare 2-meter vertical antennas made from materials used by amateurs, using methods to the best of our ability to obtain practical data. We recognize the professional literature and the way of doing business on model ranges. Presented here are our data to consider when making your choice between 1/4- and 5/8-wavelength vertical antennas.

*Not strictly correct mathematically but good enough for practical purposes. **Editor**

ham radio

antenna rotator

for medium-sized beams

Adapting TV rotators for postive directional control at reasonable cost

Most amateurs operating in the 10-15-20-meter bands use lightweight two- or three-element quads or three-element Yagis whose size and weight typically range from the Mosely TA-33 and CL-33 tribanders to the four-element 20-meter monobander such as Hy-gain's 204BA. These antennas weigh up to 40 pounds (18kg) and have a wind-loading surface area up to 7 square feet ($2m^2$). When looking for a rotator there's very little middle ground; these antennas are too large for a low-cost TV rotator but don't really justify the $100 to $200 cost of larger rotators (whose control systems leave something to be desired for operating convenience). For the mechanically inclined, the prop-pitch motor is an answer — if you can find one. However, these machines require mechanical modification plus design and construction of control circuits. This article describes an intermediate rotator system having superior operating features.

It isn't the weight of the beam, or even the rotator's ability to turn it, that's important in rotator selection; most TV rotators will *turn* much heavier beams than I've mentioned. Of more concern is braking resistance and lateral thrust, which involves the antenna's wind-loading area and turning radius. Wind forces and stopping torque determine what's needed for a rotator.[1]

Wind forces act in two directions on the rotator: a horizontal torque attempts to turn the beam off its heading (windmilling), and a vertical torque attempts to fold the rotator upon itself (lateral thrust). With enough space inside a tower, the lateral thrust can be transferred to the tower by placing the rotator inside it. But the forces attempting to turn the beam off its heading must be borne by the rotator. Note that it's not the steady, strong wind but gusts that do the most damage by causing the beam to oscillate. Following a series of articles published some time ago,[1] I installed a CL-33 tribander operated by a C-225 Alliance TV rotator. This system was at 40 feet (12m) surrounded by trees at 65 feet (19.8m), which provided some protection from wind. The rotator was backed up by an Alliance thrust bearing and was not inside a tower. Over a four-year period this rotator was just about equal to the task but wouldn't have long withstood an unprotected wind environment. Experience gained with this system encouraged me to find a way to improve it for an antenna system above the trees.

The design of the Alliance rotator is concentric with the mast, so a rotator system can be devised using two or more rotators. This arrangement, if the rotators are spaced a foot (30cm) or more apart, improves lateral thrust resistance while increasing the ability of the system to withstand windmilling. The additional rotators are mechanically in tandem, so the problem is to parallel their electrical control.

desired features

Some ideal features for a rotator system are:

1. An effective braking system.
2. Set-it-and-forget-it noiseless control.
3. Compass-rose control readout.
4. Automatic resynchronism of beam heading and control in case of rotator/mast slippage.
5. Avoidance of complex modifications or nonstandard parts.
6. Independent real-time position readout.

This is a tall order and isn't achieved in most amateur installations except very expensively. Using parts from Alliance TV rotators will fulfill the first five requirements; by bending the rule for special parts you can go all the way.

The mechanical-drive arrangement for the Alliance rotators discussed in this article is identical; their braking system is very effective. Not only does the gear train use a worm gear, effective in itself, but through a clever arrangement the motor at rest presents more resistance to rotation then when operating. I don't believe this rotator can be forced to turn without permanent damage. (Don't pin the rotator shaft to the mast!)

For wee-hour operating and DXing I prefer a control

By Forrest E. Gehrke, K2BT, 75 Crestview, Mountain Lakes, New Jersey 07046

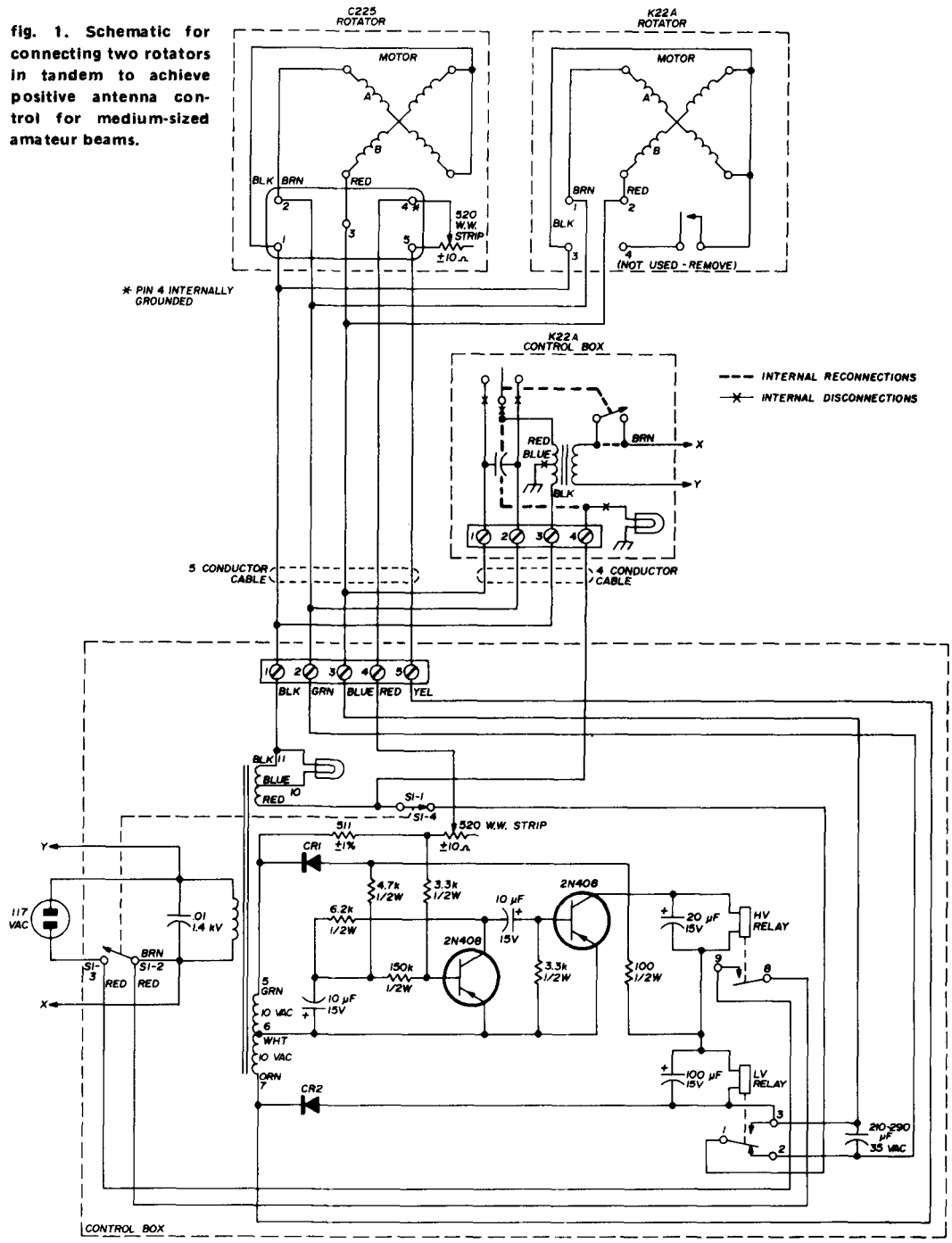


fig. 1. Schematic for connecting two rotators in tandem to achieve positive antenna control for medium-sized amateur beams.

that doesn't make a lot of clacking noises, can be set to a new heading without keeping a finger on a switch until the beam gets there, and allows a quick visual determination of great-circle headings (dial in the form of a compass rose).

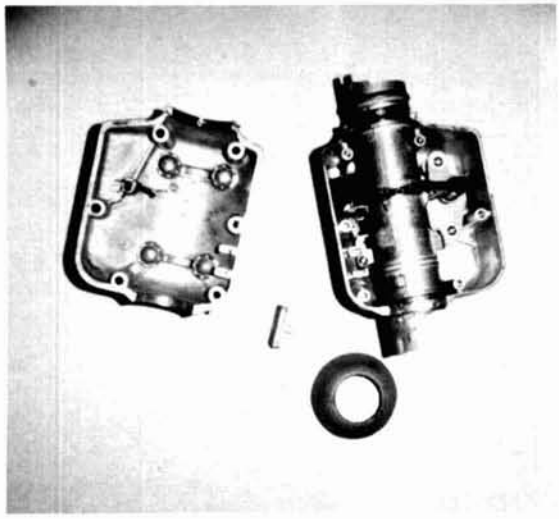
description

The Alliance model C-225* includes a control that meets these criteria. The control circuit is a transistorized bridge using in one of its arms a resistance element proportional to heading. As long as the rotator shaft maintains itself in the same position with the mast, synchronism of control and beam is automatic and reproducible. The circuit is highly reliable, in fact more so than a similar control for a much higher-cost rotator designed for larger arrays.

For additional rotators you don't have to make the same investment since only one control is needed. The Alliance model K-22A, also available from Lafayette,

*Lafayette Radio Electronics, 111 Jericho Turnpike, Syosset, New York 11791.

will provide an additional rotator and the required extra transformer and motor capacitor. These parts are connected into the C-225 control as in **fig. 1**. The K-22A control is a small plastic box and isn't objectional in appearance, so I left the needed components in their original positions and disabled the control switch by removing and taping up the leads. Only three connections must be made within the C-225 control. All other interconnections are made between the numbered control terminals. Be certain you color-match connections correctly between the two transformers and that you



Disassembled Alliance K-22A rotator with T-stop removed.

follow the numbered terminals in the schematic. This must be done to obtain correct supply phasing and proper motor rotation direction. It's a good idea to hook up this system on the bench with rotators not mechanically joined to ascertain proper operation. Avoid operating only one rotator with two motor capacitors in the circuit or the motor will rapidly overheat. The C225 rotator will determine your rotation stop direction, so be sure to return its rotation position to a known direction before mast assembly. (Most amateurs in North America use south as the stop direction.)

Adding one additional rotator to the C-225 control didn't present any problems with its actuator switch or relays because of the additional current. However, increasing the number of rotators above two will require relieving the existing control switches and relays of this higher current. This can be done with additional relays or with triacs having higher current-handling ratings, but it becomes a bit more complex and the choice is left to the knowledgeable experimenter. Because the drive-mast diameter is only 1-3/8 inches (3.5cm), I don't recommend an antenna load needing more than three driving rotators. For example the inertia of a large array such as a Wilson 520 was difficult to manage with such a small drive mast, even though the rotators were inside a tower and adapted to a larger-diameter mast above the rotators.

The stop in the K-22A rotator must be removed because the relative position of the two rotators is not important. Carefully pull off the plastic collar on the top of the rotator, remove the six screws in the wells around the housing, and lift off the smaller half of the housing. Lift out the T-shaped stop and also remove the two contact springs from the terminal board. Reassemble, making sure that the original wiring color code is maintained. If the stop were not removed, each rotator would have to be in exactly the same rotational position at the time of assembly to the mast. Furthermore, if one rotator slips relative to the other, their changed stop positions would no longer allow full 360° rotation. Note that should the C-225 rotator slip (the one with the sensing potentiometer) the antenna heading will no longer agree with the control. If the change in rotation stop direction is only a few degrees, the fix for this is to pull off the control pointer and push it back so that the pointer agrees with the changed antenna heading.

After a high wind, an observation is recommended as you may find that the rotation-stop direction has slipped, or that rotator operation will result in wrapping too much coax around the mast. In this case there's no alternative to correcting the problem at the rotator. However, if your location is free of high winds or protected, this two-rotator system is quite adequate and economical. I operated such a system for two years, accepting an occasional small change in rotation stop direction by changing the control pointer. These changes tended to cancel out over a period of time. This inconvenience can be overcome making the system independent of rotator/mast slippage while using this slippage to advantage.

I've been discussing the problem of slippage and yet I've cautioned against pinning the rotator/mast coupling. Why not pin all mechanical couplings? Pin all except one, but leave one sufficiently weak link in the drive chain, preferably the rotator/mast coupling. This is insurance for all your effort and expense against unusually high winds. If something *has* to give, it should be here where no harm is done. Also, the oscillation induced by wind gusts and the sudden starts and stops of normal operation will produce early fatigue failure if the rotator clamps are too tight or have been pinned.

When unattended, it's good practice to leave the array pointing in the direction of least resistance to prevailing storm winds, making sure your rotation stop is located well away from that direction. Determining the position of least resistance is a matter of experimentation with your particular array. For the Mosley CL-33, it's with the ends of the elements pointing into the wind, but for some arrays you may find the boom must be so aligned.

automatic resynchronism

While attempting to build a system of four rotators to drive a stacked five-element array for 15 and 20 meters, I burned out the motor of one rotator on the bench by forgetting I had four capacitors across the single motor. This rotator housing was resurrected and used only for the sensing potentiometer and the mechanical rotation stop. The motor and gear train were removed, leaving

nothing to prevent this shaft from rotating with the mast within the 360° turning range. Now the driving rotators can slip relative to each other and to the mast in any amount, but as long as the single mechanical stop isn't reached, automatic resynchronism is achieved the moment the control is actuated thereafter. If high winds should force the mast off the control heading, the sensing potentiometer position, which freely turned with the mast, will be changed. As soon as it's actuated, the system will turn the mast in whatever direction is necessary to rebalance the bridge, re-establishing identity between mast and control heading. An extra K-22A rotator is the cost for this feature, but it's effective and readily available. I now have a rotator system that has control operating features unobtainable with most commercial rotators. This system has been in trouble-free use for three years and with no need to readjust the rotation stop.

These rotators have been designed for a standard 1-1/4 inch (3.2cm) pipe drive mast. Actual OD of this pipe is 1-3/8 inches (3.5cm). The rotator shafts have an ID that allows a little more than 1/16-inch (1.5mm) clearance. Use of shim material is advised to avoid flexure fatigue failure of the die-cast metal shafts because of the slight eccentricity this clearance creates. I cut some rectangular strips of 0.030-inch-thick (1mm) aluminum sheet 1 inch wide by 4 inches (2.5 by 10cm) long, wrapped them around the mast, and forced them between mast and rotator shafts at each end before installing the clamps. An excellent service manual is available from Alliance.* The manual is highly recommended as source information on operation of the control and also contains a useful trouble-shooting procedure in the event of a problem.

independent real-time readout

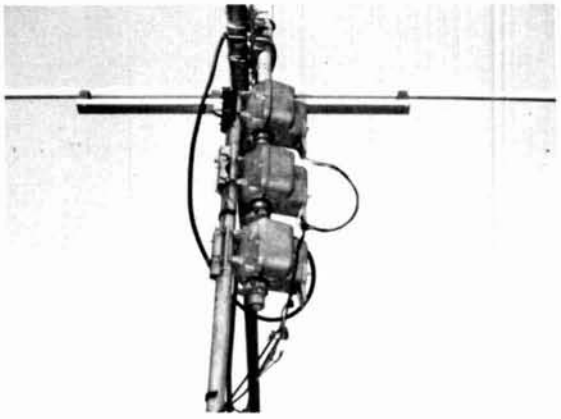
As with the previous additional feature, this refinement is optional. While automatic resynchronism is reliable, a readout independent of the rotator system is reassuring. Besides, it is sometimes useful to know the beam heading, even while rotating. Surplus 400-Hz synchronomotors were tried.† With a 7.5-volt 60-Hz supply a slight uneveness of motion (slot lock) was noted in the receiver synchro but was unobjectionable for the purpose. Because the transmitter synchro is driven directly from the mast, a special part is needed. The drive-wheel diameter must be identical to that of the mast. It was machined on a drill press from a piece of 1/4-inch (0.6cm) Lucite. My approach was to make the diameter 1/32 inch (1mm) undersize, machine a groove into the rim, fill the groove with silicone rubber, then smooth to size and cure. Silicone rubber is the only friction-drive material I've found that withstands weather. I used the same material to seal the cable opening in the motor, which is exposed to the weather. Note that the synchro motor is mounted on a metal bracket flexed so that it maintains drive-wheel pressure against the mast.

*Alliance Manufacturing Company, Inc., Alliance, Ohio 44601.

†Number SP-34 available from Meshna, Post Office Box 62, East Lynn, Massachusetts 01904.

The hookup provided with the synchros requires any one of the windings to be reversed when friction driven, so that the receiver synchro rotates in the same direction as the mast (the transmitter synchro turns oppositely). Of course, you could mount the transmitter synchro upside down, in which case the hookup should be followed as is.

A means of attaching the synchro through a small flexible shaft to the mast where it protrudes from the bottom rotator was considered but not tried. It is, of course, the better solution since it precludes slippage.



Two-rotator antenna drive with third rotator housing for potentiometer and rotation stop.

When an ice storm caused such slippage, I merely shifted the position of the receiver-synchro pointer to the new direction. I used the minute hand from a discarded clock for a pointer; however, any lightweight material may be used. The receiver synchro is mounted behind a great-circle map centered on New York City. At a glance I can see the antenna heading, whether moving or stationary. During high winds I can see the beam slipping position, a good indication that the antenna is not properly pointed into the wind.

conclusion

Being interested in electronic servo controls, I found this project to be fun. Out of it I formed a high respect for wind forces, especially after watching an 80-foot (24.4m) free-standing tower go down with my two five-element Yagis aboard (it's now securely guyed).

Most amateurs plunk down their money for a rotator, take what's commercially available, and accept the lack of convenience in control. The market doesn't warrant sophisticated control at a price most amateurs would be willing to pay. I've used low-cost automatic control aimed at a larger market and adapted it to popular amateur beams. Modifications are minor, require no hard-to-obtain parts, and are well within most amateur skills.

reference

1. E. Laird Campbell, W1CUT, "Antenna Rotators and Indicators," *QST*, April, May, 1967.

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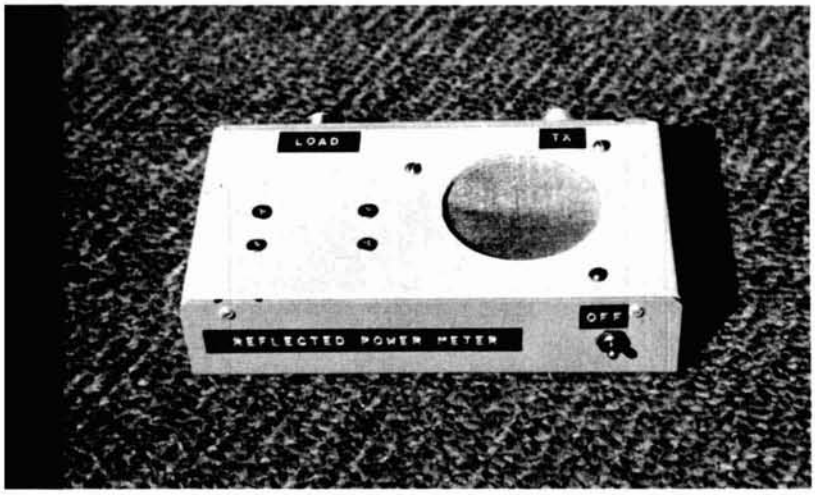


aural swr indicator

for the visually handicapped

Simple but effective impedance-matching circuit using an audio oscillator

A method of checking standing waves on a transmission line is a necessity in any amateur station. Most conventional circuits for measuring standing-wave ratio use the principle of the Wheatstone bridge or one of its variations and a high-impedance voltmeter. The voltmeter impedance must be high compared with the transmission-line impedance and also must have provisions for measuring the voltage applied to the bridge as well as the voltage applied to the bridge arms. Note that such a circuit is used to *measure* voltage standing wave ratio. Most amateurs are interested in obtaining the best possible impedance match between source and load, rather than measuring vswr, so much less sophisticated circuits than the swr bridge can be used.

A special problem exists for the blind amateur, who must rely on aural rather than visual clues to determine if the best possible match exists between source and load. The circuit shown here was built for a friend who had been using a noise bridge to adjust his matchbox antenna tuner. Not only has this swr indicator circuit saved him time, it has also helped him verify all tuning adjustments to his transmitter. This circuit is also useful for the seeing amateur, because swr can be checked aurally while watching meters.

circuit description

The swr indicator circuit is shown in **fig. 1**. An "inductive trough" transfers rf energy from the transmission line between source and load to a simple aural

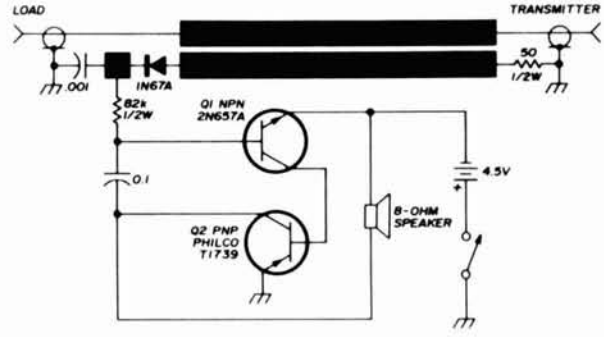
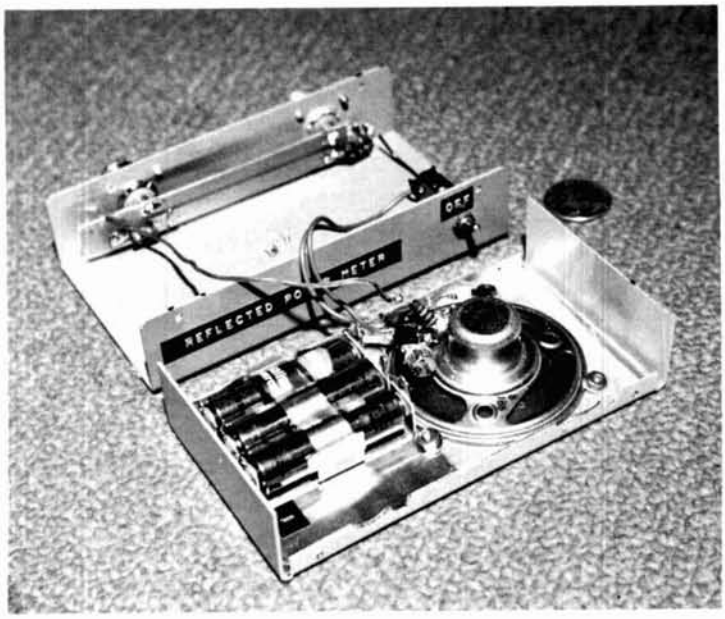


fig. 1. Aural swr indicator schematic. Darkened areas are foil strips that form an inductive circuit between source and load and audio circuit. Resistor in the base of Q1 may be increased to lower the audio tone

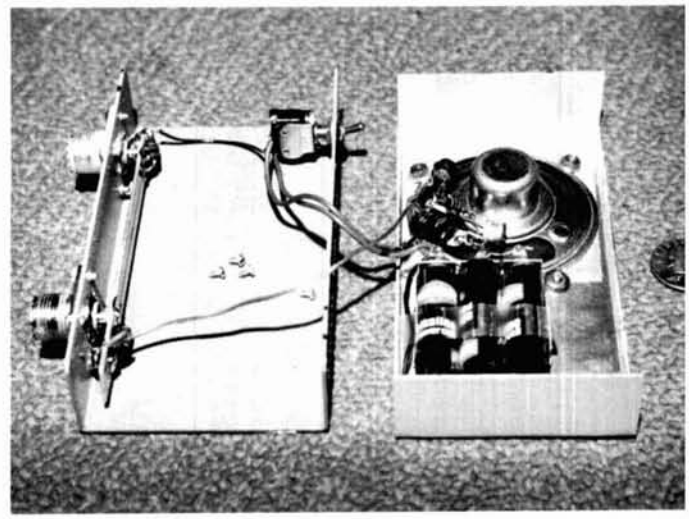
By Charles G. Bird, K6HTM, 875 Lindo Lane, Chico, California 95926



Inside the swr indicator. Foil strip inductive trough is in Minibox cover. Electronic components are wired directly to speaker terminals.

monitor.[1] The trough consists of two foil strips about ¼ inch (6mm) wide and 2-3/4 inches (70mm) long. They are spaced 1/16 inch (1.5mm) apart. One of the strips is the main conductor between coax connectors from source to load. The other strip transfers rf energy from the first strip to a germanium diode, which rectifies the rf energy to a dc voltage. This dc voltage changes the bias on the base of Q1, which causes the tone from the speaker to increase in pitch with increasing voltage.

The two transistors, 0.1 μF capacitor, and 82k resistor are mounted on the speaker terminals. Q1 and Q2 were salvaged from a surplus PC board. Their main requirements are reasonably high gain to establish oscillation and large enough dissipation to cause a loud tone. With the circuit constants shown, the idling tone is about 500 Hz. All components including three penlight batteries are enclosed in a 5½x3x1¼ inch (14x7.6x3cm) Minibox, LMB CR531.



W6HNL holds the swr indicator, which is connected between his transmitter and antenna tuning unit.

operation

Ideally only the reflected wave is sampled so that minimum swr will exist when the transmitted tone matches the idling tone. If the transmitter and load cables are transposed, a forward reading will be heard as an increase in pitch. In practice, especially on the higher frequencies, it won't be possible to match the reflected tone with the idling tone because of stray capacitance. This is an advantage when using a matchbox since it's easy to peak the transmitter for maximum output on the rising pitch, then tune the matchbox for minimum swr on the descending pitch. The indicator may be left in the circuit at all times.

Thanks to W6HNL for his enthusiastic approval of the device.

reference

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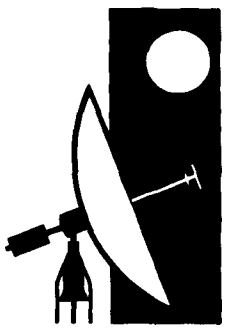
ham radio



vhf/uhf techniques

Joe Reisert, W1JAA

feeding and matching techniques for vhf and uhf antennas

If two or more amateurs get together in one place, more than likely antenna performance is one of the subjects to be discussed. This should come as no surprise because amateur antennas usually do double duty – working on both receive and transmit. Therefore, any performance degradation affects both the receiver and transmitted signal strength. Those amateurs who have good antenna systems not only receive best, they also radiate the strongest signal (all other things being equal).

A full discussion of antennas is obviously beyond the scope of this column, so I will concentrate on antenna feeding and matching techniques – both of these things affect not only the homebrew specialist, but also the owner of a commercial antenna. And, although this column is directed primarily to the vhf and uhf enthusiast, many of the same techniques are equally applicable on the lower frequency bands.

feed systems

The principal feed systems used on vhf/uhf antennas (see **fig. 1**) are the split dipole, folded dipole, delta match, tee match, gamma match and log periodic. Each of these has its own advantages and limitations, not to mention the personal preferences of some users; I'll discuss each of them and you can choose the one that you prefer. The split dipole (**fig. 1A**) is about the simplest way to feed a Yagi. Its major drawbacks are the need for insulating the feed from the boom and its low feedpoint impedance (typically 15 to 25 ohms) when this system is used to excite a Yagi beam. Hairpin loops or matching stubs are often used for impedance matching, but a balanced feedline or a balun is still desirable (more on this later).

The folded dipole (**figs. 1B** and **1C**) solves some of the problems of the simple split dipole and is a choice of many active vhf operators. One reason for its popularity is that the center of the folded dipole, opposite the feedpoint, can be directly connected to the boom. The arrangement shown in **fig. 1B** multiplies the nominal feed impedance by four times so it provides a more convenient impedance match to popularly available transmission lines.

If the input impedance of the simple folded dipole doesn't provide an impedance match, the variable ratio scheme of **fig. 1C** can be used. By changing the spacing, S, and/or the diameter ratio, $d1/d2$, this system can be used to provide a match to a variety of different transmission line impedances (see reference 1).

Above 225 MHz many amateurs have experienced problems with the folded-dipole matching systems shown in **figs. 1B** and **1C**. W1HDQ has discussed this problem in some detail[2] and offered the matching scheme in **fig. 1D** as a possible solution. Ordinary flat straps of metal can be used for element $d2$.

The folded dipole and its several variations can be used to match most antenna impedances. It's efficient, works well with popular balanced transmission-line impedances (200 to 300 ohms), and is easy to duplicate once a match has been obtained. The primary disadvantage of the folded dipole is the cut-and-try approach which is required when you have to match a new antenna.

The delta match down in **fig. 1E** is actually an extension of the W1HDQ's folded dipole in **fig. 1D**, is easy to build, and can provide a match to a wide range of balanced feedline impedances. The feedpoint impedance is adjusted by varying lengths $\ell 1$ and $\ell 2$ or the ratio $d1/d2$. However, some radiation can occur if $\ell 1$ and $\ell 2$ are large with respect to wavelength. This may lower antenna efficiency and increase side lobes, or both.

The tee match in **fig. 1F** is similar to the delta match but is less prone to radiate. Adjustments to $\ell 1$ and S and/or the ratio $d1/d2$ will provide a match to most feedline impedances. Capacitors C1 and C2 are necessary to tune out the inductive reactance of the feed system. In some cases the length of the dipole can be shortened slightly to eliminate the need for C1 and C2. The tee match is also designed for balanced feedlines and physical restrictions may limit its use above 450 MHz. The principal disadvantage of this system is the requirement for capacitors (if used) which may be sensitive to power level and weather conditions.

The gamma match in **fig. 1G** is a simplification of the tee match and is designed for unbalanced feedlines so

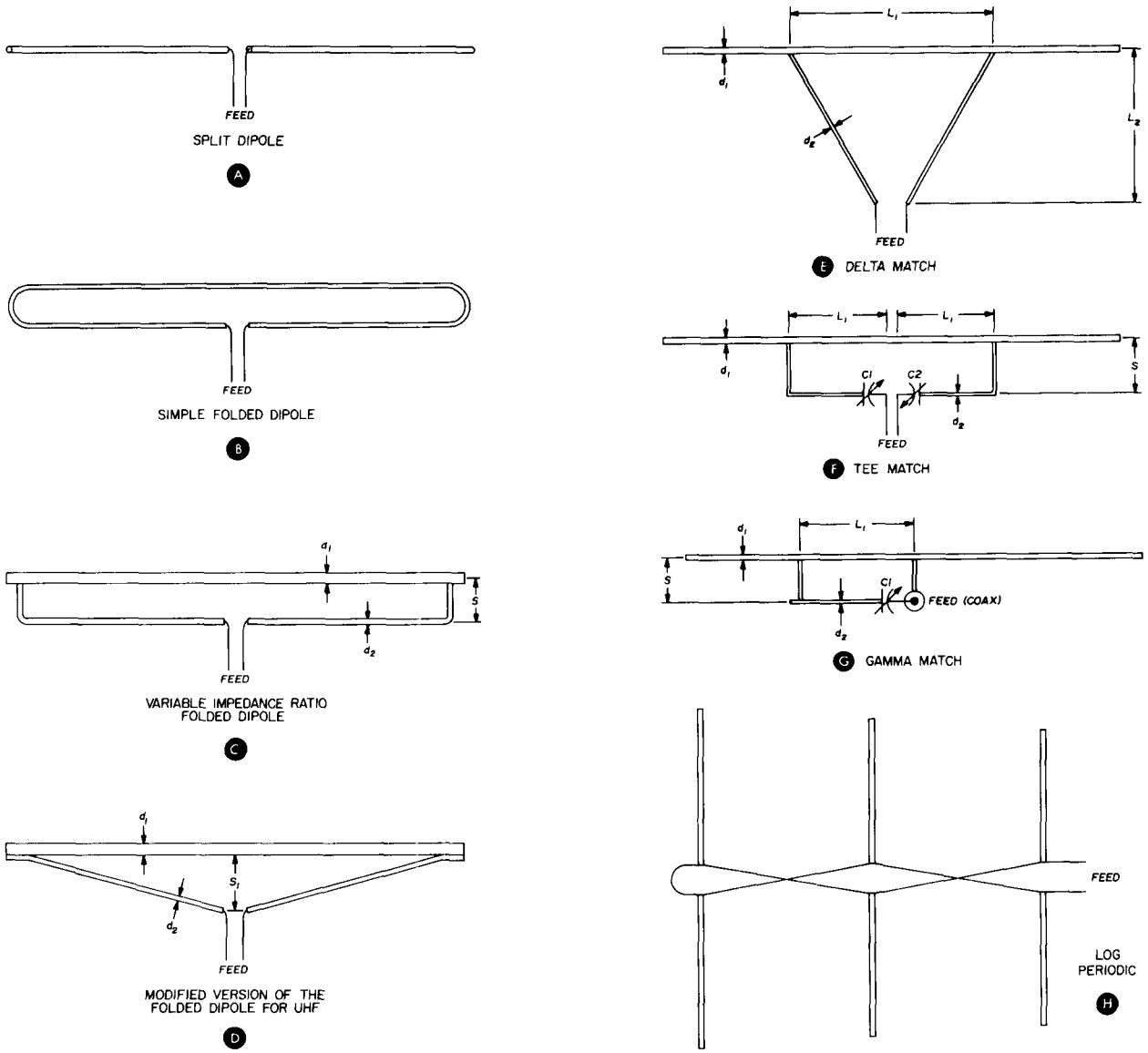


fig. 1. popular feed systems used on vhf and uhf antennas. The split dipole, folded dipole, delta match, tee match and log-periodic feed are balanced systems so a balun is required if coaxial transmission line is used. The gamma match (G) is an unbalanced system so can be used directly with coaxial cable.

coaxial transmission lines can be connected directly without a balun. The gamma match is also easy to use when different feedline impedances are desired (such as is required with circularly polarized feeds). As with the tee match, the major disadvantages of the gamma match are the capacitor and physical restrictions. A complete mathematical treatment of the gamma match is contained in reference 3.

The log-periodic feed in **fig. 1H** is relatively new and is a spinoff from the log-periodic antenna.[4,5] Two of the advantages of this type of feed are the convenient feedpoint impedance (typically about 50 ohms) and wide bandwidth. Its disadvantage is the cut-and-try which is required when this system is used to match a new antenna. Also, it is a balanced feed.

feedlines

No vhf antenna article would be complete without a short discussion of feedlines, so I will digress for a moment and discuss some important feedline considerations. The main objective when choosing a transmission line is to keep the loss as low as possible, but unfortunately this creates a big tradeoff in cost vs performance. However, you should give due consideration to the benefits of a low-loss transmission line, especially if a very long feedline is required. Why put up a large, high-gain

antenna array and then lose half or more of your transmitter power (or received signal) because of high transmission-line loss?

Most amateurs are well aware of the fact that antenna height is a big factor in vhf/uhf performance. However, there is a law of diminishing returns. Once the antenna is

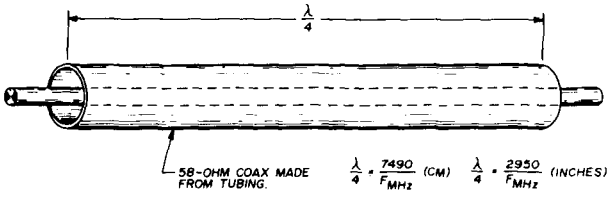


fig. 2. A quarter-wavelength coaxial transformer can be used to match a 50-ohm coaxial cable to semi-rigid 70-ohm CATV transmission line. The diameter is not important, but the ratio of the inside diameter of the outer tube to the outside diameter of the inner conductor should be 2.6:1 for a characteristic impedance of 58 ohms.

high enough that it clears most local objects and has a clear horizon, further increases in antenna height (and hence performance) may be offset by the extra feedline loss necessary to achieve that height. Therefore, put your antenna only as high as is absolutely necessary.

In recent years the trend has been toward coaxial cable instead of open-wire line or twinlead. This is because coax is easy to handle, doesn't radiate very much power, and is compatible with most modern vhf equipment (50-ohm transmitters, receivers and vswr bridges, etc.). In addition, more and better coaxial cables are becoming available, particularly on the surplus market.

So far as choosing a particular coaxial cable is concerned, small diameter RG-58/U should not be used, especially above 30 MHz. RG-8/U can be used in short runs but should be the foam-filled type with a good, full-coverage shield. Many of the bargain RG-8/U cables have only 95 per cent shielding (or less) so are very lossy at the higher frequencies. RG-8/U is particularly adaptable for running a line from an antenna, around a rotator, and to a tower. However, a lower loss transmission line should be used from the top of the tower to the radio shack.

The larger RG-17/U which is popular with many vhf/uhf operators can cause problems in areas with large temperature variations (such as New England). The expansion coefficients of the inner conductor and shield are different, so the center pin on the coaxial connector may pull back during cold weather, opening up the circuit to the antenna. This can be partially eliminated by rigidly mounting the end with several clamps (such as hose clamps). Another possible solution to this problem is the use of a type-LC coaxial connector in conjunction with an LC to type-N adapter. Type-LC connectors have more overlap on the center pin and are less likely to completely disengage in cold weather.

Semi-rigid, foam-filled coaxial cable in the ½-inch (13mm) and 7/8-inch (22mm) sizes is highly recommended. *Heliax*,* especially the air-filled type, is probably the most desirable. Semi-rigid and *Heliax* cables are usually expensive but they exhibit very low loss and have a long life expectancy, so they pay for themselves both in performance as well as in the years of service they render.

One real bargain in coaxial cables has become available in recent years because of the increased number of CATV installations. These installations often use low-loss, semi-rigid, foam-filled 70- to 75-ohm coaxial cable (in both 1/2-inch [13mm] and 7/8-inch [22mm] sizes). In many cases the unused ends of reels of this cable are given away or sold at low prices by the CATV companies. The connectors for this cable, although expensive, are not as high priced as those sold for popular semi-rigid 50-ohm coax. If you're concerned about the use of 70-ohm transmission line, a simple quarter-wavelength coaxial transformer made from 58- to 60-ohm coax will easily transform a 70-ohm line down to 50-ohms (see **fig. 2**).

Twinlead is also an acceptable feedline for vhf use. However, only the low-loss outdoor types should be used. Federal K200, when available a few years ago, was very useful. The only major problem with twinlead is its response to moisture – even the slightest amount of dampness can adversely affect both vswr and line loss.

Although skipped over quickly, open-wire transmission line, if properly installed, is useful at vhf and uhf. The line insulators should be spaced about 5 to 7 inches (13 to 18cm) apart and should be made of a low-loss material such as 1/4-inch (6.5mm) Teflon rod. Line spacing should be small in proportion to wavelength for minimum radiation (0.75 inch or 19mm maximum at 432 MHz, proportionally smaller at higher frequencies).

The best places to use open-wire transmission line are in matching and feed harnesses in large arrays and where the line will not be subjected to pulling or twisting. To prevent radiation losses the vswr on the lines should be below 3:1. Open-wire lines in multiple lengths of one-half wavelength are excellent for coupling between baluns and matching stubs (this subject will be discussed in detail in a future column).

Before leaving the subject of feedlines it should be noted that low vswr at the antenna is highly desirable at vhf and uhf, especially when line losses are high (greater than 1 or 2 dB). A 3 dB feedline loss will increase to 4 dB if the antenna vswr is 3:1, and to 6 dB for a 7:1 antenna vswr! This condition may go partially undetected because a lossy line will dissipate part of the reflected power from the antenna so a vswr indicator located at the transmitter end of the line will not see the true vswr at the antenna. The solution, of course, is to have a well-matched antenna and low feedline loss.

baluns

The present trend, as noted above, is to coaxial transmission lines. On the other hand, most of the feed systems which are used at vhf and uhf are designed for balanced feedlines (**figs. 1A through 1F and 1H**). If an un-

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balanced coaxial transmission line is connected directly to a balanced feed system there is a *possibility* that the transmission line will radiate energy, distorting the antenna's radiation pattern and possibly lowering gain. I use the word "possibility" because if a system is perfectly matched, there should be no need for a balun (per recent

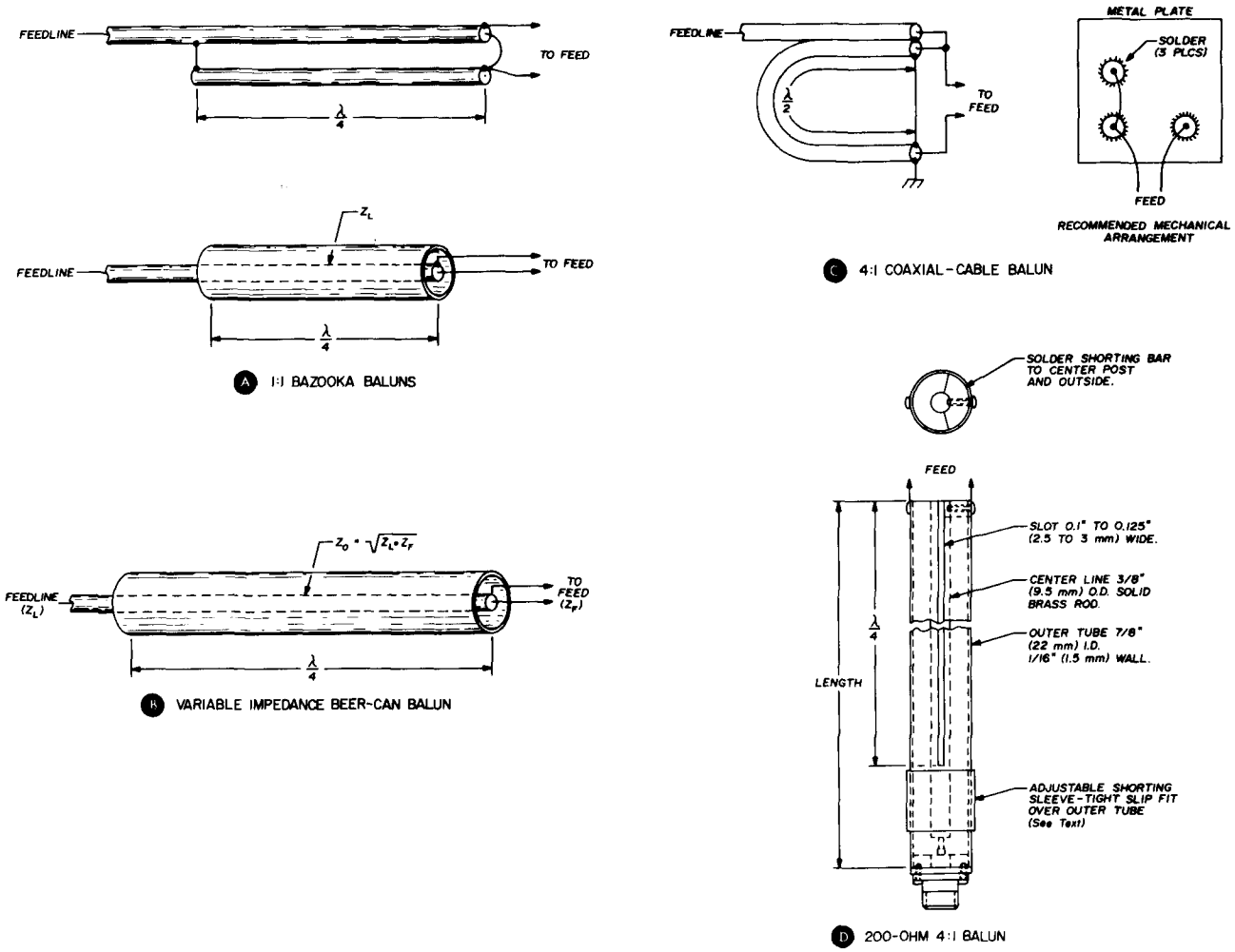

fig. 3. Various types of balanced-to-unbalanced transformers (baluns) which are suitable for vhf and uhf. Simplest type is the 1:1 bazooka balun shown in (A). The beer-can balun (B) can be used to provide an impedance step-up or step-down. The simple balun in (C) uses a half-wavelength of coaxial cable but the common ground should have low impedance; this can be accomplished with the metal plate shown to the right. The 4:1 balun in (D) can easily be set on frequency with the adjustable shorting sleeve and has no problems with undesired resonances.

conversations with several antenna experts). Unfortunately, a perfect match is seldom achieved, and if it is, it usually occurs only at one frequency. Therefore, the use of a balun, a balanced-to-unbalanced line transformer, is recommended. A good balun will prevent rf currents from flowing on the outside shield of a coaxial line, thus forcing all rf current to be confined inside the cable. Although you may have heard differently, suffice it to say that the use of balun should not degrade antenna performance – it may actually improve performance.

Baluns come in various shapes and sizes as illustrated in **fig. 3**. One of the simplest types is the so-called "bazooka" or 1:1 balun shown in **fig. 3A**. In this balun the quarter-wave line acts as a trap to any rf current on the outside of the shield. For best performance the spacing between the lines should be at least two to three times the outside diameter of the feedline.

Another form of bazooka balun, often referred to as the beer-can balun,[6] is shown in **fig. 3B**. Varying the impedance of the feedline for the last quarter wavelength (inside the balun), provides an impedance step-up or step-down which can be used to conveniently match a resistive impedance other than the feedline impedance.

The simple 4:1 balun shown in **fig. 3C** requires an electrical half-wavelength coaxial cable, preferably low-loss type (such as foam-filled RG-8/U). Since the cable is an electrical half-wavelength long, it will be shortened by the velocity factor, v_p, of the line used. Velocity factors for most popular cables are published in the ARRL *Radio Amateur's Handbook*.[7] The impedance of this

line is not important for narrow-band work (less than 10 per cent bandwidth) common in vhf or uhf amateur operation. For wide bandwidth the impedance of the line should be equal to the geometric mean between the line and the feed impedance (100 ohms when using a

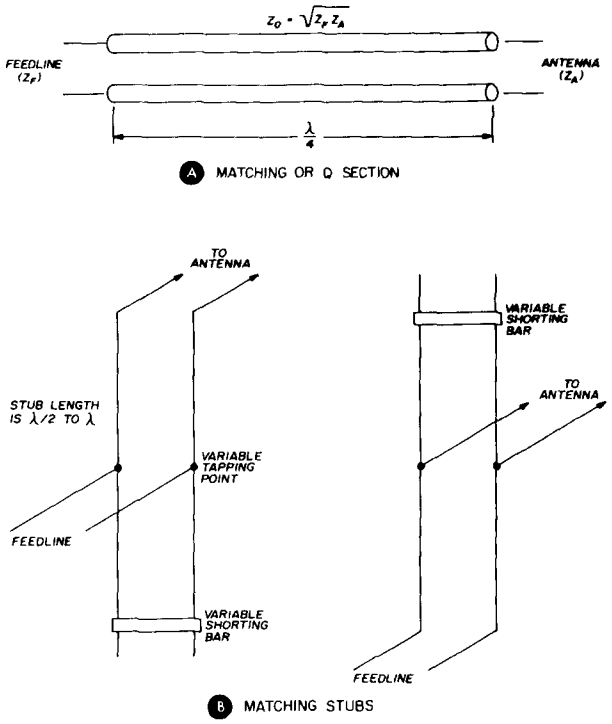

fig. 4. Matching stubs suitable for vhf and uhf. The Q section in (A) is often used if the antenna feedpoint is resistive (no reactance). The half-wave matching stub in (B) can be used to match virtually any impedance to another. The matching stub in (C) is used in those rare cases where the device to be matched is non-reactive and close to the impedance of the feedline.

50-ohm feedline and a 200-ohm antenna). The geometric mean is calculated with the following equation:

$$Z_g = \sqrt{Z1 \cdot Z2}$$

where Z_g is the geometric mean, and $Z1$ and $Z2$ are the line and feed impedances.

There is one very important consideration when using this simple balun: The ground connection at all junctions should have low impedance. In many cases the shields are simply twisted together and soldered – this causes loss and mismatches to exist. A better system is to make a small metal plate with three holes that will pass the outer braid of the cable as shown in **fig. 3C**. The braid is then dressed back and soldered to the metal plate. Use care to keep heat to a minimum by allowing the plate to cool off between soldering operations.

My favorite balun is the 4:1 type shown in **fig. 3D** which has been used by the National Bureau of Standards. This is essentially a low-loss 50-ohm coaxial line with two quarter-wavelength slots cut on opposite sides of the outer conductor. A simple shorting sleeve can be used to precisely set the balun on frequency. There are no problems with undesired resonances such as those sometimes associated with the beer-can balun (where more than one tuned element is used). In addition, the line in **fig. 3D** has no impedance steps so it is easy to build. For a more comprehensive list of balun types I would recommend reference 8.

matching networks

Since variable capacitors and inductors become a practical problem at vhf and uhf (capacitors become inductive, and vice versa), impedance matching at these frequencies is usually accomplished with tuned lines or matching stubs as shown in **fig. 4**. Matching stubs are both versatile and very efficient.

The familiar Q bar in **fig. 4A** is very handy if the antenna feedpoint is resistive (no reactance). The spacing of the rods and rod diameter are set by the geometric mean of this feedline impedance, Z_F, and the antenna feedpoint impedance, Z_A. A quarter-wavelength 283-ohm section, for example, would match a 200-ohm feedline to a 400-ohm antenna.

Usually the antenna or feed system (such as used on a collinear antenna) is not purely resistive so it's necessary to use a matching stub as shown in **fig. 4B**. A stub which is a half-wavelength long can match virtually any impedance to any other impedance with good vswr. In that rare case where the device to be matched is non-reactive and near the impedance of the feedline, the lines can be swapped as shown in **fig. 4C**.

matching techniques

With discussions of feedlines, baluns and matching networks out of the way, we can finally start talking about some matching techniques. The most popular

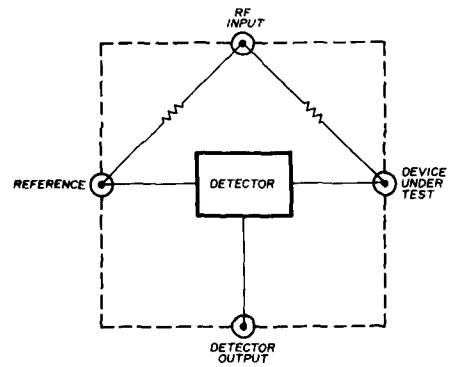

fig. 5. Simplified schematic of a vswr bridge for vhf and uhf. In use a reference load (usually 50 ohms) is compared to the device under test. If they are equal there is no output from the detector.

methods make use of a reflectometer, slotted line, network analyzer, vswr bridge or hybrid directional coupler. As with feed systems, each method has its own distinct advantages and limitations.

The reflectometer or moni-match is a form of directional coupler which uses either wire loops or a torodial

pickup. Although this device is inexpensive and works well below 50 MHz or so, at uhf it is frequently too crude and many require *watts* of power to operate.

The slotted line is one of the old stand-by vswr measurement techniques. By moving a probe along a partially

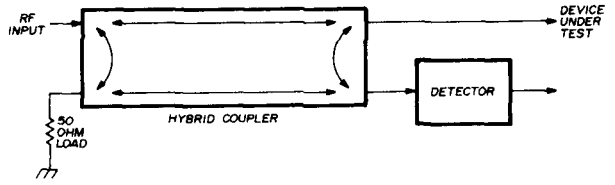

fig. 6. Hybrid coupler provides a convenient method for measuring impedance mismatches. When the device under test is tuned for minimum detected output a 1:1 vswr is virtually assured.

exposed transmission line the vswr can be interpreted by measuring the volt peaks and valleys along the line. Also, with careful calibration and some simple arithmetic any reactance presented by the antenna can be measured, then transferred to a Smith chart for interpolation. A slotted line is excellent for making precise, low-power vswr measurements. Its main drawbacks are size (at least one-half wavelength long) and use. For use on 432 MHz, for example, the slotted line must be at least 13 inches (33cm) long but a 26-inch (66cm) line is preferable. This limits the use of the slotted line to frequencies above about 400 MHz.

In addition to its size and weight, the slotted line is cumbersome to use because you must move the probe carriage back and forth after each matching change to see if you have made an improvement. Slotted lines that are suitable for amateur measurements are described in references 9 and 10.

The network analyzer is a powerful test instrument which has become very popular among microwave engineers during the past ten years. It directly displays vswr on a Smith chart and is easy to use. The primary drawback is cost, typically $10,000 or more, so its use is limited to those who have access to it in a professional laboratory.

The vswr bridge has been around for a long time, but it hasn't attained the popularity which it deserves. It's inexpensive, simple to build, and easy to use. Several are available on the commercial market. A simplified schematic is shown in **fig. 5**. This device works on the same principle as the low-frequency bridges which are common to test equipment. If an rf input is present, the power will divide between the reference and the device under test. If the reference (usually a non-reactive 50-ohm load) and the device under test are equal, the detector output will theoretically be zero. If the device under test is not equal to the reference, a voltage will be present at the detector output.

To use the vswr bridge to match a 50-ohm antenna, all that is necessary is a non-reactive 50-ohm reference load. You simply tune the antenna for minimum voltage from the detector. The beauty of the vswr bridge is that it can be used to measure various impedance levels simply by changing the reference load. Also, by substituting a known mismatch load for the device under test, the vswr can be quickly determined by interpolation.

My favorite uhf matching technique is based on the use of a hybrid directional coupler (**fig. 6**). If the antenna is properly matched, theoretically no power will reach the detector. However, even the slightest vswr will cause a detected output. All you have to do is tune your antenna for minimum detected output and a 1:1 vswr is virtually assured.

In this column I have discussed feed systems, feedlines, baluns, matching networks and matching techniques. Low-loss feedlines and low vswr have been stressed for obvious reasons. In a future column I will discuss measurements more thoroughly, and will recommend some easy-to-build test equipment which you can use to evaluate your own antenna system. Hopefully this article will inspire you to do more work on your antenna system and hence improve the performance of your vhf/uhf station.

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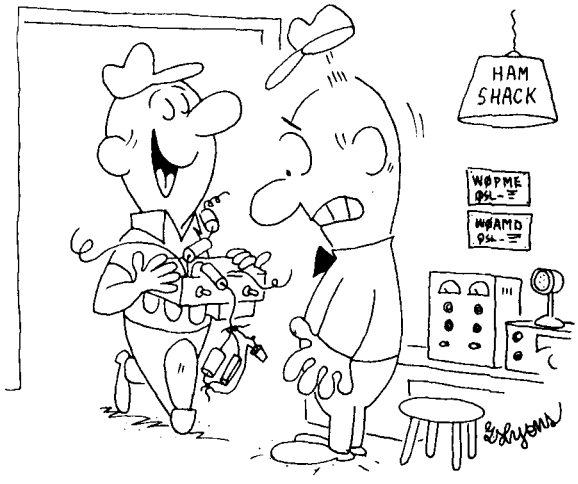

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antenna gain

Dear HR:

Antenna gains still seem to be an area of fuzziness. In microwave work it is proper and useful to refer power gain to an isotropic radiator in free space.[1] However, at high-frequencies, which concerns the majority of amateurs, confusion sets in. The IEEE standard states:

For horizontal polarization . . . the reference antenna may be a half-wave dipole at the same height. In this case the gain of the reference antenna is taken as 8 dB, which represents the approximate sum of the 2.15 dB free-space gain of a lossless half-wave dipole and the 6 dB augmentation due to the assumed perfectly conducting earth.

In other words, a simple half-wavelength dipole, which we all know well and can put up for very little money, has a power gain of 8 dBi per IEEE Standard 149.

In some cases gain is referred to an isotropic radiator at the same height and foreground. In these cases (and you are not always clearly informed as to whether the free-space condition is being used as a reference), you should deduct 2.15 dB. However, if the reference isotropic radiator is in free space, 8 dB must be deducted.

For high-frequency amateur commercial work there is no reason to go to the free-space isotropic radiator and back again to the reality of the half-wave dipole. The practical basis of comparison is always a half-wave dipole at the same height and foreground. The earth is always there. Unless, of course, you want to make the antenna you are working on seem better than it actually is. To state gain relative to a half-wave dipole, deduct 8 dB from the gain figures given per IEEE Standard 149 measurements or calculations.[2]

Even by discounting 8 dB, you cannot be sure that you have brought dBi back to a reference which you clearly and unambiguously understand. The claimant may be talking about *directive gain*. This reference, which is permissable and is defined by the IEEE, is derived from mathematical integration of the antenna pattern, and you may find that the antenna patterns are calculated, *not* measured or proven. That is, if the claims are based on anything substantial. In some cases they may be deduced from a partial measurement of the full spatial pattern.

Under the directive-gain definition there can be large losses in the antenna and ground such that, for transmitting purposes, an 11 dBi log-periodic beam could lay down a smaller field than a garden variety, half-wavelength dipole.

The Electronic Industries Association has also introduced an antenna gain standard. EIA Standard RS-409[3] says:

The gain of a lossless half-wave dipole shall be used as a standard gain unit . . . and . . . the power gain of an antenna shall be expressed in dB over the gain of a lossless half-wave dipole, or dBd.

It would be helpful if the amateur antenna manufacturers, magazine publishers and advocates of a particular high-frequency antenna design would stick to the EIA dBd.

Now, concerning log-periodics and the gains mentioned in discussion of them. As an example, I rate the *ARRL Antenna Book's* presentation,[4] taken from the excellent work of K4EWG, as first rate. However, when the average amateur reads that a well-designed log-periodic dipole array has "approximately 7.4 dB gain over a half-wave dipole," he will skip over the discussion of the design constant, T, and the relative spacing constant, σ. He will also read that, "Tilting the elements toward the apex will increase the gain 3 to 5 dB." Wow, he thinks, 7.4 + 5 = 12.4 dB gain!

However, the truth is that he would be better off with two or three 3-element Yagis (one for each band). The National Bureau of Standards made measurements on a 26-element, double-curtain, high-frequency log-periodic[5] and found that beamwidths were about 70 degrees. Gains measured 4.5 to 6.4 dBd. Another report on log-periodics,

1. "IEEE Test Procedure for Antennas," Standard 149, *IEEE Professional Group, Antennas and Propagation (PGAP)*, May, 1965. Also see definitions of terms, *PGAP*, May, 1969, and IEEE Standard 145-1973, *PGAP*, January, 1974.
2. Paul D. Rockwell, W3AFM, "Station Design for DX," *QST*, September, 1966, page 51.
3. "Minimum Standards for Amateur Radio Antennas," EIA RS-409, December, 1973, ($2.00 from EIA, 2001 Eye Street, Washington, DC 20006).
4. "The Log-Periodic Dipole Array," *The ARRL Antenna Book*, 13th edition, 1974, page 160.
5. P. P. Viezbicke, "Measured Performance of an HF LP Antenna," *NBS Report 6705*, June 20, 1960.
6. Jean E. Adams, "Measurements of the Performance of Two HF LPs," *IERTM-ITSA 94*, June, 1967.

from ITSA, is referenced to IEEE power gain.[1,6] Over the frequency range for 4 to 30 MHz the beamwidths were 39 to 70 degrees for the high-frequency log-periodic. Gains, converted to dBd by subtracting 8 dB, were 4.2 to 6.6 dBd.

Beamwidths for the VLP described in the ITSA report were 45 to 120 degrees over the frequency range from 6 to 30 MHz. Applying the 8 dB correction factor, the gains were −8.6 dBd to +2.9 dBd. The particularly disappointing results for the VLP are attributed to ground losses, end loading and unbalance, although the site (a rice paddy) and ground mat were probably much better than most amateurs could provide.

This is not to say that log-periodics are always bad. They pay their way, for example, as wideband television receiving antennas, or where full frequency agility is required as in some military applications. However, I don't think they can be justified for competitive DXing by amateurs.

Paul D. Rockwell, W3AFM
Chevy Chase, Maryland

non-synchronous impedance transformer

Dear HR:

The application of the non-synchronous impedance transformer in *ham notebook*[7] was especially interesting, and in my opinion, worth a further look. Unfortunately, the author did not discuss bandwidth except in very general terms.

Using the 2:1 transformation described by Mr. Keen, I checked his transformer against the conventional quarter wave for bandwidth at the 10% and 30% points as represented by lengthening (or shortening) the 28.13 degree length required for each section. The vswr as seen by the generator for the non-synchronous transformer is 1.14 and 1.52 against the quarter wave being 1.12 and 1.38, respectively, at 10% and 30% above the design frequency.

Though the bandwidth in terms of vswr is compromised, the difference is only about 2½ per cent when applied to the "widest" band, 75 to 80 meters. Perhaps the most profound advantage is that it requires one-third less space for matching when compared with the traditional quarter-wave section.

W5TRS is to be congratulated for bringing forth the good idea!

Raymond P. Aylor, Jr., W3DVO
Garrett Park, Maryland

432-MHz Yagi

Dear HR:

The article on the high-gain Yagi for 432-MHz in the January, 1976, issue of *ham radio* indicates that some amateurs have not been successful in reproducing the WØEYE Yagi design. I would like to point out that in all the cases I've seen where a builder did not obtain the claimed performance, modifications had been made to the original design. *Precise duplication* is the only way that performance can be guaranteed. Changing the boom or element diameter, or especially the method of mounting the elements, can have disastrous effects on gain. Tests at the East Coast VHF Society in Trenton, New Jersey, in August, 1974, showed the WØEYE 432-MHz Yagi to have approximately 0.5 dB more gain than the K2RIW design. This is to be expected in view of the fact that the boom for the WØEYE Yagi is 0.7 wavelength longer than the K2RIW Yagi (4.2λ vs 3.5λ).[8]

Don Hilliard, WØPW (exWØEYE)
Boulder, Colorado

microprocessors

Dear HR:

The microprocessor article in the December issue of *ham radio*[9] left me baffled. It compared "computers" with microprocessors, and it compared "programmable calculators" with microprocessors, but they aren't the same thing. A microprocessor with *memory and peripherals* can be either a "computer" or a "programmable calculator." A microprocessor-based system can handle the same sort of sophisticated mathematical computations that the authors imply is inherent in computers and programmable calculators, and in the same way — with a digital algorithm controlled by some sort of memory.

Ordinarily, because of the small word size and limited instruction set available in microprocessors, they are slower than most computers but they're faster than most programmable calculators. The data rate of five-hundred 16-bit samples per second is equivalent to one sample each 2000 microseconds. The modern microprocessors (8080A, 6800, 6501) run with clocks operating from 500 kHz to 3 MHz. To store a data value from a peripheral device, using the 8080, should require about 60 clock cycles. The faster 8080A runs with a 1-MHz clock so the time per sample is about 60 microseconds or 16000, 16-bit samples per second.

With Direct Memory Access (DMA), a goody which is nearly mandatory on *any* high-speed data acquisition system, the rate could be as high as one sample for each six clock cycles or 160,000 samples per second. This is faster than you can stuff the data into most mass-storage devices (tape, disk).

Microprocessors have advantages (low cost) and disadvantages (limited software) that leave the user with mixed emotions, but there is no clear-cut, qualitative distinction between microprocessor-based digital systems and computers or programmable calculators. Because of their low cost, you can think in terms of distributed systems with microprocessors ROM-programmed to perform specific functions (math, logic, control) and pipeline data to them. On the other hand, due to the paucity of useful software, you must realize that the programming costs will vary somewhere between enormous and staggering.

Microprocessor and memory costs are going down, microprocessor capabilities are going up, and software is very rapidly becoming more available and more efficient. *Today* microprocessor-based systems can give you one helluva bang per buck — a quantum jump in capability is in the wings.

C. E. Deckard, WB4FAR
Huntsville, Alabama

7. Henry Keen, W5TRS, "Non-Synchronous Impedance Transformer," *ham radio*, September, 1975, page 66.

8. The original WØEYE Yagi design information published in the January, 1972, issue of *QST* contained some errors which were corrected in the *World Above 50 MHz* column in the March, 1972, issue.

9. D. Larsen, WB4HYJ, Peter Rony, and Jonathan Titus, "An Introduction to Microprocessors," *ham radio*, December, 1975, page 32.

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More Details? CHECK–OFF Page 118

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THUNDERBIRD SPECS.

Electrical	**TH6DXX**	**TH3MK3**	**TH3JR**	**TH2MK3**
Gain	8.7 dB	8 dB	8 dB	5.5 dB
Front-to-back ratio	25 dB	25 dB	25 dB	15-20 dB
Maximum power input	1 kW AM, 2 kW PEP	1 kW AM, 2 kW PEP	300 watts AM, 600 watts PEP	1 kW AM, 2 kW PEP
VSWR (at resonance)	1.5:1	Less than 2:1	Less than 2:1	Less than 2:1
Impedance	50 ohms	50 ohms	50 ohms	50 ohms
Mechanical				
Longest element	31.1'	27'	24.2'	27.3'
Boom Length	24'	14'	12'	6'
Turning radius	20'	15.7'	14.3'	14.3'
Wind load at 80 MPH	156 lbs.	103.7 lbs.	87 lbs.	96 lbs.
Maximum wind survival	100 MPH	100 MPH	80 MPH	100 MPH
Net weight	61.5 lbs.	36 lbs.	21 lbs.	22 lbs.
Mast diameter accepted	1-1/4" to 2-1/2"	1-1/4" to 2-1/2"	1-1/4" to 1-5/8"	1-5/8"
Surface area	6.1 sq. ft.	4.03 sq. ft.	3.4 sq. ft.	3.75 sq. ft.

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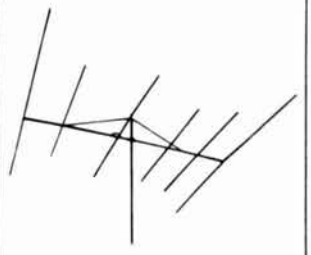
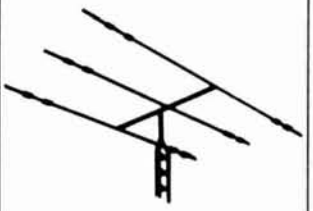


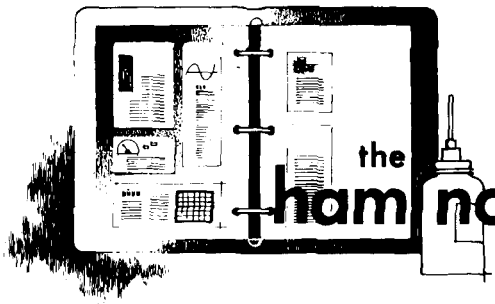
TH6DXX

TH3MK3



TH3JR

TH2MK3



low-cost two-meter colinear uses PVC pipe mast

The colinear described here is about as low cost as you can imagine for fixed-station use, costing less than ten dollars. Omnidirectional, the antenna consists of three half-wavelength stubs which can be fed directly with balanced 300-ohm line (or coaxial cable and a 4:1 balun).*

The colinear uses a 10-foot (3m) section of 3/4- or 1-inch (20-25mm) PVC water pipe as a mast and elements made from aluminum clothesline wire. PVC water pipe is available through discount and hardware stores and the Sears mail order catalog. CPVC pipe is also available but is much higher priced. A full line of fittings and special cement are available for capping and splicing. The local cost of a 10-foot (3m) length of 1-inch (25mm) PVC pipe is less than $2.00. While a three-element two-meter colinear will fit nicely on a 10 foot (3m) mast, I designed the antenna so about one quarter wavelength of the top element extends above the mast. This allows for additional room at the bottom of the mast so nothing shorts out.

To build the antenna, first unroll and straighten the aluminum wire and cut two 97.5 inch (2.48m) lengths. On one of the lengths of wire measure out 57 inches (1.45m) from the end and make a 90° bend. Make another 90° bend 1 inch (2.5cm) from the first. You now have a big hairpin with one leg 57 inches (1.45m) long and the other 39.5 inches (1m) long.

Lay the hairpins aside and drill eight 1/8-inch (3mm) holes in the PVC mast as shown in **fig. 1.** Mark both legs of the hairpin 19 inches (48cm) from the end. Now insert the long leg of the hairpin into the second hole from the top of the mast on the side opposite from the feedpoint. Put the shorter leg into the next hole and push both legs through until the marks appear. Now bend both legs of the hairpin back against the mast with the longer leg toward the top and shorter leg toward the feedpoint. Push the hairpin further through the PVC mast, bend the longer leg, and feed it through the top hole in the mast and out through the open end of the pipe. Now push the vertical elements back against the mast and secure them with vinyl tape. Form a small eye on the end of the shorter element and attach it at the feedpoint with a self-tapping screw.

The other 97.5-inch (2.48m) length of aluminum wire is used to build the lower half of the antenna. Use the same procedure as before except in this case the longer leg of the hairpin goes toward the bottom and both ends are secured with self-tapping screws. A center-drilled PVC cap slipped over the top of the PVC mast will keep undesired moisture out of the antenna. The quarter-wavelength stubs may be allowed to stick out at right angles, or they may be bent into a circle to ease handling.

On my own antenna I cut a large hole in the PVC mast at the feedpoint, split a PVC coupling lengthwise, secured the feedline and coaxial balun to the inside of the split coupling with machine screws, pushed the coax out the bottom of the mast, stuffed the balun inside, and cemented the split coupling over the hole. The ends of the elements were secured with machine screws and nuts. If you use this method, be sure to try the antenna out before you cement anything in place because the bond is *permanent*.

Although no extensive tests have been performed on this antenna, it appears to be equal to a commercial half-wavelength vertical. Best of all, it's inexpensive and requires no tuning.

Don Norman, K8LLZ

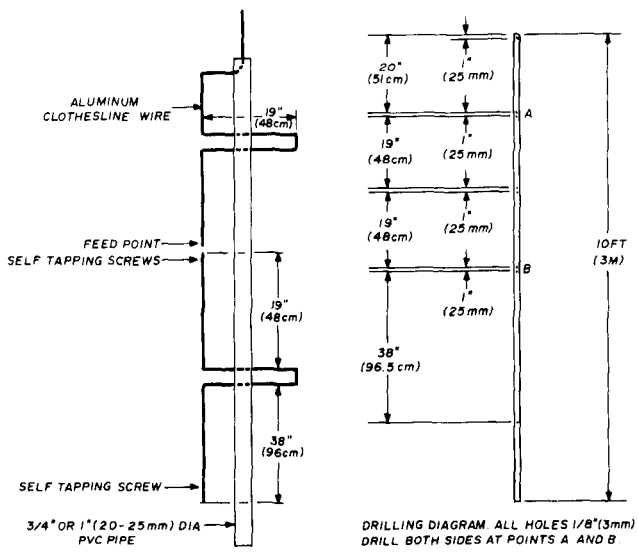


fig. 1. Low-cost, three element collinear for two meters provides omnidirectional coverage and can be built for less than ten dollars.

*Ed Tilton, W1HDQ, *The Radio Amateur's VHF Manual*, ARRL, Newington, Connecticut, 1972, page 156.

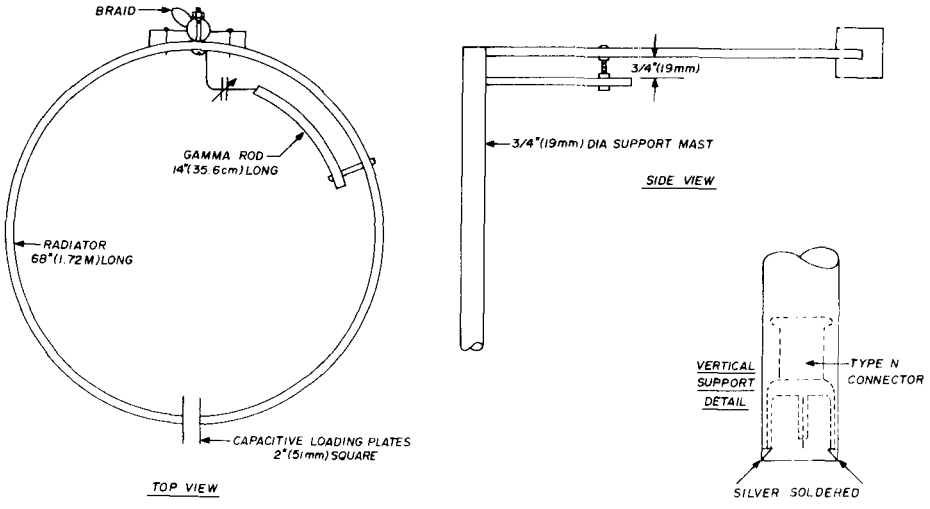


fig. 2. Full-wave halo antenna is mounted one-quarter wavelength above truck cab (or car roof). Radiator and gamma rod are 1/2" (13mm) aluminum tubing; support mast is 3/4" (19mm) copper water pipe.

mobile oscar antenna

Most amateurs aren't crazy enough to work a satellite while screaming down the freeway at 60+ mph, but if you have that desire let me suggest an antenna which is quite efficient for that type of operation.

The antenna described here was built primarily to achieve horizontal polarization for two-meter sideband operation. As a bonus I have found it works very well on the Oscar 6 and 7 mode-A uplinks. The conventional two-meter halo leaves a lot to be desired as an efficient omnidirectional horizontal radiator. I decided to use a one-wavelength loop and capacitively load the ends (see **fig. 2**).

For rigidity and simplicity I elected to use the gamma match. In order to achieve some gain I mounted the radiator approximately one-quarter wavelength above the roof of my truck. A type-N coaxial feedthrough was placed in the middle of the cab top. The quarter-wave supporting mast is made of 3/4-inch (19mm) ID copper pipe. A piece of RG-8/U coaxial cable with type-N connectors is placed inside the copper pipe, inset approximately 1/8 inch (3mm), and silver soldered in place.

The radiating portion is built from 1/2-inch (13mm) OD aluminum tubing 68 inches (1.72m) long and bent into a circle so the ends touch. Plugs, 3/8 inch (9.5mm) diameter and 1 inch (25mm) long are swaged into the ends and drilled to accept number 6 (about 3.5mm) sheet metal screws. The capacitive plates for the ends are 2-inch (51mm) aluminum squares or 2½-inch (6.5cm) aluminum disks. After attaching the capacitive plates to the ends of the radiator the spacing of 3/8 inch (9.5mm) is held constant by the use of ceramic insulators. The radiator may now be attached to the copper vertical support by using an element-to-boom insulator (25¢ each from KLM).

The gamma rod is 14 inches (35.6cm) long , has the same radius as the radiator, and is mounted below the radiator using two 3/4-inch (19mm) ceramic insulators. A 15 pF variable capacitor is mounted on the end of the gamma arm closest to the vertical support. Attach the center conductor of the coax that is coming out the top of the vertical support to the capacitor to place it in series with the gamma arm. The braided shielding may be attached to the vertical support on the center of the radiator.

Drill a hole through the gamma arm 2 inches (51mm) in from the end opposite to that where the capacitor is attached. Continue this hole through the radiator. Place a 1½ inch (3.8cm) long screw through these holes to short the radiator to the gamma arm at this point (a sliding short may also be used, possibly made from a pair of *Adel* clamps or small hose clamps and a small strip of flashing copper). This shorting point was found for 145.0 MHz ±1 MHz.

Tune up was done using a military TS-47 vhf signal generator, an HP-415 vswr indicator and a homebrew bridge detector head. The antenna is very sensitive to hand capacitance so a long non-metallic tuning tool should be used. A good quality vhf vswr indicator can also be used for tuneup with good results.

Doug A. Clingerman, W6OAL

portable magnet-mount antenna

The compact gutter-mount antenna, long popular with two-meter fm enthusiasts who have to travel, cannot be used on many of the newer cars because they're not equipped with rain gutters. Following is a description of an economical magnet-mount antenna (**fig. 3**)

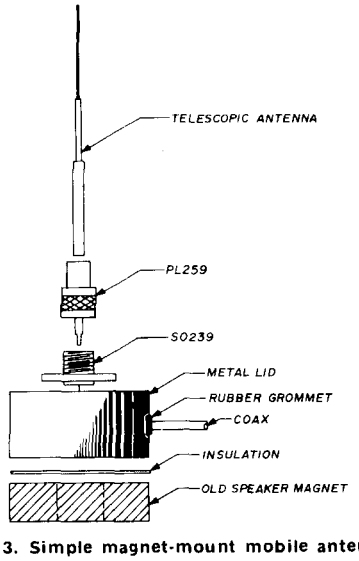


fig. 3. Simple magnet-mount mobile antenna can be built from easy to find parts, and can be tuned to 145, 220, or 440 MHz by adjusting the length of the telescopic antenna for minimum vswr.

which can be built in less than an hour from easy-to-find parts.

First solder a short length of number 12 (2mm) copper wire to the base of a short telescopic antenna, solder the other end of the wire to the center pin of a PL259 coaxial connector, then fix the telescopic antenna in place with 5-minute epoxy. Mount a SO239 coaxial socket on top of an old spray-can lid (be sure to include a ground lug for the coaxial shield connection). Drill a hole on the side of the lid for a 3/8 inch (9.5mm) rubber grommet and install a 6 foot (1.8m) length of RG-58/U coaxial transmission line. Now place some insulation inside the lid and shim the magnet so it fits tightly. I used glass tape which was held in place with fast-curing epoxy cement. The length of the telescopic antenna can be adjusted for operation on 145, 220,or 440 MHz, and can also be set for minimum standing-wave ratio.

Fred Snow, WB2YYU

7-MHz attic antenna

The 3:1 or 4:1 swr KH6HDM mentioned in his article on dipole antennas* would not pass the New York City Board of Education specification which requires an swr of 1.5:1 or better for radio and television receiving systems. This year I had 20-meter dipole in my attic which had a 1.25 swr. Since I wanted to operate on 40 meters, and this antenna is one-quarter wavelength long at 7 MHz, I short circuited the balun terminals and end fed the 32 foot (9.75m) length of wire – not unexpectedly, the swr was extremely high.

I installed an old broadcast-type 365 pF variable capacitor in series with the feedpoint but the vswr was approximately 2.8:1 at best. However, when the 365 pF variable was installed in place of the jumpered balun and adjusted for minimum reflected power the swr measured about 1:1. When a 4 foot (1.2m) length of 3/8 inch (9.5mm) copper pipe was used to replace wire which had bends in it, the swr dropped to nearly 1:1. A diagram of the complete installation is shown in **fig. 4.**

Allen Porterfield, W2ISL

*Albert Lee, KH6HDM, "Dipole Antennas," *ham radio,* November, 1975, page 60.

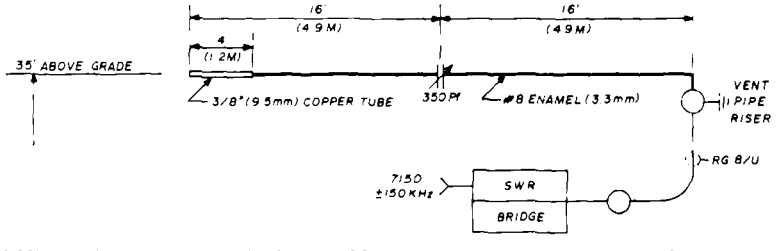


fig. 4. 7-MHz attic antenna is built from a 20-meter dipole. Swr is less than 2:1 over the entire 40-meter band. The 4-foot (1.2m) section of copper pipe may not be required if there are no bends in the antenna wire.

improved low-band inverted-vee installation

Many amateurs who own towers use some form of inverted-vee antenna on 80 and 40 meters. At my station I use an inverted-vee which is trapped for operation on 40, 75, and 80 meters.* When I first put the antenna up, however, the swr was very high on all bands and I got badly tromped in every DX pileup. A hip-pocket analysis suggested that the apex of the vee was too close to the tower – the center insulator was suspended by a two-foot (60cm) length of nylon rope about 6 inches (15cm) out from the face of the tower.

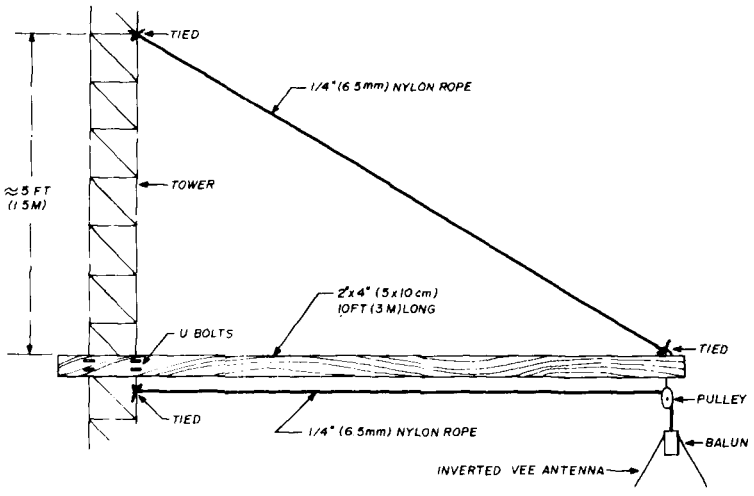


fig. 5. When inverted-vee antenna is mounted well away from the tower, as shown here, performance improves markedly.

To move the vee further out from the tower, I bought a 10-foot (3m) length of 2x4-inch (5x10cm) lumber which I bolted to the legs of the tower with four U-bolts as shown in **fig. 5,** and supported the far end with a length of 1/4-inch (6.5mm) nylon rope tied around one of the tower legs 5 feet (1.5m) above the wooden beam. A pulley was attached to the underside of the wooden beam at the far end so the inverted-vee could be lowered for repair and maintenance.

The result was very gratifying. Swr on all bands was reduced considerably, although further trimming was required for optimum results. While I continue to get tromped in the pileups by those members of the DX gang who use phased arrays or full-size ground planes, this new arrangement is far superior to dipoles and vees which are mounted close to the tower.

Bob Locher, W9KNI

improving the swr meter

The swr meter is one of the most used pieces of test gear. Many variations of the circuit have been devised and most suffer from inaccuracy. A

*Bob Polansky, W6JKR, "Low-Band Converted-Vee Antenna," *ham radio,* December, 1969, page 18.

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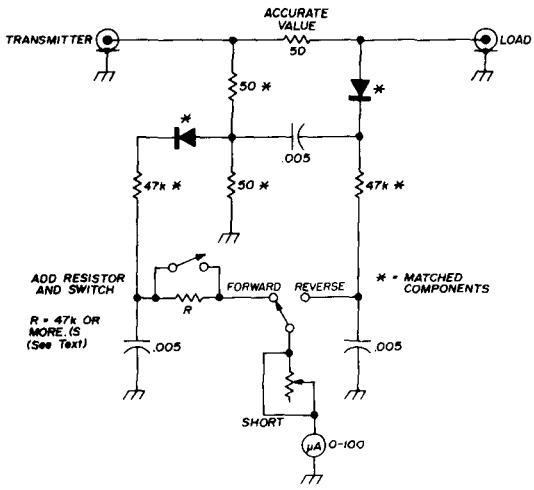

fig. 6. Swr bridge as shown in ARRL handbooks modified to provide greater accuracy at low readings.

considerable improvement can be made rather easily on the lower ranges of most meters.

Before you say, "Mine is ok," try this: Assuming a 50-ohm meter, place a 100- or 25-ohm resistor on the output and see what you get. Two 50-ohm loads on a T fitting will do. You should get a 2:1 swr reading or a reverse reading one-third of full scale. The relationship is full scale plus reverse, divided by full scale minus reverse. With a 100-microamp meter it is 100 plus 33.3 over 100 minus 33.3, which equals 1.99 or 2:1. If you get this, smile and try measuring with a different power level. If you're frowning now, here is what you can do.

Assuming good balance in the construction of the meter and adequate matching of the diodes and resistors, the major problem is in nonlinear resistance of the detector diodes. When measuring the lower swr conditions, much more current is used to calibrate the instrument in the forward position than is measured in reverse. Large series resistances and sensitive meters tend to even out this nonlinearity. However, accuracy suffers as readings get smaller and low readings will give an unduly optimistic impression of the match. Measurements at different power levels will also give different readings.

The bridge shown in **fig. 6** is from various ARRL handbooks and is meant for measurement at low power, not as an in-line device. As shown, a resistor is placed in series with the lead to the *forward* switch contact. A switch is installed across this resistor to restore normal operation. For these measurements a short is placed across the variable resistor or it is left in the most sensitive position. Transmitter power is adjusted for full-scale readings and should be limited to a few watts.

For a starting point use a resistor of about equal value to the one already in series with the *forward* diode. Install a load of 25 or 100 ohms on the bridge and make a measurement. Calibrate to full scale in *forward* (by adjusting transmitter output), then switch to *reverse* and note the reading. This is the new 2:1 point on the meter and should normally be at one-third scale except for the action of the new series resistor. Suppose this new point reads 70 microamperes on a 100-microamp meter. Multiply 70 times 3 (210) and use this figure as the new full-scale reading for future measurements:

$$\frac{210+70}{210-70}=\frac{280}{140}=2 \text{ or } 2{:}1 \text{ swr}$$

For a load that results in a reverse reading of 20 microamps:

$$\frac{210+20}{210-20}=\frac{230}{190}=1.21{:}1 \text{ swr}$$

By juggling the value of the series resistor you can place 2:1 at a given point on the meter up to full scale. Multiply this point by 3 and use this for full scale in the formula.

An alternative method of calibration would be to use 16.6 or 150 ohms for a load and place 3:1 at full scale. This should normally be at half scale so multiply 100 by 2 (200) and proceed as follows:

$$\frac{200+100}{200-100}=\frac{300}{100}=1.21{:}1 \text{ swr}$$

Of course, as you assign a higher swr to the full-scale position you begin to lose the benefits of this system.

Accurate 50-ohm, 2-watt resistors mounted in PL-259 plugs may be used with the low-power bridge. T fittings may be used to allow one, two or three loads to be put in parallel for 1:1, 2:1 and 3:1 calibration points. In-line meters may be modified in the same way if they are sensitive enough to give full-scale readings on *forward* after installation of the resistor. Original calibration and subsequent tests are made with the meter at full sensitivity and the transmitter output varied for setting to full scale on *forward*. Unless carefully constructed, accuracy of in-line meters will probably not be as good as with the resistance bridge.

This procedure places a calibrated point up on the scale instead of at zero where accuracy is poor. It expands the low end of the meter to give better accuracy for pruning antennas and matching impedances. It pushes *infinity* off the meter face. Within the inherent limitations of these bridges and meter movements this method affords greater accuracy for a very small price.

E. R. Lamprecht, W5NPD

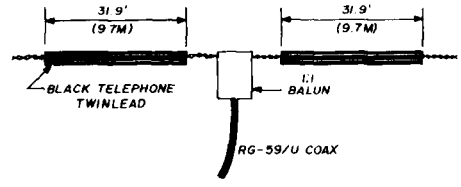

fig. 7. A 40-meter dipole made from black, telephone-company twinlead is shortened slightly because of velocity factor. Swr of this antenna is 1.2:1 at the band edges.

telephone-wire antenna

Recently I built a 40-meter dipole using slightly used, black, two-conductor (twinlead) telephone wire. To broadband the antenna the two wires were connected together at the ends as shown in **fig. 7**. Because of velocity factor I expected that the usual formula for the length of a quarter wavelength wire, $\lambda/4$ *(feet)* = $234/f_{MHz}$* would be too long, and this indeed was the case. After three cuts (three times up and down two trees), a good antenna resulted. The new length formula for this wire, $\lambda/4$ *(feet)* = $229/f_{MHz}$ may save some readers scraped arms and lost tempers. My antenna, which is centered on 7175 kHz, is fed with RG-59/U and has a maximum swr of 1.2:1 at the band edges.

Joel Elston, K9TBD

*A quarter wavelength in metric terms is given by $71.3/f_{MHz}$. The correct formula for the telephone-wire antenna is $69.8/f_{MHz}$ (length of each dipole element in meters).

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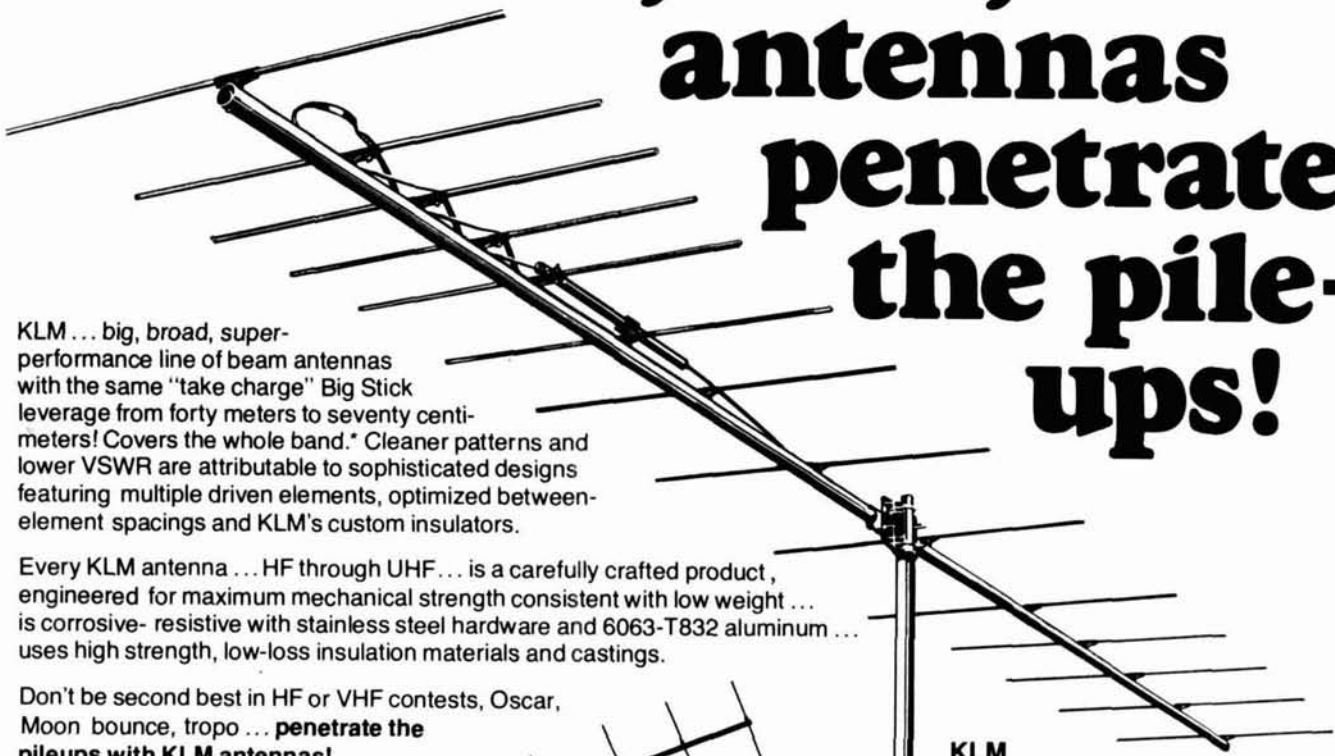

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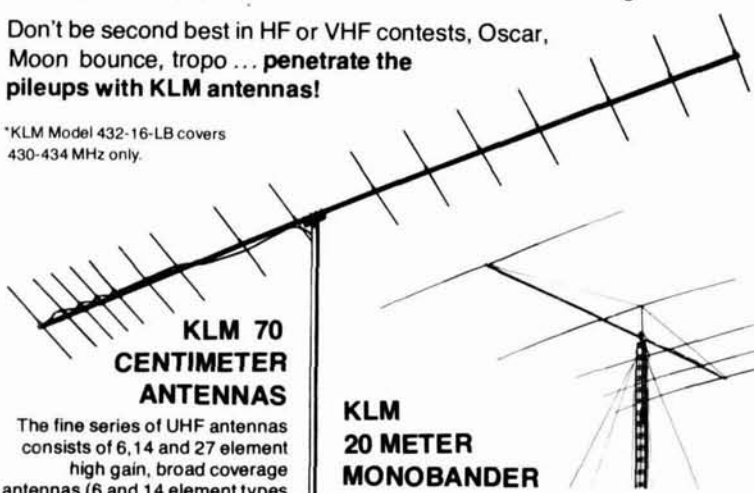

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A typical antenna: (KLM-420-470-14)
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Beam width: 18 degrees @ 3db pts.
Diameters: Boom: 1" (25.4mm). Elements ⅜"D (9.5mm)

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Other KLM beams for 40,15 and 10 meters feature dual driven elements for high gain, F/B ratio and low VSWR over both phone and CW band sections. **Also, a 7 element log periodic** w/26' turning radius, 30' boom (3", 76 mm) D **that gives continuous coverage, 10-30MHz!** Makes an excellent **NO TRAP**, 20-15-10 meter beam with gains equivalent to long boom, 3 element Yagi. Matches 50 ohm line w/4KW p.e.p. balun (supplied).

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160-meter shortened vertical antenna

When you're using a grounded, center-loaded vertical antenna and no guy wires are desired, the feed system shown in **fig. 8** solves the problem of feeding power to the antenna. The feeder may be inside or outside the lower mast section, but should be kept close to the foot of the mast so its potential is close to ground at that point. The coupling to the center loading coil is made at the mast end or "cold"end of the loading coil. I use three turns of coaxial cable with the center conductor returning to the outer braid at the bottom of the three-turn link.

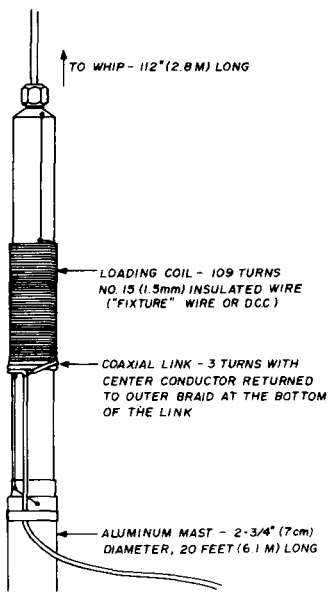
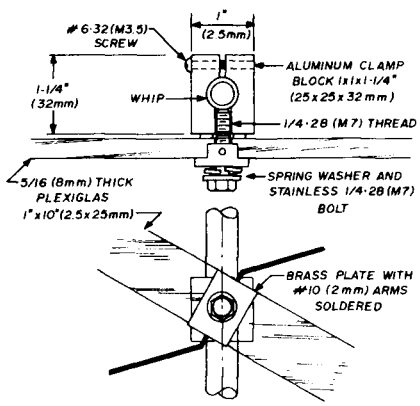


fig. 8. Center loading coil and link coupling used with the shortened vertical antenna for 160 meters. Total antenna height is about 30 feet (9.1m).

My vertical is tuned to 1800 kHz in the 160-meter band and the coil measures approximately 270 μH. This requires a total whip length above the coil of 112 inches (2.84m). The loading coil consists of 109 turns of no.15 (1.5mm) insulated wire, weather proofed with several coats of clear *Krylon* spray. The coil ia 2-3/4 inches (7cm) in diameter and 7-5/8 inches (19.4cm) long. The bottom of the coil is spaced away from the lower mast by about 5 inches (13cm). The lower section of the vertical is made of 2-3/4 inch (7cm) diameter thin-walled aluminum pipe, 20 feet (6.1m) long. This gives a total vertical height of approximately 30 feet (9.1m).

The feed resistance of my vertical, as measured with an Omega noise bridge, is close to 55 ohms. My ground system consists of ground rods and water system as well as a quarter-wavelength of no. 12 (2mm) copper wire just under the surface of the ground.

The bandwidth of the shortened vertical antenna is very narrow so I added the simple capacitive loading system shown in **fig. 9.** This consists of two 12-inch (30.5cm) lengths of no. 10 (2.6mm) copperweld wire which are attached to a swivel joint. By adjusting



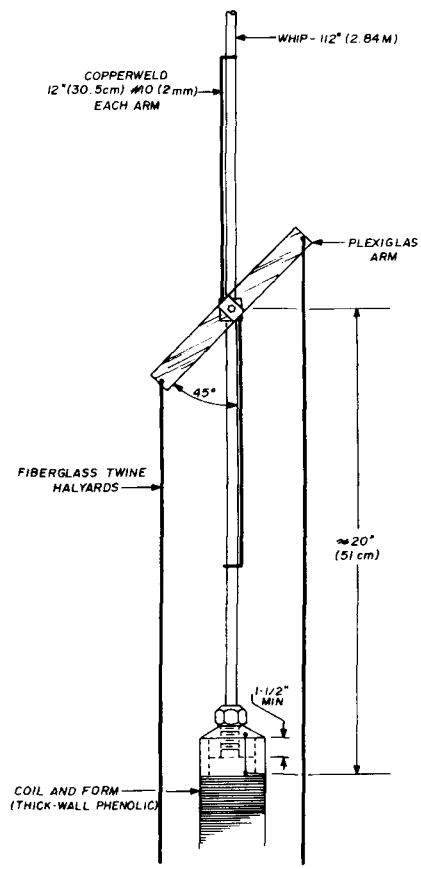


fig. 9. Movable 12" (30.5mm) lengths of no.10 (2mm) copperweld add sufficient capacitive loading that the shortened 160 vertical can be used over a 30 kHz bandwidth with a 1:1 vswr.

the angle of these rods to the mast with halyards (remotely with a selsyn, if desired), it's possible to operate over a 30 kHz bandwidth with a 1:1 vswr.

Dave Atkins, W6VX

Ham-M modification

The accuracy of the metering circuit in the Ham-M rotator is poor, at best, under conditions of varying line voltage. With a line voltage change from 105 to 125 volts, the full-scale reading in my unit varied from 325° to 365°.

While there are, undoubtedly, many modifications to this circuit that would eliminate this problem, cost and parts availability were a factor. The result, a simple voltage regulator, is shown in the schematic diagram of **fig. 10.** New parts are given in the parts list. I used two zeners in series, lacking a single one that would render proper performance. With the value shown for R1, the total zener voltage should be somewhere between 17 and 20 volts. The exact value is not critical so long as the voltage across C1 is under the control of the zener when the line voltage drops to 105 V. C1 can be of any value from 500-μF up, depending upon available parts. R2 was added to compensate for the lower voltage across the rotor pot. With the circuit constants shown, there is less than 1° of change from 105 to 125 V input after a 10-minute warm-up.

Walter Pfiester, Jr., W2TQK

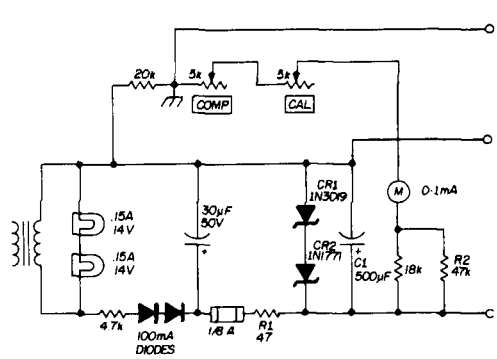


fig. 10. Ham-M meter circuit modification.

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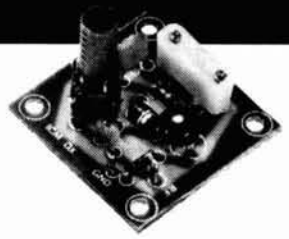

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CD4022	1 25	CD4069	45	74C161	3 25
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XR-320P	1 55	XR-1310EP	3 20
XR-556CP	1 85	XR1800P	3 20
XR-2556CP	3 20		
XR 2240CP	3 25	**WAVEFORM GENERATORS**	
		XR-205	8 40
PHASE LOCKED LOOPS		XR-2206CP	4 49
XR-210	5 20	XR-2207CP	3 85
XR 215	6 60	**MISCELLANEOUS**	
XR-567CP	1 95	XR-2211CP	6 70
XR-2567CP	2 99	XR-2261	3 79
		XR4136	2 00

DATA HANDBOOKS

7400	Pin-out & Description of 5400/7400 ICS	$2.95
CMOS	Pin-out & Description of 4000 Series ICS	$2.95
LINEAR	Pin-out & Functional Description	$2.95

ALL THREE HANDBOOKS $6.95

CONSUMER ELECTRONICS

exelar

DIGITAL WATCH
This watch is manufactured by National Semiconductor. It provides 5 functions: hours, minutes, seconds, date, A.M. indicator dot. Accuracy is assured to 5 seconds per month by precision quartz crystal. If something should go wrong with the watch, repair is assured within 48 hours after it is received. Complete with steel black leather band.

ES4-YS
3 MICRON GOLD PLATE BEZEL
$29.95
NOT A KIT

Novus

DIGITAL ALARM CLOCK
This 4 digit Novus Alarm Clock is a very reliable and smartly styled unit. It provides such features as an alarm settable to any minute of the day, a 7 minutes snooze alarm, a power failure indicator and even an A.M. P.M. indicator.

NOT A KIT **$19.95**

OPTO ELECTRONICS

XCITON
LITRONIX
MONSANTO

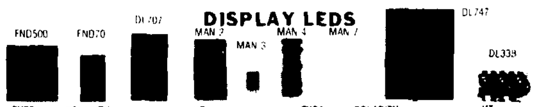
DISCRETE LEDS

R - RED
G - GREEN
Y - YELLOW
O - ORANGE

.125" dia.		.185" dia.		.190" dia.	
XC209R	5/$1	XC526R	5/$1	XC111R	5/$1
XC209G	4/$1	XC526G	4/$1	XC111G	4/$1
XC209Y	4/$1	XC526Y	4/$1	XC111Y	4/$1
XC2090	4/$1	XC5260	4/$1	XC1110	4/$1

.200" dia.		.200" dia.		.085" dia.	
XC22R	5/$1	XC556R	5/$1	MV50	
XC22G	4/$1	XC556G	4/$1	.085 dia. Micro	
XC22Y	4/$1	XC556Y	4/$1	red led	
XC22O	4/$1	XC5560	4/$1		6/$1

DISPLAY LEDS



TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	COMMON ANODE	270	$3 25	MAN 74	COMMON CATHODE	300	$1.50
MAN 2	5 x 7 DOT MATRIX	300	4 95	DL707	COMMON ANODE	300	$1 50
MAN 3	COMMON CATHODE	125	39	DL747	COMMON ANODE	600	2 25
MAN 4	COMMON CATHODE	187	1 95	DL750	COMMON CATHODE	600	2 49
MAN 7	COMMON ANODE	300	1 50	DL33B	COMMON CATHODE	110	1 25
MAN 7G	COMMON ANODE GREEN	300	1 50	FND70	COMMON CATHODE	250	50
MAN 7Y	COMMON ANODE YELLOW	300	1 50	FND500	COMMON CATHODE	500	1 75
MAN 72	COMMON ANODE	300	1 50	FND507	COMMON ANODE	500	1 75

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.43
16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)

14 pin	$.27	.25	.24	28 pin	$.99	.90	.81
16 pin	.30	.27	.25	36 pin	1.39	1.26	1.15
18 pin	.35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
				40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	1/4 WATT 5%	50 PCS
ASST. 2	5 ea	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	1/4 WATT 5%	50 PCS
ASST. 3	5 ea	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	1/4 WATT 5%	50 PCS
ASST. 4	5 ea	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	1/4 WATT 5%	50 PCS
ASST. 5	5 ea	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	1/4 WATT 5%	50 PCS
ASST. 6	5 ea	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	1/4 WATT 5%	50 PCS
ASST. 7	5 ea	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	1/4 WATT 5%	50 PCS

ALL OTHER RESISTORS FROM 2.2 OHMS - 5.6M AVAILABLE IN MULTIPLES OF 5 ea
5-25 PCS .05 ea 30-95 PCS .04 ea 100-495 PCS .03 ea 500-995 .027 ea

14 PCS. POTENTIOMETER ASSORTMENTS

ASST. A 2 ea 100 OHM 200 OHM-500 OHM 1K OHM-200 OHM-250 OHM-500 OHM
ASST. B 2 ea 1K, 2K, 2.5K 10K 20K 25K 50K
ASST. C 2 ea 50K, 100K 200K 250K, 500K 1M 2M

$9.95 Per Asst.

Each assortment contains 14 pcs of 10 turn pots. All pots are available in single unit quantities $.99 ea.

Astrisk Denotes Items On Special For This Month
Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax — Data Sheets 25c each
Send a 13c Stamp (postage) for a FREE 1976 Catalog

JAMES

P.O. BOX 822, BELMONT, CA. 94002
PHONE ORDERS — (415) 592-8097

74LS00 TTL

74LS00	39	74LS55	.39	74LS151	1 55
74LS02	39	74LS73	65	74LS153	1.89
74LS03	39	74LS74	65	74LS157	1 55
74LS04	45	74LS75	79	74LS162	2.25
74LS05	45	74LS76	65	74LS163	2 25
74LS08	39	74LS83	2.19	74LS164	2 25
74LS10	39	74LS86	65	74LS181	3 69
74LS13	79	74LS90	1 25	74LS190	2 85
74LS14	2 19	74LS92	1 25	74LS191	2 85
74LS20	39	74LS93	1 25	74LS192	2 85
74LS26	49	74LS95	2 19	74LS193	2 85
74LS27	45	74LS96	1 89	74LS194	2 25
74LS28	49	74LS107	55	74LS195	2 25
74LS30	39	74LS112	65	74LS257	1 89
74LS32	45	74LS132	1 55	74LS260	55
74LS40	49	74LS136	65	74LS279	79
74LS51	39	74LS138	1 89	74LS670	5 95

DIP SWITCH
These switches feature four SPST Rocker switches in a molded dip. They are ideally suited for microprocessor applications. **$1.95**

MINATURE TOGGLE

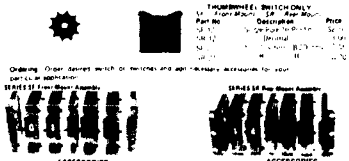
				AMT	1	2-9	10-29	30-49
	ON	OFF	ON	221	3.05	2.65	1.97	1.78
	ON	NONE	ON	223	2.80	2.25	1.60	1.51
	ON	OFF	ON	121	2.35	1.95	1.43	1.30
	ON	NONE	ON	123	2.05	1.65	1.21	1.10

PUSH BUTTON

SPDT SERIES PB 781 — Model 1 — Quantity net prices
Maintained Action Switch, Push To Make Contact And Push Again To Release Action — Number PB-123 — Each $2.35 — 2-9 $1.95 — 10-29 $1.47 — 30-99 $1.30
Momentary Action Switch, Normally Open Normally Closed — PB-126 — $2.35 — $1.95 — $1.47 — $1.30

5 AMP RATINGS

THUMBWHEEL SWITCHES



ACCESSORIES

Part No.	Description	Price	Part No.	Description	Price
SF EP	End Plate (Pair)	$.50	SR EP	End Plates (pair)	$.50
SF DP	Divider Plate (each)	.40	SR DP	Divider Plate (each)	.40
SF BB	Blank Body (each)	.40	SR BB	Blank Body (each)	.40
SF HB	Half Body (each)	.40	SR HB	Half Body (each)	.40

8 POSITION ROTARY SWITCH $79
These switches are a 7 position, one position open, rotary switch enclosed in a TO 5 can. They have a standard 8 pin configuration and will mount perfectly on printed circuit board.

ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3 3	400m	4 1 00	1N4005*	600 PIV	1 AMP	10 1 00
1N751A	5 1	400m	4 1 00	1N4006*	800 PIV	1 AMP	10 1 00
1N752	5 6	400m	4 1 00	1N4007*	1000 PIV	1 AMP	10 1 00
1N753	6 2	400m	4 1 00	1N3600	50	200m	6 1 00
1N754	6 8	400m	4 1.00	1N4148	75	10m	15 1 00
1N965B	15	400m	4/1 00	1N4154	35	10m	12/1 00
1N5232	5 6	500m	28	1N4734	5 6	1w	28
1N5234	6 2	500m	28	1N4735	6 2	1w	28
1N5235	6 8	500m	28	1N4736	6 8	1w	28
1N5236	7 5	500m	28	1N4738	8 2	1w	28
1N456	25	40m	6/1.00	1N4742	12	1w	28
1N458	150	7m	6/1 00	1N4744	15	1w	28
1N485A	180	10m	5/1 00	1N1183	50 PIV	35 AMP	1 60
1N4001	50 PIV	1 AMP	12 1 00	1N1184	100 PIV	35 AMP	1 70
1N4002	100 PIV	1 AMP	12 1 00	1N1186	200 PIV	35 AMP	1 80
1N4003	200 PIV	1 AMP	12 1 00	1N1188	400 PIV	35 AMP	3 00
1N4004	400 PIV	1 AMP	12/1 00				

TRANSISTORS

MPS A05	5/$1 00			PN4249	4/$1 00
MPS A06	5/$1 00	PN3567	3/$1 00	PN4250	4/$1 00
2N2219A	3/$1 00	PN3568	4/$1 00	2N4400	4/$1 00
2N2221	4/$1 00	PN3569	4/$1 00	2N4401	4/$1 00
2N2222A	5/$1 00	2N3704	5/$1 00	2N4402	4/$1 00
2N2369	5/$1 00	2N3705	5/$1 00	2N4403	4/$1 00
2N2369A	4/$1 00	2N3706	5/$1 00	2N4409	5/$1 00
PN2415	5/$1 00	2N3707	5/$1 00	2N5086	4/$1 00
2N2484	4/$1 00	2N3711	5/$1 00	2N5087	4/$1 00
2N2906A	4/$1 00	2N3724	$ .65	2N5088	4/$1 00
2N2907A	5/$1 00	2N3725	$1 00	2N5089	4/$1 00
2N2925	5/$1 00	2N3903	5/$1 00	2N5129	5/$1 00
2N3053	2/$1 00	2N3904	4/$1 00	2N5138	5/$1 00
2N3055	$ .69	2N3905	4/$1 00	2N5139	5/$1 00
MJE3055	$1 00	2N3906	4/$1 00	2N5209	5/$1 00
MJE2955	$1 25	2N4013	3/$1 00	2N5951	5/$1 00
2N3392	5/$1 00	2N4014	3/$1 00	C106B1SCR	2/$1 00
2N3398	5/$1 00			2N5432	$2 00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.04	.035	
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.05	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1 35V	.28	.23	.17	1.5 35V	.30	.26	.21
.15 35V	.28	.23	.17	2.2 25V	.31	.27	.22
.22 35V	.28	.23	.17	3.3 25V	.31	.27	.22
.33 35V	.28	.23	.17	4.7 25V	.32	.28	.23
.47 35V	.28	.23	.17	6.8 25V	.36	.31	.25
.68 35V	.28	.23	.17	10 25V	.40	.35	.29
1.0 35V	.28	.23	.17	15 25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47 50V	.15	.13	.10	.47 25V	.15	.13	.10
1.0 50V	.16	.14	.11	.47 50V	.16	.14	.11
3.3 50V	.15	.13	.10	1.0 16V	.15	.13	.10
4.7 25V	.16	.14	.12	1.0 25V	.16	.14	.11
10 25V	.15	.13	.10	1.0 50V	.16	.14	.11
10 50V	.16	.14	.12	4.7 16V	.15	.13	.10
22 25V	.17	.15	.12	4.7 25V	.15	.13	.10
22 50V	.24	.20	.18	4.7 50V	.16	.14	.11
47 25V	.19	.17	.15	10 16V	.14	.12	.09
47 50V	.25	.21	.19	10 25V	.15	.13	.10
100 25V	.24	.20	.18	10 50V	.16	.14	.12
100 50V	.35	.30	.28	47 50V	.24	.21	.19
220 25V	.32	.28	.25	100 16V	.19	.15	.14
220 50V	.45	.41	.38	100 25V	.24	.20	.18
470 25V	.33	.29	.27	100 50V	.35	.30	.28
1000 16V	.55	.50	.45	220 16V	.23	.17	.16
2200 16V	.70	.62	.55	470 25V	.31	.28	.26

CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case Style	Price
CY1A	1 000 MHz	HC33/U	$4.95
CY2A	2 000 MHz	HC33/U	$4.95
CY3A	4 000 MHz	HC18/U	$4.95
CY7A	5 000 MHz	HC18/U	$4.95
CY12A	10 000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18/U	$4.95
CY19A	18 000 MHz	HC18/U	$4.95
CY22A	20 000 MHz	HC18/U	$4.95
CY30B	32 000 MHz	HC18/U	$4.95

CLOCK CASES

Nicely styled cases complete with red bezel for use in such applications as desk clocks, car clocks, alarm clocks, instrument cases.
DIMENSIONS W-4" x 4½" x H-2"

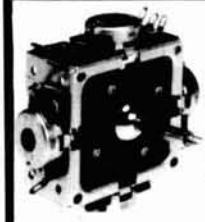
$5.95

64 Key Keyboard $24.95

This keyboard is composed of 64 Magnetic Reed Switches, in one molded unit. It is unencoded with each SPST switch brought out to two pins.

HD0165 Keyboard Encoder ROM **$7.95**

JOYSTICK



These joysticks feature four 100K potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

$9.95 ea

MOS LSI DEVICES

CLOCK CHIPS

MM5309	6 Digit, BCD Outputs, Reset PIN	$5.95
MM5311	6 Digit, BCD Outputs, 12 or 24 Hour	4.95
MM5312	4 Digit, BCD Outputs, 1 PPS Output	4.95
MM5313	6 Digit, BCD Outputs, 1PPS Output	4.95
MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
MM5316	4 Digit, Alarm, 1PPS Output	6.95
MM5318	Video Clock Chip, For Use With MM5841	9.95
CT7001	6 Digit, Calander, Alarm, 12 or 24 Hour	6.95

CALCULATOR CHIPS

MM5725	6 Digit, Four Function, Less Decimal	$2.95
MM5738	8 Digit, 5 Function, +, -, x, ÷, %	2.95
MM5739	8 Digit, 4 Function, Floating Decimal	2.95
CT5001	12 digit 4 Function	3.95
CT5005	12 digit 4 Function with Memory	5.95
CT5030	12 digit 4 Function and %	7.95

MISC. MOS

MM5320	TV Camera Sync Generator	19.95
MM5841	Video Generator For MM5318	18.00
MM5330	4½ Digit DVM Chip	9.95
MK5007	Complete 4 Digit Counter	$10.95
LD110/LD111	3½ Digit Voltmeter Chip Set	$25.00
MC1408L7	7 Bit Digital To Analog Conv	9.95

DL728

The DL728 is a dual 0.5" common cathode red display. It is ideal for use with clock chips, as segments are already multiplexed

$2.95

1/16 VECTOR BOARD

0.1" Hole Spacing P-Pattern

	Part No	Length	Width	1-19	20-49
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 02XXXP	4.50	17.00	3.69	3.32
EPOXY	64P44 062	4.50	6.50	2.07	1.86
GLASS	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin, onto component leads or terminals installed on pre-punched "P" Pattern Vectorboard® Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire

$9.50

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg. 3	250 ft. 36 AWG GREEN	$2.40
W36-3-B-Pkg. 3	250 ft. 36 AWG RED	$2.40
W36-3-C-Pkg. 3	250 ft. 36 AWG CLEAR	$2.40
W36-3-D-Pkg. 3	250 ft. 36 AWG BLUE	$2.40

1¼" x 1½" XFMERS

P.C. Mount

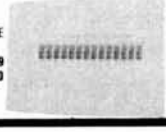
That were designed for clock type applications: 110 Vac primary @ 60 Hz
Secondaries: 8-10 Vac @ 30 mA-50 mA
50 Vac @ 30 mA-50 mA
Excellent for miniature power supplies & gas discharge displays.

SPECIAL $.79

MOLEX PINS

PINS USED AS INEXPENSIVE SUBSTITUTE FOR SOCKETS.

SPECIAL 100/1.49
SPECIAL 1000/12.00



MICROPROCESSOR COMPONENTS

8080 $24.95

8080A $39.95

CPU'S

8008	8 Bit CPU	$19.95
8080	Super 8008	$34.95
8080A	Super 8008	$39.95

SR'S

2504	1024 DYNAMIC	$9.00
2518	HEX 32 BIT	7.00
2519	HEX 40 BIT	4.00
2524	512 DYNAMIC	2.95
2525	1024 DYNAMIC	6.00
2527	DUAL 256 BIT	3.95
2529	DUAL 512 BIT	4.00
2532	QUAD 80 BIT	3.95
2533	1024 STATIC	7.95
3341	FIFO	6.95
74LS670	16X4 REG	3.95

UART'S

AY-5-1013	20K BAUD	$6.95

ROM'S

2513	CHAR GEN	11.00
7488	RANDOM BITS	3.50

RAM'S

1101	256X1	STATIC $2.25
1103	1024X1	DYNAMIC 2.95
2101	256X1	STATIC 6.95
2102	1024X1	STATIC 2.49
2107	4096X1	DYNAMIC 19.95
2111	256X4	STATIC 7.95
7010	1024X1	MNOS 29.95
7489	16X4	STATIC 2.49
8101	256X4	STATIC 7.95
8111	256X4	STATIC 7.95
8599	16X4	STATIC 3.49
91L02	1024X1	STATIC 2.75
74200	256X1	STATIC 6.95
93410	256X1	STATIC 1.75
5262	2048X1	DYNAMIC 2.95

PROMS

1702A	2048	FAMOS 15.95
5203	2048	FAMOS 14.95
82S23	32X8	OPEN C 5.00
82S123	32X8	TRISTATE 5.00

BUILD YOUR OWN JOLT MICROCOMPUTER IN JUST 3 HOURS OR LESS FOR $159.95.

A COMPLETE MICROCOMPUTER IN A SINGLE CPU KIT INCLUDES: • An MOS Technology MCS6502 NMOS microprocessor • 512 bytes of program RAM, and 64 bytes of interrupt vector RAM • 1K bytes of mask programmed ROM containing DEMON, a powerful debug monitor • 26 programmable I/O lines • Internal RC clock, or crystal controlled clock with user supplied crystal • Serial I/O ports for use with a teleprinter current loop drive/receiver, or an EIA standard driver/receiver • Expandable address and data buses • Hardware interrupt • Control panel interface lines available on card connector • Complete assembly manuals and sample programs

JOLT ACCESSORY KITS

JOLT RAM Card — Fully static 4,096 bytes of RAM with 1 microsecond access time and on-board decoding. **$199.95**

JOLT I/O Card (Peripheral Interface Adapter) — 2 PIA LSI chips, 32 I/O lines, four interrupt lines, on-board decoding and standard TTL drive. Fully programmable. **$95.50**

JOLT Power Supply — Operates at +5, +12 and -10 voltages. Supports JOLT CPU, 4K bytes of RAM and JOLT I/O card — or, CPU and 8 I/O cards. **$99.95**

JOLT +5V Booster Option — Fits onto JOLT Power Supply card. Supports CPU, 8K bytes RAM and 8 I/O CPU and cards. **$24.95**

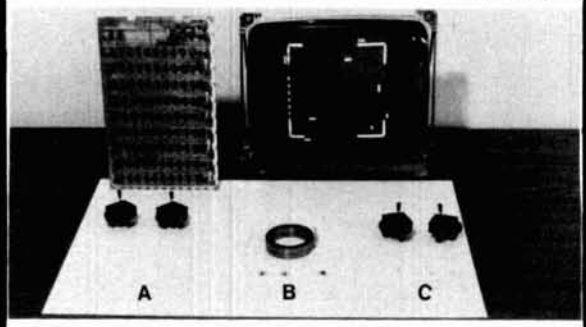
JOLT Universal Card — Same size (4¼" x 7"), same form factor as other JOLT cards. Completely blank, drilled to accept 14, 16, 24 or 40 pin sockets. **$24.95**

JOLT Accessory Bag — Contains enough hardware to connect one JOLT card to another, flat cable, connectors, card spacers, hardware, etc. **$39.95**

JOLT Resident Assembler — Fully symbolic, single pass resident assembler, all mnemonics compatible with timesharing assemblers. Delivered on four 1702A PROMs, ready for plugging into JOLT PROM card. **$149.95**

JOLT 1702A PROM Card — Sockets for 2,048 bytes of PROM memory. Place anywhere in memory with jumper selectable addresses. **$99.95**

NOW: YOUR OWN VIDEO GAME FOR THE ENTIRE FAMILY



This game comes pre-tested with two **PROFESSIONAL** Kraft joysticks. Joysticks allow 2 dimensional player control (rather than only one dimension, such as up and down.) If you require more than two players, order extra joysicks. All that's required is a 5V/2A power supply, a harness, and speaker. Comes with schematics, wiring information, and all necessary documentation. Game gives 1V composite video output, perfect for any TV monitor. Game designed so one, two, three, or four players can play at the same time. You can even play against the HOUSE. Score for each person is shown on TV set. These boards are production over runs of a well known video game manufacturer, and are **not** rejects, or in any way inferior to one presently being sold in games for over $1,000.00.

KIT A — $179.95 **PROFESSIONAL** game P.C. board, and 2 **PROFESSIONAL** joysticks. P.C. board size is 10½" x 17". This is the same **PROFESSIONAL** game as seen in commercial establishments. Don't confuse it with the simple games sold in stores, or with analog kits.

ACCESSORY B — $3.95 Six feet of ribbon cable, three SPST switches (coin simulator, hour, player, and start switch), for those of you who don't have extra wire or switches to build the harness.

ACCESSORY-C — $39.95 Two additional **PROFESSIONAL** Kraft joysticks, for third and fourth player.

DIGITAL CLOCK KIT — 3½ INCH DIGITS

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½", and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

4 DIGIT KIT $49.95 **4 DIGIT ASSEMBLED $59.95**
6 DIGIT KIT $69.95 **6 DIGIT ASSEMBLED $79.95**

Specify 12 Or 24 Hr. When Ordering

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax — Data Sheets 25c each
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AUTOTEL ™ WARNING LIGHTS ARE NOT ENOUGH

AN AUDIBLE ALARM INDICATING POTENTIAL ENGINE DAMAGE

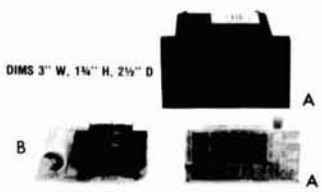
AUTOTEL is an effecient (15 ma current standby) device by which every owner of an automobile, truck or vehicle equipped with indicator lights for temperature and oil pressure can be assured of a reliable warning **before** an impending failure.

AUTOTEL, by means of an audible signal 70 db pulsing) immediately forewarns the vehicle operator of a malfunction or failure, allowing time to correct and prevent major engine failures. It is programmed so there is no sound during normal operating conditions.

AUTOTEL features CMOS circuitry, packaged in a 2½" sq. x ¾" case. The kit comes complete with all components, hardware and case to hook directly into your car's warning light system.

$9.95 Per Kit **$14.95 Assembled**

IMC 3½ DIGIT DVM KIT



This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case $49.95
B. 5V Power Supply $14.95

JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout and the MM5314 clock chip.

12 or 24 Hour

115 VAC—
$17.95
Per Kit

JE803 PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families (TTL, DTL, RTL, CMOS). It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (H) - 1 (LOW) - 0 (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit
printed circuit board

ELECTRONIC CRAPS

6½" x 3½" x 1"

Electronic craps is an entirely electronic game featuring a dice "roll down". 14 LED's form two dice that roll when activated by a push bottom. Dimensions are 6½" x 3½" x 1½".

$19.95 Per Kit
$24.95 Assembled

ELECTRONIC ROULETTE

This kit comes complete with all components, including the case and line cord. Electronic Roulette, is entirely electronic, and features 32 LED's that form a wheel, that is activated, by a push botton switch. Dimensions are 6½" x 6½" x 1½".

$29.95 Per Kit
$34.95 Assembled

Continental Specialties

PROTO BOARD 100

A low cost, big 10 IC capacity breadboard kit with all the quality of QT sockets and the best of the Proto Board series — complete down to the last nut, bolt and screw. Includes 2 QT-355 Sockets, 1 QT-358 Bus Strip, 2 5-way binding posts, 4 rubber feet, screws, nuts, bolts, and easy assembly instructions.

$19.95

More Details? CHECK–OFF Page 118

two-meter fm transceiver

A new arrival on the vhf scene is the Brimstone 144 amateur two-meter fm transceiver by Satan Electronics of Salina, Kansas. Exclusive design features, together with rugged but attractive styling, make this all-solid-state transceiver an outstanding communications package for even the most discriminating user. Frequency generation is by the Satan Electronics "Warlock Frequency Control System," which is a phase-locked-loop synthesizer that provides frequency coverage between 143.00 and 149.99 MHz, with 142-MHz coverage an optional accessory. Frequency selection is in 10-kHz steps by dialing in the desired frequency with rotary selector switches. Or, you can step the frequency in 5-kHz increments simply by pulling out the squelch-control knob. Transmit and receive frequency selection is by separate switches, and you have a choice of either repeater or simplex operation by flipping another switch. The front-panel controls and frequency readout indicators are arranged to provide maximum operating efficiency and convenience. A signal-strength meter gives a clear indication of relative transmitter power output and received signal strength.

The transmitter provides 25 watts nominal power output with a frequency stability of 0.001%, with fm frequency deviation adjustable from zero to 20 kHz. Nonharmonic spurious output is down 80 dB, thanks to the frequency control system. The modulation system uses speech-processed audio applied to a varicap modulator diode. A 500-ohm dynamic microphone is furnished with the transceiver. Any well-designed two-meter antenna will work with the Brimstone 144, which is designed for a nominal 50-ohm load.

The receiver features a low-noise, dual-gate fet rf amplifier with about 18 dB gain and a bandpass filter to minimize image and cross modulation. The receiver is a single-conversion superhet with a 10.7-MHz i-f. Sensitivity is 0.35 microvolt for 20 dB quieting and 0.25 microvolt for 12 dB SINAD. An 8-pole filter in the standard transceiver provides a 2:1 shape factor: ±7.5 and ±15 kHz respectively at 6- and 60-dB bandwidth. Even greater selectivity is available with an optional 12-pole filter.

For added versatility you can choose optional plug-in modules: tone burst for 1800-2400 Hz, Touch-Tone interface, subaudible tone, dial tone, super selectivity, and extended frequency range (142.00-149.99 MHz).

The Brimstone 144 maintenance manual is comprehensive and well written. Large, clear photos of all circuit modules with keyed parts designators are provided, including a list of all parts *and* their manufacturer. The sections on circuit description and maintenance (including troubleshooting) are especially well done, which makes the manual an extremely useful addition to the total Brimstone 144 communications package.

The standard Brimstone 144 transceiver amateur net price is $650.00, which includes the dynamic microphone and a mobile mounting bracket. For an informative brochure, including accessory module prices, write Satan Electronics, Incorporated, 2916 Arnold Avenue, Building 317, Salina, Kansas 67401, or use *check-off* on page 118.

mobile antenna mount

A new approach to mobile antenna mounts for the popular 3/8-inch (9.5mm) blind (one side) installation has been developed by Larsen Electronics, Incorporated. It's the JM antenna mount, which consists of four easy-to-install components: an anchor foot, braid nut, rubber washer, and insulator. The JM mount will accommodate any hf or vhf antenna that adapts to a 5/16-24 (approximately M12) stud. This includes most ¼-wavelength (ground plane) and gain-type antennas. Larsen also offers "match-mate" antennas for the JM antenna mount. For more details on the new JM mount, write Larsen Electronics, Incorporated, 11611 Northeast 50th Avenue, P.O. Box 1686, Vancouver, Washington 98663, or use *check-off* on page 118.

beam steering combiner

The Omega-t 2000c Beam Steering Combiner provides a low-cost means of beam steering for two- or four-element high-frequency phased arrays. The 2000c is typically used to array vertical monopole or horizontal dipole elements for receiving and transmitting applications, and is useful for arraying any type

More Details? CHECK–OFF Page 118

of elements where increased gain and directivity are required. Matching transformers, power dividers, and delay-line switching are provided for broadband 360-degree beam steering in 30 azimuth steps. Direct dial readout of the selected beam maximum azimuth is provided. Frequency range is 1.8 to 30 MHz, and power rating is 1200 watts PEP or average. For descriptive literature and pricing information, write Electrospace Systems, Inc., 320 Terrace Village, Richardson, Texas 75080, or use *check-off* on page 118.

coaxial feed-through filter

Cornell-Dubilier Electric has added three coaxial feed-through radio-frequency filters to their line of Clear[R] CB noise-filter products. They are the model CBFT 20 (20 amps, 600 working volts dc, 0.1 microfarad); model CBFT 40 (40 amps, 600 working volts dc, 0.5 microfarad); and the model CBFT 60 (60 amps, 50 working volts, 0.5 microfarad).

The CBFT filters are designed to completely enclose the conductor carrying the rf noise component. Since rf travels on the conductor surface, removal of the rf noise component is extremely effective using this type filter. CBFT filters are recommended for use on air conditioners, refrigeration units, voltage regulators, ignition systems and similar equipment. Note the current range available: 20, 40, or 60 amperes — high enough to handle most rf noise problems encountered in industrial equipment. The CBFT filters can also be used in equipment environments found in large tractor-trailer rigs.

For additional information on Cornell-Dubilier's filters, write to William Carlson, Cornell-Dubilier Electric, 150 Avenue L, Newark, New Jersey 07101 or use *check-off* on page 102.

More Details? CHECK—OFF Page 118

More Details? CHECK–OFF Page 118

COMPARE *the* Triton IV THEN DECIDE!

		TRITON IV
1.	Total solid state, including amplifier.	Yes
2.	Instant band change. No tune-up.	Yes
3.	Covers all ham frequencies, 3.5 - 30 MHz.*	Yes
4.	Power input, *all* bands, watts.	200
5.	Sensitivity (10 dB S+N/N), micro-volts.	0.3
6.	Stability. Max change for 1°F, Hz.	15
7.	Selectivity, i-f shape factor, 6/60 dB.	1.8
8.	Direct frequency readout to 1 kHz.	Yes
9.	Pulsed crystal calibrator, kHz.	25
10.	Built-in air loaded loudspeaker.	Yes
11.	150 Hz CW filter option, $25.	Yes
12.	Incremental (offset) tuning.	Yes
13.	WWV at both 10 and 15 MHz.	Yes
14.	Separate receiving capability.	Yes
15.	Automatic sideband selection, reversible.	Yes
16.	Full break-in CW.	Yes
17.	Keying rise/decay time, millisec.	2.5
18.	Sidetone level and pitch adjustable.	Yes
19.	Pre-selectable Automatic Level Control.	Yes
20.	Unwanted sideband suppression, min. dB.	60
21.	Carrier suppression, min. dB.	60
22.	Intermodulation distortion, min dB.	30
23.	Harmonic radiation, min dB.	45
24.	Built-in SWR bridge.	Yes
25.	Provisions for driving all linears.	Yes
26.	LED indicators for Offset and ALC.	Yes
27.	Ten meter crystals for 28.0-29.0 MHz supplied.	Yes
28.	Basic 12-14 volt DC operation.	Yes
29.	Five year pro-rata warranty on final transistors.	Yes
30.	Plug-in circuit boards.	Yes
31.	Price, TRITON IV, less power supply.	$699
32.	Price, power supply Model 252G.	$ 99

*160 meter adapter available.

For more information about the new TRITON, as well as the full line of accessories that will be available soon, see your dealer or write.

Owner's Manual available for $3.00 postpaid.

TEN-TEC
INCORPORATED
SEVIERVILLE, TENNESSEE 37862
EXPORT: 5715 LINCOLN AVE.
CHICAGO, ILLINOIS, 60646

Wilson Electronics Corp.

"FACTORY DIRECT ONLY"

WILSON "WE-224" MOBILE

SUMMER SPECIAL

$199.95

90 Day Warranty

10 Day Money Back Guarantee

FEATURES

1. 24 Channel Operation
2. One priority Channel
3. Selectable 1 or 10 Watts Out
4. 10.7 Monolithic Filter Installed
5. 455 KHz Ceramic Filter
6. .3 Microvolt Sensitivity for 20 dB Quieting
7. Numerical Read-out on each Channel
8. Built-in Adjustable "Tone Burst" Generator
9. Front Panel "Tone Burst" Control
10. Accepts Wilson 1402 & 1405SM Xtals
11. Individual Trimmer Capacitors for both TX/RX
12. Mosfet Front End
13. Helical Resonator
14. High VSWR Protection Circuit
15. Reverse Polarity Protection Circuit
16. NBFM - 15 KHz Channel Separation
17. Built-in Speaker
18. External Speaker Jack
19. Dynamic Microphone Included
20. Mobile Mounting Bracket Included
21. Quick Disconnect Power Cable
22. Frequency Range 144-148 MHz
23. 6½"W x 2½"H x 9½"D
24. Weight: 5½ lbs.
25. Power Requirements:
    Source: 13.5 VDC ± 10%
    Receive: .45A
    Transmit: 2.6A (10W), .7A (1W)

SPECIAL INCLUDES:

A. WILSON "WE-224"
B. MOBILE MIKE
C. MOUNTING BRACKET
D. 146.52/52 SIMPLEX CRYSTALS

SUMMER SPECIAL on Wilson Hand Held 220 and 450

2202 SM

FREQUENCY RANGE 220 - 225 MHz

- 6 Channel Operation
- Individual Trimmers on all TX/RX Crystals
- All Crystals Plug In
- 12 KHz Ceramic Filter
- 10.7 and 455 KC IF
- .3 Microvolt Sensitivity for 20 dB Quieting
- Weight: 1 lb. 14 oz. less Battery
- Battery Indicator
- Size: 8 7/8 x 1 3/4 x 2 7/8
- Switchable 1 & 2.5 Watts Output @ 12 VDC
- Current Drain: RX 14 MA, TX 500 MA
- Microswitch Mike Button
- Unbreakable Lexan® Case

USES SAME ACCESSORIES AS 1405

SUMMER SPECIAL

$239.95

INCLUDES

1. 2202 SM
2. Flex Antenna
3. 223.50 Simplex Installed

4502 SM

FREQUENCY RANGE 420 - 450 MHz

- 6 Channel Operation
- Individual Trimmers on all TX/RX Crystals
- All Crystals Plug In
- 12 KHz Ceramic Filter
- 21.4 and 455 KC IF
- .3 Microvolt Sensitivity for 20 dB Quieting
- Weight: 1 lb. 14 oz. less Battery
- Battery Indicator
- Size: 8 7/8 x 1 3/4 x 2 7/8
- Switchable 1 & 1.8 Watts Output @ 12 VDC
- Current Drain: RX 14 MA, TX 500 MA
- Microswitch Mike Button
- Unbreakable Lexan® Case

USES SAME ACCESSORIES AS 1405

SUMMER SPECIAL

$279.95

INCLUDES

1. 4502 SM
2. Flex Antenna
3. 446.00 Simplex Installed

ACCESSORY SPECIALS

	DESCRIPTION	SPECIAL PRICE
BC1	BATTERY CHARGER	$34.95
BP1	10 EA. AA GOULD NICAD BATTERIES	14.95
BT1	EXTRA BATTERY TRAY	6.00
LC1	LEATHER CASE 1402	9.95
LC2	LEATHER CASE 1405, 2202, 4502	9.95
SM1	SPEAKER MIKE FOR EARLY MODEL 1402 9 PIN CONNECTOR	24.95
SM2	SPEAKER MIKE FOR ALL NEW HAND HELDS WITH ROUND 6 PIN CONNECTOR	24.95
TE-1	SUB-AUDIBLE TONE ENCODER INSTALLED	34.95
TTP	TOUCH-TONE PAD	49.95
	INSTALLATION AT TIME OF RADIO PURCHASE	FREE
	INSTALLATION AT LATER DATE, ADD	15.00
XF-1	10.7 KC MONOLITHIC XTAL FILTER	9.95
CRYSTALS	TX or RX (Common Frequency Only)	3.75

BC-1 BATTERY CHARGER

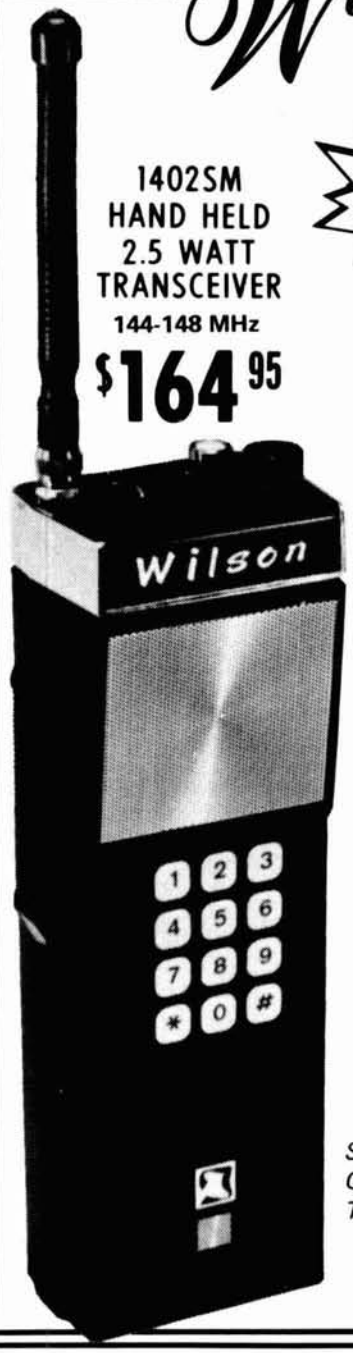
More Details? CHECK–OFF Page 118

Wilson Electronics Corp.

FACTORY DIRECT ONLY

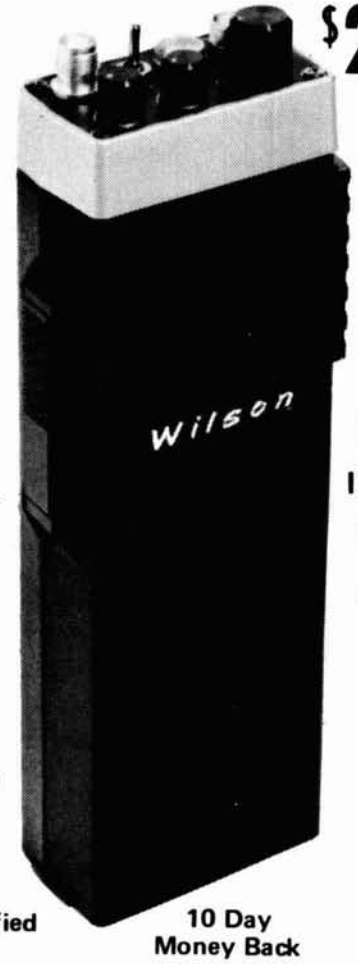
SUMMER SPECIAL

1402SM HAND HELD 2.5 WATT TRANSCEIVER
144-148 MHz
$164.95



Shown With Optional Touch-Tone Pad

1405SM HAND HELD 5 WATT TRANSCEIVER
144-148 MHz
$239.95



FEATURES

1402 SM	1405 SM
• 6 Channel Operation	• 6 Channel Operation
• Individual Trimmers on all TX/RX Crystals	• Individual Trimmers on all TX/RX Crystals
• All Crystals Plug In	• All Crystals Plug In
• 12 KHz Ceramic Filter	• 12 KHz Ceramic Filter
• 10.7 IF and 455 KC IF	• 10.7 and 455 KC IF
• .3 Microvolt Sensitivity for 20 dB Quieting	• .3 Microvolt Sensitivity for 20 dB Quieting
• Weight: 1 lb. 14 oz. less Battery	• Weight: 1 lb. 14 oz. less Battery
• S-Meter/Battery Indicator	• Battery Indicator
• Size: 8 7/8 x 1 7/8 x 2 7/8	• Size: 8 7/8 x 1 3/4 x 2 7/8
• 2.5 Watts Minimum Output @ 12 VDC	• Switchable 1 & 5 Watts Minimum Output @ 12 VDC
• Current Drain RX 14 MA TX 500 MA	• Current Drain: RX 14 MA TX 400 MA (lw) 900 MA (5W)
• Microswitch Mike Button	• Microswitch Mike Button
• High Impact Plastic Case	• Unbreakable Lexan® Case

SPECIAL ON EACH RADIO INCLUDES:
Flex Antenna
52/52
Simplex Xtal

Can be Modified for MARS or CAP

10 Day Money Back Guarantee

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SUMMER SPECIAL DIRECT SALE ORDER BLANK

___ 1402SM @ $164.95
___ 1405SM @ $239.95
___ WE224 @ $199.95
___ 2202SM @ $239.95
___ 4502SM @ $279.95
___ BC1 @ $34.95
___ BP1 @ $14.95
___ BT1 @ $6.00
___ LC1 @ $9.95
___ LC2 @ $9.95
___ SM1 @ $24.95
___ SM2 @ $24.95
___ TE1 @ $34.95

___ TTP @ $49.95
___ XF1 @ $9.95
___ TX or RX XTALS @ $3.75 ea.
___ FACTORY XTAL INSTALLATION/ NETTING @ $7.50/Radio

EQUIP TRANSCEIVER AS FOLLOWS:

	XTALS TX	RX		XTALS TX	RX
A.	52	52	G.		
B.			H.		
C.			I.		
D.			J.		
E.			K.		
F.			L.		

(SPECIFY FREQUENCY _____)

ENCLOSED IS _____ ☐CHECK ☐MONEY ORDER ☐MC ☐BAC

CARD # _____

EXPIRATION DATE _____

NAME _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

SIGNATURE _____

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HR **VALID ONLY MAY 1 THRU 31, 1976**

More Details? CHECK–OFF Page 118

Everybody wants the ultimate ham station, but the only way most of us are going to get it is to start now and grow into it.

And the best way to start is with our 700CX.

Then you'll have an excellent transceiver with 700 solid watts P.E.P. input of SSB power at the lowest cost per watt—about a buck—of any comparable equipment.

And when you're ready to add capability and features, plug in or hook up Swan accessory equipment for easy expandability.

For instance, just plug in our 510-X crystal oscillator when you want extra frequency coverage. Want VOX? Plug in the Swan VX-2 and start talking. Or hook up our FP-1 telephone patch in minutes.

And when you're ready for that big jump to all-the-law-allows, our 2000 watt P.E.P. input Mark II linear amp is waiting in the wings.

Add our complete selection of power supplies, microphones and other options and you've got everything you need for a full-house rig in matching specs and matching decor.

So your ham station will look and perform like it belongs together.

The 700CX is designed to handle problems like cross-modulation and front end overload. And you get all bands from 10 to 80 meters with selectable upper or lower sideband, AM, or CW with sidetone.

Get started on your dream rig today. See the 700CX and all of its accessories at your nearest Swan dealer. Use your Swan credit card. Applications at your dealer or write to us.

700CX Champion Transceiver..... $649.95
117-XC 110V AC Power Supply..... $159.95
(includes Speaker and Cabinet)
117-X 110V AC Power Supply..... $114.95
(less Speaker and Cabinet)
510-X Crystal Oscillator..... $ 67.95
VX-2 Plug-In VOX..... $ 44.95
FP-1 Telephone Patch..... $ 64.95
Mark II Linear Amplifier..... $849.95
(complete with 110/220 VAC power supply and tubes)
(prices FOB Oceanside, CA)

Dealers throughout the world

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SWAN 700CX TRANSCEIVER.

IT'S THE WAY TO GROW.

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NEW MEXICO
Gene Hansen Company, Corrales

NEW YORK
Harrison Radio, Farmingdale

NORTH CAROLINA
Freck Radio & Supply Company, Asheville
Slep Electronics Company, Otto

OHIO
Amateur Electronics Supply, Cleveland
Coston Electronics, Cincinnati

OKLAHOMA
Radio Store Inc., Oklahoma City

OREGON
Portland Radio, Portland

PENNSYLVANIA
Hamtronics, Trevose
Whiteside Electronics, Pittsburg

SOUTH DAKOTA
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TEXAS
Electronics Center Inc., Dallas
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WASHINGTON
Amateur Radio Supply Co., Seattle
HCJ Electronics, Spokane

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Amateur Electronics Supply, Milwaukee

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A subsidiary of Cubic Corporation
305 Airport Road, Oceanside, CA 92054
(714) 757-7525

Great New Turn On

Howard Microsystems introduces MOCO II, the newest and most efficient Morse Code translator in the state of the art.

MOCO II ushers in a new generation of Morse Code Readers. Its central processing unit is combined with computer programmed firmware totalling more than 8,000 bits of memory, which permit **MOCO** II to translate standard alpha-numeric Morse Code, even punctuation automatically.

Simply connect **MOCO** II to the speaker leads and then just turn it on. No knobs, no adjustments. One switch calibration automatically determines and displays sending speed.

MOCO II is not a kit. It's completely assembled and tested, includes integral power supply, parallel ASCII and Baudot outputs for existing display units.

PRICE: $199.00

Available as options are a video display, or a teletype driver with 60 ma. loop supplies.

Order from Howard Microsystems, Inc., 6950 France Avenue South, Minneapolis, MN 55435 (612) 925-2474.

DISPLAY OPTIONS
A. Baudot Driver/Interface for TTY $75.00
B. Video Character Display — connects with your TV $200.00
(Kit ..... $125.00)
All orders — add $2.75 shipping/handling
Allow 4 to 6 weeks delivery

HOWARD MICROSYSTEMS, INC.

★DYNAMIC DUO★

★ **COMPU-CHRON DIGITAL CLOCK KIT** ★
- 12 OR 24 HOUR OPERATION
- LARGE .33" RED LED READOUT
- CUSTOM EXTRUDED ALUMINUM CASE IN BLACK, GOLD OR SILVER FINISH **$23.95**
- COMPLETE KIT, NO EXTRAS TO BUY

★ **COMPU-TEMP 127 BINARY THERMOMETER** ★
- READS TEMPERATURE IN FAHRENHEIT WITH 1° ACCURACY
- ADD ALL LIT NUMBERS FOR TEMPERATURE (71° SHOWN) **$19.95**
- CUSTOM EXTRUDED ALUMINUM CASE IN BLACK, GOLD OR SILVER FINISH
- COMPLETE KIT, NO EXTRAS TO BUY

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N.Y residents add sales tax
P.O. Box 4072
ROCHESTER, N.Y. 14610

ARRL NATIONAL CONVENTION

TUNE IN THE SPIRIT OF '76

DENVER, JULY 16, 17 & 18

Some of the things you'll find at the 1976 ARRL National Convention.

Friday
0800 Registration
0800 Bus Tour to Hewlett Packard
1200 Ham's Hospitality Room
1200 Exhibits
1300 Bus Tour to Bureau of Standards
1400 Microprocessors for Beginners
1400 Microprocessors for Advanced
1400 General Hospitality Rooms with Entertainment
1800 Microprocessor Sharing Session
1900 QCWA Open Breakfast

Saturday
0700 Exhibits
0800 10X Forum
0900 Powerline Noise Forum
0900 Public Service Company of Colorado Introduction to Amateur Radio
0900 ARRL Staff
1000 DX Forum
Jack Reed, VE3GMT (Member, 1975 Sable Island DXpedition)
1000 Ionosphere Modification Project
1100 Search & Rescue Emergency Communications in Northern New Mexico
1100 Optical Communications in the Atmosphere
Dr. Jack Baird (University of Colorado)
1100 Contestors Forum
1200 Lunch
1230 Antenna Forum/Basics
1230 Antenna Forum/Advanced
1230 Advances in Antenna Matching
Jerry Sevick, W2NMI (Bell Labs)
1300 Amateur Radio for the Handicapped
1300 MARS/Combined Seminar
1300 Fiber Optics Communications
Joe Mullins (Manager, Digital Trunk Department, Bell Labs, Holmdel, New Jersey)
1400 FM Forum
1500 Amateur Radio Talks to the Media
1600 Printed Circuit Board Construction & Demonstration
1600 Free Time
1700 Banquet with Two Featured Speakers
'Father David L. Reddy, CEØAE, of Easter Island fame
'Geoffrey Bryson (Director of Documentary Programming for BBC, London, England)
2100 ARRL Forum
2100 Ladies Variety Show
2400 Wouff Hong Ceremony

Sunday
0530 Sunrise Service at Civic Center (Multi-Denominational)
0700 Open Buffet Breakfast
0700 Registration
0800 Exhibits
0800 MARS/Army, Navy, Air Force
0830 National Bureau of Standards
0930 Time & Frequency Service (Time by Satellite)
0930 YLRL Forum
1030 FCC Forum
1200 Hotel Check-Out Time
1300 Lunch & The Great Prize Give-A-Way

Convention Stations:
HF/VHF via NCØARL
All day family bus tour of Pikes Peak Region on Saturday. Make reservations for tours in advance.
FCC exams for all classes of licenses Friday afternoon and Saturday morning. Contact Denver Field Office for exams. First come, first served.
Variety of family activities.
2 Meter "Talk-In" via 146.34/94
Oscar demonstration by AMSAT.
Propagation & tracking report on a balloon suspended repeater.
More technical and operating sessions being scheduled.

Come to Centennial Colorado. There's more happening for you and your family than at any other Amateur Radio convention.

Send for your application **now!**
Write to: ARRL National Convention
c/o Slats Council, 2450 South Quitman
Denver, Colorado 80219

More Details? CHECK–OFF Page 118

HERE ARE **THE BUYS** FROM GENAVE

MADE IN US

GTX-100

1¼-Meter FM
100 Channel Combinations—12 watts

Separate controls for independent transmit and receive frequency selection . . . Pre-selected paired frequency lock allows one knob operation . . . Backlighted.

Down from $199.95 **$149.95**
(Incl. 223.5 MHz)

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COMMON 2-M CRYSTALS
FOR IMMEDIATE DELIVERY

These crystals can be used in most makes that employ the following circuitry:

Transmit:
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Receive:
3 times for 10.7 MHz IF in 32 pf capacitance circuits (low side)

Genave

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(317+546-1111)

☐ **GTX-200-T** — $249.95
2-meter FM, 100 channel combinations, 30 watts with factory installed tone encoder (Incl. 146.94 MHz)

☐ **GTX-200** — $199.95
2-meter FM, 100 channel combinations, 30 watts (Incl. 146.94 MHz)

☐ **GTX-100** — $149.95
1-¼ meter FM, 100 channel combinations, 12 watts (Incl. 223.5 MHz)

☐ **GTX-10-S** — $139.95
2-meter FM, 10 channels, 10 watts (Xtals not included)

☐ **GTX-2** — $189.95
2-meter FM, 10 channels, 30 watts with pushbutton frequency selector (Incl. 146.94 MHz)

☐ **GTX-600** — $149.95
6-meter FM, 100 channel combinations, 35 watts (Incl. 52.525 MHz)

☐ **GTX-I** — $249.95 (Bat. not incl.)
2-meter FM, 6-channel, 3.5 watts Hand-Held

☐ **GTX-IT** — Operate Auto Patch $299.95 (Bat. not incl.)
Same as GTX-1, plus Factory Installed Tone Encoder

☐ **Ringo Ranger ARX-2 6 db 2-M Base Antenna** @ $29.95 $_____

☐ **Lambda/4 2-M and 6-M Trunk Antenna** @ $29.95 $_____

☐ **TE-I Tone Encoder Pad** for plug-in installation on most amateur transceivers @ $59.95 $_____

☐ **TE-II Tone Encoder Pad** for installation on most Hand-Helds @ $49.95 $_____

☐ **PS-1 AC Power Supply** for use with all makes of transceivers 14 VDC-6 amps @ $69.95 $_____

and the following **standard** crystals @ $4.50 each $_____
Non-standard crystals @ $6.50 each: ..... $_____

For factory crystal installation add 8.50 per transceiver.

ACCESSORIES FOR GTX-1 and GTX-1T

☐ **PSI-18** Optional Nicad battery pack $29.95 $_____
☐ **PS-2** Charger for GTX-1(T) battery pack $39.95 $_____
☐ **GLC-1** Leather carrying case .....$12.95 $_____
☐ **TE-III** Tone Encoder (for use with GTX-1) $49.95 $_____

NAME _____ AMATEUR CALL _____
ADDRESS _____ CITY _____ STATE & ZIP _____

Payment by:
☐ Certified Check/Money Order ☐ Personal Check ☐ C.O.D. Include 20% Down
Note: Orders accompanied by personal checks will require about two weeks to process.
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Sub-Total: $_____
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IN residents add 4% sales tax: }
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All orders shipped post-paid within continental U.S
(allow 8 weeks delivery.)

576

CLIP OUT AND ORDER NOW — CLIP OUT AND ORDER NOW

More Details? CHECK–OFF Page 118

More Details? CHECK–OFF Page 118

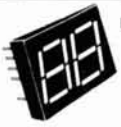
AT LAST!

4 & 6 DIGIT PC BOARDS

PC Board for 4 digit display MAN series or DL707	$1.75
PC Board for 6 digit display MAN series or DL707	$2.25
PC Board for 4 digit display FND503	$2.00
PC Board for 6 digit display FND503	$3.00
PC Board for 4 digit display DL747	$2.50
PC Board for 6 digit display DL747	$3.00
PC Board for 4 digit display DL727	$2.25
PC Board for 6 digit display DL727	$3.00
PC Board for 4 digit display FND70	$1.75

All PC display Boards are multiplexed for adding additional digits.

DL747
Jumbo .6 in. high, and only 20mA per segment.
$2.75



DL727
One of our best readouts .5 in. high, 20 mA per segment. Common anode.
$3.75

DL707
Red, .30 in. high 15 mA per segment. Common anode
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DL33
If you like an array of displays, we have it. 10mA per segment. Common Cathode
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HP7730
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MAN5 GREEN
MAN7 RED
MAN8 YELLOW
Why not make a clock in 3 diff. colors. .27 in. high. Common anode.
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BURROUGHS 12 DIGIT
.25 in. high orange digit. 160V DC. Free skt.
$3.25

FND503
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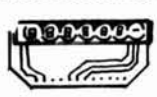
5 for $7.50
New .5 in. display by Fairchild. Common Cathode.

LEDs

Mini red	.12
Jumbo red	.15
Jumbo green	.20
Jumbo yellow	.25

DISPLAY SPECIAL



$1.30

Fully multiplexed, common cathode. Goldplated. Ideal for mini 6 digit clock.

THE KING OF ALTAJ

INTRODUCING:

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FOUR DIGIT TEMPERATURE KIT

FATIMA, the first in a series of time sharing kits to interface with **THE KING**.

FATIMA – FEATURES: $19.95

1) 4-digit temperature display
2) Farenheit or Centigrade
3) Temperature 10 sec. display; time 20 sec. display
4) Complete C-Mos application
5) Kit uses 7002 4-digit counter

Kit includes all components, PC Board and instructions for interfacing with THE KING 6-digit alarm clock.

Watch next issue for yet another addition!

THE KING – FEATURES:

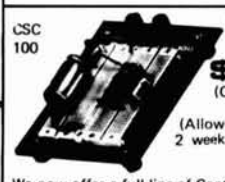
1) 6 digit, 12 hr. 60 cycle or 24 hr. 50 cycle alarm clock
2) Time sharing capability for display of additional information.
3) Built-in alarm generator and automatic output for intensity control of LEDs.
4) Single 12v. supply and a minimum of interface components.
5) AM-PM and automatic power failure indications.
6) 10 minute snooze
7) Complete data and construction manual enclosed.

THE KING $23.50

Kit No. 70250-1R	(Red readouts)
Kit No. 70250-1G	(Green readouts)
Kit No. 70250-1Y	(Yellow readouts)
Kit No. 70250-2R	(DL727 readouts) $28.50
Kit No. 70250-3R	(DL747 readouts) $28.50

All kits include Components, PC Boards, Transformer, and Case.

CSC 100



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Power Supply Kit ; 5Volt 1Amp. Reg.
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Kit includes Components, PC board, Transf., Fuse Pilot Light
Nothing else to buy:
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TTL

7400	.16
7402	.16
7404	.16
7406	.24
7408	.16
7410	.16
7413	.49
7420	.16
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7430	.16
7437	.39
7438	.35
7440	.16
7442	.69
7447	.89
7448	.89
7453	.16
7473	.37
7474	.37
7475	.65
7476	.39
7483	.85
7490	.69
7492	.75
7493	.75
7495	.75
7496	.75
74121	.38
74123	.75
74151	.75
74153	.89
74154	.95
74161	.99
74163	1.19
74164	1.89
74165	1.49
74174	1.29
74175	1.39
74181	2.75
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74193	1.25
74195	.79
74197	.79

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CD4000	.24
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CD4006	1.49
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CD4008	1.15
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CD4011	.24
CD4012	.24
CD4013	.59
CD4014	1.49
CD4015	1.19
CD4016	.59
CD4017	1.29
CD4018	1.49
CD4019	.59
CD4020	1.59
CD4021	1.49
CD4022	1.19
CD4023	.24
CD4024	.99
CD4025	.24
CD4026	1.49
CD4027	.59
CD4028	.99
CD4029	1.39
CD4030	.49
CD4032	.24
CD4033	1.49
CD4034	3.25
CD4035	1.39
CD4037	4.50
CD4040	1.59
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Module contains 2 transistors plus other components. Used as audio pre amps. With specs 4/$1

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Chip No. 7020 with direct segment drive. 8 digit.
Priced to sell: **$2.25**

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2N3055 NPN 115W TO3 Power	0.85
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50 for $0.95
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Satisfaction Guaranteed.

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60 Watt COLOR ORGAN

Completely self-contained unit, with 120 volt power cord included.
$1.50

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MEMOREX computer boards with TTL's Diodes and Transistors, etc.
5 Boards containing 150-250 IC's.
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FM Transformer Asst.
Includes FORD 19 KHZ, 38 KHZ, Osc. coils, etc. Used in AM FM car radios. All new 10 PC. ASSMT.
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1N4004 400PIV	15	for 1.00
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1N746 3.3Zen.	4	for 1.00
1N4148 Switch	20	for 1.00

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555 Timer Mini dip.	0.45
8038 Functional generator	4.25
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565 Phase Lock Loop	0.95
567V Tone Decoder	1.50
LM723 Pos. Volt. Reg.	0.55
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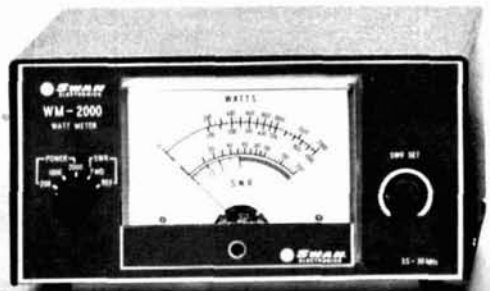
These wattmeters tell you what's going on.

With one of these in-line wattmeters you'll know if you're getting it all together all the time. Need high accuracy? High power handling? Peak power readings? For whatever purpose we've got the wattmeter for you. Use your Swan credit card. Applications at your dealer or write to us.



WM2000 In-Line Wattmeter With Muscle. Scales to 2000 watts. New flat-response directional coupler for maximum accuracy. **$49.95**

WM3000 Peak-reading Wattmeter. Reads RMS power, then with the flick of a switch, true peak power of your single-sideband signal. That's what counts on SSB. **$66.95**

WM1500 High-Accuracy In-Line Wattmeter. 10% full scale accuracy on 5, 50, 500 and 1500 watt scales, 2 to 30 MHz. Forward and reflected power. Use it for trouble-shooting, too. **$64.95**

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7.5" x 12"	$1.50
ELECTROLYTICS	
1000 µf @ 6. 3 volts	25¢ ea.
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0.1 µf @ 200V	20/$1.00
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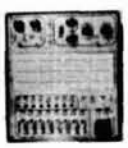
YOUR BEST BUY IN KITS



ANALOG-DIGI-LAB
Features 3 Regulated power Supplies. 3 Output wave forms. 8 digital level switches. 2 no bounce pulser switches. 8 LEDs with drivers. 1 AP Super strip. Easily constructed. Designed by RETS Electronic Schools.
1st time offer **$139.00**

Discrete basic clock kit **$16.95**
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FREQUENCY COUNTER

7 Digit 0-300 MHz Freq. counter $99.00
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Cabinet accessory package available for above **$24.95**

DVM available about March

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Send SASE for flyer. Featuring Electronic component and kits available.

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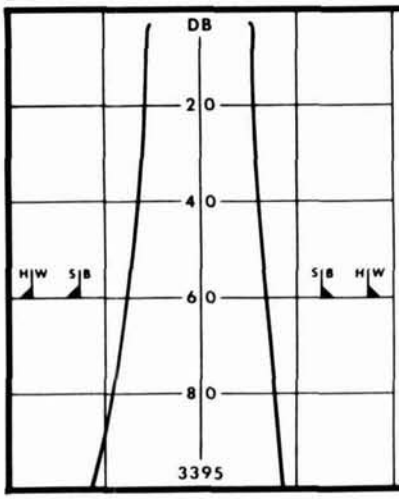


HEATH HW and SB KIT OWNERS

Do you want a sideband filter which is completely compatible with your gear (except HW and SB-104) and offers up to 70 dB improvement over the original filter? We have it!

SUPERFILTER MK-II

2100 Hz	6 dB Bandwidth
3100 Hz	60 dB Bandwidth
3800 Hz	90 dB Bandwidth
110 dB	Ultimate Rejection

Look at the graph - compare your present filter with our "frustration resolver" - then order one or write for more details! 100% USA Manufactured.

ONLY $125.00 DELIVERED IN U.S.A.

SIGNAL MANAGEMENT SCIENCES
Long Green, Maryland 21092 U.S.A.

More Details? CHECK–OFF Page 118

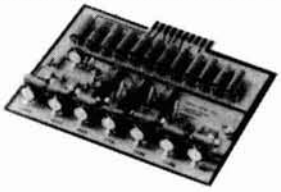
Tone Encoding–Decoding at its BEST

DELUXE REPEATER AUTO PATCH

The auto-patch your club will be proud to own. It's complete in every aspect. Two 1-4 digit access codes, one 1-4 digit disconnect, rotary dial or regenerated Data Tone output, dial-in capability, "1", "0" and numerical disconnects, ID bypass, audio monitor, keyboard, digital readout, plus many other features. Send for brochure. Rack mount only.

RAP-101 Sh. Wt. 15 lbs. **$949.00**

DATA-TONE DECODERS — TTD-12 & TTD-16



The TTD-12 (TTD-16) is a complete 12-digit (16-digit) Data Tone decoder. It uses the latest Phased Locked Loop technology to provide an extremely compact, low-power receiver/decoder. The TTD-12 accepts the standard 2 out of 7 (the TTD-16 accepts 2 out of 8) tone frequencies, providing a valid output for each tone pair. Standard outputs are available with heavy duty relays or TTL logic. The TTD-12 and TTD-16 provide simple and reliable selective signaling capability. They are ideally suited for remote control purposes where unattended operation over radio links, private lines or the telephone network are required.

TTD-12L, TTL output **$89.50 wired**
TTD-12R, Relay output **$109.50 wired**
TTD-16L, TTL output **$99.50 wired**
TTD-16R, Relay output **$129.50 wired**

AUDIO AUTOMATIC GAIN CONTROL AMPLIFIER

Is your tone decoder having problems due to input variations? If so, eliminate these and other problems caused by weak, strong or varying input signels. The AAGC-1 will take signal levels between 50 mV to 5 Volts and feed a clean rock stable signal to any decoder for perfect operation. Give your decoder a chance to decode properly with our AAGC-1 amplifier.

Shipping Weight 3 oz. **$24.50 wired**

AUTOMATIC DATA TONE DIALER

Automatic mobile telephone dialing is now available. By the push of a single button you can automatically dial up to six separate 7-digit numbers. All solid-state micro-power COS-MOS design. Automatic PTT operation. Programmable to send telephone number only, access code plus telephone number or telephone number plus an identification number. Low profile dash mount, easy installation. Compatible with most radio equipment. Available with keyboard for manual dialing of numbers. Manual operation provides automatic PTT operation with 1½ second transmitter hold.

AD-6 Without keyboard **99.50**
AMD-6 With keyboard **119.50**

Factory programming of numbers $7.50.

DATA TONE PADS

Standard size 12 and 16 digit Data Tone Pads. Automatic PTT operation with 1½ second transmitter hold. Self powered via internal 9V battery. Audio and PTT outputs, TTP-1 and TTP-2 also has low volume audio monitor for acoustically coupling of tones to microphone. Zero quiescent current. Operating temperature −20°F to +150°F. R. F. proof.

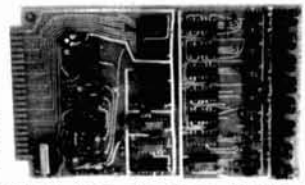
TTP-1 16 digit 3″ x 5½″ x 1½″. Sh. Wt. 2 lbs. **59.50**
TTP-2 12 digit 3″ x 5½″ x 1½″. Sh. Wt. 2 lbs. **59.50**

DATA TONE TO DIAL PULSE CONVERTER

Convert standard 0-9 Data Tone digits to Bell System compatible dial pulse code. Completely solid state. Includes state-of-the-art Phased Locked Loop anti-falsing Data Tone decoder, large capacity 64-digit memory and solid state pulsing. Starts dialing on first incoming digit. Memory will not become congested due to rapid succession of incoming digits. Cancel and redial function. * and # digits are decoded and provided for remote control purposes. Available as p.c. board or rack mounting.

DPC-121 P.C. Board **$195.00**
DPC-121R Rack Mount **$285.00**

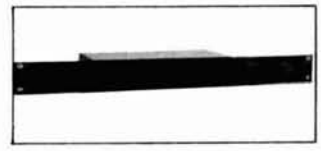
ANTI-FALSING DATA TONE DECODER



Now, a true anti-falsing decoder/receiver. Virtually immune to high noise or audio falsing. Twelve or 16 digit capability. Completely solid state, uses latest Phased Locked Loop decoding. Single 5-volt power supply. Heavy duty transistor output. Available as p.c. board or 19″ rack.

TTD-126-12 12 digit P.C. **$149.95** Rack **$219.95**
TTD-126-16 16 digit P.C. **$169.95** Rack **$239.95**

REPEATER AUTO PATCH



It's complete — a single digit access/disconnect Auto Patch facility. All you need is a repeater and the phone line. Complete with automatic disconnect, dialing capability, two way audio monitor plus remote control. When used with a rotary dial exchange, Data Signal's DPC-121 dial converter is also required. P.C. board or Rack Mount available.

RAP-2 PC **$99.50** Sh. Wt. 2 lbs. Rack **$149.50** Sh. Wt. 8 lbs.

DELUXE P.C. KEYER

In either a 5 volt TTL or a 9 volt C-MOS version this new module type IC keyer can be easily adapted to your own custom package or equipment. Versatile controls allow wide character weight variations, speeds from 5 to 50 w.p.m. plus volume and tone control. Solid-state output switching saves power, eliminates all those annoying relay problems and is compatible with both grid block and solid-state circuitry. With its side-tone monitor and 90 day warranty the Data Signal PC Keyer is the one for you.

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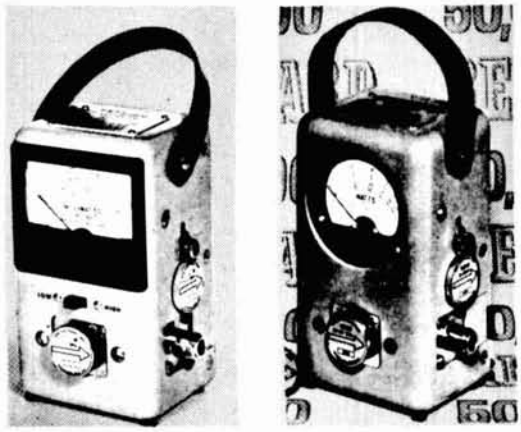

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the TR-7200A

Kenwood's superb 2-meter FM mobile transceiver. Designed to withstand the most severe punishment while providing consistently excellent performance.

Packed with features like the PRIORITY function . . . Put your favorite crystals in channel 7, and the 7200A automatically returns to that frequency when it senses activity there. 146-148 MHz coverage, 22 channels, 6 supplied. Completely solid state. Voltage required: 13.8 VDC. Antenna impedance: 50 ohms. Frequency adjusting trimmers on every crystal. RF output power: 10 watts (or 1 watt at low power). Adjustable frequency deviation (factory set at ±5 kHz). Automatic VSWR protection. Receiver sensitivity less than .5 uV for 27 dB. Selectivity: 12 kHz/−6 dB and 24 kHz/−70 dB. Size: 7-1/16" W x 2-3/8" H x 9-7/16" D, 5-1/2 lbs.

Complete with dynamic mike, DC power cord, mobile mount, mike hanger, auxiliary connector and external speaker plug. Amateur net . . . $249.00.

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Kenwood's high performance portable 2-meter FM transceiver . . . completely transistorized, rugged and compact.

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BARREL KIT #1
SN7400 DIP IC'S
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Marked 14 and/or with 16 pin dips, may include gates, registers, flip flops, counters. Who knows! GUARANTEED SATISFACTION!
Cat.No.5H 2415 Untested.

BARREL KIT #2
LINEAR OP AMPS, DIPS
Untested **75 for $1.98**
May include 709's, 741's, 703's, 560 series. 555 includes marked and unmarked. Cat.No.5H 2416

BARREL KIT # 3
1N4148/914 SWITCHING DIODES
100 for $1.98
You never saw this before. Imagine famous switching diodes at these prices!
Cat.No.5H 2418 Untested.

BARREL KIT #4
"4000" RECTIFIERS
100 for $1.98
Untested.
These are the famous micro miniature rectifiers of the 1N4000 series. May include 25, 50, 100, 200, 400, 600, 800 and 1000 volters. Cat.No.5H 2417

BARREL KIT #5
SCRS, TRIACS, QUADRACS
40 for $1.98
All the famous plastic power tab type. Raw factory stock! All the 10 amp types.
Cat.No.5H 2419 Untested.

BARREL KIT #7
VOLUME CONTROL BONANZA!
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Singles, duals, variety of values, styles, big ones — small ones. Cat.No. 5H2421

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100% good.
100 for $1.98
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BARREL KIT #10
ROMS-REGISTERS
50 for $1.98
Untested
2-8 to 40 pin devices, marked, internal factory numbers, etc Cat.No.5H2424

BARREL KIT #12
POWER TAB TRANSISTORS
40 for $1.98
PNP, plastic TO220 type. Assorted 2N numbers.
Cat.No. 5H 2426 Untested.

BARREL KIT #13
RESISTOR NETWORKS
60 for $1.98
Untested.
By Corning Glass, in 14-pin dip paks. Cat.No. 5H 2427

BARREL KIT #15
MOSFET TRANSISTORS
60 for $1.98
All 4 leaders TO-18 case, includes UHF transistors too! Cat.No.5H 2429

BARREL KIT #17
LINEAR & 7400 DIPS
Untested
100 for $1.98
Marked and unmarked, internal numbers of raw factory stock. Cat.No. 5H 2431

BARREL KIT #19
DIPPED MYLARS
60 for $1.98
Finest capacitors made, shiny finish. Imagine factory dumping 'em in barrels.
Cat.No.5H2597 100% good.

BARREL KIT #20
LONG LEAD DISCS
150 for $1.98
Factory distributor stock "auction sale". Prime, marked only. Long leads
Cat.No 5H2598 100% good

BARREL KIT #25
METAL CAN TRANSISTORS
100 for $1.98
Untested,
Includes TO-5, 18, etc., assorted 2N numbers, unmarked etc.
Cat.No.5H 2603

BARREL KIT #26
PLASTIC TRANSISTORS
100 for $1.98
Untested.
Type TO-92 (TO-18). all manufacturers. variety of 2N #'s. Cat.No.5H 2604

BARREL KIT #30
PREFORMED RESISTORS
250 for $1.98
We got barrels of ¼ and ½ watters for pc use. You'll get even amount. 100: ¼, 100 ½ watters.
Cat.No.5H 2608 100% good

BARREL KIT #31
METALLIC RESISTORS
100 for $1.98
100% good.
Made mostly by Corning, the finest resistor made. Mostly ½ watters, 1% to 5% tol. & a barrel of values. Cat.No.5H 2609

BARREL KIT #32
TRANSISTORS WITH A HOLE IN IT
50 for $1.98
Cat.No. 5H 2610 Untested.
Can't name factory but we bought barrels of 25 watters with mtg. hole in middle. PNP'S and NPN'S.

BARREL KIT #35
NEON LAMPS
40 for $1.98
100% good.
Famous NE-2's. All prime, but factory made millions and barrel'ed 'em. Your advantage Cat.No 5H2613

BARREL KIT #36
GERMANIUM DIODES
200 for $1.98
Untested
Famous maker, popular item. Never grows old. But this is the way the RE-TESTERS buy 'em from the factories. Cat.No.5H 2614

BARREL KIT #37
1 AMP "BULLETT" RECTIFIERS Untested.
100 for $1.98
Famous style, asstd. voltages, silicon, axial includes all types of voltages to 1KV. Cat.No. 5H2615

BARREL KIT #38
2 AMP RECTIFIERS
75 for $1.98
Untested.
"CYLINDER" type, silicon, Mallory, includes all voltages up to 1KV. Axial leads. Cat.No.5H 2616

BARREL KIT #39
2N3055 & HOBBY TRANSISTORS
15 for $1.98
100% good.
From factory to you, these fallouts are the famous 2N3055. We have 10 barrels. Cat.No. 5H2617

BARREL KIT #40
PNP HIGH-POWER TRANSISTORS
20 for $1.98
Popular germanium TO-3 case units, usually available at "good ole barrel" prices.
Cat.No. 5H 2618 100% good.

BARREL KIT #46
G.E. 3.5 WATT AMPLIFIERS
PA-265
25 for $1.98
Untested.
Hobby type, factory fallouts, we purchased them in barrels. These are unknowns. Cat.No. 5H2624

BARREL KIT #50
SIGNAL SILICON DIODES
200 for $1.98
Includes many, many types of switching, signal silicon types, all axial leads. Some may be zeners.
Cat.No.5H 2628 Untested.

BARREL KIT #61
HOBBY OPTO COUPLERS Untested.
40 for $1.98
We bet 1,000's unknown both the sensor or transmitter may be good, or both. WE DON'T KNOW! We don't know the types. 1500V isolation. Cat.No.5H 2629

BARREL KIT #52
DISCS!
500 for $1.98
Cat.No.5H2630 100% good
The bargain of a lifetime! First time ever offered by Poly Paks for the economy-minded bargain hunters.

BARREL KIT #53
JUMBO RESISTOR PAK
100-pc. $1.98
Cat.No. 5H 2721
Assortm metal films, precisions, carbons, metal oxide powers, from ⅛ watt to 7 watts. Color coded & 100% good. Worth $10.

BARREL KIT #58
SLIDE SWITCHES
30 for $1.98
All shapes, sizes, spst, dpdt, momentaries, etc. Tremendous shop pak for 100's of switching projects.
Cat.No. 5H 2726 100% good.

BARREL KIT #59
POWER TRANSISTORS
40 for $1.98
15 watt Bendix B-5000 pellet transistors, npn, all good, purchased from a pretester, have millions of
100% good Cat.No. 5H 2727

BARREL KIT #60
DTL'S IC'S
75 for $1.98
Untested.
This is prime barrel material. Who wants DTL's? 930, 936, 946's. Your gain is our loss. They're marked too. Cat.No. 5H 2728

BARREL KIT #61
POLYSTYRENE CAPS
100% good
100 for $1.98
Finest caps made. As a gamble we bought 10 barrels from factory, mixed values; all good. Cat.No. 5H 2729

BARREL KIT #65
MIXED READOUTS
15 for $1.98
Factory returns — such numbers as MAN-4's, MAN-7's, MAN-8's, 11 barrels & no time to separate.
Cat.No.5H 2733 Untested.

BARREL KIT #68
2 WATTERS
100 for $1.98
100% good.
Nobody seems to want 'em! So many suppliers don't count, but throw 'em in the barrel. It's a lil' gold mine
All marked. Cat.No.5H 2735

BARREL KIT #71
CAPACITOR SPECIAL
100 pcs. $1.98
Emptied stockrooms into barrels of mylars, poly's, micas, molded, plastics, ceramics, discs, etc. Nifty
100% good. Cat.No. 5H 2738

BARREL KIT #73
TRANSISTOR ELECTROS
50 for $1.98
It "bugs" us why the factories dump 'em in barrels. We don't wish to separate wide asst voltages & values up to 300 mf. Cat. 5H2747

BARREL KIT #75
400MW ZENERS
100 for $1.98
Factory out of biz! Amazing offer: 6, 8, 10, 12 to 15V. You test. Hermetically sealed glass pak. Double plug.
Cat.No. 5H 2740

BARREL KIT #76
1-WATT ZENERS
100 for $1.98
Untested.
Factory same as 400-mw's. Never-to-see-again offer. 6, 8, 10, 12, 15V. under glass. Double plug.
Cat.No. 5H 2741

BARREL KIT #77
"BROWN" BODY TRANSISTORS
40 for $1.98
G-E D-40 series: has hi-voltage, Darlingtons, hi-current, npn's. Factory line discontinued. Power tabs.
Cat.No. 5H 2742 Untested.

BARREL KIT #78
"RED" BODY TRANSISTORS
40 for $1.98
D-42 series. You test—go into your own biz! High current, hi-V, NPN.
Cat.No. 5H2743 Untested

BARREL KIT #81
SUBMINI RESISTORS
200 for $1.98
100% good.
PC, upright type, color coded, ⅛ watt. Asst values. Came to us in a barrel.
Cat.No. 5H 2746

BARREL KIT #83
15 for $1.98
LM-3407 Untested
VOLTAGE REGULATORS
Factory rejected them for length of leads. May include 5, 6, 8, 12, 15, 18, 24 volts. Power tab Cat.No. 5H 2635

BARREL KIT #87
NATIONAL IC BONANZA
100 for $1.98
Factory dumps into barrels. Types 8000, 7400 series, DTLs, ROMs, registers, clock & calc. chips, linears, etc.
Cat.No. 5H 2860 Untested.

BARREL KIT #91
SILVER MICAS
100 for $1.98
Cat.No.5H 3018
For the first time silver micas so low in price! Axial, red case, variety of physical sizes & values. Big savings from distributor prices, Wt. 1 lb.

BARREL KIT #94
"BUBBLE" READOUTS
12 for $1.98
DL-338 bubble magnifiers, Segs missing. Truthfully so many of 'em we don't care. Untested. 3 oz. No.5H.3046

BARREL KIT #99
PHOTO ELECTRIC CELLS
10 for $1.98
Asst. GE types, CDS types. Mixed by factory. Big job for us to separate. 100% good. Cat.No.5H 3052

BARREL KIT #102
CLOCK CHIPS
5 for $1.98 No.5H 3055
National is dumping! MM-5316 — what's wrong with 'em, we don't know, but we got barrels. Hobby special. Wt. 2 oz.

BARREL KIT #104
SLIDE VOLUME CONTROLS
10 for $1.98
Cat.No. 5H 3057
Used in hi-fi, volume control maker unloads. Asst. values, what a buy. Worth $1 ea. We've got barrels of 100% material.

BARREL KIT#107
SQUARE OHMS
60 for $1.98 Cat.No. 5H 3096
Factory people are sometimes "squares" when they topple prime square ohms mix 'em up in barrels. Asst. values watts. Wt. 1 lb.

BARREL KIT #108
TO-5 PLASTIC TRANSISTORS
Cat.No.5H3101
40 for $1.98
Includes PNP, NPN, 2N-3638, 2N3641, 2N5000 series, etc. Untested, but guaranteed to a 60% yield.

BARREL KIT #109
TERMINAL STRIPS
150 for $1.98
Wide asst. of terminal strip connectors, from 2 contact up. Strip manufacturers barrel dump is your gain. Wt. 1 lb. Cat.No. 5H3136

BARREL KIT #110
SUPPRESSOR DIODES
50 for $1.98 Cat.No.5H3137
Keeps ignition noises out axial. Untested, but the of your eqpt., car, industrial, etc. Double plug.

BARREL KIT #111
MULTI DIGIT READOUTS
8 for $1.98
barrels of blemished 3, 4 and/or 5 digit readouts to USA for "dump". Untested.
Cat.No.5H3138

BARREL KIT #112
MICRO MINI LEDS
40 for $1.98
All the tiny leds, axial, upright of Monsanto, Litronix, variety of colors. Yield 50% or better.
Cat.No.5H 3139

BARREL KIT #113
STABISTORS
50 for $1.98 Cat.No.5H 3140
Regulator, sensing and computer circuitry. Axial double plug type. Discontinued factory line. PIV 20 volts. 80% yield. U test 'n save!

BARREL KIT #114
PLASTIC SCRS
25 for $1.98 Untested.
Cat.No.5H3143
Factory is changin' style, top grade yield 80% to 90%. Includes 15, 20, 60, 100, 150, 200 volts. TO-92. A buy? You betcha!

BARREL KIT #115
MOLEX SOCKETS
300 for $1.98
100% good.
Calculator maker dump! We got a zillion of 'em. Used for IC sockets, etc.
Cat.No.5H 3144

BARREL KIT #116
BUTTONS 'N FEEDTHRU'S
100 for $1.98
100% good
Truthfully worth a small fortune. Wide asst. of button-feedthru caps! HAMS TAKE NOTE! RF, UHF, etc. Wt. 1 lb. Cat.No.5H3141

BARREL KIT #117
20-MIL OPTICAL FIBERS
200-FT. $1.98
Fiber optics factory bankruptcy purchase! High quality, most-commonly used size (20-mil), CLEAR. Lowest price. $H3206

BARREL KIT #118
MINI SCRS
50 for $1.98
UNBELIEVABLE! TO-92 plastic SCRS in barrels . . . rite from factory. Includes all voltages up thru 200 prv. 5H3135

BARREL KIT #119
MODULAR SWITCHES
25 for $1.98
Centralab "push-ON" switches. TV-makers excess. Dpdt, 6pdt, etc. Brand new. Cat. No. 5H3150

BARREL KIT #120
TRIGGER DIODES
25 for $1.98
Type ER-900, same type used to trigger scrs, triacs. Sometimes called "diacs". Untested. No. 5H3160

BARREL KIT #121
"MINI" MAGNETS
100 for $1.98
Magnet circular and rectangular cuttings from a major maker — For reed switches & micro-circuitry.
Cat. No. 5H3168

BARREL KIT #122
PLASTIC OPTICAL FIBERS
500-Ft. $1.98
Pop'lr 10-mil size. Excellent for making lite pipes, experiments, lamp sprays.
Cat. No. 5H3159

BARREL KIT #123
CD-4002 C-MOS IC
15 for $1.98
mostly good. But we have 250,000. Can never sell 'em out. YOUR GAIN! Their number is CD-5602.
Cat. No. 5H 3217

BARREL KIT #126
UPRIGHT ELECTROS
40 for $1.98
Wide asst. of values from 1mf to 300mf in mixture of voltages, 100% marked 'n good. Why barreled? U-got-a-buy!
Cat. No. 5H3226

BARREL KIT #127
AXIAL ELECTROS
40 for $1.98
Truthfully the factories (by mixing 'em in barrels) do all of us a favor, WUT A BUY! Asst. capacities and voltages.
Cat. No. 5H3227

BARREL KIT #128
MINI DIP ICS
75 for $1.98
Large mfgr dumped 100's of lbs into barrels. Includes 741s, LM-380-8, 703, 567, 555, 556—but who knows? Factory to you. All mixed, you test. Wt. 1 lb.
Cat. No. 5H3245

NEVER BEFORE!

U-TEST EM-N-CHOOSE EM IC'S

Order by Cat. No. and Type No.

7400 SERIES

Cat. No. 5H3170

Type	Sale
SN7400	50 for $1.98
SN7402	50 for 1.98
SN7404	40 for 1.98
SN7410	50 for 1.98
SN7413	25 for 1.98
SN7420	50 for 1.98
SN7440	50 for 1.98
SN7442	25 for 1.98
SN7452	50 for 1.98
SN7474	40 for 1.98
SN7475	30 for 1.98
SN7476	30 for 1.98
SN7483	40 for 1.98
SN7486	40 for 1.98
SN7490	25 for 1.98
SN7493	30 for 1.98
SN7495	30 for 1.98
SN74107	40 for 1.98
SN74112	40 for 1.98
SN74123	30 for 1.98
SN74128	40 for 1.98
SN74150	30 for 1.98
SN74157	30 for 1.98
SN74164	30 for 1.98
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SN74192	30 for 1.98
SN74193	30 for 1.98
SN74198	30 for 1.98

MONEY BACK GUARANTEE PER PAK!

NEW FACTORY ARRANGEMENTS! Why mix 'em? They decided to "bag" same types, then throw bags into barrels. WE DON'T TEST! You test 'em yourself. Buy types of your choice at BARREL PRICES!

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Cat. No. 5H 3171

LM300H	30 for $1.98
LM301V	50 for 1.98
LM307V	40 for 1.98
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LM318V*	30 for 1.98
LM319V	30 for 1.98
LM324N	30 for 1.98
LM339N	30 for 1.98
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LM380N	30 for 1.98
LM380V*	30 for 1.98
LM381N	30 for 1.98
LM382N	30 for 1.98
LM555V	30 for 1.98
LM709H	50 for 1.98
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LM741V	30 for 1.98
LM747N	30 for 1.98
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*Mini †TO-5

Terms: Add postage Rated: net 30
Phone: Wakefield, Mass. (617) 245-3829
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MINIMUM ORDER — $6.00

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flea market

RATES Non-commercial ads 10¢ per word; commercial ads 40¢ per word both payable in advance. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing). Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** can not check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

COLLINS ACCESSORIES available now at reduced prices. Items are new 351 DE Mobile mount, reg. $487.00, now $329.00; 516F2 AC supply, reg. $265.00, now $198.00; CC-2 carry case, reg. $160.00, now $121.00; MP-1 DC supply, reg. $440.00, now $329.00. Write for list of used gear. HCJ Electronics, 8214 E. Sprague, Spokane, Wash., or phone 509-924-2343.

STOP don't junk that television set. ASE manufactures the world's most complete line of television picture tubes. Over 1700 types. Most types immediate delivery. Tubes for Old or New TV's, black & white and color. 2 year factory warranty. Lowest prices anywhere. Allied Sales & Engineering, Inc., Dept. 22, Pimento, IN 47866. Telephone 812-495-6555.

TELETYPES: Model 19, $175. Model 15, $75. 516-581-6509, Al Shapiro.

LOOKING FOR USED GEAR? Buyers & Sellers radio brokerage has the equipment you want at the prices you want to pay. Call our Ham Gear Hotline: 617-536-8777, weekdays 9-5 EST.

FOR SALE: Janel 6&2 FET converters, $75 ea./pair $135. Jim, W1VYB, 617-922-3850.

VERY in-ter-est-ing! Next 4 big issues $1. "The Ham Trader," Sycamore, IL 60178.

RECONDITIONED TEST EQUIPMENT for sale. Catalog $.50. Walter, 2697 Nickel, San Pablo, Ca. 94806.

KLM PRODUCTS, Larsen ants., Icom, police and fire scanners. Send for prices. Not given over phone. Narwid Electronics, 61 Bellot Road, Ringwood, N. J. 07456.

SAVE! Bomar FM, xtals $4.00 ppd. Dentron, Hustler, CushCraft, W. M. Nye, Ameco. Used gear. Complete catalog - write Ferris Radio, 308 E. Harry, Hazel Park, Mich. 48030.

REGENCY TMR-1H RECEIVER CASE comes complete with transformer, speaker, front panel controls, power plug, and mobile mounting bracket. Makes a great case for any mobile ham project! 12.95 2/25.00. Avel Electronics P.O. Box 4072 Rochester, New York 14610.

WANTED: Good working used ham band and SSB transmitters and receivers. receivers should not be older than 1955, will pay cash or trade. Write HCJ Electronics, 8214 E. Sprague, Spokane, Wa. 99030 or phone 509-924-2343.

CLASSICAL LP RECORDS, unscratched, Bought - Sold. R. Junker, 583 6th Ave., San Francisco, Ca. 94118.

SIGNAL/ONE REPAIRS. K6BE. 415-548-1889.

WESTERN ELECTRIC TOUCH TONE PADS. 12 button, 10 wire. Brand new with schematic. Model 35NIA, $12.00 each + $1.00 each shipping and handling. (Calif. res. add 6% sales tax). Send Check or money order, W. A. Maitrejean, P. O. Box 8205, Fountain Valley, Calif. 92708.

CIRCUIT BOARDS. Artwork, negatives, etching. SASE for details. Karl Raup, WB4OXG, Box 498, Springfield, Virginia 22150.

KILOWATT HOMEBREW FINAL on 6 and 2 meters includes 600 watt plate modulator and all power supplies with Variac control, $200.00. SASE for details. Daskam, 206 Hillspoint Road, Westport, CT. 06880.

CANADIAN JUMBO SURPLUS and Parts Catalogs. Bargains Galore. Send $1. ETCO-HR, Box 741, Montreal "A" H3c 2V2.

VHF-BELL, Motorola IMTS car telephone 11 channels, 22 watts output, with black MJ head & gain antenna. $1400. We'll pay postage. (303) 447-9072.

PORTA-PAK the accessory that makes your mobile really portable. $59.95 and $39.95. Dealer inquiries invited. P. O. Box 67, Somers, Wisc. 53171.

RTTY TERMINAL UNIT: PLL decoder, AFSK generator, loop supply, handsome cabinet, wired and tested, $169.95. Save, separate boards & kits available. Com Tech Electronics, P. O. Box 73, Rensselaer, N. Y. 12144.

SCANNER RECEIVER REGENCY ACT-R-10H/L/U 10 channels, 3 bands (covers 2 meters by retuning) AC/DC, 10 free crystal certificates, all for $169.00. Also all Regency, Cushcraft, Antenna Specialists products. All shipped UPS cash COD. Dealer inquiries invited. Radio Communications Service, 430 Maple Ave., Hodgenville, Ky. 42748.

WANTED: Old radio show transcription discs, any size, any speed. Also wire recordings. Billy Stricklin, 118 Coburn Drive, Chattanooga, Tenn. 37415.

TRADE: R-1051/URR for T-827/URT. WA6FAD, 528 Bonita, Pleasanton, California 94566.

PUBLIC SALE: Texas Inst. Chart Recorder, 1 MA full scale, serviced & calibrated. Excellent condition. Instruction manual. Minimum bid $385. Also — 6 Motorola fixed channel VHF-FM mobile transceivers, 6/12 VDC input, approx. 156 MC - less xtals. Some with control heads, no cables. Minimum bid $120. For viewing appointment & information contact Police Property Unit. Sealed bids sent Attn: City Clerk, 6th Floor. Bids must be in by: 2 p.m., Friday, May 28, 1976. City of Newark, 37101 Newark Blvd., Newark, CA 94560 (415) 793-1400. The city has right to reject any and all bids.

HICKOK DYNAMIC TRANSISTOR TESTOR model 870. Latest 1975 roll chart and manual. Excellent. Hatfield, WA4FRV, 804-272-8403.

FREQUENCY COUNTER BOARDS, Jan. 76 HR, double sided glass epoxy. Includes 500 MHz prescaler circuitry and LED board. Instructions and parts source listing $15.00. CSJ Electronics, 5201 Cameron Court, Lincoln, NE 68512.

TRAVEL-PAK QSL KIT — Send call and 25¢; receive your call sample kit in return. Samco, Box 203, Wynantskill, N. Y. 12198.

NEW CANADIAN MAGAZINE. "Electronics Work Shop". $5.00 yearly, sample $1.00. ETCOB, Box 741, Montreal, H3C 2V2.

FREE Electronics Surplus Catalog. Electronic Specialties, 1659 Wetmore, Tucson, AZ 85705.

MANUALS for most ham gear made 1940/65, some earlier. Send SASE for specific quote. Hobby Industry, WØJJK, Box H-864, Council Bluffs, Iowa 51501.

MODERN 60 MIN. CODE CASSETTES. Novice 0-5 wpm, Progressive 5-13 wpm, General 13-15 wpm, Extra 20-22 wpm. $3 each, 4/$10. Royal, Box 2174, Sandusky, Ohio 44870.

LSI-CHIP COLOR BAR GENERATOR. 16 patterns. Pocket size. Complete plans $4.95. Parts, PC boards, kits available. Workshop, Box 393H, Bethpage, N. Y. 11714.

CUSTOM EMBROIDERED EMBLEMS. your design, low minimum. Emblems, Dept. 709, Littleton, New Hampshire 03561.

CRYSTALS — 50¢ each, send stamped envelope and 25¢ for list (refunded with order). Artrip, Box 163, Ivy, Virginia 22945.

QRP TRANSMATCH for HW7, Ten-Tec, and others. Send stamp for details to Peter Meacham Associates, 19 Loretta Road, Waltham, Mass. 02154.

SIDESWIPER only $13. Airmailed USA. Kungsimport, Box 257, Kungsbacka, Sweden.

More Details? CHECK–OFF Page 118

flea market

WANT — Gonset model 330 SW converter. Contact Bob Sidebottom, 206 Stanley Ave., Pensacola, Florida 32503.

MOTOROLA HT220, HT200, Pageboy, and other popular 2M FM transceiver (Standard, Regency, etc.) service and modifications performed at reasonable rates. WA4FRV, (804) 272-8403.

SEVERELY HANDICAPPED AMATEUR wants equipment to work OSCAR 6 & OSCAR 7. Will anyone who can help please contact WB2PBY, 125 Lincoln Ave., Apt. 204, Trenton, N. J. 08609.

ANTENNAS: Dipole, multiple band arrays. 15 thru 75 meters from $59.50. Mobile Antennas — CB, 20M, 40M, and 2M from $19.50. Baluns: 1:1 and 4:1 - $12.95 ea. Data Available. Savoy Electronics, Inc., P. O. Box 5727, Ft. Lauderdale, Fla. 33310.

FREE CATALOG. LED's, strobe lights, uarts, memories, microphones, IC's, relays, ultrasonic devices, precision trimmer capacitors, digital thermometers, unique components. Chaney's, Box 15431, Lakewood, Colo. 80215.

BAZOOKA. DIPOLE . . . . Ready to use, with fiberglass center SO239, end insulator 80M, $29.50; 40M, $26.50; 20-15-10M, $23.50. Fiberglass central insulator with SO239, 1000 pound test, $5.95. Trap 2 KW 80/40, 40/20, $18.50, ppd. Jac-Tenna, 13850 Victorin, Tracy, P. Que., Canada.

MOTOROLA HT220 HIBAND 4 freq. universal $250. Handi-Com 6 meter 4 freq. with battery, carrying case, new still in carton. $300. K6KTP Daniel M. Herlihy, 2338 Berry St., Lemon Grove, Cal. 92045. Tel. 714-466-7558.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines in assembled or kit forms, plus many other suppression accessories. Free literature. Estes Engineering, 930 Marine Dr., Port Angeles, WA. 98362.

HW-7, new, bargain, $95; Drake 2B, $170, excellent condition. Write: WB2CDX, Coney Island ARC, 2790 W5 St., Brooklyn, NY 11224.

IC APPLICATIONS MANUAL — Analog/Digital $3.95. Digital IC manual - latest edition-3000 latest types/pinout diagrams/cross references $6.95. Electronetics-HRM, P. O. Box 127, Hopedale, MA. 01747.

WANTED: Motorola HT220 any condition. Also any available accessories. WA2HQD 105 18 131 St., Richmond Hill, NY 11419. 212-641-2559.

R/9 AND RADIO MAGAZINES needed to complete my library. Some duplicates available for trade with other collectors. Also have many early radio publications and Handbooks for sale or trade. Send SASE for list. Jim Fisk, W1DTY, Ham Radio, Greenville, NH 03048.

NOVICES: 15 WATT MONOBAND transceivers 80 - 40 - 15 or 10 meters. VFO controlled. Built-in power supply. All solid state. No frills, no gimmicks, unconditionally guaranteed. All you need is key and antenna to be on air immediately. Only $94.50 postpaid. Literature available. Hermes International, Box 35, Dania, Florida 33004.

RADIO MUSEUM now open. Free admission. 15,000 pieces of equipment from 1850 telegraph instruments to amateur and commercial transmitters of the 1920's. Amateur station W2AN. Write for information. Antique Wireless Assn., Main St., Holcomb, N. Y. 14469.

MOTOROLA RAILROAD MOTRACS. R43HHT-1139CA with manual. $100. VE2BFT, 460 Greenock Ave., Montreal, P. Q., H3P 2H2. 514-733-8841.

PC's, Send large S.A.S.E. for list. Semtronics, Rt. #3, Box 1, Bellaire, Ohio 43906.

FOR SALE: SB-102 w/HP-23A and SB-600, $345; HP-13, $40; SB-610, $65; SB-630, $65; SB-640, $75; W6PBU, Joe Chance, 156 Banbury Court, Benicia, Ca. 94510.

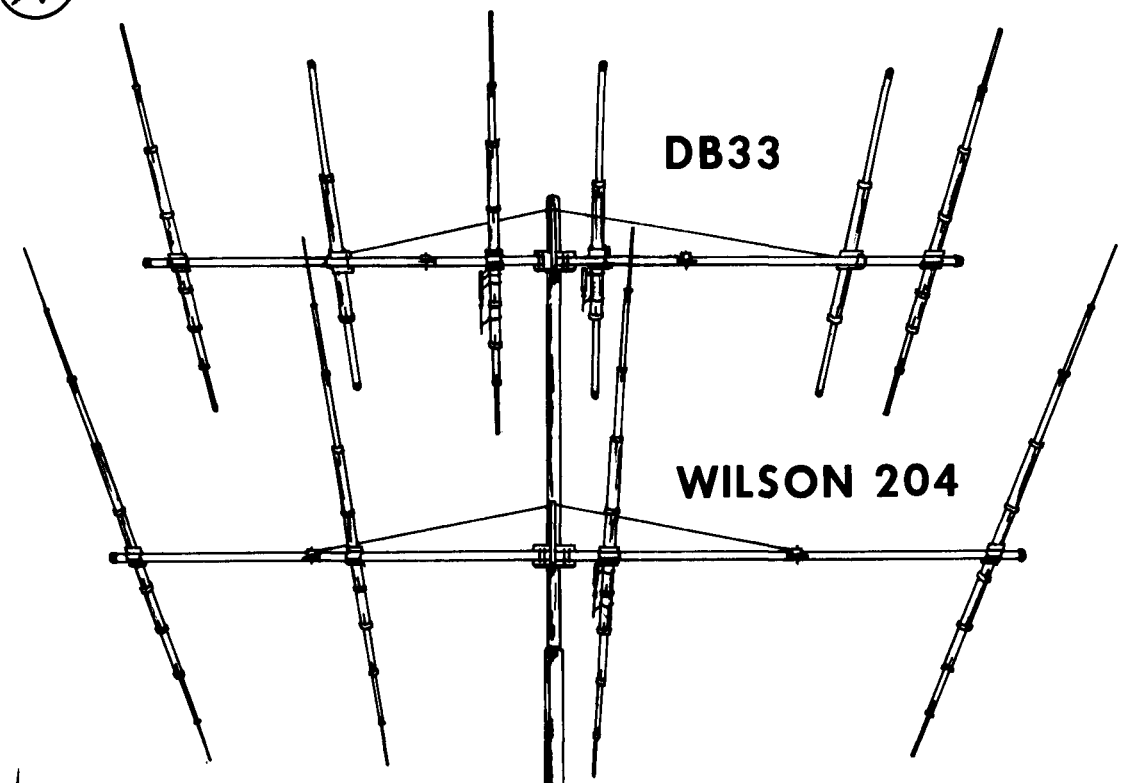
DO-IT-URSELF DXPEDITION — Stay at ZF1SB — Cayman Is. Vertical antenna and Caribbean at your doorstep. Diving/fishing if band folds. Write Spanish Bay Reef Resort, Box 800K, Grand Cayman, B. W. I.

T.V. — SERIOUS EXPERIMENTERS — R.C.A. military image orthicon system, camera, sync unit, power supply, 7" monitor, 600 lines resolution. Info, Peter S. Gerry, 34 Newcomb Dr., New Providence, N. J. 07974.

FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada. MIS 3B4.

More Details? CHECK–OFF Page 118

Wilson Electronics Corp.



TRISTAO SUPER MINI-MAST

Self-supporting rotating crank-up masts for supporting large beams of up to 9 square feet in 50 MPH winds. Exclusive new Rotator Bases for rotating complete masts from base with CDE or similar rotators.

15% OFF ON TOWERS

Now "Wilson Electronics", the finest name in antennas, brings you "Tristao" - the finest name in towers - at a special price. Order any Wilson Antenna, and receive 15% Discount on your Tristao Tower. Write today - or call (702) 739-1931 and discuss your requirements. Towers & Antennas are in stock now and ready to be shipped to you.

The Wilson 204 is the best and most economical antenna of its type on the market. Four elements on a 26' boom plus a Gamma Match (no balun required) make for high performance on CW & phone across the entire 20 meter band. The 204 Monobander is built rugged at the high stress points. Using taper swaged slotted tubing permits larger diameter tubing where it counts, for maximum strength with minimum wind loading.

The DB33 is the newest addition to the Wilson line of antennas. Designed for the amateur who wants a lightweight economical antenna package, the DB33 compliments the M204 for an excellent DXers combination.

WILSON AMATEUR ANTENNA SPECIFICATIONS

	Boom Length (ft)	Number Elements	Turning Radius (ft)	Surface Area (sq ft)	Wind load at 80 MPH (lbs)	Assembled Weight (lbs)	Shipping Weight (lbs)	Price
M520	40	5	27'0"	5.0	125	90	96	269.00
M204	26	4	22'6"	3.9	100	46	49	139.00
M155	26	5	18'0"	3.7	93	41	44	139.00
M154	20	4	15'9"	3.0	75	30	32	89.00
M106	31	6	16'1"	2.9	73	34	36	99.00
DB64(20)	40	5	27'0"	7.9	198	105	119	299.00
(15)		4						
DB43(15)	19	4	15'8"	4.3	108	36	38	119.00
(10)		3						
DB33(15)	17	3	12'2"	3.8	95	31	33	89.00
(10)		3						

All Wilson Monoband and Duoband beams have the following common features:

- Taper Swaged Tubing
- Full Compression Clamps
- No Holes Drilled in Elements
- 2" or 3" Aluminum Booms
- Adjustable 52 Ω Gamma Match
- Quality Aluminum
- Handle 4kw
- Heavy Extruded Element to Boom Mounts

All Wilson Antennas are FACTORY DIRECT ONLY! The low prices are possible by eliminating the dealer's discount. Most antennas in stock. If you order any antenna, you may purchase a CDR Ham II for $129.95 or a CDR CD44 for $109.95. Send check or money order, or phone in BankAmericard or Master Charge. All 2" Boom antennas shipped UPS, 3" by truck.

Wilson Electronics Corporation

4288 S. Polaris Avenue • Las Vegas, Nevada 89103

(702) 739-1931

More Details? CHECK–OFF Page 118

flea market

ATTENTION BAY AREA: Model 19 Teletype units complete. Free delivery S. F. Bay area. $75.00. Mr-20 Motorola Microwave complete. WA6DNR Alan, 86 Valley Rd., San Anselmo, Calif. 94960.

ENGRAVED RADIO LICENSE. Exact reproduction in solid brass. Permanent identification. Send good Xerox copy, with $5.00, to Metal Art Graphics, 1136 Potomac Ave., Hagerstown, Md. 21740.

ICOM 22A, Ser. 3985, like new, 10 crystals; $189 postpaid. Visual Projects, Roslyn Heights, N. Y. 11577.

TELETYPE EQUIPMENT FOR SALE for beginners and experienced operators. RTTY machines, parts, supplies. Special beginners package consists of Model 15 page printer and TH5-TG demodulator, $125.00. Atlantic Surplus Sales, 3730 Nautilus Ave., Brooklyn, N. Y. 11224. Tel: (212) 372-0349.

YAESU FT-100 OWNERS. Add Fast-Slow-No AGC easily. For complete details send dollar (creditable towards dues) for April issue of Newsletter. International Fox-Tango Club, 248 Lake Dora Drive, W. Palm Beach, FL 33411.

QSL CARDS — Something **completely** different. Nothing even close to it on the market! Samples: 25¢. W5UTT, Box 1171D, Garland, TX 75040.

RTTY — NS-1A PLLTU (RTTY Journal 1/76) FSK-AFSK. Wired/tested $29.95 ppd. Boards, parts, kits available. Stamp for info. Nat Stinnette Electronics, Tavares, FL 32778.

TELETYPEWRITER PARTS, gears, manuals, supplies, tape, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, Fl. 33310. Buy parts, late machines.

WANTED XTALS FOR SP600 JX14. Need National HRO 60 MW, LW, and VLF coils. VLF receiver wanted. Godbey, Box 16053, West Palm Beach, Fla. 33406. (305) 686-8548.

QSL'S — BROWNIE W3CJI — 3035B Lehigh. Allentown, Pa. 18103. Samples with cut catalog 50¢.

PC BOARD negatives made photographically from your magazine's artwork. Now obtain professional results quickly, simply. 4 x 5, $3.00 or SASE for information. WA4FRV, 10139 Apache Road, Richmond, Virginia 23235. 804-272-8403.

EXCLUSIVELY HAM TELETYPE 21st year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35¢. $3.50 per year. Box 837, Royal Oak, Michigan 48068.

ANYBODY OUT THERE ever heard of an Eldico S-119 SSB Communication System? I need manuals, copies, or leads to information. Fred Shuman, 112 Freeman, Starkville, MS 39759.

OSCAR 7, SSB-CW TRANSMIT CONVERTERS. For 28 or 50 MHz input at 20 mw. 432 MHz output at 1 watt. Solid state, for 12 volt supply. 35 watt solid state amplifier available for this converter. Units designed and built by WØENC. Write for information. UHF-VHF Communications, 53 St. Andrew, Rapid City, S. D. 57701.

AN/URM-25G generator, 10 kHz-50 MHz, metered output, precision attenuator $200, accessories $45. AN/TRM-1 generator, .19-400 MHz, metered output, precision attenuator, $250. TS-1379A spectrum analyzer, 2-30 MHz, solid state, $350. Boonton 202B FM generator, 54-214 MHz, piston attenuator, metered output, $150. Manuals supplied. James Walter, 2697 Nickel, San Pablo, Ca. 94806.

BALUN, 1:1 ratio, full legal power stainless steel eyescrews, with hang-up hook, coax fitting, $11.95 pp., Technitronics, 4568 Rushton, S. Euclid, Ohio 44121.

TECH MANUALS — $6.50 each: SP-600JX, URM-25D, OS-8R/U, BC-348JNQ. Thousands more available. Send 50¢ (coin) for large list. W3IHD, 7218 Roanne Drive, Washington, D. C. 20021.

WANTED: Transceiver, receiver or transmitter in good condition. Send information-price. WA7IBT, 1122 East Hays St., Boise, ID 83702.

HALLICRAFTERS SX-117, HT-44 with 8236's/6DQ5's, built in relay, P-150-120 power supply, tubes, xtals, manuals $395 package. Will split, trade or haggle. Phil Carpenter, K1DFC, 4 Westwood Drive, Belchertown, Mass. 01007 or 413-323-4088.

TRANSFORMER FILAMENT for 304TL 5V, 60A, $12. Telephone pad, $10, whole phone $15, 1966 Cadillac AM-FM radio, $30, Sams to 300, 50¢ ea. Al Svirmick, 6601 S. Whipple, Chicago, Ill. 60629.

TELL YOUR FRIENDS about the BIG NEW Ham Radio Magazine!

More Details? CHECK–OFF Page 118

ANNOUNCING!

The ARRL Southeastern Division Convention and Atlanta HamFestival 1976

WHEN: Saturday and Sunday, June 12th and 13th!

WHERE: Dunfey's Royal Coach Motor Hotel
I-75 at Howell Mill Road
Atlanta, Georgia 30318

Contact the Hotel directly for room reservations at special HamFestival rates: $16 single, $21 double!

- Airconditioned Exhibit Hall with nearly 100 manufacturers, distributors, and other exhibitors!
- Saturday Night Awards Banquet and Dance!
- Forums and meetings galore:

  ARRL—DX—RTTY—VHF/UHF—Microprocessors—Digital Circuits —Antennas—Slow and fast scan TV—73 Forum with Wayne Green —Contests—Novice/beginner—Mars—and many more!
- FCC Exams! Free Bus to FCC from Hotel Saturday Morning!
- Outdoor (but mostly covered) Fleamarket; space for more than 100 cars. $5 per space, first come, first served!
- Activities for the wives and kids, too!
- See Six Flags Over Georgia, the Cyclorama, Stone Mountain, Lion Country Safari, Braves vs Pirates and more!

PRE-REGISTRATION: Individual $3.00, at the door $4.00
Family $5.00, at the door $6.00

You must be pre-registered to attend the Banquet.

You must be registered to attend Forums, Meetings, and the Indoor Exhibit Hall.

For pre-registration forms and additional information, send your name and address to:

Atlanta HamFestival 1976
53 Old Stone Mill Road
Marietta, Georgia 30062

or call Area 404/971-HAMS day or night. See You There!!

More Details? CHECK–OFF Page 118

flea market

Coming Events

NEW YORK CITY Annual Hall of Science Radio Club Auction Flea Market, Saturday, June 5 at World's Fair Grounds, Flushing, L. I. Admission $1.00, Sellers $2.00. No sellers commission but 10% fee on auctioned items. Zoo, boating, childrens farm, art and science museum adjacent. Field Day goodies galore. Box 1032, Flushing, 11352.

ROCHESTER HAMFEST, Official New York State ARRL Convention, May 21-23. Write Rochester Hamfest, Box 1388, Rochester, N. Y. 14603 for full details. See our display ad in this issue.

WEST VIRGINIA: Tri-State Amateur Radio Association (TARA) 14th Annual Hamfest, Sunday, June 6th, 11:30 a.m., Camden Park, Rt. 60 West, Huntington, W. Va. Talk-in W8VA/8, 146.04-.64, .16-.76 and .34-.94. For info and tickets to: TARA, P. O. Box 1295, zip 25715.

HAMFEST! Indiana's friendliest and largest Spring hamfest. Wabash County Amateur Radio Club's 8th Annual Hamfest will be held Sunday, May 23, 1976, rain or shine, at the 4-H Fairgrounds in Wabash, Indiana. Large flea market (no table or set-up charge), technical forums, bingo for XYL's, free overnight camping with AC hookup, plenty of parking. Lots of good food at reasonable prices. Admission is $1.50 for advance tickets, $2.00 at the gate. For more information or advanced tickets, write Bob Mitting, 663 Spring Street, Wabash, Indiana 46992.

TENNESSEE — Humboldt ARC Hamfest is Sunday, May 30, at Shady Acres city park in Trenton, TN. Flea market, ladies activities, playground. Contact Ed Holmes, W4IGW, 501 N. 18th Ave., Humboldt, TN 38343.

POTTSTOWN, PA.: Pottstown Area Repeater Team Hamfest and Flea [illegible]et. Sunday, May 23, 9:00 a.m.-4:00 p[illegible]? Hiway Drivein, 8 miles east of [illegible] Prizes, auction, contests, ref[illegible] CANCELLED -in 52/52, 81/21, 66/06. Regis[illegible]..00, tailgate $1.00. A. Jefferson, WA[illegible] SEE AD BELOW , 444 Roland Ave., Pottstown, Pa. 19464.

CANCELLED: The May 23rd Pottstown Area Repeater Team Ham Fest and Flea Market is cancelled. A. Jefferson, WA3VYS, 444 Roland Ave., Pottstown, Pa. 19464.

HAMFEST-76. Southeastern Michigan Amateur Radio Hamfest, Sunday, June 6, 1976. 6 a.m. to 4 p.m. Wayne County Fairgrounds, Belleville, MI. Maior prizes, indoor exhibits, booths available. Info and tickets write to: Hamfest, Box 1976, Belleville, MI 48111. $2.00 advance tickets, $2.50 at gate.

W6LS 11th BURBANK CALIFORNIA HAMFEST. Saturday and Sunday, May 15 & 16. Flea market, prizes. 2814 Empire Avenue, Burbank, California 91504.

ELECTRONIC FLEA MARKET, Old Westbury, L. I., NY, Sunday, June 6, 1976 (Rain date June 20) 9 a.m. to 4 p.m. Admission: $1.00 per buyer, $2 per space seller at N. Y. Institute of Technology, Rte. 25A and Whitney Lane. Sponsored by Long Island Mobile Amateur Radio Club (LIMARC). No advance notice necessary . . . just come. Talk-in 25/85. Additional info from W2KPQ — (516) 938-5661.

SOCIETY OF WIRELESS PIONEERS (SOWP) is planning a Bicentennial CW QSO Party for the weekend of June 5 and 6, 1976. Specific details from K4JPF, send SASE.

PORTLAND AMATEUR WIRELESS ASSOCIATION will hold an auction and dinner at the Portland, Maine, Ramada Inn, 1230 Congress Street (just off I-295, Exit Five (5)) on Saturday, May 22. Auction will start at 10:00 a.m. — dinner will start at 6:30 p.m. For more information contact Martin Feeney (K1OYB), 38 Howard Street, Portland, Maine 04101. Phone (207) 775-2274.

KENTUCKY HAM-O-RAMA — Sunday, May 30 (Memorial Day Weekend) at Boone County Fairgrounds, Burlington, Kentucky. 10 minutes south of Cincinnati, Ohio near I-75. Prizes, forums, XYL programs, exhibits, flea market. Tickets $1.50 advance. Info: NKARC, P. O. Box 31, Fort Mitchell, Kentucky 41017.

More Details? CHECK–OFF Page 118

DIGITAL DATA RECORDER

for Computer or Teletype Use
Up to 4800 Baud

Uses the industry standard tape saturation method to beat all FSK systems ten to one. No modems or FSK decoders required. Loads 8K of memory in 17 seconds. This recorder enables you to back up your computer by loading and dumping programs and data fast as you go, thus enabling you to get by with less memory. Great for small business bookkeeping. Imagine! A year's books on one cassette.

$149.95

Can be software controlled. Comes complete with a software program used to test the units in production (8080). Manual includes software control hook up data and programs for 8080 and 6800.

SPECIFICATIONS — MODEL CC7:

A. Recording Mode: Tape saturation binary. This is not an FSK or Home type recorder. No voice capability. No modem. Runs at 2400 baud or less Asynchronous and 4800 baud Synchronous. (Simple external Synchronizer diagram furnished.) Runs at 3.1"/sec. Speed mechanically regulated ±.5%.

B. Two channels (1) Clock, (2) Data. Or two data channels providing four (4) tracks on the cassette. Can also be used for NRZ, Bi-Phase, etc.

C. Inputs: Two (2). Will accept TTY, TTL or RS 232 digital.

D. Outputs: Two (2). Board changeable from TTY, RS232 or TTL digital.

E. Erase: Erases while recording one track at a time. Record new data on one track and preserve three or record on two and preserve two.

F. Compatability: Will interface any computer using a UART or ACIA board. (Altair, Sphere, M6800 etc.)

G. Other Data: 110/220 V, 50/60 Hz; 2 Watts total; UL listed #955D; three wire line cord; on/off switch; audio, meter and light operation monitors. Remote control of motor optional. Four foot, seven conductor remoting cable provided.

H. Warrantee: 90 days. All units tested at 110 and 4800 baud before shipment. Test cassette with 8080 software program included. This cassette was recorded and played back during quality control.

Also available — Model CC7A with variable motor speed which is electronically regulated. Runs 4800 baud Synchronous or Asynchronous without external synchronizer board. Recommended for quantity users who require tape interchangeability. Comes with speed calibration tape to set exact speed. $169.95

Build Your Own —
Kit version of the CC7 circuit board for use with your own recorder (cassette or reel to reel). Go to 9800 baud with suitable heads and tape speeds. This kit contains the P.C. board and switches with the power supply in a black bakelite box. Also includes the synchronizer circuit for 4800 baud. $59.95

COMING SOON — IN KIT FORM

- Hexadecimal Keyboard — Load programs direct from keyboards' 16 keys and verifying display. Does not use Computer I/O.
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More Details? CHECK–OFF Page 118

flea market

TEXAS STATE RACES CONFERENCE, May 29 and 30, 1976. Department of Public Safety, Box 4087, Austin, Texas 78773, 512-452-0331, Ext. 295.

WISCONSIN STATE QSO PARTY 0000 May 22 through 2400 May 23. Sponsored by the Neenah-Menasha Amateur Club. Phone and CW separate bands. The same station may be worked on each band and mode and Wisconsin amateurs may work in-state stations for QSO and multiplier credit. SASE for complete rules to: Neenah-Menasha Amateur Radio Club., Inc., Mark Michel, W9PJT, 700 Kinzie Court, Menasha, Wisconsin 54952.

ANNUAL SWAPFEST, Saturday, May 1, 1976 8 to 4. Exhibits - Prizes - Superdeals - Superfun. For info contact: W9PJT, 700 Kinzie St., Menasha, Wis. 54952. Phone 414-722-4034. Admission $1.50. Tables $1.00. Talk-in on .94 and .16-.76 at Labor Temple on Green Bay Road, one block east of U.S. Hiway 41 between State Hiways 114 and 150.

ATLANTA: The ARRL Southeastern Division Convention and the Atlanta HamFestival 1976 will be held on June 12-13th at Dunfey's Royal Coach Motor Hotel, I-75 at Howell Mill Road, Atlanta, Georgia. See our display ad this issue.

VIRGINIA: Roanoke Valley Amateur Radio Club W4CA Annual Hamfest. Vinton War Memorial, Vinton, VA. Sunday, May 30, 1976. Registration, 7:00 a.m. - 9:00 a.m. Hamfest and flea market 9:00 a.m. - 3:00 p.m. Registration: $1.50 each or 4 tickets for $5.00. Talk-in on 2 meters, 34/94, 28/88, 38/98, 94 direct. Info: W4AEPW.

YELLOW THUNDER HAMFEST 76: Saturday, May 22, 1976 at the Dell View Hotel in Lake Delton, Wis. starting at 10:00 a.m. For further information contact Kenneth A. Ebneter, K9GSC, 822 Waouna Trail, Portage, Wis. 53901

EASTERN SHORE OF MARYLAND HAMFEST May 23, 1976. Second annual - sponsored by The Easton Amateur Radio Society on May 23, 1976, rain or shine, 10 a.m. - 4 p.m. Only hamfest this year on the Eastern Shore of Md. or Delaware south of Wilmington. Located 5 miles north of of Easton, Md. on Rt. 50 at the Talbot County Agriculture Center. From Balto.-DC area go across the Chesapeake Bay Bridge and stay right on Rt. 50 for approx. ½ hour after crossing the bridge. There will be hamfest signs going in both directions on Rt. 50 and talk in on 52 & 94 and 146.445-147.045 rept in Cambridge. Plenty of tables and chairs provided and reasonably priced food and drinks, and lots of room for tailgaters. Admission to cover our expenses — $2 with additional $2 for tailgating. For info. contact: Tim Meekins, Jr., K3RUQ, P. O. Box 805, Cambridge, Md. 21613 - (301-228-8534).

HOSSTRADERS NET THIRD ANNUAL TAILGATE SWAPFEST: Saturday, May 8, 11 a.m. at Addams' Campground on Rt. 286 in Seabrook, N. H. Just off I-95 at the Mass.-N. H. border. Admission is 75¢ per person, excess revenues to benefit the March of Dimes Birth Defects Campaign. No commission or percentage. FM clinic sponsored by Saddleback Repeater Association. Talk-in on 146.40-147.00, .52 direct, and/or 3940 kHz. S.A.S.E. to Norm, WA1IVB, P. O. Box 32, Cornish, Maine 04020 if any questions.

AKRON, OHIO: The Goodyear Amateur Radio Club (WA8UXP), 9th Annual Fathers' Day (Hamfest Picnic), on June 20, 1976. Huge flea market, ham gear displays, swap and shop. Prizes on the hour. Picnic tables available. Adult and children's play area all day. Join us and approximately 3,000 other persons for an enjoyable day of entertainment. Hours 10:00 a.m. to 6:00 p.m. Family admission $2.00 prepaid, $2.50 at the gate. For details, tickets, map and program, write to Floyd T. Gilbert, WB8ALK, 1976 Newdale Ave., Akron, Ohio 44320.

VACATIONLAND HAMFEST. Date: Sunday, May 23, 1976. Place: Erie County Fairgrounds. Time: Daybreak till 3:00 p.m. Featuring: Free camping Saturday night, free transportation to Cedar Point ferry boat dock. Bring the family and let them visit the greatest amusement park in the U.S.A. Plenty of flea market tables. Dealers welcome. 8 acres for trunk sales. 1st Grand Prize: 1200 watt A.C. gasoline generator. Many other main and hourly prizes. Call in on 52-52. For further information or reservations write: E.A.R.S., P. O. Box 2037, Sandusky, Ohio 44870.

KNOXVILLE HAMFEST. May 29 and 30 at the Tennessee National Guard Armory, located at 3330 Sutherland Ave. N.W. Info from WB4JGF.

More Details? CHECK–OFF Page 118

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(See Feb 75 CQ, Apr 75 HR, Feb 76 QST, Radio Handbook 75)

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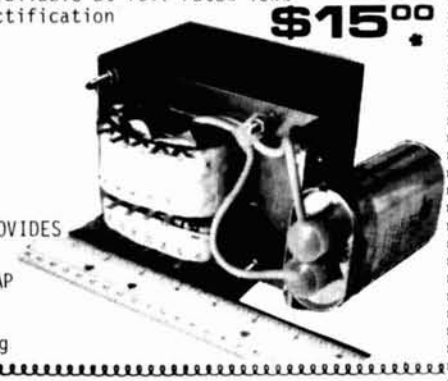

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More Details? CHECK–OFF Page 118

flea market

MARYLAND MOBILEERS AMATEUR RADIO CLUB Sixth Annual Hamfest, Sunday, June 13, 1976 at Anne Arundel Community College, Arnold, Maryland. Gates open at 9 a.m. *Registration: $2.00. Tailgaters: $3.00* plus registration fee. Drawings at 3 p.m. First prize: $200 Savings Bond, second prize: $50 Savings Bond, third prize: $25 Savings Bond. Talk-ins on 146.10/.70 - 146.52 - 146.16/.76. Info: WA3WAN.

1976 SOUTH DAKOTA HAM PICNIC, Sioux Falls, June 12 & 13. For information send SASE to Sioux Falls Amateur Radio Club, Inc., P. O. Box 91, Sioux Falls, SD 57101.

INDIANA'S LARGEST SPRING HAMFEST. Wabash County Amateur Radio Club's 8th Annual Hamfest, May 23, 1976. 4-H Fairgrounds, Wabash, IN. Advance admission $1.50 per person ($2.00 at gate), under 12 years - free. Time: 7-4 p.m. For further information contact: Bob Mitting, WB9DKH, 663 N. Spring Street, Wabash, IN 46992.

SIX METER CLUB OF CHICAGO INC. 19th Annual Hamfest, Sunday, June 13, 1976 at Santa Fe Park, 91st Street and Wolf Road in Willow Springs, Illinois. Food and drinks available, a swap and shop section, and a special area for manufacturers. Advance registration is $1.50 and at the gate it will be $2.00. For further information, contact K9ENZ.

SAN JOSE BICENTENNIAL AWARD. The Santa Clara County Amateur Radio Association (SCCARA) is issuing a San Jose Bicentennial Award to all amateurs who request it and qualify for it by working a number of San Jose, Santa Clara County and Pacific Division stations for a total of 200 points. For full details send SASE to Club Secretary, SCCARA, P. O. Box 6, San Jose, CA 95103.

MANASSAS, VIRGINIA HAMFEST: the Ole Virginia Hams A.R.C. of Manassas annual Mid-Atlantic area "Quality Hamfest", June 6, 1976 at the Prince William County fairgrounds, Route 234, ½ mile south of Manassas, Va. Featuring, large display and exhibit area, electronic flea market, ladies programs, children's entertainment and many valuable door prizes including a 5 band HF transceiver, 2 meter transceiver, Bird thruline wattmeter and many more. Food service available, trailer parking and hook-ups. Write for information and advanced registrations to WA4GVX, 1708 Sharp Drive, Woodbridge, Va. 22191.

EVANSVILLE HAMFEST, *Sunday, May 16th* at the Vanderburgh Co. 4-H Center (8 mi. N. of Evansville on Hiway 41). Large indoor flea market area, displays, grand prize (HR2MS), prizes, and auction. Lunch available. Admission free. Talk in 147.75/.15, 146.52/.52. For info and prize tickets contact WA9QDZ, 2851 Wayside Dr., Evansville, IN 47711 (812) 476-2188 or WB9RDS, 1552 Keck Ave., Evansville, IN 47711 (812) 464-3111.

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Stolen Equipment

REALISTIC POCKET SCANNER. No Serial Number, has SSN 095-42-1177 engraved on set. Stolen 29 Feb., 1976 at PPRAA Swap Fest, *Peterson Field, Colo. Please notify police* dept. or; James R. Einolf, 303-841-2105, 12149 N. Piney Ln. Rd., Parker, Colo. 80134.

HW-202 TRANSCEIVER. Serial #09512. Has following crystals installed: 07-67, 34-94. Had WBØQGF engraved on outside and inside. Stolen from: *Joel Humpke, WBØQGF,* 516 Zion St., Aurora, Colo. Stolen 1 March, 1976 from parking lot of radio station KLMN. Please notify police dept. or owner.

CLEGG FM-27B, S/N 27043-1649. Taken in Huntington on 2/21/76. Also touchtone pad and tone burst generator in minibox. Report to Suffolk County Police 2nd Precinct or call Dave Metal, W2FTH, home 864-1130, or business 368-2200. This equipment can be positively identified.

STOLEN: CLEGG FM-DX, 2/19/76, Boston, Mass. Slide bracket riveted to top, serial number 056, police ID# 141449314PTH WB2ZSD. Call 201-263-0376 anytime.

FM 27B #27053-1805 with attached Touchtone pad. Contact Dick Vuillequez, E & L Instruments, 61 First Street, Derby, CT 06418.

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Instructions & parts - 12 or 24 hour format.
Four digit clock kit includes all parts for complete clock: 3⅛"x 2":
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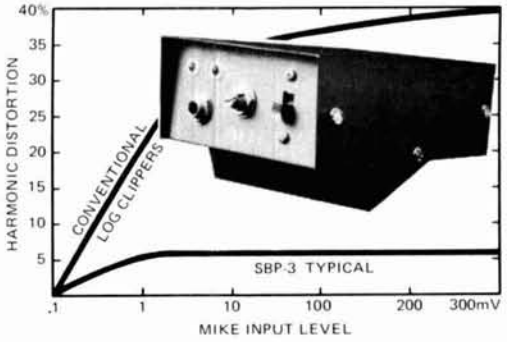

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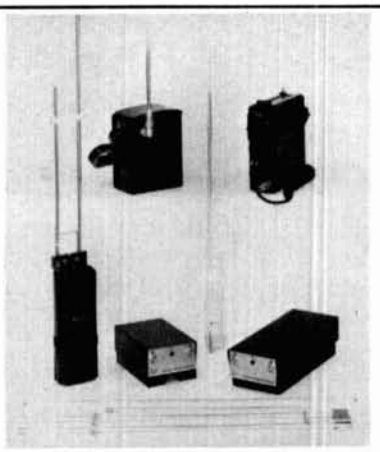

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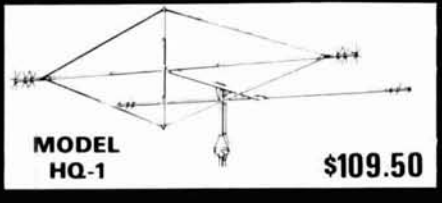

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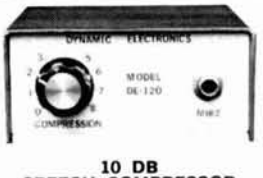

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May 1976

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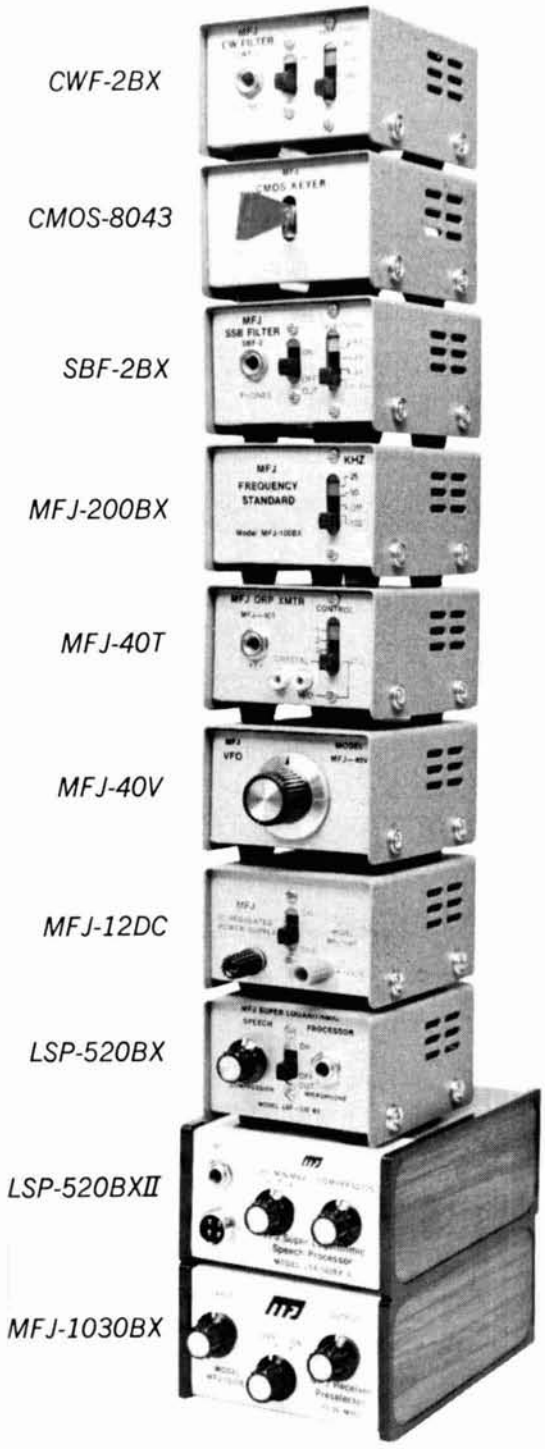

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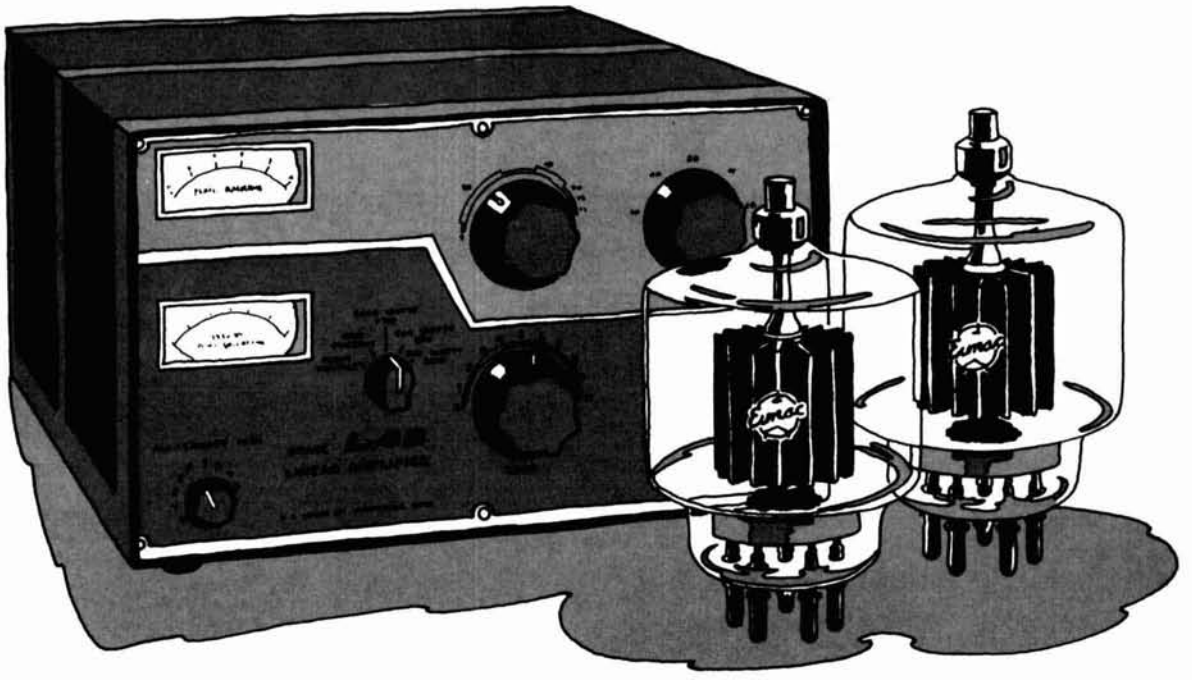

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To find out more about the reason Drake's first choice is EIMAC, or to ask about our design flexibility to meet individual applications, drop us a line or call. We have no secrets.

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