<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>carrier-operated relay</td>
<td>16</td>
</tr>
<tr>
<td>vhf receiver</td>
<td>22</td>
</tr>
<tr>
<td>two-meter frequency synthesizer</td>
<td>34</td>
</tr>
<tr>
<td>antenna matching</td>
<td>58</td>
</tr>
<tr>
<td>sweepstakes winners</td>
<td>68</td>
</tr>
</tbody>
</table>
High efficiency mobile and portable antennas for all amateur bands, CAP, MARS, CB, SECURITY, PUBLIC SERVICE, MARINE, AND GOVERNMENT USE.

- 2-6-10-15-20-40-75
- Identical size, cost, and appearance
- FULLY ADJUSTABLE TO FREQUENCY IN FIELD
- Low weight, low drag, high strength fiberglass
- Polished chrome brass standard 3/8-24 thread
- High gain collinear on 2 meters

MODEL DGA-2M
$29.50 postpaid in U.S.A.

HIGH ACCURACY CRYSTALS FOR OVER 30 YEARS

Either type for amateur VHF in Regency, Swan, Standard, Drake, Varitronics, Tempo, Yaesu, Galaxy, Trio, Sonar, Clegg, SBE, Genave.

Quotes on request for amateur or commercial crystals for use in all other equipments.

Specify crystal type, frequency, make of equipment and whether transmit or receive when ordering.

The famous sealed helium filled Balum. The Balum is employed with the G6A Series Antenna Systems. Subtle sound center insulator having more than full legal power while reducing unwanted noise radiated. Equipped with a special SO-239 type connector and available either 1:1 or 4:1.

MODEL G6A-2000-B $12.95
Postpaid in U.S.A.

BASSETT VACUUM BALA

BASSETT

High efficiency mobile and portable antennas for all amateur bands, CAP, MARS, CB, SECURITY, PUBLIC SERVICE, MARINE, AND GOVERNMENT USE.

- 2-6-10-15-20-40-75
- Identical size, cost, and appearance
- FULLY ADJUSTABLE TO FREQUENCY IN FIELD
- Low weight, low drag, high strength fiberglass
- Polished chrome brass standard 3/8-24 thread
- High gain collinear on 2 meters

MODEL DGA-2M
$29.50 postpaid in U.S.A.

HIGH ACCURACY CRYSTALS FOR OVER 30 YEARS

Either type for amateur VHF in Regency, Swan, Standard, Drake, Varitronics, Tempo, Yaesu, Galaxy, Trio, Sonar, Clegg, SBE, Genave.

Quotes on request for amateur or commercial crystals for use in all other equipments.

Specify crystal type, frequency, make of equipment and whether transmit or receive when ordering.

BASSETT VACUUM BALA

BASSETT

High efficiency mobile and portable antennas for all amateur bands, CAP, MARS, CB, SECURITY, PUBLIC SERVICE, MARINE, AND GOVERNMENT USE.

- 2-6-10-15-20-40-75
- Identical size, cost, and appearance
- FULLY ADJUSTABLE TO FREQUENCY IN FIELD
- Low weight, low drag, high strength fiberglass
- Polished chrome brass standard 3/8-24 thread
- High gain collinear on 2 meters

MODEL DGA-2M
$29.50 postpaid in U.S.A.

HIGH ACCURACY CRYSTALS FOR OVER 30 YEARS

Either type for amateur VHF in Regency, Swan, Standard, Drake, Varitronics, Tempo, Yaesu, Galaxy, Trio, Sonar, Clegg, SBE, Genave.

Quotes on request for amateur or commercial crystals for use in all other equipments.

Specify crystal type, frequency, make of equipment and whether transmit or receive when ordering.

BASSETT VACUUM BALA

BASSETT

High efficiency mobile and portable antennas for all amateur bands, CAP, MARS, CB, SECURITY, PUBLIC SERVICE, MARINE, AND GOVERNMENT USE.

- 2-6-10-15-20-40-75
- Identical size, cost, and appearance
- FULLY ADJUSTABLE TO FREQUENCY IN FIELD
- Low weight, low drag, high strength fiberglass
- Polished chrome brass standard 3/8-24 thread
- High gain collinear on 2 meters

MODEL DGA-2M
$29.50 postpaid in U.S.A.
“OPERATING ON-THE-AIR WITH THE ALPHA 77 IS A PURE PLEASURE”

"IF THE AMATEUR WANTS TO GO FIRST CLASS IN EVERY SENSE OF THE WORD, THE ALPHA 77 IS ONE WAY TO DO IT."

(QST – March 1973)

The superb ALPHA 77 legal-limit amplifier is truly in a class by itself... a sleek desk-top powerhouse that delivers a whole rack full of performance. The '77 is engineered and built to operate continuously at maximum legal power in any mode including FSK or SSTV — and to stay cool and quiet in the process.

Now the ALPHA 77 is the only linear to provide full standard coverage of 10 through 160 meters — a feature not available elsewhere even as an option.

You really have to see and use the ALPHA 77 to fully appreciate its unmatched quality and ruggedness. If you enjoy owning and using the very finest, you owe it to yourself to at least investigate the ALPHA 77 by phoning or writing for detailed literature. Available direct from ETO and from selected dealers coast-to-coast. ALPHA 77 domestic net price, $1995.

ETO
EHRHORN TECHNOLOGICAL OPERATIONS, INC.
BROOKSVILLE, FLORIDA 33512
(904) 596-3711
A product in the amateur market gets a reputation very quickly. It measures up to what you expect in engineering, performance and quality—or else. That’s why A/S amateur antennas are built to the identical design and construction standards as their commercial counterparts. Standards that have made them specified for more police and public safety vehicle installations than all other brands combined.

**NEW ASCOM® TOWERS**

High strength, low maintenance aluminum towers for HF and VHF antenna installations. There is a complete line of ASCOM self-supporting towers—in heights from 30 to 90 feet—at attractive prices!

**HM-177**

2 Meters

Features new high conductivity copper and nickel coated 17-7 PH stainless steel whip. Shunt fed coil encased in waterproof PVC jacket. All fittings chrome plated brass. Easy snap-in mounting. 3 dB gain.*

**HM-175**

¾ Meters

Collinear design with truly high performance! Base fittings have silver plated contacts. Can handle 100 watts. Whip and phasing coil assembly is a one piece molded design to resist vibration and moisture. 5 dB gain.*

**HM-223**

1¼ Meters (220 MHz)

High performance ¾ wavelength design for the new 220 MHz activity! Directly fed with low loss coil in new low-profile design. Spring and whip easily removable leaving only ½” high base for car wash clearance. 3 dB gain.*

**HM-4**

2 Meters


**HM-5**

Same as above but for Drake and other packetset portables with SO-239 fittings.

*Measured over a 1/4 wavelength whip

WRITE FOR FREE AMATEUR ANTENNA and/or TOWER CATALOGS

**HM-223**

2 Meters

Features new high conductivity copper and nickel coated 17-7 PH stainless steel whip. Shunt fed coil encased in waterproof PVC jacket. All fittings chrome plated brass. Easy snap-in mounting. 3 dB gain.*
July, 1973
volume 6, number 7

staff
James R. Fisk, W1DTY
editor
Patricia A. Hawes, WN1QJN
editorial assistant
Nicholas D. Skeer, K1PSR
vhf editor
J. Jay O'Brien, W6GDO
fm editor
Alfred Wilson, W6NIF
James A. Harvey, WA6IAK
associate editors
Wayne T. Pierce, K3SUUK
cover
T.H. Tenney, Jr., W1NLB
publisher
Hilda M. Wetherbee
assistant publisher
advertising manager

offices
Greenville, New Hampshire 03048
Telephone: 603-878-1441

ham radio magazine is published monthly by
Communications Technology, Inc
Greenville, New Hampshire 03048

Subscription rates, world wide
one year, $7.00, three years, $14.00
Second class postage
paid at Greenville, N.H. 03048
and at additional mailing offices

Foreign subscription agents
United Kingdom
Radio Society of Great Britain
35 Doughty Street, London WC1, England

All European countries
Eskil Persson, SM5CPJ, Frotunagrand 1
19400 Upplands Vasby, Sweden

African continent
Holland Radio, 143 Greenway
Greenside, Johannesburg
Republic of South Africa

Copyright 1973 by
Communications Technology, Inc
Title registered at U.S. Patent Office
Printed by Wellesley Press, Inc
Framingham, Massachusetts 01701, USA

ham radio is available to the blind
and physically handicapped on magnetic tape
from Science for the Blind
221 Rock Hill Road, Bala Cynwyd
Pennsylvania 19440
Microfilm copies of current
and back issues are available
from University Microfilms
Ann Arbor, Michigan 48103

Postmaster: Please send form 3579 to
ham radio magazine, Greenville
New Hampshire 03048

contents

6 slow-scan tv test generator
A. A. Kelley, K4EEU

16 carrier-operated relay
J. Jay O'Brien, W6GDO

22 superregenerative receiver for vhf
Courtney Hall, WA5SNZ

26 standing-wave ratios
Earl W. Whyman, W2HB

34 frequency synthesizer
for two-meter fm
William H. Craig, WB4FPK

52 transistor curve tracer
Daniel G. Wright, WA9LCX

58 antenna-matching systems
Robert E. Baird, W7CSD

64 comparing rf amplifier efficiency
Carl C. Drumeller, W5JJ

68 1973 sweepstakes winners
T. H. Tenney, Jr., W1NLB

4 a second look 110 advertisers index
70 ham notebook 74 new products
99 flea market 110 reader service
Amateur radio operators, especially those on two-meter fm, are using more and more dry batteries than ever before. Zinc-carbon batteries rate very high on the list because they are relatively inexpensive and easy to find, although some amateurs use the more expensive but higher powered alkaline-manganese cell, and a few swear by rechargeable nicads. A new dry battery, which will be on the market in the near future, just might revolutionize the whole field of portable dc power.

The new battery, the lithium organic cell, has been receiving enthusiastic reviews from the military, which depends on man-carried batteries for much of its power. The reason for the enthusiasm is that lithium apparently produces a battery with greater energy density than that of any other existing type. Lithium batteries are lighter, have greater power output, can operate over wide temperature ranges and have a remarkably long shelf life — up to 20 years.

Several companies are currently manufacturing lithium cells, including Mallory, Eagle-Picher and Power Conversion, Inc. Both Mallory and Power Conversion use lithium with a sulfur dioxide electrolyte; experimental Eagle-Picher lithium batteries are based on lithium and a carbon flourine compound in conjunction with an organic electrolyte.

Mallory also has a solid-state lithium battery that uses a metal lithium anode and a metal salt as the cathode. The electrolyte is an electronically insulating solid. Because of the reactive nature of these materials when exposed to the atmosphere, this battery must be hermetically sealed. However, the absence of any liquid in the battery completely eliminates any corrosion or gassing. In fact, these cells have been stored for long periods at more than 200° F with no detectable loss in energy capacity.

One of the big advantages of the new lithium batteries is their very high energy density. Prior to this, the most energetic batteries have been the silver-zinc units used on the manned Apollo program — they provided approximately 110 watt-hours per pound per cell. Some of the new lithium batteries can generate 200 watt-hours per pound per cell, a nearly 85% increase. When compared to carbon/zinc and other commonly used batteries, the energy density of the lithium cell is even more impressive. What this means, basically, is that if you presently use 5 pounds of batteries to power your communications gear, lithium batteries would cut the weight in half, approximately.

As far as power output is concerned, the energy from one lithium D-cell at a discharge rate of 1 ampere is equivalent to four mercury-zinc cells, five alkaline-manganese or 30 carbon-zinc cells! The introductory cost for these new lithium batteries is expected to be quite high, about $9.00 each for D-cells, but that price can be expected to come down as usage and production increase. However, when you consider that one lithium D-cell can provide the same power as 30 carbon-zinc units, the price isn’t nearly as astronomical as it first appears. Now, if somebody can figure out a way to recharge them...

Jim Fisk, W1DTY
editor
From Olson Electronics...
**AN EXTRAORDINARY PURCHASE OPPORTUNITY**

**Olson**

MAIL ORDER ONLY

189.95
Plus S3 Shipping

*Manufactured Prior to Revaluation of the Dollar—Manufacturer's Cost Today Would Be Greater Than Our Selling Price!*

The Unimetrix ULTRACOM-25 is a 144-148 MHz FM transceiver with provision for 12 crystal-control transmit channels and 12 crystal-control receive channels. It features rugged, commercial-quality construction throughout. The dual-gate FET front end results in a sensitivity of better than 0.5 uV for 20 dB quieting. It includes controls for volume, power and squelch, illuminated channel selector, RF power output signal-strength meter, hand-held dynamic mike and mounting bracket. The transceiver is factory equipped for operation on the following frequencies—94/94 Simplex, 34/.76 Duplex, .76/.76 Simplex and 34/.94 Duplex. It also has an integral 12VDC power supply—if you purchase it with our antenna below, you’ll be ready for immediate mobile operation. An AC power supply, additional crystals, and touch-tone pad for auto patch are also available. For further information or phone orders, contact Walt Corrigan WB8PCP, Olson Electronics (216) 535-1800.

**Hustler 2-Meter Mobile Antenna. 5/8 wavelength, stainless steel, 3.4 dB gain. With trunk lip mobile mount.**

**Regulated AC Power Supply. 4 amps, 12 volts. Operate the Ultracom-25 from 117 VAC house current.**

**Crystal Certificates.** Fill out and mail to manufacturer with desired transmit or receive frequency indicated. Each certificate good for a single crystal.

**Touch-Tone Encoder.** Ties Ultracom-25 into repeaters with TT auto patch facilities.

**FREE! 1974 Olson Catalog**

Reg. $2 W9IOP DX Calculator GIVEn AWAY with first 250 catalog requests!

Please send me the following:

- Ultracom-25.
- AC Power Supply.
- Mobile Antenna.
- Phone Patch.
- Crystal Certificate.

Check or money order for $____ enclosed. (Total amount plus applicable sales taxes).

**FREE!** 1974 Olson Catalog (DX calculator with 1st 250 requests!)

Name__________________________
Address__________________________Apt.
City__________________________State_______

Charge Card No.__________________Zip  ____

Charge my purchase to

- BankAmericard
- Master Charge

*Interbank No.__________________

Good Thru Date:__________________

More Details? CHECK-OFF Page 110
Anyone who builds his own slow-scan television equipment soon learns why so many other operators go the commercial equipment route. It's not so much the circuit complexity or parts procurement problems as it is the difficulty of getting the circuits properly adjusted. Almost all the circuits in the SSTV monitor have to be operating correctly before you can see any results on the picture tube, so the monitor itself is useless as a test unit.

Some authors have suggested that a tape recorder and a length of audio tape be used as a test signal during adjustments. However, unless this tape is obtained from a SSTV manufacturer, the quality is questionable. The sync and video pulses may be off frequency because it is almost impossible to accurately tune in a SSTV signal without a monitor. To add to the difficulty, video quality will vary from station to station, and there is usually interference from nearby stations. Any good transmissions will be short so the tape will have to be rewound again and again during use.

What is needed is a SSTV test generator which can deliver a continuous high quality test signal and require no atten-
tion. The unit described here can be used to align and test bandpass filters, video discriminators, video amplifiers and sync separators, as well as to check horizontal and vertical sweep linearity and size.

features

If test equipment is to be useful, it should be accurate. The sync and video frequencies in this SSTV test generator are inherently accurate because they are derived from sources that do not vary. Digital logic does the rest. The division ratios are set by selection of IC types and the pin-to-pin strapping. There are no multivibrators that have to be locked in with a pot adjustment.

The three basic frequencies are derived from crystal oscillators and divided down to the SSTV range with digital logic. Digital division removes switching transients and increases the accuracy of the audio tones. The 1.2-MHz crystal may be as much as 1 kHz off frequency, but the SSTV sync frequency will still be within 1 Hz of the nominal 1200 Hz. This means that the SSTV circuits may be adjusted with confidence in your signal source.

test signals

A checkerboard test pattern was chosen as the primary test signal because the deep transitions between peak white and picture black will critically test any sync separator circuits. The 60-Hz square wave “video” is an easily recognized pattern that can be traced through the video circuits of the SSTV monitor with any scope.

Since the transitions are sharp and clean, the reproduced picture should have sharp, clean edges and this gives an excellent indication of picture resolution (see checkerboard photo).

The horizontal and vertical bars are a good indication of sweep linearity although the checkerboard pattern could also be used for this purpose. Since the horizontal and vertical signals are already available in the circuitry, it was only a

---

**fig. 1. Block diagram of the slow-scan TV test-pattern generator.**
fig. 2. Circuit for the SSTV test generator makes extensive use of integrated circuits. Complete unit is housed in a small 3-1/2 x 6 x 10-inch Minibox.

matter of adding a selector switch to provide three video patterns as well as the three basic slow-scan audio tones of 1200, 1500 and 2300 Hz. These tones can be used to tune discriminator coils or the all important sync-separator circuit.

how it works

Refer to the block diagram in fig. 1 and the logic diagram in fig. 2. The 60-Hz signal that drives the test generator is obtained from one side of a 24-volt center-tapped power transformer, filtered, and connected to a transistor, Q1, which turns on for each positive going half-cycle of the waveform. The bias on Q1 is adjusted by a 50k trimmer to make the output symmetrical. The signal is
further squared by three sections of a SN7404 integrated circuit, U5.

The square-wave output from U5 is applied to a JK flip-flop, U6, which divides by four. This is the slow-scan horizontal scanning frequency. However, the pulses are too long so they are used to trigger a 5-millisecond pulse generator, U12. Each pulse generator IC has two outputs. One output is normally low and one is normally high. The positive-going pulse at the Q output is connected to the rear panel jacks for external use.

Two cascaded IC counters, U7 and U14, count the 120 horizontal lines and trigger the 30-millisecond vertical mono-stable oscillator, U13. Horizontal and vertical sync pulses are then combined in the sync adder, U8. The sync signal is connected to signal gates so that sync always has precedence.

The three key frequencies in the generator are provided by continuously operating crystal oscillators that generate rf square waves. These three oscillators are gated so that only one signal may be on at a time. The output is a sequentially switched rf waveform divided down to the audio range by U9, U10 and U11.

The lowpass audio filter* does a good job cleaning up the square wave output from U11. The measured harmonic distortion is only 2.4% at 1200 Hz, 0.53% at 1500 Hz and 0.1% at 2300 Hz.

the digital logic

The TTL logic used in this circuit is fairly fast — much faster than needed. This can be a problem if the filtering is omitted at the base of Q1 or the input to U5 — the unit would become sensitive to power line spikes and result in erratic operation. This logic, however, provides at least two advantages. First, the signal frequencies used in this generator are mostly dc or 60 Hz so any small oscilloscope may be used. Also, most of the circuits are ordinary simple TTL NAND gates, so they are not hard to understand or to troubleshoot.

As an example, let's examine the sync oscillator, U2 (see fig. 2). Two sections of this package form the oscillator, one section is used as a gate, and one as an inverter. A NAND gate has to have all inputs positive to get a low, or zero, volt output. If pins 4 and 5 of U2 are connected together the gate is converted to an inverter. If, on one section of the

*The 88-mH toroids used in the low-pass filter may be obtained from M. Weinschenker, Box 353, Irwin, Pennsylvania 15642, five for $2.00, postpaid.
Checkerboard test pattern displayed on the K4EEU SSTV monitor. The gray bars on left are due to second harmonics of the sync frequency, removed by the test-generator filter, but restored by the limiter in the monitor. This second harmonic, at 2400 Hz, is close to 2300 Hz, SSTV picture white.

Vertical-bar test pattern displayed on the SSTV monitor. Gray bar on the left side of the monitor tube is caused by the second harmonic of the sync frequency.

SSTV horizontal-bar test pattern, displayed on K4EEU's monitor.

IC, the output is connected back to the input with a resistor, an inverse feedback connection is made which linearizes the gate to a degree and prevents crystal lockup or starting problems.

The output at pin 3, U2, is a 3.5-volt p-p rf square wave, or, more accurately, it is a pulsating dc voltage which rises in a positive direction from the zero baseline up to 3.5 volts and falls again to zero at an rf rate. If this square wave is applied to pin 10, U2, it will pass through, inverted, to pin 8 provided the gate is enabled by making pin 9 positive. Normally, however, pin 9 of U2 is at zero volts and the gate is inhibited. Therefore, the output at pin 8 is high and stays high regardless of what signal is applied to the input, pin 10. To turn off any input to a NAND gate, any of the other inputs can be made low.

The sync-pulse monostable outputs at pin 1 of U12 and U13 are normally high; both are connected to the sync adder gate, U8. With both inputs high, the output at pin 6 of U8 is low. If either input to this gate goes low, as during a horizontal or vertical sync pulse, pin 6 goes high for the duration of that pulse. This enables pin 9, U2, and the sync rf passes through the gate.

When any gate is cut off, the output is high, so several such gates may be connected to a mixer such as U3 without inversion. When U2, pin 9, is high, turning on the sync, U2, pin 6, is low, or inverted, which inhibits the other two gates and prevents picture frequencies from passing during the sync interval. Pin 2, U5, is connected to pin 4, U3, so that either the black or white picture gates may be enabled, but not both at the same time.

The waveform reversing gate, U8, reverses the phase of the 60-Hz square wave every twelve picture lines. The output appears alternately at pin 8 or pin 11 of U8, but not both at the same time.

construction

Most of the components are mounted on a 5½ x 8-inch circuit board with the
rest of the parts mounted on the ends of a small 3½ x 6 x 10-inch Minibox. A LM309K voltage-regulator IC is directly bolted to the rear of the Minibox, which is used as a heat sink.

Complete information on board layout is given in fig. 6. The circuit trails are the input of the LM309K voltage regulator is properly connected before turning on the supply. Verify the 5-volt output before wiring in any of the TTL devices (it is possible to have 18 volts unregulated where there should be only 5 volts). The regulator needs no adjust-

![fig. 3. Power supply for the sstv generator. LM309K voltage-regulator IC uses one end of the Minibox enclosure for a heat sink.](image)

drawn on the copper with a RMP-700 Kepro resist pen, or one similar. A parts list and epoxy, plated circuit board is available from the author for $10.00 postpaid in the United States.*

Inexpensive crystals are available from JAN crystals from stock in the FT-243 holder, but I prefer the HC-6/U crystal holder since it takes less space on a printed-circuit board. The tolerance of the crystal is not critical; if you wish, however, 0.005% tolerance custom ground crystals can be obtained.

Since this is a fairly complex construction project, I always build in sections and debug if necessary, starting at the power supply, fig. 3. Make sure

*A kit of parts is available from Truman Boerkoel, K8JUG, Stotts-Friedman Company, 108 N. Jefferson Street, Dayton, Ohio 45402.

![fig. 4. Output waveforms of the slow-scan television test generator.](image)

The sync generator section can now be built and checked out with an oscilloscope. There should be a square wave at the collector of the transistor Q1 at the input to U6, pins 9 and 12. The pulse width at pin 6, U12, should be 5 milliseconds. This can be measured with suf-
sufficient accuracy by referencing the scope to one cycle of the 60-Hz signal which has a time interval of 16.66 milliseconds. The sync pulse width should be about one-third the length of one 60-Hz cycle (see fig. 4).

The vertical sync pulse is a little more difficult to measure because it occurs once every eight seconds. This may be speeded up, either by repeatedly operating the reset button or by temporarily rerouting the lead that runs from pin 3, U13, to U14 so that it is connected directly to pin 5, U6. The pulse from U13 will then be at a 15-Hz rate and much easier to measure on a scope.
The pulse width should not be less than 30 milliseconds. Two 60-Hz waves are about 33-milliseconds long and this is close enough for practical purposes. The pulse widths should be sufficiently close without any circuit changes. However, if they are not, the pulse width can be adjusted by changing the value of the resistor connected to pin 11 of the appropriate 74121 IC.

The pattern generator can be checked out by wiring in the waveform reversing gate, U8, and checking the waveform at pin 3. Externally sync your scope and see if the polarity of the waveform is reversing about once a second.

If you cannot observe the crystal oscillators on a scope, the signal can be detected on a broadcast receiver. Of course, if you have an output at the filter, it's a good indication that the crystal oscillators are operating all right.

The foregoing is not intended to emphasize the complications but to be of assistance if troubleshooting becomes necessary. Usually ICs can be wired into a circuit as so many building blocks, and, if wired correctly, everything works.

**Operation**

The SSTV test generator can be used with an oscilloscope to check the slow-scan signal at the different points in the monitor. If you want to see if the input bandpass filter is operating correctly, put the test generator switch on pattern or bars and look at the output of the filter with a scope. The amplitude should be the same for the three frequencies. Similarly, the demodulated composite video signal can be seen at the discriminator.

Clipped and restored horizontal sync pulse taken from the sync separator of the K4EEU SSTV monitor.
output and traced up to the picture tube grid.

The sync separator circuit in the monitor should show a clean sync pulse with no interference between the sync and the black video pulses. This circuit can be optimized by setting the selector to 1200 Hz and tuning.

The sstv monitor may use a discriminator circuit similar to that used in a RTTY demodulator (fig. 5). The discriminator coils can be individually set on frequency with the test generator and then the exact value of the damping resistors selected by viewing the demodulated pattern on a scope. The correct resistor will result in minimum ringing and best square wave response, and can be found in less time than it takes to tell about it by using variable pot (about 50k). The sync pulse waveform is relatively unimportant here but it should be separated from picture black. The sync circuit will clean up the sync pulse.

The reset button was installed on the test generator so that a vertical pulse could be obtained immediately at any time when working with a sync circuit in a monitor. Otherwise, the pulses are separated with an 8-second time interval. If this button is omitted, pins 6 and 7 of U7 and U14 must be grounded or the dividers will not operate.

Once you build this sstv test set, you will wonder how you ever got along without it. At my station it revived a faltering monitor project. With only a few hours work a trouble in the monitor sync separator was cleared and I started receiving good pictures.
If you like 2 METER . . .

YOU'LL LOVE OUR

ALL NEW

220 MHz

ALL AMERICAN MADE
SOLID STATE TRANSCIEVER

10 OR 1 WATT POWER OUT/SWITCH SELECTABLE /
FULL 12 CHANNEL TRANSMIT AND RECEIVE CAPABILITY

All the advantages of 2 Meter FM . . . away from the crowds. With the HR-220, Regency pioneers the way to put you out on the most exciting ham band ever. The HR-220 is equipped with all the quality features you demand—compact design, big signal power at low current drain, HI/LO power switch, crystal clear reception, superb sensitivity and low price.

$239.00 AMATEUR NET
includes plug-in ceramic mike, dash mounting bracket and factory installed transmit and receive crystals for 223.50 MHz.

THE FM LEADER IN 2 METER AND 6 METER...AND NOW 220 MHz
The SOOPAR, A Signal-Operated Operational Amplifier Relay, is the answer to your carrier-operated relay troubles. This circuit uses an inexpensive integrated circuit, an inexpensive, easy-to-obtain relay and a few parts to provide you with a reliable unit that can be adjusted to fit your needs for receiver control of an external device. The external device could be a light to indicate the receiver is receiving a signal, a Transmitter in a repeater system, or control functions such as a garage door opener, etc.

Operational Relay

The SOOPAR — a Signal-Operated Operational Relay

Squelch Circuit

The Motorola compensated squelch circuit, diagrammed in fig. 1, operates to silence the speaker when no signal is present. The SOOPAR derives its input signal from this squelch circuit.

The squelch circuit operation is as follows: Signal and noise from the antenna, mixers and the i-f amplifier stages are fed into the limiter stages which are driven into saturation, thus limiting the limiter output to a constant voltage. This output voltage, at the last i-f, is the same whether it is signal or noise or any proportion of both.

The action of driving the last limiter stage into saturation generates limiter grid current and, thus, a negative voltage at the limiter grid. This grid voltage is picked off, filtered and used as bias by the later squelch stages. The i-f output of the limiter is connected to the discriminator stage where it is converted to audio. The voice-audio components are amplified by the audio amplifiers and drive the speaker when the first audio stage is unsquelched.

Audio components produced by the discriminator that are above the voice-range (noise) are filtered out from the voice-range components and amplified by the noise amplifier. The noise amplifier gain may be adjusted by a variable resistor in the cathode circuit; this variable resistor is the squelch control.

The output of the noise amplifier is rectified by the noise rectifier. The positive-going dc output of the noise rectifier
is proportional to the noise output of the noise amplifier. That is, more noise into the rectifier produces a more positive dc voltage out of the rectifier.

The dc output of the noise rectifier is connected in series with the negative bias obtained from the limiter stage and is sation built into the biasing arrangement. When the drive to the limiter stage is reduced as a result of tube aging or low supply voltage, the negative bias derived from the limiter is reduced proportionately. The noise component of the discriminator output is also reduced with tube aging or reduced supply voltage, resulting in a lower positive going noise rectifier output. Since these two voltages are of opposite polarity and are connected in series, the result is a negligible change in power level.

The SOOPAR, ready to be installed and connected to an external relay.

**Editor’s note:** This is more than an article on a signal-operated op-amp relay — it also presents a comprehensive review of squelch operation in Motorola tube-type fm receivers.
the voltage fed to the dc amplifier from the noise rectifier. Thus, supply voltage changes and tube aging tend to be automatically compensated for by this circuit.

When the squelch control is set for reception of a slightly noisy but usable signal, the voltage presented to the dc amplifier when no signal is being received is approximately +5 volts.

**tube-type carrier-operated relays**

Tube-type carrier-operated relay (COR) circuits, when used, are connected to sample the voltage presented to the dc amplifier. A representative circuit is shown in fig. 2.

The signal voltage applied to the grid of the dc amplifier is sampled through R1 and connected to the grid of the first half of the COR tube which goes into conduction whenever the sampled voltage is more positive than the 1.8-volt cathode bias developed by R2 and R3. When the first half of the tube conducts, the voltage at its plate approaches zero. This is connected to the grid of the second half of the tube, which, under this condition, draws little current. The voltage drop across relay K1 is 27 volts or less, and K1 is released.

When the receiver is unsquelched, the voltage presented to the dc amplifier and sampled by the COR goes negative. This causes the current drawn thru R4 by the first half of the COR tube to reduce. As this current reduces, the voltage drop across R4 reduces, making the voltage on the grid of the second half of the COR more positive. When this voltage rises to about 50 volts, the neon tube fires, preventing the voltage from reaching a higher potential that could damage the tube.

When the voltage at the second grid goes more positive, the second half of the COR draws more current through K1. When the current is sufficient to produce a 35-volt drop across K1, it closes, actuating the external device.

**COR disadvantages**

Users of conventional tube type CORs will agree that the COR is the real trouble spot in a repeater receiver. Part of this is due to the fact that the voltage across the relay does not go from zero to "all on" when a signal is received. Rather, the relay operate and release voltages play an important part in COR operation. As the COR tube ages, the voltage presented to the relay changes, thus effectively changing the COR sensitivity. A circuit that would only produce two relay voltage conditions, full on and full off, would eliminate most of these relay problems.

Another problem is the inconsistent loading effect that the COR has on the receiver squelch circuit. When the squelch voltage is more positive than the voltage on the cathode of the first half of the COR tube, the grid and cathode act like a diode and conduct current, placing a 1-megohm load on the squelch circuit and reducing its adjustment range. Below this voltage, the current is negligible unless the COR tube becomes gassy; when this happens, the effect is unpredictable.
It is difficult to adjust this type of tube COR to open and close in the correct relationship to the audio squelch. The proper relationship is one where the audio squelch opens just before the COR closes as a received signal is slowly increased in level, and where the COR opens just before or at the same time as the audio squelch closes when the signal is decreased. This is almost impossible to maintain with a tube-type COR, even if an additional control is added to independently adjust COR sensitivity.

**op-amp relay**

A simple circuit using an op-amp to sense an input voltage and operate a relay is shown in fig. 3. A negative 12-volt supply is connected to the op-amp and to a voltage divider, R1 and R2. The inverting input of the op-amp is connected to the junction of R1 and R2, whose values are chosen to present a bias potential of -5 volts. The non-inverting input of the op-amp is the input terminal of the op-amp relay.

If the input voltage is between zero and -5 volts, the relay is released. When the voltage is raised above -5 volts, the relay is operated. To prevent damage to the op-amp the input voltage should not exceed the supply voltages. The current drawn by relay K1 must not exceed the rating of the op-amp. Diode CR1 prevents damage to the op-amp from reverse voltage spikes generated by K1 when it is released.

**soopar**

The signal-operated op-amp relay or SOOPAR is an adaption of the op-amp relay circuit and is shown in fig. 4. Resistor R5 takes the place of R1 and R2 in fig. 3 and is set, nominally, to about -5 volts. R1 is connected to the squelch circuit of the receiver, and R4 picks off the limiter voltage. C1 and R4 act as a filter to remove the i-f signal voltage present at the grid of the last limiter.

Resistors R1, R2, R3 and R4 make up

![A SOOPAR and power supply mounted on the Permakay filter of a Motorola Sensicon G receiver. The relay is shown mounted on the power-supply chassis.](image-url)
a complex voltage divider; their values are chosen to present a potential of about -5 volts to the non-inverting input of the op-amp. The values are also chosen to limit the maximum voltage presented to the op-amp to less than the +12-volt op-amp supply voltage.

**hysteresis**

The advantage of the SOOPAR to turn on and off with a very small input voltage change is a disadvantage when very weak signals are received. The relay will chatter, going on and off rapidly. The tube-type COR avoids this due to the inherent magnetic "hysteresis" in the relay; that is, once the relay is operated, you can reduce the voltage across the relay somewhat and it will remain energized.

The relay's pick-up and drop-out voltages are a major factor in the proper operation of a tube-type COR. Resistors R6 and R7 are added to the SOOPAR to introduce electrical hysteresis. The bias presented to the inverting input of the op-amp is raised when voltage is applied to K1 by the op-amp. The amount of this change in potential is determined by the values of R6 and R7.

The net effect of the hysteresis is to cause the relay to release at a SOOPAR input voltage lower than the input voltage required to operate the relay. For example, if the relay drops out at -3 volts (at the non-inverting, or + op-amp input), and picks up at -4 volts, it will release again at -4 volts if there is no hysteresis. By adding hysteresis, it drops out at -3.5 volts.

Incidentally, if you don't want it, this action is called "slop" or "backlash;" it is called "hysteresis" if you do want it. If more hysteresis is desired in the SOOPAR, raise the value of R6 — try 220k or 330k. For less hysteresis try 47k; if no hysteresis is desired, disconnect R7 and short out R6.

**receiver connection**

Typical connections to Motorola receivers are shown in table 1. Resistors R1 and R4 should be connected directly to the tube socket pins shown, and C1 should be connected directly to R7 and ground. The lead length from R1, R2 and R3 to the op-amp should be kept at a minimum to reduce stray rf pickup. The op-amp itself should be mounted inside the receiver; relay K1 may be mounted externally.

If you adapt the SOOPAR to a different receiver, connect R1, R2, R3, R4 and C1 before connecting the op-amp. Measure the voltage at the junction of R1, R2 and R3 with a vtvm or high-impedance fet volt-meter. It should be between -3 and -6 volts with the receiver set for nominal squelch sensitivity, and should not exceed -12 volts with a saturating signal applied to the receiver input. If necessary, adjust R3 (and perhaps R2) to satisfy these conditions, then

---

**Table 1. Connection points for installing the signal-operated operational relay into Motorola FM receivers.**

<table>
<thead>
<tr>
<th>Typical</th>
<th>Motorola receiver</th>
<th>lead X</th>
<th>lead Y</th>
<th>R3 value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensicon A</td>
<td>high-band PA 8433/8476</td>
<td>V309</td>
<td>V312</td>
<td>2.2M</td>
</tr>
<tr>
<td>Sensicon G</td>
<td>high-band TA 140</td>
<td>V110</td>
<td>V113</td>
<td>not used</td>
</tr>
<tr>
<td>T44 type</td>
<td>uhf rcvr TA 141</td>
<td>V14B</td>
<td>V12B</td>
<td>2.2M</td>
</tr>
</tbody>
</table>

---

*20 July 1973*
connect the remainder of the SOOPAR circuit.

**Adjustment**

The threshold adjustment is R5. First adjust the receiver squelch control to quiet the receiver, then adjust R5 to the point where K1 just releases. This adjustment should suffice for most applications, but R5 may be trimmed as necessary to track the SOOPAR operation with the audio squelch.

**construction**

As long as the input leads are kept short, the layout of the SOOPAR is not critical. Small 8-lug terminal strips have been used by some builders. Spare terminals on existing terminal strips within receivers have been used by others. The recommended relay, a Sigma 65FP1-12DC, is a 90-mW, 12-volt dc relay with a 1600-ohm coil. These are available from Allied Radio and others for less than $3.00 each.

A simple voltage-doubler power supply for the SOOPAR is shown in fig. 5. Any small power diodes may be used for CR1 and CR2, and any value of capacitance of 100 µF or more will suffice for C1 and C2. This power supply may be built on a small multi-lug terminal strip similar to the SOOPAR.

**conclusion**

Several SOOPARs are presently in use in Northern California repeater receivers, including the vhf input receivers of the Mt. Vaca Radio Club’s repeaters. This circuit has proven itself reliable under temperature extremes and continuous usage.

---

**CRYSTAL FILTERS and DISCRIMINATORS**

by K.V.G.

1 27/64" x 1 3/64" x 3/4"

**9.0 MHz DISCRIMINATORS**

<table>
<thead>
<tr>
<th>Model</th>
<th>Discrimination</th>
<th>Carriers</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>XD9-01</td>
<td>± 5 kHz</td>
<td>RTTY</td>
<td>$21.10</td>
</tr>
<tr>
<td>XD9-02</td>
<td>± 10 kHz</td>
<td>NBFM</td>
<td>$21.95</td>
</tr>
<tr>
<td>XD9-03</td>
<td>± 12 kHz</td>
<td>NBFM</td>
<td>$21.10</td>
</tr>
</tbody>
</table>

**9 MHz CRYSTALS (Hc25/u)**

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency</th>
<th>Carrier</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF900</td>
<td>9000.0 kHz</td>
<td>Carrier</td>
<td>$3.35</td>
</tr>
<tr>
<td>XF901</td>
<td>8998.5 kHz</td>
<td>USB</td>
<td>$3.35</td>
</tr>
<tr>
<td>XF902</td>
<td>9001.5 kHz</td>
<td>LSB</td>
<td>$3.35</td>
</tr>
<tr>
<td>XF903</td>
<td>8999.0 kHz</td>
<td>BFO</td>
<td>$3.35</td>
</tr>
<tr>
<td>F-05</td>
<td>Hc25/u Socket</td>
<td>.50</td>
<td></td>
</tr>
</tbody>
</table>

**9.0 MHz FILTERS**

<table>
<thead>
<tr>
<th>Model</th>
<th>Bandwidth</th>
<th>Modulation</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF9-A</td>
<td>2.5 kHz</td>
<td>SSB TX</td>
<td>$27.95</td>
</tr>
<tr>
<td>XF9-B</td>
<td>2.4 kHz</td>
<td>SSB RX</td>
<td>$39.75</td>
</tr>
<tr>
<td>XF9-C</td>
<td>3.75 kHz</td>
<td>AM</td>
<td>$42.85</td>
</tr>
<tr>
<td>XF9-D</td>
<td>5.0 kHz</td>
<td>AM</td>
<td>$42.85</td>
</tr>
<tr>
<td>XF9-E</td>
<td>12.0 kHz</td>
<td>NBFM</td>
<td>$42.85</td>
</tr>
<tr>
<td>XF9-M</td>
<td>0.5 kHz</td>
<td>CW</td>
<td>$29.95</td>
</tr>
</tbody>
</table>

**VARACTOR VHF TRIPLERS UHF**

**MMv 432**

$69.95

**INPUT:** 140-153 MHz
20 watts max.

**OUTPUT:** 420-459 MHz
12 watts min.

**Size:** 4½" x 2½" x 1¼" + Connectors

**MMv 1296**

$79.95

**INPUT:** 420-459 MHz
12 watts max.

**OUTPUT:** 1260-1377 MHz
6 watts min.

**Size:** 4½" x 2½" x 1¼" + Connectors
low-voltage superregenerative receiver for vhf

This superregenerative receiver tunes from 100 to 170 MHz and operates from a single flashlight battery.

This receiver was built as an experiment to investigate the quality of reception that could be expected from various modulation modes using a superregenerative detector, and to experiment with the diode tank loading technique discussed in previous articles. Another design goal was to operate the receiver from a single flashlight battery and to achieve long battery life at low cost. The frequency range of approximately 100 to 170 MHz covers wide-band fm in the fm broadcast band, a-m in the aircraft band and narrow-band fm in the public service band.

Since superregenerative detector theory is covered in the above referenced articles and elsewhere, I will not go into that here.

circuitry

As shown in fig. 1, the receiver consists of a superregenerative detector followed by a three-stage audio amplifier which drives a pair of 2000-ohm headphones. Regeneration is controlled by varying the base bias on the detector transistor. A two-section RC filter between the detector and audio amplifier...
attenuates the detector's quench frequency, and each stage of the audio amplifier is "rolled off" with a 180-pF feedback capacitor to prevent response at the quench frequency.

The TIS97 transistors used in the audio amplifier have dc current gains of around 500; if lower beta transistors are substituted, the 150k base-bias resistors may need to be decreased to set the dc collector voltage at about 0.8 volt. Since current drain is about one milliampere, an AA penlight cell could be used instead of the D cell I used.

The tuning capacitor is a Hammarlund HF-15-X having about 15-pF maximum capacitance; the coil is three turns of Miniductor stock, 0.5 inch diameter, 8 turns-per-inch. The emitter and antenna are connected to the center of the coil. I found that if the antenna was coupled too tightly to the tank circuit, the detector would not operate properly at the high end of its frequency range.

I used a gimmick capacitor made from two pieces of number-22 hookup wire twisted together for a length of 1.25 inches and inserted between the antenna terminal and the coil. This seemed to provide a good compromise between sensitivity and stable operation when using a three-foot wire antenna.

construction

The entire receiver, including battery, is housed in an LMB 555N aluminum cabinet, which is a five-inch cube. A piece of copper-clad board is held on the inside of the front panel by the tuning capacitor's mounting bushing. This provides a ground plane to which all of the detector's ground connections are soldered.

All detector wiring should be as short and direct as possible. In my receiver...
operation

For best results, the regeneration control should be advanced to a point just above the spot where the rushing sound begins; this adjustment is not critical, but may need to be varied somewhat with tuning. The receiver should be tuned slightly to one side of an fm station's frequency to achieve slope detection.

Using a three-foot wire antenna, local fm broadcast stations and aircraft came in loud and clear; the aircraft signals are a-m while the fm broadcast signals are wide-band fm. Narrowband fm signals in the public-service band were difficult to copy; although their carriers can completely quiet the receiver's noise, their low deviation doesn't provide much audio output from the detector.

I experimented with germanium diodes connected across part or all of the tank coil as described in the referenced articles, but I was unable to detect any improvement in performance.

audio power amplifier

Most of my audio circuits are designed to drive 2000-ohm headphones; these phones are easy to drive, and the rest of the household doesn't want to listen to all that shortwave racket, anyway. At times, however, it's desirable to have speaker capability so I built a simple power amplifier which plugs into the phone jack (fig. 2). It is mounted with a 4-inch speaker and batteries in a 6x6x4-inch LMB 664 aluminum box.

Any circuit which will drive a pair of 2000-ohm headphones will drive this unit and produce plenty of room volume. Although I have used only 2N697s and 2N5449s, the circuit should work well with almost any medium power silicon npn devices.

Allied Radio part numbers are shown for the transformers, but any of the less expensive imported transformers having the same impedance levels should be ok. No volume control is included because I usually have one on the equipment designed to drive the phones. Battery drain is 10 mA or less, depending on output level, and four AA penlight cells connected in series will last a long time.

conclusion

Superregenerative receivers can be designed to operate from a 1.5 volt dc supply; they are suitable for a-m and wideband fm reception, but their performance with narrowband fm is poor. Operation of these detectors from a very low voltage source can decrease their radiated power and lessen the possibility of interference to other nearby receivers.

references


fig. 2. Simple audio power amplifier may be used with any small receiver which is capable of driving a pair of 2000-ohm headphones.
NOW.
Top-of-the-Line Tri-Ex Towers for HAM operators at basic prices!

Now you can afford the best! Free-standing or guyed, Tri-Ex Towers stress quality. All towers are hot dipped galvanized after fabrication for longer life. Each series is specifically engineered to HAM operator requirements.

W Series
An aerodynamic tower designed to hold 9 square feet in a 50 mph wind. Six models at different heights.

MW Series
Self-supporting when attached at first section — will hold normal Tri-Band beam. Six models.

LM Series
A 'W' brace motorized tower. Holds large antenna loads up to 70 feet high. Super buy.

TM Series
Features tubular construction for really big antenna loads. Up to 100 feet. Free-standing, with motors to raise and lower.

THD Series

Start with Top-of-the-Line Tri-Ex Towers. At basic prices. Write today, for your best buy.

Tri-Ex®
TOWER CORPORATION
7182 Rasmussen Ave.
Visalia, Calif. 93277
This discussion of standing-wave ratios should clear up many of the misunderstandings that persist among many radio amateurs.

Twenty five years ago the Micromatch, the first of many vswr bridges designed for use by the radio amateur, was introduced in the pages of QST. Prior to that time the radio amateur had not given much attention to vswr and his understanding on the subject was accordingly limited. The fact that vswr measurement might provide a means of effectively evaluating and monitoring the performance of an antenna system was an exciting prospect, and amateurs began to realize that the vswr bridge was a significant development.

Thus, vswr became the subject of many technical articles in the amateur journals, with each writer addressing himself to a discussion of the various phenomenon associated with the presence of standing waves. A considerable bibliography on the subject of vswr has been accumulated, but, nevertheless, a brief period of listening on the amateur bands will reveal that a great deal of misunderstanding continues to exist. For example, it is still a widespread belief that radiated power will increase with decreasing vswr; that reflected power represents lost power; and that the reflected power is somehow dissipated within the transmitting system. One of the invalid theories postulates the reflected power returning to the output stage of the transmitter where it causes overheating of the output tube.

The following discussion is aimed at enabling the reader to obtain a better understanding of the effects of standing waves, and to do so in terms of transmission line theory with which the radio amateur is already well acquainted. In particular, the role of the reflected wave, which has become such an enigma as a result of so many conflicting opinions, will be explained in a way that I believe to be unique.

Part of the discussion will be in the form of a description of experiments performed upon a transmission system which has been mismatched to cause a vswr of 2:1 to exist. In addition, the effects of system vswr upon the output network of the transmitter will be discussed with the aid of numerical examples, and it will be shown that the criteria...
of proper operation is simply the ability to tune the transmitter for normal rated plate current.

Knowledge of basic transmission line theory, such as found in the *ARRL Handbook*, is all that is necessary to understand this material. However, a brief review of this theory, with particular emphasis on the aspects most pertinent to this discussion, is included with this article in the form of an appendix. It is suggested that you first review this appendix if only to identify the theoretical aspects which I wish to emphasize.

**the experimental system**

The most common form of amateur antenna installation in use today uses coaxial cable for the transmission line. Therefore, it is appropriate to base this discussion on the coaxial system shown in fig. 1 where provisions have been made to facilitate the performance of some experimental tests. Connectors have been installed in the transmission line, dividing it into three identical line-sections, each one-quarter wavelength (90°) long. The total length is, therefore, 3/4-wavelength (270°).

The transmission line may be readily opened at the junction points for measurements, and for other purposes to be detailed later in this article. Each line-section, each junction-point and each connector have been assigned a number for reference in the text. In addition, means for monitoring the vswr on each line-section has been provided.

Although a means for opening the transmission line at the resistive impedance points is essential for the experiments to be performed, it is not necessary to control total line length or to select a specific load impedance. The values selected for the system of fig. 1 are simply convenient and lead to less complication in the analytical discussion.

Fig. 1 also shows the position of the
standing wave and the location of the points of maximum and minimum impedance. From transmission line theory we know that the maximum and minimum impedance points are the only points on the transmission line where the impedance is a pure resistance. Later it will be shown that the points of pure resistance are of particular significance in understanding the action of reflected waves.

The system of fig. 1 has other conditions to be specially noted and kept in mind: First, each line-section is made of RG-8A/U coaxial cable which has a characteristic impedance \( Z_o \) of 52 ohms; second, a vswr of 2:1 exists on each line-section as a result of the 26-ohm resistive load at connector no. 1. Finally, each line-section may be considered separately as a quarter-wave impedance transformer where the impedance at its input connector (connectors 3, 5 and 7) may be readily found by dividing the square of line impedance, \( Z_o \) (\( 52^2 = 2704 \)), by the impedance at its output connector (connectors 2, 4 and 6). Thus, the impedance at connector 3 is 2704/26 = 104 ohms. Since connector 3 and connector 4 are joined together, the impedance at connector 5 is 2704/104 - 26 ohms. In a like manner, the impedance at connector 7 is found to be 104 ohms; this is the impedance seen by the transmitter.

experiments and observations

Referring again to fig. 1, let's conduct our first experiment by inserting a short section of transmission line between connector 3 and connector 4 so that the system appears as shown in fig. 2. A section of transmission line with a characteristic impedance of 104 ohms is chosen for this purpose so that it will be perfectly terminated (matched) by the 104-ohm resistive load which we know exists at connector 3.

We also know that when a transmission line is operated in this manner there will be no standing wave on it, and the input impedance will be equal to the characteristic impedance, \( Z_o \), regardless of the length of the line. Therefore, at connector 2A the impedance is 104 ohms, and the load impedance on line-section 2 remains unchanged. Indeed, if you made detailed comparisons of vswr and impedance between the system of fig. 1 and the system of fig. 2, you would be unable to detect any differences — in spite of the fact that the latter system includes the 104-ohm line-section on which there is no reflected wave. The only change is some additional phase delay which is not important to this system.

An interesting and extremely important point has been demonstrated by this experiment. Since no standing wave is present on the 104-ohm line-section, the reflected wave on line-section 1 has ceased to exist at the junction of connectors 3 and 1A. More significant, however, is the fact that the reflected wave has ceased to exist at a point on the transmission line where the impedance is a pure resistance. And, if you were to repeat the above experiment for all other points where the impedance is a pure resistance, the results would be the same.

Thus, in the system of fig. 1 there are three points on the line where the reflected waves cease to exist. However, the impedance at junction-point 2 (104 ohms) is a mismatch for line-section 2, and the impedance at junction-point 3 (26 ohms) is a mismatch for line-section 3. Thus, each of the three line-sections is mismatched by the load impedance at its respective output connector, and the magnitude of the mismatch is such as to cause a vswr of 2:1 on each line-section. Reflected waves are therefore developed independently on each line-section and it is apparent that the reflected wave due to a mismatched antenna load does not travel back toward the transmitter without interruption.

Although it may be somewhat redundant to discuss further the change that was made to convert the system of fig. 1 into the system of fig. 2, some readers may appreciate further clarification of the role of the inserted line-section. Suppose that we experiment further with the
system of fig. 2 by shortening the 104-ohm line-section in successive steps, each time cutting the remaining line-section in half. Theoretically, the line-section would never be reduced to zero length. However, from a practical standpoint you can see that, as a limit, its length would approach zero, thereby making the systems of fig. 1 and fig. 2 identical. Furthermore, if the system is examined after each shortening operation, you would find the operational characteristics (such as vswr and impedance at each junction-point) unchanged. Therefore, it must be concluded that the system is independent of the length of the 104-ohm line-section, including zero length.

The 104-ohm line-section in this case has served as an analytical tool to enable the behavior of the reflected wave to be observed, and to further prove that this behavior remains unchanged after the line-section is removed from the system.

The principle applied in the foregoing experiments is the basis of many impedance-matching systems and was applied years ago in the design of the "Q-Match Antenna." In this system the 75-ohm impedance of a center-fed half-wave dipole is matched to 600-ohm open-wire transmission line by using a quarter-wave section of transmission line with a $Z_0$ of 212 ohms. The 212-ohm line operates with a vswr of 2.8:1, and the 600-ohm line with a vswr of 1:1. Thus, as demonstrated in the foregoing, the reflected wave on the 212-ohm line ceases to exist at the junction of the two lines because the impedance exhibited at that point is a pure resistance of 600 ohms.

**effects on the transmitter**

Most present day transmitter designs use a pi-network to couple the antenna system to the output stage. In general the pi networks are designed for a nominal load impedance of 50 ohms at a maximum vswr of 2:1. This means that the transmitter can be loaded to its rated power input as long as the load impedance is maintained within specific limits. By specifying a maximum allowable vswr
the manufacturer is indirectly specifying the impedance limits of the transmitter and the amateur is provided with a parameter he is able to measure.

The easiest way to determine the impedance values which this specification permits is to make a plot on a Smith chart. Simply scribe a circle, with a radius equivalent to a vswr of 2:1, about the center of the chart. This circle is the locus of all possible values of impedance on a system with a vswr of 2:1. A Smith chart with a vswr = 2:1 plot, based upon a Z₀ of 52 ohms, is shown in fig. 3; points 1 and 2 on the circle locate the only resistive impedances (26 ohms and 104 ohms, respectively) and point 3 locates the complex impedance of 41.6 + j31.2 ohms for later use in this discussion.

When designing a pi network the value of inductance, L, is determined such that the inductive reactance

\[ X_L = \frac{QR_1 + \left(\frac{R_1 R_2}{X_{C_2}}\right)}{Q^2 + 1} \]

This expression contains two terms which may be separately equated, one to \(X_{L1}\) and the other to \(X_{L2}\), the sum of which is equal to \(X_L\). The significance of \(X_{L1}\) and \(X_{L2}\) lies in the fact that any pi network can be shown to be exactly equivalent to two L-networks connected back-to-back as shown in fig. 4A. It is no coincidence therefore that \(X_{L1}\) and \(X_{L2}\) are the respective values of inductive reactance required for L-network 1 and L-network 2. The junction point of the two L-networks must be an impedance match. In fact, if you were to analyze any specific pi-network design you would find that at the junction point the impedance is always a pure resistance with a value lower than either the input or output impedances. For convenience, this point will be referred to as the intermediate impedance of the pi network. Referring again to fig. 4A, capacitors C₁ and C₂ are the conventional tuning and loading controls, respectively, and L is an inductance value that is fixed for each band. Specific values of reactance for each of these elements is required when a particular pi-network design is desired.

As an example, a pi-network designed to match a single 6146 AB1 linear amplifier to a nominal 52-ohm resistive load is shown in fig. 4B. This network is designed to provide a 3000-ohm resistive load for the 6146 and to operate at a Q of 15. In this case the intermediate impedance is 13.27 ohms. When a load impedance other than 52 ohms resistive is used with this network, C₁ and C₂ are simply adjusted until normal rated plate current is obtained. When this is done the plate load will always be 3000 ohms resistive — however, the intermediate impedance and the operating Q of the network will change. Fig. 4C shows the values of \(X_{C1}\) and \(X_{C2}\) readjusted to match a load of 104 ohms resistive; the intermediate impedance is now 11.95 ohms and the operating Q has increased slightly to about 15.8.

When the load at the transmitter’s
terminals is complex, i.e., some combination of resistance and reactance, the reactance will affect the tuning of the output network in the transmitter.

Every value of complex impedance can be shown to be simultaneously equivalent to either a resistance in series with a reactance, or a resistance in parallel with a reactance. Thus, there is a choice of using either a series or parallel reactance can be determined for a match to this value of resistive load. This value of $X_{c2}$ is then combined with the required compensating reactance to obtain the final circuit value of $X_{c2}$.

The result of applying the above procedure to a pi-network designed for use with the 6146 linear amplifier is shown in fig. 5. Fig. 5A illustrates that when an 86-ohm capacitive reactance, $X_{C}$, is
to tune out, or compensate for, the load reactance. However, the value of the compensating reactance, and the value of the resulting resistive load, are different in each case.

Thus, point 3 on the Smith chart, fig. 3, is a complex impedance consisting of a 41.6-ohm resistance in series with a 31.2-ohm inductive reactance; its parallel equivalent is a resistance of 65 ohms and an inductive reactance of 86 ohms. The parallel form is of special interest because $C_2$ in the pi network is ideally situated to provide the required compensating reactance in addition to performing its normal function. Since the compensating reactance converts the load impedance into a pure resistance, values of $X_{C1}$ and $X_{C2}$

shunted across the parallel equivalent of the above complex load the result is a pure resistance of 65 ohms. Fig. 5B shows the network of fig. 4B tuned for a load of 65 ohms resistive. Fig. 5C shows the final network values when $X_{c2}$ is adjusted to include the compensating reactance. Note that the network’s internal impedance is 12.6 ohms and its operating Q is 15.6. Thus, the capacitance of $C_2$ had to be increased to supply the compensating reactance. If the load had contained a capacitive reactance, the capacitance of $C_2$ would have to be decreased to achieve compensation.

In practice, the dual role of $C_2$ is obscured by the ease with which the circuit can be adjusted. As long as normal
rated plate current can be obtained the compensation takes place without the operator being aware of it. If it is found that the transmitter cannot be tuned for normal plate current, the vswr is probably in excess of that specified for the transmitter and the output network is unable to provide the required amount of compensation. The solution is either to revise the antenna system or to use some type of antenna tuner.

Figs. 4B, 4C and 5C demonstrate that a pi network designed for a nominal load of 52 ohms resistive can be used with an antenna system on which the vswr is 2:1. In each case the network is tunable to provide a pure resistance load of 3000 ohms for the plate circuit of the tube, the internal impedance of the pi network is a pure resistance, and the deviation from the desired operating Q is minimal.

**summary**

Throughout this article the points of resistive impedance have been given special emphasis. When the experiments performed on the transmission line were discussed, the points of resistive impedance were significant because it was shown that reflected waves cease at these points. When the operation of the pi network was discussed it was shown that, for moderate values of system vswr, the network can always be tuned to produce the proper value of resistive load for the power tube and the intermediate impedance is always a pure resistance.

Whenever a pure resistance exists in a circuit, at that point power can flow in only one direction. Therefore, power must flow from the generator (or transmitter) toward, and into, the point of pure resistance. This is so because resistance is strictly passive. That is, it cannot reflect, and all of the power that flows into it must be absorbed. A resistive point

![Diagram](image)

In each case the network is tunable to provide a pure resistance load of 3000 ohms for the plate circuit of the tube, the internal impedance of the pi network is a pure resistance, and the deviation from the desired operating Q is minimal.

**summary**

Throughout this article the points of resistive impedance have been given special emphasis. When the experiments performed on the transmission line were discussed, the points of resistive impedance were significant because it was shown that reflected waves cease at these points. When the operation of the pi network was discussed it was shown that, for moderate values of system vswr, the network can always be tuned to produce the proper value of resistive load for the power tube and the intermediate impedance is always a pure resistance.

Whenever a pure resistance exists in a circuit, at that point power can flow in only one direction. Therefore, power must flow from the generator (or transmitter) toward, and into, the point of pure resistance. This is so because resistance is strictly passive. That is, it cannot reflect, and all of the power that flows into it must be absorbed. A resistive point

![Diagram](image)

Appendix

Standing waves on a transmission line are the result of a reflected voltage wave combining with (or interfering with) the forward voltage wave. Since the two
waves are traveling in opposite directions at a constant velocity, the resulting rms voltage at any point on the transmission line will be constant and will depend upon the relative phase and amplitude of the two waves.

Locations of peak voltage will occur where the forward and reverse wave voltages are in exact phase and add together; in the same manner, voltage nulls will occur where the forward wave voltage and the reverse wave voltage are in exact opposite phase and the resulting amplitude is the difference between the two voltages. Peaks and nulls will be alternately spaced at one-quarter wave intervals (90 electrical degrees) along the transmission line with their number dependent upon the electrical length of the line.

The vswr is obviously the ratio of the voltage at peak to the voltage at a null and may be stated algebraically as

\[
\text{vswr} = \frac{E_f + E_r}{E_f - E_r} \quad (1)
\]

where \( E_f \) is the voltage amplitude of the forward wave and \( E_r \) is the voltage amplitude of the reflected wave. Eq. 1 can be rearranged, and if at the same time \( E_r \) is assigned a value of unity, a new expression is obtained

\[
E_r = \frac{\text{vswr} - 1}{\text{vswr} + 1} \quad (2)
\]

The amplitude of the reflected wave voltage can now be expressed as a fraction of the forward wave voltage for any value of vswr. For example, if the vswr is 2:1, the reflected wave will be 1/3 the amplitude of the forward wave.

Transmission-line theory is frequently discussed in what is termed “the lossless case.” The assumption is made that there is no loss in the dielectric material of the transmission line and no losses in the electrical conductors. Nevertheless, in the practical case losses do exist in both the dielectric and the conductors. However, if the system being considered is limited in length to a few wavelengths, and if the operating frequency is not above the high-frequency range, there is little error involved in assuming the losses to be zero and the discussion becomes much more manageable.

If the transmission-line losses are assumed to be zero, the product of line voltage and line current must be the same for any point on the line. It follows that to satisfy this condition of constant power, a standing wave of current must exist such that the current nulls coincide with the voltage peaks, and the current peaks coincide with the voltage nulls. Since impedance is the ratio of voltage to current, \( Z = E/I \), it should be noted that high line impedance occurs at voltage peaks, and low line impedance occurs at voltage nulls. With a little further manipulation of the foregoing analysis the ratio of maximum impedance, \( Z_{\text{max}} \), to minimum impedance, \( Z_{\text{min}} \), may be expressed as a function of vswr

\[
\frac{Z_{\text{max}}}{Z_{\text{min}}} = \text{vswr}^2 \quad (3)
\]

This ratio is 4 when the vswr is 2:1.

One quarter-wavelength (90°) sections of transmission line have the unique property of operating as impedance transformers when terminated in any impedance other than \( Z_0 \). Thus, the input impedance \( (Z_{\text{in}}) \) for any value of output impedance \( (Z_{\text{out}}) \) is readily found from

\[
Z_{\text{in}} = \frac{Z_0^2}{Z_{\text{out}}} \quad (4)
\]

It is obvious that when \( Z_{\text{out}} \) is equal to \( Z_0 \), the input impedance will be equal to \( Z_0 \) and no impedance transformation will take place. It is also apparent that the input impedance will be a pure resistance only when the output impedance is a pure resistance.

**references**

*Ham Radio*
frequency synthesizer for two-meter fm

Although this all-channel two-meter frequency synthesizer was designed for the GE Progress Line, it may be used with other equipment commercial equipment, not to mention that commercial equipment usually has a far better intermodulation figure than most of the amateur rigs currently available. This can be a very valuable asset in areas served by several repeaters that are not very far apart in frequency.

Obviously, to invest in a large number of crystals would be a financial hardship to the ham with a limited pocketbook, and hardly anyone would be interested in purchasing 100-plus crystals just to be able to cover all the available channel combinations, simplex and duplex. My aim in designing this unit was to have a low-cost unit with limited capability. This unit will only synthesize frequencies that are spaced at 30-kHz intervals starting at 146.01 MHz, which allows full coverage of the entire portion of the two-meter band which is available for repeater operation.

Naturally, this presents certain limitations, as in some areas there are still repeaters which are not on “standard” frequencies. But they are (fortunately) few and far between. In a situation like this, the synthesizer could be used to drive one channel of a two-frequency rig, and the special crystals could be installed in the other channel.

Synthesizers have been covered in quite great detail in recent months in various publications, so I refer you to the articles mentioned in the reference list at the conclusion of this article.
While I designed this unit for use with the GE Progress Line equipment, it can be modified to operate with other commercial equipment such as Motorola, RCA, etc. I would be glad to assist anyone interested in adapting the unit to other equipment if they will send me full details of what they want to do, as well as the multiplication factors of the receiver and transmitter and the receiver first i-f frequency, etc., along with a stamped, self-addressed envelope.

To permit rapid channel switching, channel selection is accomplished by means of a 24-position, 10-deck rotary switch, in conjunction with small diode matrices, which are used to convert the binary-coded decimal (BCD) numbers required by the programmable dividers into their decimal values. While this involves considerable wiring at the switch, it also makes operation much simpler, as changing channels only requires a twist of the wrist, as would be compared to some similar circuits which would require setting 6 to 8 thumb-wheel switches. Again, some versatility is sacrificed, but there is a way out of this which I will discuss later.

The 10-deck switch is in reality, two 5-deck switches on a common shaft. A second band switch, a six-pdt rotary switch, selects either one or the other bank of five decks, depending upon whether the frequency desired is above or below 147.00 MHz. In this manner, 24 possible combinations are available in either bank, each covering a full MHz. A dual set of channel markings is provided on the front panel, one set for Band A, the other for Band B. You could simply eliminate all frequencies above 147.00 MHz, and use a 5-deck switch (which would also eliminate the other band-switch) as you would have to retune the transmitter at least in order to operate over the frequency spread that the synthesizer is capable of. The receiver will operate reasonably well over a wider range than the manufacturer specifies, however. A base-station operator might wish to retain the full coverage so he can take advantage of possible DX openings.

Whenever possible, I used low-cost general-purpose replacement type transistors to eliminate any problem of procuring replacements (these items can be obtained in most any radio/TV supply house in the country). All ICs used were of the lowest cost types available at this time, and can be obtained from most of the specialty houses dealing in these items at very nominal cost.

circuit description

The programmable dividers are made from SN74192N decade up/down counters, wired in a modulo n configuration. These divider ICs have a parallel load capability, which allows you to enter a certain count, and then count down to zero, whereupon, an output will be generated and the number will again be re-entered into the dividers.

The number is entered in BCD form, as was mentioned previously, which is derived from diode matrices. Note that only the units and 10s of the numbers to be entered require the matrices, as the 100s only change at infrequent points during the coverage of the 2-MHz segment. The 1000s never change and are coded directly at the PC board. The coding of the 100s occurs at two decks of the channel switch.

For those readers not acquainted with BCD numbers, each of the dividers is provided with a parallel input lettered A, B, C and D which correspond to the BDC numbers 1, 2, 4 and 8, respectively. If we were to connect the A input to a 1 voltage (more than approximately +2.0 V), the divider would preset to the count of 1; if we wanted to encode the number 7, we would connect the A, B and C inputs to 1, etc. All other inputs are connected to zero (less than 0.8 V) or grounded. Of course, we would also have to apply the proper signal to the load control lead from this package before we could enter
C1 10 pF, N750
C2 20 pF, N750
CR1,CR2 22-pF varicap (TRW PC-116)
L1 24 turns no. 24 enamelled on Millen 69041 slug-tuned form
L2 10 turns no. 24 enamelled on Millen 69041 slug-tuned form
L3,L4 turns as required on Millen 69041 slug-tuned form (see text)
C_A,C_B temperature-compensating capacitors (see text)
C_T 0.8 to 11 pF piston capacitor (JFD NVC9G)
X1 5-MHz crystal (International Crystal HA-1)
fig. 1. Circuit diagram for the two-meter transmit and receive synthesizer. This unit covers the entire two-meter fm band in 30-kHz steps, starting at 146.01 MHz. The 10-μH rf chokes are J.W. Miller type 9340-20. L1-4 are James Millen type 69041. L1 is 24 turns no. 24 enameled wire. L2 is 10 turns no. 24 enameled wire (scramble wound). Schematic for receiver divider board is on the next page.
the numbers. The load lead requires a zero to enter the data.

Each package has two clock inputs and two outputs marked count up, count down, carry and borrow. In this particular application we are only going to count down. The rules for using this IC require that the unused clock input be connected to 1 voltage. The carry output is not connected to anything in this particular application.

when an output occurs at its borrow, toggling the second divider in the chain one time. The first divider continues to count down 9,8,7, etc., until zero is reached again, and the second divider is again toggled. As you will note, the divider is working as a decade divider after it counts down the initial 6 of our number 4866.

This process continues until the second divider has counted down from the initial 60 it was coded with, indicating we have counted the 66 part of our original number, where the second divider also now acts as a decade divider in conjunction with the first divider to divide by 100 which will toggle the third divider in exactly the same fashion until the total number 4866 is reached, whereupon an output will occur at the borrow of the last divider in the chain. This causes the number to be re-entered into all the dividers again though the action of the output signal also being applied to the load leads of each package.

However, one little problem slips in

Schematic for the receiver divider board. Circuit points F and H are connected to the circuit in fig. 1, shown on the preceding pages.

Note that all the load inputs are connected to the borrow of the last (most significant number) divider. It happens that whenever an output occurs from the borrow the output changes from 1 to zero. It becomes apparent then that every time an output occurs from the divider chain the same signal is applied to all the parallel load leads re-entering the number into the dividers.

Suppose we take a short-cut and say we already have the number 4866 entered in our dividers. Now we apply clock pulses to the first count down input and the divider counts down, "6,5,4,3,2,1,0,"

Therefore, one little problem slips in...
here, but it's quite simple to solve. Note that the dividers don't toggle on the negative transition of the clock pulse or the borrow pulse, but on the positive transition, meaning that the total count is short-changed by almost a full clock pulse. Note that as soon as the borrow occurs (not at the end of the borrow as is occuring between the sections of the dividers) the new number is re-entered into the dividers again. As soon as this number is reentered, the output obviously cannot any longer be zero because the number 4 has just been entered. So instead of getting an output pulse that is equal in length to one cycle of the input frequency (about 166 nanoseconds at 6 MHz) the output pulse is shortened to something on the order of 5-10 nanoseconds — the switching time of the TTL logic, and counting starts immediately instead of at the end of 166 nanoseconds as would be the case if you were using the more expensive modulo n dividers such as are manufactured by Motorola.

The solution to this problem is quite simple. We merely say that, instead of counting by 4866, we actually counted by 4867. The net result is that the frequency error is quite minute if we simply deduct one number from the division ratios that we calculate (the tables accompanying this article take this into account), and we end up with modulo-n counters at about one-half the price of devices intended specifically for this purpose.

Note that all the inputs that will require programming are connected to 1 via resistors. Those inputs that never change are connected to either zero or 1 directly at the PC board, as is appropriate in each instance. By shorting the inputs that go to 1 to ground (via resistors) through paths developed within the diode matrices or the bandswitch and channel switch, you can program the dividers for any count, within certain limits. The count can be programmed for considerably further range than is listed in the tables, however, if desired.

Since the basic crystal frequency of the GE Progress Line transmitter is in the 6-MHz range, and is multiplied by 24 to the output frequency, you can determine the required division ratio for the divider by dividing the desired output frequency by 24, and then by the reference frequency (1250 Hz in the case of the transmitter) remembering to subtract one count from the answer as explained above. After working out a few of these it becomes apparent that the reference frequency is related to the channel spacing (1.25 kHz x 24 = 30 kHz).

The same procedure is used to determine the division ratio required for the receiver divider, bearing in mind that the multiplication factor is only 12 in this case and subtracting the first i-f frequency from the desired receive frequency before dividing by 12. This figure is then divided by the reference frequency which in the case of the receiver is now 2.5 kHz (2.5 kHz x 12 = 30 kHz). Don't forget to deduct the one count from the final answer here, also.

The output of each programmable divider is buffered through a TTL gate to eliminate any possible transients that may appear in the output signal which are below the threshold level of the gate but which might affect the action of the phase detector. Large value capacitors are provided liberally on the PC boards to help reduce transient amplitude which could alter the total count.

phase detectors

Phase detector circuits are provided for each of the programmable dividers, and their associated vcos. External components must be added to provide an active low-pass filter circuit which is tailored to the referency frequency, the maximum number of divider steps (loop sensitivity), the maximum lockup time desired, and the maximum permissible overshoot. To go into the math for the design of these filters would be beyond the scope of this article and the interested reader is referred to Motorola Application Note AN-535. The use of a fet transistor

july 1973 39
rather than a bipolar type in the low-pass filter circuit makes the filtering easier to accomplish as the time constants of the associated R-C components are not affected as badly by the relatively high gate impedance of the fet.

Notice that the circuit provides for rf decoupling in the supply leads to both the active filters and phase detectors. This is required to prevent the steep wave front of the reference and output signals from the dividers from pulse modulating the resulting dc control voltage which is being obtained from the phase detector circuit and which would also modulate the vcos in turn.

**voltage controlled oscillators**

The vcos are conventional Colpitts design, with a single transistor buffer stage. Frequency variation is accomplished by applying the voltage derived from the phase detectors to a varicap diode wired into the tank circuit. Isolation of the rf is adequately provided by a series resistor to this diode, which also serves the purpose of limiting the swing of the oscillator, as the diode will be somewhat self-biased by some rectified rf from the oscillator tank circuit. This requires that the applied control voltage be raised above this value before any appreciable change in capacitance can occur.

The chosen L/C ratios for the two oscillators cover the required frequency spread by about a ratio of 2:1, ensuring that adequate margin will exist in the event that the oscillator changes frequency due to changes in temperature, but when corrected by the output from the phase detector, will still be within the range of that circuit. Some frequency stability is imparted by the parallel padding capacitors in each tank circuit. However, this could probably be improved somewhat if the builder has available N-1500 type capacitors instead of the specified N-750 types. The oscillators operate from 12 volts, and are ac coupled to the following logic buffer stages. The two oscillators are identical in construction, with the exception of

---

**Table 1. Division ratios for standard repeater pairs and simplex pairs.**

<table>
<thead>
<tr>
<th>switch</th>
<th>xmit freq (MHz)</th>
<th>receive freq (MHz)</th>
<th>xmit xtal frequency (kHz)</th>
<th>xmit divisor</th>
<th>rcv xtal frequency (kHz)</th>
<th>receive divisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>group A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>146.01</td>
<td>146.61</td>
<td>6083.75</td>
<td>4866</td>
<td>11492.5</td>
<td>4596</td>
</tr>
<tr>
<td>2</td>
<td>146.04</td>
<td>146.64</td>
<td>6085.00</td>
<td>4867</td>
<td>11495.0</td>
<td>4597</td>
</tr>
<tr>
<td>3</td>
<td>146.07</td>
<td>146.67</td>
<td>6086.24</td>
<td>4868</td>
<td>11497.5</td>
<td>4598</td>
</tr>
<tr>
<td>4</td>
<td>146.10</td>
<td>146.70</td>
<td>6087.50</td>
<td>4869</td>
<td>11500.0</td>
<td>4599</td>
</tr>
<tr>
<td>5</td>
<td>146.13</td>
<td>146.73</td>
<td>6088.75</td>
<td>4870</td>
<td>11502.5</td>
<td>4600</td>
</tr>
<tr>
<td>6</td>
<td>146.16</td>
<td>146.76</td>
<td>6090.00</td>
<td>4871</td>
<td>11505.0</td>
<td>4601</td>
</tr>
<tr>
<td>7</td>
<td>146.19</td>
<td>146.79</td>
<td>6091.25</td>
<td>4872</td>
<td>11507.5</td>
<td>4602</td>
</tr>
<tr>
<td>8</td>
<td>146.22</td>
<td>146.82</td>
<td>6092.50</td>
<td>4873</td>
<td>11510.0</td>
<td>4603</td>
</tr>
<tr>
<td>9</td>
<td>146.25</td>
<td>146.85</td>
<td>6093.75</td>
<td>4874</td>
<td>11512.5</td>
<td>4604</td>
</tr>
<tr>
<td>10</td>
<td>146.28</td>
<td>146.88</td>
<td>6095.00</td>
<td>4875</td>
<td>11515.0</td>
<td>4605</td>
</tr>
<tr>
<td>group B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>147.03</td>
<td>147.63</td>
<td>6126.25</td>
<td>4900</td>
<td>11577.5</td>
<td>4630</td>
</tr>
<tr>
<td>2</td>
<td>147.06</td>
<td>147.66</td>
<td>6127.50</td>
<td>4901</td>
<td>11580.0</td>
<td>4631</td>
</tr>
<tr>
<td>3</td>
<td>147.09</td>
<td>147.69</td>
<td>6128.75</td>
<td>4902</td>
<td>11582.5</td>
<td>4632</td>
</tr>
<tr>
<td>4</td>
<td>147.12</td>
<td>147.72</td>
<td>6130.00</td>
<td>4903</td>
<td>11585.0</td>
<td>4633</td>
</tr>
<tr>
<td>5</td>
<td>147.15</td>
<td>147.75</td>
<td>6131.25</td>
<td>4904</td>
<td>11587.5</td>
<td>4634</td>
</tr>
<tr>
<td>6</td>
<td>147.18</td>
<td>147.78</td>
<td>6132.50</td>
<td>4905</td>
<td>11590.0</td>
<td>4635</td>
</tr>
<tr>
<td>7</td>
<td>147.21</td>
<td>147.81</td>
<td>6133.75</td>
<td>4906</td>
<td>11592.5</td>
<td>4636</td>
</tr>
<tr>
<td>8</td>
<td>147.24</td>
<td>147.84</td>
<td>6135.00</td>
<td>4907</td>
<td>11595.0</td>
<td>4637</td>
</tr>
<tr>
<td>9</td>
<td>147.27</td>
<td>147.87</td>
<td>6136.25</td>
<td>4908</td>
<td>11597.5</td>
<td>4638</td>
</tr>
<tr>
<td>10</td>
<td>147.30</td>
<td>147.90</td>
<td>6137.50</td>
<td>4909</td>
<td>11600.0</td>
<td>4639</td>
</tr>
<tr>
<td>11</td>
<td>147.33</td>
<td>147.93</td>
<td>6138.75</td>
<td>4910</td>
<td>11602.5</td>
<td>4640</td>
</tr>
<tr>
<td>12</td>
<td>147.36</td>
<td>147.96</td>
<td>6140.00</td>
<td>4911</td>
<td>11605.0</td>
<td>4641</td>
</tr>
<tr>
<td>13</td>
<td>147.39</td>
<td>147.99</td>
<td>6141.25</td>
<td>4912</td>
<td>11607.5</td>
<td>4642</td>
</tr>
<tr>
<td>14</td>
<td>147.42</td>
<td>147.42</td>
<td>6142.50</td>
<td>4913</td>
<td>11560.0</td>
<td>4623</td>
</tr>
<tr>
<td>15</td>
<td>147.45</td>
<td>147.45</td>
<td>6143.75</td>
<td>4914</td>
<td>11562.5</td>
<td>4624</td>
</tr>
<tr>
<td>16</td>
<td>147.48</td>
<td>147.48</td>
<td>6145.00</td>
<td>4915</td>
<td>11565.0</td>
<td>4625</td>
</tr>
<tr>
<td>17</td>
<td>147.51</td>
<td>147.51</td>
<td>6146.25</td>
<td>4916</td>
<td>11567.5</td>
<td>4626</td>
</tr>
<tr>
<td>18</td>
<td>147.54</td>
<td>147.54</td>
<td>6147.50</td>
<td>4917</td>
<td>11570.0</td>
<td>4627</td>
</tr>
<tr>
<td>19</td>
<td>147.57</td>
<td>147.57</td>
<td>6148.75</td>
<td>4918</td>
<td>11572.5</td>
<td>4628</td>
</tr>
</tbody>
</table>
changed circuit values of the tank components and the series resistor to the varicap diode.

**logic buffer stages**

A quad two-input gate is used to provide direct coupling to the GE unit and the logic divider stage. One section is used as a buffer between the vco and the dividers, and also drives the inputs of two gates wired in parallel that are used as the output buffers to drive the GE unit. Note that by ac coupling the output of the oscillator stage in the synthesizer to this parallel, and the transmitter buffer only two, as I wanted to use one gate section as an inverter. Note that the unused inputs to the gates in the transmitter buffer are not returned to +5 volts as they are in the receiver buffer, but are connected to the output of this inverter stage. The input of this inverter is connected to the line running between the transmitter push-to-talk relay and the microphone switch contacts. When the push-to-talk button is released, approximately +12 volts appears on this line, driving the output of this gate to zero,

[diagram]

Fig. 2. Crystal oscillator reference generator board.

The output from the paralleled gates is fed to the GE unit through a length of coaxial cable. The length is not especially critical, as I tried lengths up to 15 feet and still obtained adequate drive for the multiplier stages, even though the end of this line was terminated in a 220-ohm resistor.

The two buffer stages are essentially alike in their function, although the receiver buffer has three gates tied in gate, the gate can only respond to that portion of the sine wave output of the oscillator that is 0.8 volt above the zero axis of the ac signal. Consequently, the rise and fall times of the output of the gate are more than adequately fast enough to drive the divider stages without the need of a Schmitt trigger or other pulse-forming device (approximately 40 nanoseconds rise/fall time as measured on a Tektronix 513D scope).

The output from the paralleled gates is fed to the GE unit through a length of coaxial cable. The length is not especially critical, as I tried lengths up to 15 feet and still obtained adequate drive for the multiplier stages, even though the end of this line was terminated in a 220-ohm resistor.

The two buffer stages are essentially alike in their function, although the receiver buffer has three gates tied in which disables the two buffer gates. During transmitter operation this same point is at ground and consequently the output of the inverter is at 1, which enables the buffer gates. Since it only controls the buffers and doesn't interrupt the path between the output of the vco and the dividers, no frequency searching occurs when going from transmit to receive. This suppresses the output of the transmitter oscillator signal to a level below the internal noise level of the receiver strip so as not to interfere with weak-signal reception.

This was ascertained with a narrow-

*Some GE Progress Line equipment uses the -22 volt bias supply to operate the relays. In this case connect the center pin to the cathode of the 6AQ5 audio output tube in the receiver instead of connecting it to pin 18 of the Jones connector.*
band receiver strip that was carefully checked for sensitivity and found to be somewhat better than the original specifications for this strip. However, the addition of a preamplifier would probably change the entire picture, and it would probably become necessary to supply transmit excitation through a coaxial relay keyed along with the transmitter relays. Good shielding will help in this instance more than any other technique.

**construction details**

The printed-circuit boards are stacked to provide as compact a package as possible. With the arrangement shown, all the ICs can be replaced without the necessity of dismantling anything. It is most important that the two oscillators and their two buffers be mounted in as tight a package as you can possibly make! Any coupling between the two oscillators will result in spurious outputs due to the fact that the mixing of the two signals will produce sidebands at intervals of 312.5 and 412.5 kHz when operating on repeater pairs spaced at 600 kHz. These spurious outputs will be treated by the transmitter as modulation components due to their equal spacing from the synthesized frequency, and will be multiplied, and appear in the output at the same spacing!

Bear in mind that an fm transmitter, although it multiplies the carrier and the sideband frequencies an identical amount, also causes the modulation index to increase with each multiplication. Consequently, the spurious outputs still
appear at the output. However, these that are apparent are the offspring of the original pairs since multiplication causes additional side frequencies to appear which will be spaced at the same intervals from the carrier as the original pairs were.

The compartment for the two oscillators was made from sheet copper bent into a channel shape to form the sides, and has an internal divider also made of sheet copper, and top and bottom made of PC board. Input power leads, vco control leads, etc., are bypassed immediately inside the compartment. Each oscillator has its own separate power leads. This is also most important to prevent mixing of the two rf signals. The buffer stages are treated in the same manner. However, in this case I constructed the shielded compartments entirely from copper clad PC board, soldering the sides and bottom entirely, and then lining the openings with Eimac finger stock. A rectangular shaped piece was then formed from a strip of \( \frac{1}{4} \)-inch wide copper strap, which was made a tight press fit into the opening.

The edges of these pieces were then soldered to lids made from PC board to complete the installation. The circuit boards that are installed inside these compartments are soldered to the sides of the compartment using small no. 6 solder lugs bent at right angles to reinforce the solder joint. Leads are then run from the boards to the appropriate terminal connections on the wall of the enclosure.

This type of construction is most necessary at these points to prevent rf from the output of the transmitter from being re-amplified which would cause hum, excessively wide bandwidth of the transmitter output, audio distortion, etc. The series inductors that I mentioned earlier in the discussion of the buffer stages also help to some extent to decouple the rf path that would otherwise exist on the center conductor of the coax. BNC connectors were used extensively here, which also helps in this regard.

Good quality phono connectors such as the Switchcraft 3502 plugs and 3501FP jacks are a good choice for the reference leads going from the buffer compartments to the programmable dividers. These plugs are completely shielded, and the jacks only require a single \( \frac{1}{4} \)-inch hole for mounting.

Notice that the 24-position channel switch is mounted directly to the two matrice boards (front two boards) that contain the four diode matrices. This provides for very short leads here (not really a necessity here as only dc paths are located here) which makes for a neater layout. The front board contains the two matrices for encoding the units of the receive and transmit dividers, the board immediately to the rear of this contains the two matrices for encoding the receive and transmit 10s of the dividers, and the board next to the rear of that position is the transmit divider board. To the rear of that board is the receive divider board, the phase-detector board, then the compartments housing the two oscillators, and lastly, the compartments housing the buffers.

The diodes used in the matrices are germanium types to permit remote location of the channel switch if desired, as this would allow for almost 0.5 V drop across the interconnecting wiring. This type of diode is recommended in all cases to provide margin for error, and to allow future additions to the equipment. This would permit the synthesizer to be trunk mounted in a mobile installation with just the channel switch mounted at the dash in a Minibox.

Not included in my rig are the time-base and power supply boards, which were not used with this particular unit as the reference and supply voltages were obtained from a frequency standard that was already in the shack. However, I have included the necessary information for building these boards. The crystal oscillator board and its dividers can be mounted to the left of the stack of boards so the trimmer capacitor would be accessible from the front panel through a small opening. The power supply board can be
mounted on the righthand side or wherever is most convenient to the constructor.

The oscillator board uses the Motorola dual-vco package (only one-half used) as the crystal oscillator circuit. This makes construction quite simple as the only external components required are the crystal, trimmer capacitor and a temperature compensating capacitor. A high quality crystal is recommended here, as the output frequency stability of the determination of the fixed temperature compensating capacitor is left to the builder. As a start, set the trimmer to approximately half capacity and install a 10-pF N-750 capacitor on the pads provided (CA). Tune in WWV (at the highest frequency possible) and attempt to zero beat the oscillator to WWV’s signal by adjusting the trimmer. It may be necessary to add or subtract some capacitance from CA in order to get the oscillator in

![Diagram](image)

**fig. 4. Ac power supply for the frequency synthesizer. Transformer T1 is a control or doorbell transformer with 16 to 18 volts output across the secondary.**

the proper range of the trimmer. Once in zero beat, hang a 100-watt lamp a foot or so above the board and allow the board to be warmed by this for about an hour.

Unless you are extremely lucky, the oscillator should no longer be in zero beat with WWV. Carefully noting which way you have to turn it, adjust the trimmer to bring the oscillator back into zero beat again. If you had to turn it clockwise (more capacitance) then the oscillator is over-compensated. Remove the capacitor from CA and install one of half that value (still type N-750) and in addition, install another capacitor of the same value at CB (type NPO) and repeat the test. If, after the initial test, you instead had to turn the capacitor counter-clockwise (less capacitance) the oscillator was not sufficient-
ly compensated. In this case install a N-1500 type capacitor as a replacement for the original N-750 type and again repeat the test. (The circuit board should be permitted to cool between tests so as not to give meaningless indications.) By using various ratios of capacitance at CA and CB (the former being either N-750 or N-1500, the latter NPO) any intermediate value of compensation can be obtained.

**power supply**

The power supply is quite simple, using two self-contained, protected ICs to provide the regulated outputs. The power transformer can be a doorbell transformer or control transformer with 16-18 volts output at 1 amp. This output is rectified by a bridge circuit and applied to the two regulators. A fuse is provided in the secondary (as well as the primary) in the unlikely event of a short in one of the rectifiers or ICs. The 5-volt regulator is a National Semiconductor LM-309K (in a TO-3 case). The 12-volt regulator can be either the National LM-336 (in TO-5 case) or the Fairchild μA7812 (TO-220 case). For mobile use, the 12-volt regulator is deleted, the 12-volt battery is applied directly to the 5-volt regulator input, and also to a simple shunt zener diode regulator operating at 10-volts. (This will require readjustment of the oscillators with the lower supply voltage, however.) The output from the zener regulator is additionally filtered through four 88-mH toroids wired in series.

If PC board layouts shown* are used, the construction of the boards is just a matter of mounting parts. It is strongly recommended that you use IC sockets on all the boards (as well as transistor sockets in the two oscillator boards) to make changing of defective ICs and transistors simple, as some of the PC board wiring is quite minute and could easily be damaged by repeated soldering and unsoldering of components. Also, in the oscillator compartments, the sockets would eliminate the need of unsoldering the small printed-circuit boards from the enclosure if a transistor becomes defective. After all the boards are mounted, solder a heavy braid from each board to the next with as short a lead as possible.

All cables that are indicated as shielded on the schematic diagram should be RG-58/U coax unless otherwise indicated. Both ends of the cable shield must be grounded to the nearest ground point and the inner conductor should be as little exposed as possible. Note that all power and control leads leaving or entering the vco and buffer shielded compartments must be bypassed immediately within the compartment with 0.02-μF disc capacitors with the shortest possible leads, soldered directly to the copper surface of the compartment. (The small electrolytic capacitors indicated are also mounted in a similar fashion.) The power and control leads were made through miniature pin jacks to make it easy to disconnect a sub-assembly for repair or testing. Feed-through capacitors could also be used in lieu of these but would require that the leads be unsoldered to disconnect it from the rest of the wiring.

**synthesizer adjustment**

After completing construction, connect the logic circuits to the output of the 5-volt supply with a milliammeter inserted in series (0-1 amp range). Note the current, which should be between 450-550 mA for the logic circuits, exclusive of the crystal oscillator and divider board. If it is more or less than this range you have either a defective IC or filter capacitor or something that isn't connected. If this checks ok, connect the oscillators to the 12-volt supply with a series milliammeter (0-100 mA scale) and note the current here, which should be 30-40 mA (both oscillators). If all checks well to this point, connect a voltmeter (20,000 ohm/volt or vtm) from the vco control line to the receiver oscillator (and to ground) and turn the channel switch to

*Full-size templates of the original prototype printed-circuit boards are available from the author along with additional schematics and parts placement diagrams for $1.00 postpaid.
the highest receive frequency (refer to the chart, as the highest receive frequency is not necessarily the highest switch position) and adjust the slug in the receive oscillator coil form (L2) for a reading of 3.8-4.0 V (use the 0-10 volt scale). Then turn the channel switch to the lowest receive frequency and note the meter reading, which should be between 2.5-3.0 volts. If outside these limits, the L/C ratio and adjust the slug in the receive oscillator coil form (L2) for a reading of 3.8-4.0 V (use the 0-10 volt scale). Then turn the channel switch to the lowest receive frequency and note the meter reading, which should be between 2.5-3.0 volts. If outside these limits, the L/C ratio

of the oscillator tank circuit must be adjusted, since this indicates that the oscillator control sensitivity is not correct.

If the voltage is too high, add more parallel padder capacitance to the tank circuit and reduce total inductance. Repeat the adjustment procedure until the voltage falls within these limits. If the voltage is too low, remove some of the parallel padder capacitance and increase the inductance.

Repeat this procedure for the transmit oscillator (L1), checking at the transmit vco control lead. This is probably locking the barn door after the horse has strayed, but I hope you read all the instructions before starting on this project. The oscillator compartments should be provided with access holes for adjustment of the coil slugs. Do not remove the compartment covers to make this adjustment. The coil forms should not be mounted to the exterior wall of the compartment and the threaded shank should be used to make the adjustments.

**Troubleshooting**

If the voltage stays at or near zero or +4.8 volts, some problem exists in the loop circuits. This can be caused by any number of interrelated problems such as no reference input to the phase detector,

![Fig. 5. Alternate dc power supply for 12 to 15 Vdc input.](image-url)
indicates that there is no input to the phase detector from the reference frequency source, or that the oscillator is tuned too high in frequency. A general-coverage receiver is handy at this point to determine if there is any output from the oscillators at all or any output from the buffer stages.

Once you have determined that the oscillators are working and the loops are

<table>
<thead>
<tr>
<th>switch pos</th>
<th>Deck 10 AT</th>
<th>Deck 9 BT</th>
<th>Deck 8 AR</th>
<th>Deck 7 BR</th>
<th>Deck 6</th>
<th>Deck 5</th>
<th>Deck 4</th>
<th>Deck 3</th>
<th>Deck 2</th>
<th>Deck 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>9</td>
<td>5</td>
<td>9</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>13</td>
<td>8</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>14</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>8</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>8</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>17</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>19</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>spare 5</td>
<td>spare 8</td>
<td>spare 8</td>
<td>spare 9</td>
<td>spare 5</td>
<td>spare 9</td>
<td>spare 5</td>
<td>spare 9</td>
<td>spare 6</td>
</tr>
<tr>
<td>21</td>
<td>9</td>
<td>spare 9</td>
<td>spare 8</td>
<td>spare 8</td>
<td>spare 9</td>
<td>spare 5</td>
<td>spare 9</td>
<td>spare 5</td>
<td>spare 9</td>
<td>spare 6</td>
</tr>
<tr>
<td>22</td>
<td>spare</td>
<td>spare</td>
<td>spare</td>
<td>spare</td>
<td>spare 8</td>
<td>spare 9</td>
<td>spare 0</td>
<td>spare 6</td>
<td>spare 9</td>
<td>spare 6</td>
</tr>
<tr>
<td>23</td>
<td>7</td>
<td>spare 7</td>
<td>spare 9</td>
<td>spare 9</td>
<td>spare 2</td>
<td>spare 6</td>
<td>spare 6</td>
<td>spare 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

locking, tune in the output frequencies on a general-coverage receiver and, with the bfo turned on, note whether the tone is stable and reasonably pure. (Don't overload the frontend of the receiver as this will give erroneous results. Keep the rf gain control turned as low as possible while making this test.)

interconnections

Once you have determined that the synthesizer is working correctly, the next step is to make the necessary connections to the GE unit. Begin by installing a phono jack on the front panel as near to the receiver oscillator crystal socket as possible. Attach one of the ends of a short piece (6 to 8 inches) of RG-58/U coax to this jack, and install a suitable plug on the other end that will mate with the crystal socket. (A suitable plug can be

made from a defunct FT-241 crystal holder. Some radio/tv supply houses carry a twin-lead plug that also has the correct dimensions.) Solder a 220-ohm resistor across the plug, too.

The grounded side of the plug should go in the crystal pin hole that is nearest the right-hand edge of the receiver chassis (when looking from the front). Install a known, good crystal and measure the multiplier voltage at the jack provided on
the chassis with a 20,000 ohm/volt meter set on the 0-2.5 V scale. Note this reading. Remove the crystal and connect the plug from the synthesizer instead, and again note the reading. It should be nearly the same or higher.

Adjust the series inductor in the buffer compartment (L4) to obtain the highest possible reading and tune the synthesizer to a channel that is in use. Observe if the audio output from the receiver is distortion free and if there is anything more than just the slightest trace of the 2.5-kHz reference frequency apparent. (If everything is working correctly you should only be able to hear, and then just barely, the reference frequency with receiver gain wide open when listening to a strong unmodulated carrier.)

If an objectionable level of reference frequency is apparent it is probably due to insufficient shielding of the oscillator in the synthesizer, or of the buffer stages, or insufficient bypassing of the supply and control leads. It is possible, but not very likely, that the components used in the phase detector are incorrect in value. However, there is quite a bit of leeway here, and the values would have to be drastically different from those specified to cause this. In some instances, adjustment of the series inductor in the buffer compartment will reduce the amplitude of the reference-frequency trace and should be tried first. However, after the final adjustment you should still have adequate meter indication at the multiplier test jack.

Assuming that the receiver is now working correctly, install a BNC connector on the front panel of the GE unit as far to the left as possible from the jack installed for the receiver. This should be a bulkhead-type connector so that the cable shielding is uninterrupted. Attach an 18-inch length of RG-58/U cable to this connector and install a phono plug on the other end. Route this cable down the left-hand edge of the receiver chassis, around the rear of the receiver to the left-hand corner of the transmitter chassis. There is just enough room in the left rear corner of the transmitter chassis to mount a phono jack. From the center pin of this jack, run a short stiff wire to the grid of the A oscillator tube (single-channel versions) or a short length of miniature coax to the grid of the B oscillator tube (two-frequency versions). Wire a 220-ohm resistor across the existing 100k grid resistor. For best results it is strongly recommended that you convert the oscillator tube to an amplifier by bypassing the screen and cathode of the tube with .02-μF disc capacitors.

If you only have a single-channel rig it is suggested that you convert it to a two-frequency version for this application. You don't need any special parts such as trimmers or temperature compensating capacitors if it's only going to be used as an amplifier, and this will leave the A channel available for crystal operation if so desired. In the two-frequency version, the screen lead of the B oscillator should be disconnected from the screen lead of the A channel oscillator tube socket, and then connected through a 47k resistor to the B+ point. This will prevent the added bypassing at the screen and cathode of the B oscillator from bypassing the A oscillator as well. Refer to the appropriate GE manual for your rig for the proper connections for making a two-frequency rig from your unit. It's a simple job.

tuneup

The transmitter can now be connected to a dummy load, placed in the tune position, and, with a multimeter connected to the first multiplier test jack, note the voltage which is obtained from a known, good crystal. (If you have a single frequency model, make this measurement before converting the oscillator to an amplifier and note the reading for future reference.) Connect the synthesizer, preferably at or near the same frequency as the crystal was, and compare the readings. These should be as nearly alike as possible, and may be changed by adjusting the series inductor in the buffer compartment (L3).
If the voltage is too high, you probably have too much series inductance; too low, not sufficient inductance. About 8 to 10 turns of no. 24 enameled wire is correct for a three-foot length of cable. The voltage at the multiplier test point must remain nearly the same as with a crystal as otherwise the modulation index will change.

Next, listen to the transmitter on a good FM receiver and carefully adjust the series coil, until you null out any hum that is apparent on the carrier. Hum in this case is usually caused by RF feedback, and careful adjustment will usually eliminate the path through the coax. If the hum persists, and the adjustment of the inductor doesn't seem to change it, then possibly RF is getting back into the buffer or oscillator stages by another path. All the shielding should be carefully checked to eliminate any other entry points for RF. If this eliminates the hum switch to high power and listen again. Note if there is any audio distortion or echo apparent; this is also an indication of RF feedback.

If everything is fine up to this point, listen carefully to the unmodulated carrier with an FM receiver for noise (this noise, if present, will probably sound like weak static). If this condition is noted, try adding a 5-pF capacitor from the transmit VCO control line to ground, and increase this value up to 20-pF to eliminate this condition. This problem is caused by variation in tolerances in the components used in the low-pass filter in the phase detector. Don't add this capacitor unless it's really needed, as it will slow down the loop lock-up time.

At this point the only remaining thing to do is to install a phono jack on the front panel of the GE unit near the Jones connector going to the control head. From the center pin of this jack run a lead to pin no. 18 of the Jones connector. Install a shielded cable from the jack to the control connection to the inverter stage in the transmitter buffer compartment. This circuit will suppress the output from the transmit buffer during receiving periods.

The oscillator board (crystal oscillator) should now be zero beat against WWV. If a frequency counter is available the output of the synthesizer should be measured. Table 3. Division ratios for all frequencies between 147.99 and 146.01 MHz.

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Transmit Divisor</th>
<th>Receive Divisor</th>
<th>Frequency (MHz)</th>
<th>Transmit Divisor</th>
<th>Receive Divisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>146.01</td>
<td>4866</td>
<td>4576</td>
<td>147.00</td>
<td>4899</td>
<td>4609</td>
</tr>
<tr>
<td>146.04</td>
<td>4867</td>
<td>4577</td>
<td>147.03</td>
<td>4900</td>
<td>4610</td>
</tr>
<tr>
<td>146.07</td>
<td>4868</td>
<td>4578</td>
<td>147.06</td>
<td>4901</td>
<td>4611</td>
</tr>
<tr>
<td>146.10</td>
<td>4869</td>
<td>4579</td>
<td>147.09</td>
<td>4902</td>
<td>4612</td>
</tr>
<tr>
<td>146.13</td>
<td>4870</td>
<td>4580</td>
<td>147.12</td>
<td>4903</td>
<td>4613</td>
</tr>
<tr>
<td>146.16</td>
<td>4871</td>
<td>4581</td>
<td>147.15</td>
<td>4904</td>
<td>4614</td>
</tr>
<tr>
<td>146.19</td>
<td>4872</td>
<td>4582</td>
<td>147.18</td>
<td>4905</td>
<td>4615</td>
</tr>
<tr>
<td>146.22</td>
<td>4873</td>
<td>4583</td>
<td>147.21</td>
<td>4906</td>
<td>4616</td>
</tr>
<tr>
<td>146.25</td>
<td>4874</td>
<td>4584</td>
<td>147.24</td>
<td>4907</td>
<td>4617</td>
</tr>
<tr>
<td>146.28</td>
<td>4875</td>
<td>4585</td>
<td>147.27</td>
<td>4908</td>
<td>4618</td>
</tr>
<tr>
<td>146.31</td>
<td>4876</td>
<td>4586</td>
<td>147.30</td>
<td>4909</td>
<td>4619</td>
</tr>
<tr>
<td>146.34</td>
<td>4877</td>
<td>4587</td>
<td>147.33</td>
<td>4910</td>
<td>4620</td>
</tr>
<tr>
<td>146.37</td>
<td>4878</td>
<td>4588</td>
<td>147.36</td>
<td>4911</td>
<td>4621</td>
</tr>
<tr>
<td>146.40</td>
<td>4879</td>
<td>4589</td>
<td>147.39</td>
<td>4912</td>
<td>4622</td>
</tr>
<tr>
<td>146.43</td>
<td>4880</td>
<td>4590</td>
<td>147.42</td>
<td>4913</td>
<td>4623</td>
</tr>
<tr>
<td>146.46</td>
<td>4881</td>
<td>4591</td>
<td>147.45</td>
<td>4914</td>
<td>4624</td>
</tr>
<tr>
<td>146.49</td>
<td>4882</td>
<td>4592</td>
<td>147.48</td>
<td>4915</td>
<td>4625</td>
</tr>
<tr>
<td>146.52</td>
<td>4883</td>
<td>4593</td>
<td>147.51</td>
<td>4916</td>
<td>4626</td>
</tr>
<tr>
<td>146.55</td>
<td>4884</td>
<td>4594</td>
<td>147.54</td>
<td>4917</td>
<td>4627</td>
</tr>
<tr>
<td>146.58</td>
<td>4885</td>
<td>4595</td>
<td>147.57</td>
<td>4918</td>
<td>4628</td>
</tr>
<tr>
<td>146.61</td>
<td>4886</td>
<td>4596</td>
<td>147.60</td>
<td>4919</td>
<td>4629</td>
</tr>
<tr>
<td>146.64</td>
<td>4887</td>
<td>4597</td>
<td>147.63</td>
<td>4920</td>
<td>4630</td>
</tr>
<tr>
<td>146.67</td>
<td>4888</td>
<td>4598</td>
<td>147.66</td>
<td>4921</td>
<td>4631</td>
</tr>
<tr>
<td>146.70</td>
<td>4889</td>
<td>4599</td>
<td>147.69</td>
<td>4922</td>
<td>4632</td>
</tr>
<tr>
<td>146.73</td>
<td>4890</td>
<td>4600</td>
<td>147.72</td>
<td>4923</td>
<td>4633</td>
</tr>
<tr>
<td>146.76</td>
<td>4891</td>
<td>4601</td>
<td>147.75</td>
<td>4924</td>
<td>4634</td>
</tr>
<tr>
<td>146.79</td>
<td>4892</td>
<td>4602</td>
<td>147.78</td>
<td>4925</td>
<td>4635</td>
</tr>
<tr>
<td>146.82</td>
<td>4893</td>
<td>4603</td>
<td>147.81</td>
<td>4926</td>
<td>4636</td>
</tr>
<tr>
<td>146.85</td>
<td>4894</td>
<td>4604</td>
<td>147.84</td>
<td>4927</td>
<td>4637</td>
</tr>
<tr>
<td>146.88</td>
<td>4895</td>
<td>4605</td>
<td>147.87</td>
<td>4928</td>
<td>4638</td>
</tr>
<tr>
<td>146.91</td>
<td>4896</td>
<td>4606</td>
<td>147.90</td>
<td>4929</td>
<td>4639</td>
</tr>
<tr>
<td>146.94</td>
<td>4897</td>
<td>4607</td>
<td>147.93</td>
<td>4930</td>
<td>4640</td>
</tr>
<tr>
<td>146.97</td>
<td>4898</td>
<td>4608</td>
<td>147.96</td>
<td>4931</td>
<td>4641</td>
</tr>
<tr>
<td>147.00</td>
<td>4899</td>
<td>4609</td>
<td>147.99</td>
<td>4932</td>
<td>4642</td>
</tr>
</tbody>
</table>

July 1973
ured and the crystal trimmer adjusted accordingly. It's not a bad idea to check all the output frequencies (including the receiver) to make sure that you actually wired the band and channel switches correctly as well as to make certain that the synthesizer is locking on all frequencies.

other frequencies

As I mentioned earlier there is a way to externally program the unit for unusual channel combinations if desired: for example, you might want a .34 simplex combination for some testing purpose. This is quite simple to do if you leave the last position of the rotary channel switch in the second group (B) of frequencies blank and mark this external on the front panel. You then bring out all the decimal leads from the matrices, the hundreds leads from the receiver divider board, and the hundred lead from the transmit divider board. The Units and 10s leads are wired to thumb-wheel switches (the decimal encoding types, not the BCD type) with the hundreds leads from the receiver divider board going to a spdt toggle switch. The common leads from all these switches are returned to the position 24 segments of the B group decks on the channel switch.

The hundreds lead from the transmit divider can be obtained from the unused connection on the bandswitch, run to one side of a spst toggle switch the other side of which is connected to ground.

The proper division ratios are then read from a frequency chart and entered into the switches to obtain these special frequencies. You must remember to leave the transmit hundreds switch in the 900 position, however, whenever using the regular channel selector switch in the B group. (When using the A group this precaution is not necessary as the external switch will be disconnected by the bandswitch and the lead is normally grounded by the bandswitch.) A chart of the division ratios that would have to be set on the thumbwheels and toggle switches is included for frequencies from 146.01 to 147.99 MHz (see table 3).

acknowledgement

I would like to express my thanks to Don Rees, W4VQA, and Chuck de Santis, WBBFQY, who were most helpful in providing suggestions and assistance in the initial testing of the synthesizer, as well as to all the patient people who use the Huntington machine who had to live through the birth pains and countless hours of discussion and testing that went on. Their patience and comments are greatly appreciated.

references

the most powerful antennas under the sun!

The Best Vertical There IS!
80 through 10 meters

**Hy-gain 18AVT/WB**

New, from the inventors of wideband verticals.

Pack some punch! All the omnidirectional performance of Hy-Gain's famous 14AVQ/WB...plus 80 meter capability! Unrivaled performance, rugged extra heavy duty construction, and the price you want...all in one powerful package!

- Automatic switching on all five bands through the use of three beefed-up Hy-Q traps...featuring extra large diameter coils for exceptional L/C ratio and extremely high Q.
- Recessed coax connector furnished.
- Top loading coil and four element static hat.
- Constructed of extra heavy wall high tensile aluminum.
- Hot performance all the way across the band with just one setting (10 through 40).
- Hy-Q traps effectively isolate antenna sections for full 1/4 wave resonance on all bands.
- No dissimilar metals to cause noise.
- SWR 2:1 or less at band edges.
- Maximum legal power with low frequency drift.
- Exceedingly low radiation angle makes DX and long haul contacts a cinch...whether roof or ground mounted.
- Very low RF absorption from insulating materials.

The 18AVT/WB is constructed of extra heavy duty, taper swaged, seamless aircraft aluminum with full circumference, corrosion resistant compression clamps at all tubing joints. This antenna is so rigid, so rugged...that its full 25' height may be mounted using only a 12" double grip mast bracket...no guy wires, no extra support...the 18AVT/WB just stands up and dishes it out!

Order No. 386 $69.95

Get the strength, the performance and the price you want...from the man who sells the complete line of quality Hy-Gain equipment.

HY-GAIN ELECTRONICS CORPORATION
Box 5407 - WG Lincoln, Nebraska 68505

More Details? CHECK-OFF Page 110
transistor curve tracer

This semiconductor curve tracer can be used with npn and pnp transistors, junction fets and mosfets, as well as diodes.

Nothing is more frustrating than trying to design a circuit without the family of characteristic curves for the device you're going to use. In many instances the curves are not readily available or the device is unmarked. The simple-to-build, low-cost (less than $30) curve tracer shown in the photograph is the answer to this problem. It will display a family of collector characteristic curves for npn, pnp, jfets (P and N channel) and mosfets. It can also be used to display the volt/current characteristics of two-terminal semiconductors.

circuit

To produce the family of curves it is necessary to vary the base voltage in discrete steps while sweeping the collector voltage from zero to maximum at each step. As shown in fig. 1, the collector voltage is a 120-Hz rectified sine wave from a bridge rectifier, CR10-CR13. The maximum collector voltage is varied by R36 and the proper polarity is selected by S5.

The base voltage steps are synchronized to the 120-Hz collector voltage by Q1, Q2 and Q3. Transistor Q1 is an input amplifier that squares up the rectified sine wave. Q2 and Q3 form a one-shot
fig. 1. Circuit of the transistor curve tracer. The values for resistors R15-R32 were made from selected 10% resistors to produce 5% accuracy. Resistors R33, R34 and R35 are 5% units. All resistors are 1/2-watt unless otherwise specified. C6 must be a tantalum. The MPU131 programmable unijunction transistor, Q5, and the MPS-A14 Darlington transistor, Q6, are manufactured by Motorola.

multivibrator. The output pulse from the multivibrator is differentiated by R10 and C5. This pulse is synchronized with the beginning of the collector sweep by adjusting R6. Each time the step generator transistor Q4 is turned on by the synchronizing pulse, C6 receives equal current pulses, producing equal voltage steps.

The voltage between each step is controlled by R10. The programmable unijunction transistor, Q5, resets the stair-step generator back to zero. When the anode voltage goes higher than the gate voltage, the unijunction transistor fires and the generator is reset. The gate voltage is adjusted by R12. The stair-step voltage waveform is coupled to the selectable bias resistors (R15 - R32) for the test transistor by Q6 and Q7. The base bias is selected by S3 and the proper bias polarity is selected by S2.

The collector voltage is measured directly and applied to the horizontal
input of the oscilloscope. The collector current is determined by measuring the voltage across one of the load resistors (R33, R34 or R35) and applying it to the vertical input of the scope.

Alignment is fairly simple. First, preset R12 to minimum resistance. Monitor the step voltage output at the emitter of Q7 selecting and combining 10% resistors to obtain the necessary 5% tolerance.

construction and alignment

The curve tracer can be built on a perforated board or a printed circuit board, depending on the builder. Parts layout is not critical although it seems logical to keep all lead lengths short to minimize any stray signal pick-up. The base resistors (R15 - R32) are made by

with a scope and adjust R10 to produce the first step at approximately 2.2 volts. Adjust R12 to produce six steps before Q5 resets the generator. Adjust R6 so the base steps are synchronized with the collector waveform as shown in fig. 2. If a dual-trace scope is not available, this alignment can be made by adjusting R6 for the least amount of clutter on the
scope when a transistor is being tested on the curve tracer.

**parts substitution**

Before starting a project such as this, you always wonder if your junkbox parts can be substituted. This circuit seems to be very forgiving. Almost any npn transistor can be used for Q1, Q2 and Q3 (I used 2N1605s because that is what was in my junkbox). Almost any pnp transistor can be used for Q4. If you replace Q7, be sure to replace it with one of equal power dissipation and collector current.

I do not recommend any substitutions for Q5 or Q6. They seem to work better than any of the other devices I tried, and they only cost 80 cents each from the surplus houses. The diodes can be substituted as needed so long as the replacements have similar PIV and forward current characteristics.

**operation**

Operation of the curve tracer is straightforward. First, select the proper base current and collector voltage for the device being tested. Select a load resistor, 1000 ohms for most small-signal devices, 10 ohms for power devices or 10k when you want to limit current for breakdown tests. Adjust your scope for a horizontal sensitivity of 2 volts/cm (this setting is convenient for most cases). The vertical sensitivity can be computed from the formula

$$I_c/cm = \frac{\text{sensitivity/cm}}{R_L}$$

Now, connect the transistor to the curve tracer. For fets the C terminal is connected to the drain, the B terminal is connected to the gate and the E terminal is connected to the source. Fig. 3 through fig. 6 show actual scope displays for various devices that were tested on this curve tracer.

**conclusion**

The completion of this project is only the beginning. If you consult a good textbook on transistors the meaning of these curves becomes much more explicit. If you do much work with semiconductors the information gained from these curves will save you countless hours of trial and error. I wish to thank my wife for her encouragement throughout this project.

*ham radio*

**fig. 6.** The curve tracer can also be used to display the voltage-current characteristics of a two-terminal semiconductor, such as a diode. This is the characteristic curve of a 1N429 zener diode. Vertical sensitivity is 2mA/cm and horizontal sensitivity is 1V/cm.
JULY SPECIALS

TRI-EX-HYGAIN ANTENNA TOWER PACKAGE
W-51 Free-Standing Tower w/base, HYGAIN TH6DXX antenna, Ham-m rotor ................................................................. $599.00

TRI-EX-HYGAIN TRI-EX MW-35 SELF SUPPORTING
Complete w/HYGAIN TH3MK3 antenna, and TR44 rotor* ...... $319.95
*Add $50.00 for Ham-m, Add $90.00 for HyGain Rotor Brake

TRI-EX-HYGAIN "SUPER" TOWER PACKAGE
LM354 Tower w/base, HYGAIN TH6DXX, and Ham-m rotor...... $849.00

FREIGHT PREPAID in Continental USA
48 hour shipment with cashier's check or money order.
Add 4% to Master Charge, BankAmericard or American Express Card Orders.

WRITE FOR OTHER ANTENNA/TOWER PKG DEALS!!
Closed Sundays and Mondays

"WEST COAST’S FASTEST GROWING AMATEUR RADIO DISTRIBUTOR"
"WE SELL ONLY THE BEST"

Electronix Sales
23044 S. CRENSHAW BLVD., TORRANCE, CALIF. 90505
Phone: (213) 534-4402
HOME of LA AMATEUR RADIO SALES
## FM 2 METER ANTENNAS

From the world's leading manufacturer of VHF/UHF communication antennas.

### A) FM GAIN RINGO

- **AR-2**: 100 watts, 135-175 MHz, $12.50
- **AR-25**: 500 watts, 135-175 MHz, 17.50
- **AR-220**: 100 watts, 220-225 MHz, 12.50
- **AR-450**: 100 watts, 420-470 MHz, 12.50
- **AR-6**: 100 watts, 50-54 MHz, 18.50

### B) 4 POLE

- **AFM-4D**: 1000 watts, 146-148 MHz, $42.50
- **AFM-24D**: 1000 watts, 220-225 MHz, 40.50
- **AFM-44D**: 1000 watts, 435-450 MHz, 38.50

### C) FM MOBILE

- **AM-147**: 146-175 MHz mobile, $26.95

### D) POWER PACK

- **A147-22**: 1000 watts, 146-148 MHz, $49.50

### E) 4-6-11 ELEMENT YAGIS

- **A147-4**: 1000 watts, 146-148 MHz, $9.95
- **A147-11**: 1000 watts, 146-148 MHz, 17.95
- **A220-11**: 1000 watts, 220-225 MHz, 15.95
- **A449-6**: 1000 watts, 440-450 MHz, 10.95
- **A449-11**: 1000 watts, 440-450 MHz, 13.95

### F) FM TWIST

- **A147-20T**: 1000 watts, 145 & 147 MHz, $39.50

Freight prepaid in Continental U.S.A.
Write for King Sized Savings on other Antenna/Tower Package Deals.

More Details? CHECK-OFF Page 110
designing
impedance-matching
systems

A graphical method
of designing
impedance-matching networks
for your
favorite antenna

There's a line from Porgy and Bess, "the things that you're liable to read in the Bible — they ain't necessarily so." It's also a fact that the things you read in a good antenna theory book ain't necessarily so when it comes to your particular antenna.

What is the impedance of a vertical antenna? Well, you can look up the impedance on carefully constructed charts with electrical height in one direction and ohms in the other and get some ball-park estimates for both resistance and reactance. But what is the impedance of your vertical? What is its electrical height and is it the same for a 3-inch pipe as it is for a piece of wire? Down at the bottom of the page containing the graph you may find a footnote that says, "over a perfect ground." (Sometimes this footnote appears 3 pages removed from the chart.) Now, do you have a perfect saltwater ground or do you have a piece of wire ten-feet long or do you have the body of a motor vehicle?

There are just too many variables to come up with an answer either by eyeballing or by taking physical measurements. To really know, you need to take some electrical measurements. And, to get any kind of precision, you need a good rf bridge. A $1000 rf bridge is not available to everybody but I had the use of one for a short time and came up with some rather surprising results.

mobile-mounted vertical

This article will involve itself with a couple of outstanding examples, but to start with, I was motivated by the results I obtained from a vehicle-mounted vertical. I don't care much about mobiling but I do like to ham from a camp location once I get there. If there are trees around, a good dipole is hard to beat. I get mine up by shooting a fish sinker, attached to a spinning outfit, with a slingshot. These surgical rubber tubing slingshots (available in any sports store) will shoot a one-ounce sinker over a fifty-foot-high limb quite easily. Then you reel the fish line back with a nylon cord attached, and raise your antenna.

But in some places, like the seashore, trees are not handy. So, I wanted a good vertical whip, a full quarter-wavelength high on 20, 15 and 10 meters. This was made from telescoping aluminum tubing.
The time-honored method of grid dipping to achieve resonance was followed to get the required length on the three bands.

I have a Ford van station wagon which has quite an expanse of roof for a ground plane. I looked in the good book for an approximate resistance for a quarter-wave ground plane and came up with the magic number of 36 ohms. "Aha, two hunks of 72-ohm coax in parallel should yield 36 ohms." Well, maybe it does, but my swr was higher than a cat's back and adjusting the telescoping whip to some point off resonance didn't help at all.

Finally, I took off one of the pieces of coax and things were just as bad as before (this was on 20 meters). In desperation I got a piece of 50-ohm coax and everything was hunky-dory. Then, I went to 15 meters — with 50-ohm line the swr was way too high. I changed back to 72-ohm coax and got on board. I had the same experience on 10 meters.

**Impedance Measurement**

Well, I finally got everything working all right, but I wondered just what was really going on, anyway. So, I borrowed an rf bridge and made some measurements. The General Radio 1606A rf bridge has two dials that read out resistance and reactance. At resonance the so-called j-factor or reactive component should read zero. With the vertical adjusted to the proper height in the middle of the 20-meter phone band I obtained a readout of $52 \pm j0$. On 15 meters the reading was $70 \pm j0$, and on 10 meters, $75 \pm j0$. All of these measurements were for one-quarter wavelength height. The differences in $R$ seems to be attributable to the mounting (one corner of the van) and the extent of the ground plane (vehicle body). They would, of course, differ for every installation and every vehicle. However, I suspect that a lot of installations would work best with a 50-ohm line on one band and a 72-ohm line on another.

Measurements were actually made at the end of an electrically measured half wavelength of line in each case, in order to remove the equipment from proximity to the vehicle.

**Vertical Antenna**

In the W7CSD part of the world, crops are irrigated, and a 40-foot length of aluminum irrigation pipe is pretty easy to come by. ($14.30 for 3-inch tubing.) I set a one-quart soft-drink bottle in concrete and mounted a 40-foot section of irrigation pipe on top of it guyed with polyurethane rope (the kind used for water skiing). I thought this would work pretty well on 20 meters and also 40 and 75. The big problem was building matching networks for each band.

First of all, I needed to make some impedance measurements to see what I had. The first thing that I determined was that long radials will work fine on 20 meters, but short radials will not work well on 75. So, I used three 75-foot radials (actually, not really radial, but following convenient fence lines). More
would be better -- the more the merrier. The same problems result as far as network design is concerned, whatever the ground system.

Forty feet on 20 meters is nearly 5/8 wavelength so you expect some kind of medium resistance value and capacitive reactance. 40 feet on 40 is more than 1/4 wavelength so you expect greater than quarter-wave resistance and inductive reactance. On 75 meters a 40-foot antenna is less than a quarter wavelength long so you would expect low resistance and a capacitive reactance. Actually, you need to know pretty close to the right values to be able to design the matching networks. With a ballpark estimate and a swr meter you might be able to get on board with some trial and error.

Taking advantage of the availability of the rf bridge again, I obtained the following measurements:

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Impedance (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.30</td>
<td>80 - j260</td>
</tr>
<tr>
<td>7.25</td>
<td>142 + j90</td>
</tr>
<tr>
<td>3.90</td>
<td>54 - j167</td>
</tr>
</tbody>
</table>

I wanted to match the above impedances to a 50-ohm line.

Matching a complex impedance to 50-ohm line with a T- or L-network by analytical methods is a lot of work. However, George Frese, A Consulting Radio Engineer in Wenatchee, Washington (ex W7FMI) came up with a fairly simple graphical solution to this type of problem. Non-resonant vertical antennas are typical in a-m broadcasting.

The graph has two calibrations, one for impedance in ohms and one for admittance in mhos. The two vertical calibrations have reversed signs; i.e., reactance going up is a +j, susceptance going up is –j (see fig. 1). Choice of scales is determined by the characteristics of the line and the antenna.

**example 1**

Let’s take the 40-meter situation above as an example. I want to match 142 + j90 ohms to a 50 ± j0 transmission line. Since I have 142 ohms of resistance, the horizontal axis should go out to about 150 ohms. Likewise, the vertical should go to ± j100. The transmission line has an R of 50; 1/50 = 0.02 mhos = diameter of circle corresponding to 50 ohms. Therefore, 0.01 = radius of 50-ohm circle, needs to be on the paper, 20 squares = 0.01 seems appropriate, fig. 1.

1. With a good compass, draw the 50-ohm circle, radius = 0.01 mhos.
fig. 2. Another graphical solution for an impedance-matching network for a 40-foot irrigation pipe vertical for use on 7.25 MHz. Compare this network with the one shown in fig. 1.

2. Draw the 142-ohm circle, diameter \( \frac{1}{142} = 0.00705 \), radius \( 0.00352 \).

3. Point \( Z_1 = 142 + j90 = 142 \) to right and \( 90^\circ \) up.

4. Draw line from Point \( Z_1 \) to origin.

5. Transfer \( 21 \) to \( Y_1 \) along this line to the 142-ohm circle.

6. Draw vertical line from point \( Y_1 \) down to \( Y_2 \) on the 50-ohm circle. The distance \( Y_1 \) to \( Y_2 \) is the susceptance of \( Y_c = +jB = 0.01175 \) mhos or \( X_c = 85 \) ohms. \( C = 0.000256 \) mF at 7.25 MHz (use a 0.00025 mica).

7. Draw line from \( Y_2 \) through origin.

8. From the origin go out 50 ohms on the horizontal and draw a vertical line to the intersection of the line drawn in step 7. (In this case it just happens to coincide with line drawn in step 6.) This vertical distance (actually from \( Z_3 \) to the horizontal) is \( X_L = 87 \) ohms; \( L = 1.9 \) microhenries.

Now, in case you are suspicious of all this hocus-pocus, let's take the result and work it out to see if it is true. Looking into the network, we are supposed to see \( 50 \pm j0 \) ohms. Going out to the far end, we have the antenna, \( 142 + j90 \) ohms in parallel with the capacitor, \( 0 - j85 \) ohms. Using the formula for parallel impedances,

\[
Z_{\text{combination}} = \frac{Z_1 \cdot Z_2}{Z_1 + Z_2}
\]

\[
Z = \frac{(-j85)(142 + j90)}{-j85 + 142 + j90}
\]

Changing to the polar form,

\[
Z = \frac{(85 / -90^\circ)(168 / 32.4^\circ)}{142 / 2^\circ}
\]

\[
= 101 / -59.6^\circ = 51 - j87 \text{ ohms}
\]

Combining the series inductance, \( X_L = 87 \) ohms, we obtain \( 51 - j87 + j87 = 51 \pm j0 \) ohms. Accuracy is as good as the graphical method. Greater accuracy can be obtained from a larger graph.

The above solution is the one you want for two reasons. First of all, the network should look like a low-pass filter which will discriminate against harmonics. Also, you can eyeball the 75-meter situation and see that all you need is a series inductance, \( X_L = j167 \) ohms — the 54 ohms \( R \) is close enough. Likewise, the same kind of network is desirable for 20 meters so that the same coil, tapped at the proper places, can be used for all three bands. However, there is another solution which, for another problem, might be more desirable.

example 2

Steps 1 through 5 same as in example 1.

6. Draw vertical line from point \( Y_1 \) up to \( Y_2 \) to the 50-ohm circle. This vertical distance (in the up direction = \( -jB \), is the susceptance \( Y_L = -jB = 0.0055 \) mhos or \( K_L = 180 \) ohms; \( L = 4 \) microhenries (see fig. 2).
7. Draw line from Y2 through the origin.

8. From the origin go out 50 ohms horizontal and draw a vertical line to intersect the line drawn in step 7. (This line happens to nearly coincide with the line of step 6.) This vertical distance equals 87 ohms and is downward going so has capacitive reactance; \( C = 0.00025 \mu\text{F}, \) approximately.

\[
Z_{in} = 49.8 + j86.2 - j87 = 49.8 - j0.8 \text{ ohms}
\]

Both answers should be 50 ± j0, but due to the inaccuracies of graphic construction, \( X_L \) in example 1 appears to be a little to the right of where it should be, and \( X_C \) in example 2 seems to be to the left of where it should be. Either way, you are within ±2%. It is doubtful that you will be able to get a capacitor or wind an inductor within this tolerance.

**example 3**

Now, let's look at 20 meters (14.3 MHz). You can use the same admittance scale but the impedance scale will have to be one square = 10 ohms to get everything on the graph (fig. 3). Since you want capacitance to ground and a series inductor, raise the horizontal axis and work below the line only. The distance Y1 to Y2 is very short and, hence, of questionable accuracy. If you had used the other solution and gone up instead of down, Y1 to Y2 would have been much greater and much more accurately measurable. But, for the reasons mentioned before you do not want this solution.

So, as closely as you can measure, Y1 to Y2 = 0.001 mhos or \( X_C = 1000 \text{ ohms} \) and \( C = 11 \mu\text{F} \). Locating Z2 is a little uncertain on this graph, too, but it comes out with \( X_L = 210 \text{ ohms} \) and \( L = 2.33 \mu\text{H} \). If you care to work out the problem again you will get \( Z = 48 + j8 \). This is still pretty close to 50 ohms.

**proof of the pudding**

Two months transpired between making the measurements and building the matching networks, and the commercial rf impedance bridge had been returned. With the aid of an L/C meter I wound and tapped a coil at 1.9, 2.33 and 6.84 microhenries. This could be done by any other method, including grid dipping using a known capacitor in a resonant circuit and solving for \( L \). A 0.00025-\mu\text{F} mica capacitor was readily available. I used a small variable for the 11-pF capacitor.

On 75 and 40 meters I had an swr of...
1.0:1 on the first trial. The swr on 20 meters was up near 1.5:1 and minimum was with the little 11-pF variable wide open. Removal of the variable capacitor and moving the inductor tap one-half turn yielded an swr of 1.0:1. Apparently, the capacitance of the coil to the aluminum box housing the network was very close to the required 11-pF. The final circuit of the network is shown in fig. 4.

![fig. 4. Three-band impedance matching system for the 40-foot vertical antenna.](image)

**summary**

I have received excellent reports on all bands. I have no comparison on 75 and 40. On 20 the vertical cannot compete with a cubical quad, but this is not surprising. However, on DX contacts it is only down about 1 S-unit.

The big problem is how to measure the impedance of the antenna without a $1000 bridge. I think I may have some answers for this which I will verify when antenna weather comes again. There are several possibilities that are close enough that little trial and error would be necessary to get everything tuned up.

**reference**

how to compare
the efficiency of
linear power amplifiers

Accurately comparing
the efficiency
of two linear amplifiers
is not difficult,
but it requires
some care

While listening on an amateur band, I
overheard one amateur telling another his
results in comparing the efficiency of two
commercially-built rf power amplifiers.
Each of these amplifiers used vacuum
tubes, and was designed for amplifying
the output of ssb exciters. The comparison
was based solely upon the ratio of dc
power input to rf power output while
speaking the same words into the ex-
citer’s microphone at approximately the
same amplitude.

This seems to be a commonly-used and
more or less universally accepted means
of evaluating the efficiency and effectiv-
ity of rf power amplifiers used as linear
amplifiers. But is it a valid comparison?

In the particular instance in question,
one rf power amplifier showed an effi-
ciency of 67%, the other 40%. The high
apparent efficiency of one is an immedi-
ate flag for suspecting the validity of the
test. That figure, 67%, borders upon the
theoretical maximum that a vacuum-tube
amplifying stage can produce in linear
service. It supposes that every parameter
is at its perfect peak of optimum adjust-
ment, that associated circuits are without
loss, that nirvana has been achieved. The
other figure, 40%, is a much more believ-
able one!

the comparison

What, then, constitutes a valid means
of comparing the efficiency of two linear
amplifiers? The clue lies in that term,
linear. Vacuum-tube amplifiers can be
designed and constructed to be amazingly
efficient as converters of dc power input
into rf power output. By running dc grid
bias very, very high (many times the
cutoff point) and running the rf grid
excitation high enough to saturate the
tube, an efficiency of around 90% can be
achieved.

But, would you want it? You probably
wouldn’t, for that rf output would con-
tain as much power in harmonics as in the
fundamental. This is not precisely what you would desire if you wanted to keep on good terms with the FCC. Nor is it what you would want for amplifying any form of amplitude-modulated signal, and, of course, ssb is one form of amplitude modulation.

Leaving such an extreme, really a class-C stage, and looking toward class B or AB, the classes usually associated with linear amplification, you do not find a high degree of efficiency. The true efficiency, the conversion of dc input power into rf output power of the desired frequency, is not significantly less than that achieved with a class-C stage. What you do find, however, is the possibility of approaching truly linear amplification, amplification in which the output waveform is a true reproduction (in every manner except amplitude) of the input waveform. And this is what you desire when you build, buy, or tune up an amplifying stage connected to the output of a ssb exciter. A serendipitous side effect of such a stage is a satisfying reduction in the generation of harmonics.

how to do it

This suggests some guidelines for comparative tests. You would like to set some limits on just how much of a departure from linearity you will tolerate in the interest of efficiency. Manufacturers do this sort of thing; they come up with a figure like, say, -35 dB for third-order intermodulation products.

Like most trustworthy and informative measurements, such a measurement requires rather expensive tools. In this case, the tools are a two-tone oscillator (really neither difficult to build nor expensive to buy) and a simple spectrum analyzer, such as the Heathkit SB-620. The two-tone audio-frequency signal generating device needs to embody a low duty cycle pulser, something that will let the signal through for a third or less of the time. This permits running the amplifier under test at full load for moderate periods of time without cooking the tubes.

Of course, for any power output test you have to have a dummy load/rf wattmeter. And for the dc input measure-

fig. 1. Equipment arrangement for comparing the efficiency of two rf power amplifiers. The amplifiers are switched in and out of the line with their own built-in bypass relays.

ments you have to have the needed voltage and current meters.

As most linear amplifiers are built with integral dpdt bypass relays, a convenient way of making a comparison test is to arrange the two linear amplifiers in series, following the exciter. The control actuating the in-circuit or out-of-circuit status of the bypass relay can then be used to instantly select the particular amplifier to be observed. Fig. 1 shows a block diagram of the necessary arrangement.

linearity

Since it's highly probable that any amplifier approaching true linearity will have low harmonic output, it is not necessary to use a wideband spectrum analyzer to check the relative (or the absolute) power contained in harmonics. Only a narrow-band analyzer is needed. The odd-order, or intermodulation, distortion products shown in fig. 2 can be observed only with an analyzer that has fairly good resolution. However, such resolution is not absolutely necessary; an ideal of relative magnitude of, say, $2f_2-f_1$.
L. I. Electronic Supermart
(Off the wall self service)

New P.C. Boards — G10, 1 oz. - 1 side copper-fiber glass
5” x 6”, 80c ea. — 6 x 12, $1.50 ea. - 12 x $2.50
New P.C. Boards — G10, 1 oz. - 2 side copper-fiber glass
5” x 6”, $1.10 ea. - 6 x 12, $2.00 ea. - 12 x $3.75 ea.

New P.C. Boards — G10, Fiber glass punch:
P Pattern 4 x 5, .062 holes, per 1/4” $1.30
P Pattern 4 x 5, .062 holes, 10 per 1/10” $1.35
G Pattern, 4.5 x 6.5, .062 holes, $1.30
Pkg. 10 Birch P.C. Board, metal 2” x 4” $1.00
Package of 50 flea clips for above punched Boards, .062 $0.75
30 1/4 or 1/2 W. resistors, packaged 5 per value your choice of values .......... $1.00
25-1W. resistors, packaged 5 per value, your choice of values .......... $1.00
15-2W. resistors, packaged 5 per value, your choice of values .......... $1.00
5 1/4 or 1/2 W. 1% resistors, packaged 5 per value, your choice of values .. 50
5 ceramic disk caps, .001-01, packaged 5 per value, your choice of values .. 50
5 mica dip caps, 1 pf-150 pf, packaged 5 per value, your choice of values .. 50
5 mica dip caps, 180 pf-820 pf, packaged 5 per value, your choice of values .. 75
5 mica dip caps, 820 pf-1500 pf, packaged 5 per value, your choice of values .. 1.00
Wire Kit #22 solid PVC, 6 spools, 6 colors, 50' ea. spool $3.50
Wire Kit #22 stranded PVC, 6 spools, 6 colors, 50’ ea. spool $3.50
Wire Kit #22 Solid PVC, 6 spools, 6 colors, 50’ ea. spool $3.50
Central Lab DPDT push momentary, SPEC. 4/$1.00
Connectors, PL259, $4.45, PL258, $70; 170U or 176U, $20 ea.; UG 88 cu., $50; UG 201 a/u (N to BNC adapter), $7.50
Encapsulated choke, 60uH to 50Mh, choice 3/$1.00
Varo type mini bridge rectifiers, approx. 3/8” sq. size: 2 amp. - 50 v., $1.25; 4 amp. - 50 v., $1.25
1.25; 2 amp. - 100 v. - 80 v., $1.25; 2 amp. - 100 v., $1.25; 4 amp. - 100 v., $1.25
2 amp. - 200 v., $1.50; 4 amp. - 200 v., $1.50
2 amp. - 400 v., $1.50; 4 amp. - 400 v., $1.50
To-5 case, 1 amp - 200 v., $.70 ea.; 1 amp - 400 v., $1.00 ea.
SCR 200 v. - 1 amp. thermo tab ........... $.80 ea.
SEND SELF ADDRESSED ENVELOPE FOR FREE MAILER. INCLUDES MANY HUNDREDS OF ITEMS NOT LISTED ABOVE.

FREE BONUS WITH EACH $10.00 ORDER
50’ SPOOL 600 V. #22 PVC WIRE

KRP
ELECTRONIC SUPERMART, INC.
219 WEST SUNRISE HIGHWAY
FREEPORT, L. I., N. Y. 11520
516-623-3346-9

as compared with either f1 or f2 (which probably will be seen as a single blip) can be quite definitive. By making a note of this relationship and then shifting over to the other amplifier, you can form an accurate idea of their relative linearity.

Having established an idea of relative linearity, the next step is to optimize the linearity of each amplifier by careful adjustment of tuning, loading and rf excitation. Then, make both amplifiers exhibit equal linearity by decreasing the rf excitation to the amplifier having the greater distortion. Measure its dc power input and rf power output. Go to the other amplifier, remembering to restore the rf excitation to its optimum value, and measure its input and output. Then and only then are you in a position to talk about the relative efficiency of two different rf power amplifiers.

references

fig. 2. Spectrum of odd-order distortion products in an rf amplifier with input frequencies f1 and f2.

ELECTRONIC SUPERMART, INC.
219 WEST SUNRISE HIGHWAY
FREEPORT, L. I., N. Y. 11520
516-623-3346-9

ham radio
The Clegg FM 27B ACTUALLY COSTS YOU LESS in the long run!
Check these specifications:

**GENERAL**

**POWER REQUIREMENTS:** 12 to 14 VDC
Current Consumption at 13.5 VDC:
Receive: 400 mA squelched,
1.2 amps unsquelched,
Transmit: 6 amps max.

**DIMENSIONS:** 7½” x 3½” x 9¼”
deep; 4 lbs. net weight.

**RECEIVER**

**TUNING RANGE:** 146.00 to 148.00 MHz,
continuously tuneable with reset
capability of approx. 1 KHz to any
frequency in range.

**SENSITIVITY:** .35 μV max. for 20 db
quieting; .1 μV for reliable squelch action.

**SELECTIVITY:** 11 KHz at 3 db; Less than
30 KHz at 70 db. Adjacent (30 KHz
spaced) channel rejection more than 70 db.

**AUDIO OUTPUT:** 2.0 watts (min.) at less
than 10% THD into internal or external
ohm speaker.

**TRANSMITTER**

**TUNING RANGE:** Same as RECEIVER.

**POWER OUTPUT:** 25 watts Min. into 50
ohm load. P/A transistor protected
for infinite VSWR.

**MODULATION:** Internally adjustable up to
10 KHz deviation and up to 12 bd
peak clipping.

After buying any other transceiver, plus an amplifier
with 25 watts or more and a handful of crystals, you've
spent more than the cost of the Clegg FM 27B. And you
still don't have the **only** rig that's totally integrated with
all the coverage built-in. Why settle for half a rig? Get
it all—get a Clegg FM 27B!

Amateur Net $479.95

More Details? CHECK-OFF Page 110
WA9YII wins grand prize, puts new Drake TR-4C hf transceiver and L-4B linear on the air; WB4KIT is lucky winner of Robot sstv camera and monitor.

Our Grand prize winner was Randy E. Thompson, WA9YII. He won a brand new R.L. Drake TR-4C Transceiver and AC power Supply plus a Drake L4-B Linear Amplifier. Randy tells us that although he is now a Technician he is going for his Advanced license in the very near future. He is in the graduating class at the Vocational-Technical Institute of Southern Illinois University and has accepted a position with the National Accelerator Laboratory near Batavia, Illinois.

The new TR-4C offers everything that made it's predecessor, the TR-4, so popu-

It was more work than ever, opening ten's of thousands of your letters and trying to keep our records straight. However, the 1973 Ham Radio Sweepstakes is now history, and our local post office can take a breather and so can we.

This year's contest seems to have created more interest than ever before, not only through the mail, but also at many of the Hamfests we have visited this year such as SAROC, the Tropical Ham-boree, the Dayton Hamvention and a number of others.
lar, plus a number of new features including 1-kHz dial calibration. This versatile transceiver provides ssb, CW and a-m operation on all amateur bands from 80 to 15 meters plus 28.5 to 29.1 MHz. Accessory crystals are available to cover the complete 10 meter band.

Of course, the L4-B is one of the best known 2-kW amplifiers in the business. Rugged and dependable, it features a trouble-free, conservative design. Randy should be set for many years of service from this fine equipment. The L4-B uses a pair of Eimac 3-500Zs in a class-B grounded-grid circuit featuring a broadband-tuned input, negative rf feedback and transmitting agc for higher audio level without clipping.

The second prize, a Robot Slow-Scan Television Camera and Monitor, created much interest from many of our entrants. This is the same package that has added a whole new dimension, that of sight, to amateur radio for so many operators all over the World. The lucky winner of the Robot Model 70 SSTV Monitor and Model 80 SSTV Camera was John S. Harvey, WB4KIT. We'll all be "looking" for him on the air very soon.

Both the Robot Camera and the Robot Monitor feature an all solid-state design except for the picture and camera tubes. Particular design attention has been given to making these units easily adaptable to virtually any ssb station. A couple of patch cables, one to the microphone jack and one to the audio output, is all that is necessary to connect the equipment to your rig, and put it on the air.

Versatility plus was the third prize. Each of our three third-prize winners received a Drake TR-22 Two-Meter FM Transceiver. This is that wonderful little unit that is equally at home over your shoulder, in your car or at home. It can operate on its own battery pack or on 12 Vdc or 115 Vac. John R. Low, K3YHR, Vinton A. Buffenarger, WGPSC, and Robert K. Jackson, WBBISI will be coming through on their local repeaters in the near future, and we're sure that they'll be saying good things about their nifty new rigs.

We're sorry that everyone couldn't win this year, but there are some exciting, new prizes that we're lining up for 1974. We hope that you'll plan on winning one of them and we will try our best to help you out.
arc suppression networks

Unless special precautions are taken, operation of a relay or switch in close proximity to sensitive electronic circuits is a potential source of trouble. This trouble generally results from arcs caused by opening of the relay contacts, causing transients that can easily interfere with the proper operation of sensitive circuits.

The effects of these arcs can be minimized by the installation of an arc suppression network directly across the relay contacts to absorb the energy which would otherwise be dissipated in the arc itself.

The network itself is simply a resistor and capacitor in series. The capacitor just "absorbs" the arc by charging when the contacts open (see fig. 1). The resistor limits the current generated by the discharging capacitor upon contact closure.

Were it not for the resistor, severe contact pitting could result from large momentary discharge currents.

The optimum values of $R$ and $C$ can be chosen by the equation

$$R = \frac{E}{10 \left(3.16 \sqrt{C}\right) \frac{1}{1} \frac{50}{E}}$$

where $R$ is the resistance in ohms, $C$ the capacitance in microfarads and $E$ the open-circuit potential in volts. Obviously, this equation is rather unwieldy, and selection of values from it could prove to be quite a chore! For convenience, this equation has been solved graphically in fig. 2. By using this nomograph any number of $R$-$C$ combinations can be chosen with ease.

Suppose, for example, that a suppres-
pilot-lamp life

For some time, I have been experiencing relatively short life for the 120-volt pilot lights I use. Investigation showed that the green light had short life, but the high-voltage indicator (red bulb) seemed to last indefinitely. The reason? The red indicator came on by steps — that is, half-power, then full power.

An ohmmeter check showed that the hot resistance of the S6 bulb was 2400 ohms, while the cold resistance was only 200 ohms. This meant that the small bulb had to sustain a temporary power surge of 72 watts. I recalled that BC stations, where dependability is of great importance, have, for years, used a dropping resistance in series with most indicator lamps. The resulting setup at W2OLU calls for a dropping resistor of approximately 450 ohms. This is not at all critical — any value from 400 to 500 ohms will do. The resultant hot current is about 42 mA and the maximum surge is reduced to a small fraction of its former value.

Neil Johnson, W2OLU

pogo stick for reflex klystrons

Stabilizing klystrons is an important part of the microwave station. There are several ways of accomplishing this, but the following, I feel, is more advantageous than others. The primary problem is connecting the output of the afc network which is operating at low voltage levels to the high voltage levels of the klystron.

The output from the receiver discriminator is around zero. It is therefore logical to make the afc compatible. Type 741 op amps connected as an integrator, impedance matcher and inverter perform this function at minimum cost and parts.

Now the problem comes to light. How do we get this to the reflector of the klystron and do it inexpensively with semi-conductors? After all, excluding the klystron, the entire station consists of semiconductors. Let’s not spoil it.

ICU1 is not necessary to the operation of this circuit (see fig. 3). However, with the afc disconnected, the voltage at point C is not controllable. The fact that the input to U1 is a voltage node and the loop is operating around zero means we can open the loop at point X and not appreciably change the output frequency of the klystron. The slight change that does occur is due to the input offset current of the 741 IC.

Let’s disconnect R7 at point X and look at the operation of this circuit. The output of U1 is zero with R7 open or grounded. If point A is zero, and the base of Q1 is at -12 V, we must have approximately 1 mA through R1. If the emitter current of Q1 is 1 mA then the collector current is 1 mA; 1 mA through R2 gives us 75 volts across R2.

Note the voltage divider R3 and R4 which makes the base of Q2 -150 V. Therefore, the emitter must be the same, plus one diode drop, which is insignificant. With the emitter of Q2 at -150 V, 75 V across R2 and 12 V across R1, we are left with approximately 63 V across Q1.
The reason for Q2 is now evident. It is not necessary except that if only Q1 was used it would have to be a high-voltage device which implies high cost. As the circuit stands, Q1 and Q2 can be 100 volt devices and still maintain a good safety margin.

We established earlier that the current through R1 was 1 mA. Q1 and Q2 are in series with R1, thus the current in the series string is 1 mA. This results in Q2 and R5 having the same voltage drops as Q1 and R2 respectively. The voltage at point Y is now 300 volts. This leaves 300 volts across R6 and R9. R6 is a ten-turn Helipot for adjusting the voltage on the klystron repeller so it is operating in its proper mode (160 volt mode is used at this station).

Understanding that Q1, Q2 and the resistors constitute a series circuit is important. With this in mind let's put a positive voltage at point X. Point A goes negative (U1 inverts). With point A less than zero the current in R1 reduces, thus reducing the current in the series string. With a reduced current the voltage across R9 reduces, making point C more negative. With a negative voltage at point X, A goes positive. More current results in the string causing point C to become less negative (positive direction).

By changing R7, the gain of U1 changes, thus changing the loop transfer function (ratio of point-X voltage change to point-C voltage change). The value of R7 will thus be determined primarily by the transfer function of the particular afc circuit used. (In my station U1 is operated with a gain of -10.)

Resistor R1 is chosen so the voltage at point-Y is approximately -350 V (slightly more than 1 mA). This is to insure a good voltage swing at point X without causing point C to go above -300 volts. CR1 is for protection of the klystron. The repeller should never go positive with respect to the cathode.

This circuit is in use at two stations operating at 3335 and 3365 MHz with great results. The klystron is able to track over its entire electrical tuning range. Total cost was less than $5.

Francis E. Adams, W6BPK
Heathkit “Maxi Rig” with Digital Display

New Heathkit Digital Frequency Display...counts the 3 frequencies produced in receiver, computes and displays operational frequency within 100 Hz accuracy. Six bright digits let you read frequencies 80 through 10 meters from up to 30 ft. away. Reads kHz to 5 places, plus tenths of a kHz. No band-switching necessary. Operates with Heathkit SB-100/101/102 Transceivers; HW-100/101 Transceivers; and SB-300/301/303 Receivers. With transceivers, it displays both transmitted and received frequencies.

Kit SB-650, 10 lbs. .................. 179.95*

Heathkit SB-102 — the “big one”...with better than 0.35µV sensitivity for 10 dB S+N/N; solid-state LMO with 1 kHz calibration; less than 100 Hz drift per hr. after 10 min. warmup; dial resettable to 200 Hz and bandspread equal to 10 ft. per MHz; switch selection of built-in 2.1 kHz SSB filter or optional 400 Hz filter, plus upper and lower sideband; built-in 100 kHz crystal calibrator; 180 watts PEP SSB input, 170 watts CW; built-in sidetone and VOX; 5-position metering facilities.

Kit SB-102, 24 lbs. ................ 385.00*

Heathkit SB-220 2 kW Linear...with 2 Eimac 3-500Zs in grounded grid circuit delivering up to 2000 W PEP SSB or a full 1 kW on both CW & RTTY, requiring only 100 W of drive; broad-band pre-tuned pi input; solid-state 120/240 VAC power supply; circuit breaker; zener diode regulating operating bias; ALC; metered grid current, high voltage and relative power; big quiet fan.

Kit SB-220, 69 lbs. ............... 369.95*

Visit your nearest Heathkit Electronic Center...or send for FREE catalog

HEATH COMPANY, Dept. 122-7
Benton Harbor, Michigan 49022

Please send FREE Heathkit Catalog. I
Enclosed is $ ........................................
Please send model(s) ________________________________
Name ________________________________
Address ________________________________
City ______ State ______ Zip ______

World's largest selection of electronic kits

HEATHKIT ELECTRONIC CENTERS — ARIZ.: Phoenix; CALIF.: Anaheim, El Corrilo, Los Angeles, Pomona, Redwood City, San Diego (La Mesa), Woodland Hills; COLO.: Denver; CONN.: Hartford (Avon); FLA.: Miami (Hialeah); GA.: Atlanta; ILL.: Chicago, Downers Grove; IND.: Indianapolis; KANSAS: Kansas City (Mission); MD.: Baltimore, Rockville; MASS.: Boston (Wellesley); MICH.: Detroit; MINN.: Minneapolis (Hopkins); MO.: St. Louis; N.J.: Fair Lawn; N.Y.: Buffalo (Amherst), New York City, Jericho; L.I.: Rochester; OHIO: Cincinnati (Woodlawn), Cleveland; PA.: Philadelphia, Pittsburgh; R.I.: Providence (Warwick); TEXAS: Dallas, Houston; WASH.: Seattle; Wis.: Milwaukee.

More Details? CHECK-OFF Page 110  

july 1973
Regency Electronics has moved in to a new area of electronic equipment with production of a six-digit electronic frequency counter. The all American made unit, the EC-175 Electronic Counter, is priced at $449.00.

The unit's low price, combined with high stability, ease of operation and portability make the Regency Counter very desirable. The EC-175 is designed to enable the operator to measure crystal frequencies without mathematical computation. The counter reads out frequencies ranging from 5 Hz to 175 MHz. A five-position range switch with gate times of 1 ms, 10 ms, 100 ms, 1 second and 10 seconds allows direct measurement of any in-range frequencies to within 0.1 Hz.

The six-digit LED display features automatic blanking, automatic decimal point positioning and leading zero suppression. There is an overrange LED indicator for readings over 6 digits and separate LED indicator for count rate.

EC-175's proportional oven-controlled time base gives a short-term stability of 2 parts in $10^8$ per day for FCC certification work. Long term stability is one part in $10^6$ per 6 months. Temperature stability is 3 parts in $10^9$ per degree Centigrade from zero to 50°C.

The Regency frequency counter has a built-in 100-kHz harmonic generator for direct calibration to WWV. A 10.7-MHz crystal oscillator for AFC locking and i-f alignment work is also a built-in feature. A built-in mosfet preamp gives sensitivity of 100 mV at 100 MHz.

The Regency EC-175 Electronic Counter is now available from Regency distributors throughout the country. For more information, write to Regency Electronics, Inc., 7900 Pendleton Pike, Indianapolis, Indiana 46226 or use check-off on page 110.

**keyer memory**

A large capacity programmable-reprogrammable CW message memory, designed as a plug-in accessory for the EK-420 keyer, has been announced by Curtis Electro Devices. Aimed to satisfy the most demanding contestor or traffic handler, the standard KM-420 offers a solid-state memory capacity of 1,024-bits — equivalent to 100 Morse characters. A second, options, 1,024-bit plug-in memory doubles this capacity. For maximum flexibility, the memory organization is switch selected to yield four different program arrangements.

Programs are selected and started by...
pushbuttons; terminated by a message pause or by manual break-in. A “reset” button instantly stops and resets the memory, a “hold” function allows manual insertion into a sequency. A 1 to 20 second repeat feature allows send and wait operation.

Memory programming is accomplished simply by sending the desired sequence in the “record” mode. Messages may be written as often as desired and stored indefinitely. Automatic and manual sending are indistinguishable. The KM-420 is priced at $299.95. The optional extra memory is $34.95. A remote control head for the Brown Brothers CTL Key is also $34.95.

For additional information, contact Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040, or use check-off on page 110.

vintage radio

This new pictorial album of old radio equipment, edited by Morgan E. McMahon, should hold particular interest to amateurs and antique radio buffs who would like to know more about radio during the early part of the century. The book is filled with interesting photographs and text describing much of the early apparatus used by such wireless pioneers as Marconi, DeForest and Sir Oliver Lodge. There’s a complete section on early receivers including models manufactured by Grebe, Remler, Atwater-Kent and RCA; early vacuum tubes, coherers, crystal sets, headphones, horn speakers, test equipment, horns, and many special components. The list of 3000 radio models by manufacturer and year should be a particular aid to collectors who are having trouble dating a particular radio in their collection.

Soft-bound, 263 pages, hundreds of photographs and drawings, $4.95. Also available with hard cover for $6.95. Order from Vintage Radio, Box 2045, Palos Verdes Peninsula, California 90274. For more information, use check-off on page 110.

NEW


<table>
<thead>
<tr>
<th>DISC CERAMIC CAPACITORS</th>
<th>ALL FULL LEADS AMERICAN MADE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 Mfd @ 1000 Volts</td>
<td></td>
</tr>
<tr>
<td>0.001 Mfd @ 1000 Volts</td>
<td></td>
</tr>
<tr>
<td>0.005 Mfd @ 1000 Volts</td>
<td></td>
</tr>
<tr>
<td>0.01 Mfd @ 500 Volts</td>
<td></td>
</tr>
<tr>
<td>0.001 Mfd @ 500 Volts</td>
<td></td>
</tr>
<tr>
<td>0.015 Mfd @ 500 Volts</td>
<td></td>
</tr>
<tr>
<td>YOUR CHOICE 20 for $1.00 p.p.d.</td>
<td></td>
</tr>
</tbody>
</table>

MOLDED 1/2 AMP BRIDGE RECTIFIER
1200 Volts PIV Per Leg. Ideal For P.C. Board Use. Size Approximately 1/2” Square x 3/16” Thick. $1.00 each 3 for $2.50 p.p.d.

3 AMP BRIDGE RECTIFIER
400 Volts PIV Per Leg. Manufactured by Semtech. $1.00 Each or 3 for $2.50 p.p.d.

Black, Aluminum Anodized, Heat Sink. Size Approximately 4 1/2” x 1 1/2” w. Predrilled For TO-3 Transistors. Delco Part #7277151, Factory New. 75¢ Each. 3 for $2.00 p.p.d.

DUAL SECTION ELECTROLYTIC CAPACITOR.
100 mfd x 100 mfd Both at 380 Volts. Common Ground. Ideal for Transceiver power supplies. $1.00 ea. p.p.d.

High quality, American Made Transformer. 115 Volt Primary. Secondary 17-0-17 Volt @ 150 ma. Tap At 6.3 Volt For Pilot Light. Ideal For Transistor Pre-Amps, VFO’s, etc. Fully Shielded. $1.50 Each p.p.d.


6.3 Volt 1 Amp Transformer. Fully shielded $1.60 Each p.p.d.

Toroids-Unpotted-Center-tapped. Your choice — 88 mhy or 44 mhy 5 for $2.00 p.p.d. or 15 for $5.00 p.p.d.

Transformer — American Made fully shielded. 115 Volt Primary Secondary #1 18-0-18 Volts @ 4 Amps Secondary #2 5 Volts @ 2 Amps A very useful unit for LV Power supply use. Price — A low $4.75 p.p.d.

PRINTED CIRCUIT BOARD MATERIAL

Pa. Residents add 6% State sales tax ALL ITEMS PPD. USA

m. weinshenker
K 3DPJ BOX 353 - IRWIN, PA. 15642

More Details? CHECK—OFF Page 110

july 1973
Motorola's new MECL Data Book is a fact book and a design guide wrapped in one cover. Basic performance specifications are provided for each IC device in the MECL II, MECL III and MECL 10,000 logic families. In 410 pages, complete dc, ac and performance data are given for each MECL product announced up to press-time. Convenient abbreviated guides offer a quick selector for MECL logic blocks.

In the 36-page general information section is contained a synoptic discussion of topics of value to the designer planning a MECL system: product performance data, design rules, system considerations, etc. In addition, dimensioned drawings of MECL IC packages are shown. References to the extensive MECL software support available are included by way of Motorola Application note abstracts, as well as references to a sampling of MECL articles in the trade press.

Motorola's MECL Data Book may be purchased for $2.00 per copy. Copies may be obtained by sending check or money order payable to Motorola, Inc. at Post Office Box 20924, Phoenix, Arizona 85036.

**rf load resistor**

A nearly hundred-to-one breakthrough in size reduction for a coaxial rf load resistor has been accomplished by Bird Electronic Corporation. The New Termaline Miniload® Model 8071 100-watt load weighs just 1/4 ounces and requires less than 3/4 cubic inch of space. Designed for reflection-free termination of 50-ohm coaxial systems, these dry miniature
high-power loads may be directly mounted to equipment cabinets or panels which serve as its heat sink.

Miniloads can be built into avionics transceivers, laboratory power oscillators or any rf signal source where space is at a premium and the environment is unfavorable. In this unique design, the terminating element is solidly tied to the component body, resulting in the lightest, tiniest package available. Model 8071 miniature construction also permits excellent performance over the entire frequency range of dc - 2000 MHz (vswr is below 1.1 from dc - 1000 MHz, and below 1.2 to 2000 MHz) with a female SMA connector.

The Model 8071 100-watt Termaline Miniload® is priced at S125. For more information, write to Bird Electronic Corporation, 30303 Aurora Road, Cleveland (Solon), Ohio 44139, or use check-off on page 110.

computer dictionary and handbook

Computers are quickly becoming common-place in today’s technological society. In fact, computer language has expanded an astounding 250% in the past ten years. The second edition of the popular Howard Sams Computer Dictionary and Handbook is designed especially to keep abreast with the constantly changing computerized world.

It’s new and updated and compiled from an information base of over 22,000 separate definitions and concept explanations. Each entry in the first edition has been checked and rechecked. Whenever necessary, the definition has been revised to reflect the present state of the art—or to give added meanings to the term. Also the hundreds of new terms—not in use when the first edition was produced—have been clearly defined and added.

Over 450 pages are devoted to defining computer-related terms. Principles and procedures of computer systems, computer systems personnel, operations re-
search, number systems, mathematical definitions, and computer languages are just a few of the subjects covered in the 13 appendices. The book concludes with a sound report on the progress, impact, and future of computers.

New additions include: a description of the structure of the computer industry, an evaluation of the latest types of main memory hierarchies, a discussion of the intricacies of the various operating systems and a classification of new information storage devices by function. These and others enhance the reference value of this already popular book.


**portable uhf/vhf a-m radio**

A new three-band portable radio that includes uhf has been introduced by Radio Shack at a price the company says is well below any other radio with uhf capability presently on the market.

The Realistic® Patrolman®-3 tunes a-m, 450-470 MHz uhf and 144-174 MHz vhf for police, fire, public utilities, business radio, weather broadcasts, two-meter amateur radio and other two-way radio services. The uhf band is currently used by many major metropolitan areas for
police, fire and municipal services. Separate tuning controls are provided for a-m and for uhf/vhf, and each band has a window-type rotary dial for accurate frequency selection. An adjustable squelch control reduces background noise while monitoring.

The Realistic Patrolman-3 is priced at $49.95 and includes four penlight cells and an earphone, and high-impact case with carrying handle. An optional ac adapter is available for $4.95.

Realistic products are available at more than 1600 Radio Shack and Allied Radio stores in all 50 states and Canada. For more information, use check-off on page 110.

scientific and technical catalog

Do you work in a scientific or technical career field? Are you an electronics enthusiast or do-it-yourselfer? Then Howard W. Sams & Co., Inc. has a new book catalog published especially for you.

It has 80 information-packed pages featuring over 400 popular hardbound and paperback books. Electronics, electricity, amateur radio, audio & hi-fi, mathematics, plus Audel do-it-yourself books on appliances, mechanical power, sheet metal, etc., are just a few of the dozens of topics covered.

The titles, which range from ABC's of Electronics and Tape Recording for the Hobbyist to Modern Dictionary of Electronics and Upholstering, are available through electronic parts distributors and book-stores or directly from the publisher. They're authored by experts and professionals, written in easy-to-understand language, and made completely clear with show-how photographs and drawings.

Copies of the catalog are available free of charge from Robert W. Soel, Advertising Coordinator, Howard W. Sams & Co., Inc., 4300 W. 62nd Street, Indianapolis, Indiana 46268, or use check-off on page 110.
2 METER AMATEUR REPEATER — ONLY $600.00

PROVEN STATE OF THE ART DESIGN
INSTALLATIONS WORKING GREAT IN U.S., EUROPE AND ASIA
STOCK FREQUENCY DELIVERED IMMEDIATELY, OTHERS 3-4 WEEKS
WRITE FOR FREE DATA SHEET — FULL MANUAL $5.00

DYCOMM
948 AVENUE E P.O. BOX 10116
RIVIERA BEACH, FLA. 33404

SUPER CRYSTAL
THE NEW DELUXE DIGITAL SYNTHESIZER!! FROM RP

MFA-22 DUAL VERSION
Also Available MFA-2 SINGLE VERSION
- Transmit and Receive Operation: All units have both Simplex and Repeater Modes
- Accurate Frequency Control: .0005% accuracy
- Stable Low Drift Outputs: 20 Hz per degree C typical
- Full 2 Meter Band Coverage: 144.00 to 147.99 MHz in 10KC steps
- Fast Acting Circuit: 0.15 second typical settling time
- Low Impedance (50 ohm) Outputs: Allow long cable runs for mobiles
- Low Spurious Output Level: similar to crystal output
SEND FOR FREE DETAILS
RP Electronics
Prices MFA-2 $210.00 BOX 1201H
MFA-22 $275.00 CHAMPAIGN, ILL.
Shipping $3.00 extra 61820

NEW - 440 MHZ PREAMPS

$54.95 POSTPAID
432PA-1
Two stage preamps use KMC Bipolar and Mos- fet Transistors. 20db gain, 20 MHz bandwidth. These are high quality preamps suitable for the most demanding applications. AC models have die cast case, others have metal enclosure.
432PA 3.5db NF 12VDC $29.95
432PA-1 3.5db NF 117VAC $54.95
432PC 1.5 to 2.0db NF 12VDC $69.95
432PC-1 1.5 to 2.0db NF 117VAC $94.95
Write for our new catalog.
JANEL LABORATORIES
P. O. BOX 112
SUCASUNNA, N. J. 07876
201-584-6521

WE’VE MOVED!
Your VHF-FM Headquarters for South Florida
Now in new larger quarters to keep up with your growing needs.
EMPORIUM SOUNDS OF POMPANO
1304 E. Atlantic Blvd.
Pompano Beach, Florida 33060
305-782-3464

August 1973
Drake gear keeps getting better and better...

NOW, OUR FINEST...

THE NEW

D r a k e  C - L i n e

NEW FEATURES:
- 1 kHz Dual Concentric Dial Readout
- Receiver and transmitter lock together in transceive operation
- No side controls
- Iridited cadmium-plated chassis
- Compatible with all previous Drake lines

NEW R-4C FEATURES:
- 8-pole crystal filter combined with passband tuning, SSB filter supplied
- Provision for 15 additional accessory 500 kHz ranges
- Transistorized audio
- Optional high-performance noise blanker
- AVC with 3 selectable time constants
- Optional 8 pole filters available for CW, AM, RTTY
- $499.95

NEW T-4XC FEATURES:
- Plug-in relay
- More flexible VOC operation; including separate delay controls for phone and CW
- Crystal control from front panel for amateur, Mars, commercial uses
- Provision for AFSK RTTY operation
- $529.95

See for yourself—at your dealer's.

R. L. DRAKE COMPANY
540 Richard Street, Miamisburg, Ohio 45342 • Phone (513) 866-2421 • Telex 288-017

More Details? CHECK-OFF Page 110
LOW PRICES ON POPULAR COMPONENTS

- Monolithic crystal filters at 10.7 and
  16.9 MHz
- Ceramic filters at 455 kHz

SEMI CONDUCTORS
- VHF power transistors by CTC-Varian
- J and MOS FETS
- Linear ICs — AM/FM IF, Audio PA
- Bipolar — RF and AF popular types

INDUCTORS
- Molded chokes
- Coil forms — with adjustable cores

CAPACITORS
- Popular variable types

QUALITY COMPONENTS
- No seconds or surplus
- Name brands — fully guaranteed
- Spec sheets on request

GREAT PRICES
- Price breaks at low quantities
- Prices below large mail-order houses

WRITE FOR CATALOG 173
AMTECH
P. O. BOX 624, MARION, IOWA 52302
(319) 377-7927 or (319) 377-2638

K2DEI.
KNIGHT RAIDERS VHF CLUB INC.
SEVENTH ANNUAL HAMFEST
PASSAIC-CLIFTON YM-YWHA DAY CAMP
West Paterson, N. J.
SATURDAY, AUGUST 11, 1973
10:00 A.M. TIL DUSK
Gigantic Flea Market, Equipment Displays, Contests, Door Prizes, Swimming, Boating and Play Area.
Talk-in station on 50.2, 145.71 and 148.94 FM. Tables and Cooking area. Come early — Stay late!
ADULTS — $1.00 IN ADVANCE
$1.50 AT THE DOOR
CHILDREN UNDER 12 — FREE

EXCLUSIVE 66 FOOT
75 THRU 10 METER DIPOLE
NO TRAPS — NO COILS — NO STUBS — NO CAPACITORS
FULLY AIR TESTED — THOUSANDS ALREADY IN USE

#16 40% Copper Weld wire annealed so it handles like soft Copper wire—Rated for better than full legal power AM/CW or SSB-Coxial or Balanced 50 to 75 ohm feed line—VSWR under 1.5 to 1 at most heights—Stainless Steel Hardware—Drop Proof Insulators—Terroric Performance—No coils or traps to break down or change under weather conditions—Com鄄letely Assembled ready to put up—Guaranteed 1 year—ONE DESIGN DOES IT ALL: 75-10HD—ONLY $12.00 A BAND!

Model 75-10HD .........$60.00 66 Ft. 75 Thru 10 Meters
Model 75-20HD .........$50.00 66 Ft. 75 Thru 20 Meters
Model 80-40HD .........$42.00 69 Ft. 80-40-15 Meter (CW)

ORDER DIRECT OR WRITE FOR FULL INFORMATION
3004 Shawnee
Leavenworth, Kansas 66048

MORE AGAIN

More Details? CHECK—OFF Page 110
CW or RTTY, whichever way you go,  
HAL HAS TOP QUALITY  
YOU CAN AFFORD!

TOP QUALITY RTTY...WITH THE HAL  
MAINLINE ST-6 TU. Only 7 HAL circuit boards  
(drilled G10 glass) for all features, plug-in IC sockets, and  
custom Thordarson transformer for both supplies, 115/  
230 V, 50-60 Hz. Kit without cabinet, only $135.00; screened,  
punched cabinet with pre-drilled connector rails, $35.00;  
boards and complete manual, $19.50; wired and tested  
units, only $280.00 (with AK-1, $320.00).*

OTHER HAL PRODUCTS INCLUDE:  
ID-1 Repeater Identifier (wired circuit board) $75.00*  
ID-1 (completely assembled in 1½" rack  
cabinet) ............................................. $115.00*  
HAL ARRL FM Transmitter Kit $50.00*  
W3FG SSTV Converter Kit $55.00*  
Mainline ST-5 TU Kit $50.00*  
Mainline AK-1 AFSK Kit $27.50*

NEW FROM HAL—TOP QUALITY  
RVD-1002 RTTY VIDEO DISPLAY  
UNIT. Revolutionary approach to amateur RTTY...provides visual display of received  
RTTY signal from any TU, at four speeds (60, 66, 75, and 100 WPM), using a TV receiver modified  
for video monitoring. Panasonic solid-state TV receiver/monitor, or monitor only, available.  
RVD-1002, $525.00; Panasonic TV receiver/  
monitor, $160.00; monitor only, $140.00.*

HAL provides a complete line of components, semi-conductors, and IC's to fill practically any con-  
struction need. Send 24¢ to cover postage for catalog with info and photos on all HAL products  
available.

*Above prices do not include shipping costs. Please add 75¢ on parts orders, $2.00 on larger kits.  
Shipping via UPS whenever possible; therefore, street address required.

HAL COMMUNICATIONS CORP., Box 365 H, Urbana, Illinois 61801  

TOP QUALITY...WITH THE HAL  
RVD-1002 VIDEO DISPLAY  
TTV KEYBOARD. Gives you typewriter-easy op-  
eration with automatic letter/number shift at four  
speeds (60, 66, 75, and 100 WPM). Use with RVD-1002  
video display system, or insert in loop of any tele-  
printer, for fast and easy RTTY. Completely solid state,  
TTL circuitry using G10 glass boards, regulated power supplies, and high voltage transistor switch.  
RVD-1002 assembled, only $275.00.*
ON LINE SWR & POWER METERS

PRICE — $29.95
FREQUENCY RANGE: 3 - 150 MHz
IMPEDANCE: 50 ohms
POWER: 0 - 1 Kw

PRICE — $49.95
FREQUENCY RANGE: 3.5 - 150 MHz
IMPEDANCE: 50 or 75 ohms
POWER: 0 - 2 Kw

For further information and catalogs write, cable or call:
CARVILL INTERNATIONAL CORP.
P. O. Box 4039, Foster City, Ca., U.S.A. 94404
Phone (415) 341-9959. Telex 349334

KITS

Sub-Audible Tone Decoder $9.95
Encoders & Wires $13.95

Compatible with all sub-audible tone systems such as Private Line, Channel Guard, Quiet Channel, etc.
Glass epoxy PCB's & Silicon xstres throughout
Any reeds, except special dual coil types may be used: Motorola, G.E., RCA, S.D.L., Branco, etc.
All are powered by 12 vdc
Use on any tone frequency 67 Hz to 250 Hz
Small size 1.5 x 4 x .75"
All parts included except reed and reed socket
Postpaid — Calif. residents add 5% sales tax

COMMUNICATIONS SPECIALISTS
P. O. Box 153, Brea, CA 92621

FM Schematic Digest

A COLLECTION OF MOTOROLA SCHEMATICS
Alignment, Crystal, and Technical Notes covering 1947-1960
136 pages 11½" x 17" ppd $6.50
S. Wolf
P. O. Box 535
Lexington, Massachusetts 02173

SPECIAL SALE...
QVS NI-CAD TESTER

This dual meter unit gives positive proof of Ni-Cad battery quality. Cell meter has expanded scale (1.15-1.33v by .01v) Battery meter is three range — tests up to 20 cells. All units checked — guaranteed satisfaction or money back.

PRICE — $199.95
FREQUENCY RANGE: 3.5 - 150 MHz
IMPEDANCE: 50 or 75 ohms
POWER: 0 - 2 Kw

OTHER TEST EQUIPMENT

For further information and catalogs write, cable or call:
GRAY Electronics
P. O. Box 941, Monroe, MI 48161
Specializing in used test equipment

F.C.C. EXAM MANUAL

PASS F.C.C. EXAMS! Memorize study — 1973 Tests-Answers for F.C.C. First and Second class Radio-telephone licenses. Newly revised multiple-choice questions and diagrams cover all areas tested in F.C.C. exams. — also "Self-Study Ability Test." $9.95 Postpaid

COMMAND PRODUCTIONS
P.O. BOX 26348-K
SAN FRANCISCO, CALIF. 94126

46 Element Multibeam For 432 MHz Band

Gain: 20 dB over Dipole
Length: 104/" Width: 18/"
Weight: 6 Lbs.
Hor. Beamwidth (~3 dB: 24°)
Broadband — works over entire 420-450 MHz Band.
70/MBM 46 $52.50 FOB Distributor

VHF COMMUNICATIONS

CENTRAL 59 ST. ANDREW RAPID CITY, S. D. 57701
WESTERN CANADA 1170 BARRIE CREEK, W. MEDICINE HAT, A.B., CANADA

GRAY Electronics
P. O. Box 941, Monroe, MI 48161
Specializing in used test equipment

FM Schematic Digest

A COLLECTION OF MOTOROLA SCHEMATICS
Alignment, Crystal, and Technical Notes covering 1947-1960
136 pages 11½" x 17" ppd $6.50
S. Wolf
P. O. Box 535
Lexington, Massachusetts 02173

FM Schematic Digest

A COLLECTION OF MOTOROLA SCHEMATICS
Alignment, Crystal, and Technical Notes covering 1947-1960
136 pages 11½" x 17" ppd $6.50
S. Wolf
P. O. Box 535
Lexington, Massachusetts 02173

FM Schematic Digest

A COLLECTION OF MOTOROLA SCHEMATICS
Alignment, Crystal, and Technical Notes covering 1947-1960
136 pages 11½" x 17" ppd $6.50
S. Wolf
P. O. Box 535
Lexington, Massachusetts 02173
HOLD OF .... 22 channels of pure pleasure

$289 gets you 22 channels of pure pleasure with...

- TEN crystals ... (now that alone is going to save you about $40.00) ... easy to hold noise canceling dynamic mike ... a quick disconnect mobile mount ... battery saving HI (10 watts)/Lo (1 watt) power option. Your IC-22 will have a receiver that just won't quit with a super hot mosfet front end, 5 helical resonators (you can forget about inter-mod), and a large speaker that will punch out plenty of audio for the car.
- You'll also be on frequency with trimmer caps on both trans. and rev. on all 22 channels ... with a discriminator output jack in the back to let you get on and stay on freq. 
- PLUS the '22' is one good lookin' compact rig that you will be proud to put in your car—(the XYL won't mind it either)—with soft green back lighting on the front panel and a light to silently let you know you are getting out ... and a second light to let you know there is an incoming signal (even though you may have the volume down).
- There is much, much more to tell you about the IC-22, but suffice it to say, the IC-22, with all of its unique features and performance record at $289.00, has got to be one of the best all-around values available on two meters today!

SEE THE WHOLE ICOM FAMILY ... AND GRAB HOLD OF YOUR IC-22 AT ANY OF THE AUTHORIZED ICOM DEALERS LISTED BELOW:

**ALABAMA**
Wolfe Electronics
Box 358
Foley, Alabama 36535

Gavin Electronics
516 Ridgeway
Little Rock, Ark. 72205

**ARKANSAS**
Eli Dee Enterprises
1342 AE, Indian School Rd.
Phoenix, Ariz. 85014
(602) 942-9715

**ARIZONA**
FLORIDA
Resource
Box 3561
Pensacola, Fla. 32506

**CALIFORNIA**
ICOM FM Sales
6234 A. Fountain Blvd.
Hollywood, Calif. 90228
(213) 462-1502

**MARYLAND**
COM Electronics
900 Crain Hwy, S.W.
Glenn Burnie, Md. 21061
(301) 761-3666

**NEW YORK**
R. E. Nebel Laboratories
31 Whitehall Blvd.
Garden City, N.Y. 11530

**OHIO**
H & C Electronics
6271 Hammel Ave.
Cincinnati, Ohio 45237

**OKLAHOMA**
Blacks Radio Company
413 N.E. 38th Terrace
Oklahoma City, Okla. 73106
Roland Radio Company
5923 E. 31st Street
Tulsa, Okla 74114
(918) 836-6833

**OREGON**
Portland Radio Supply
Portland, Oregon

**SOUTH CAROLINA**
Electronic Systems Inc.
1518 Gregg Street
Columbia, S.C. 29201

**TEXAS**
Bellaire Electronic Supply
8204 Bellaire Blvd.
Houston, Texas 77036
(713) 667-4294

**UTAH**
ABC Communications
17541 - 15th N.E.
Seattle, Wash. 98155
(206) 364-6410

**WASHINGTON**
ABC Communications
2002 Madison Ave.
Everett, Wash. 98201
(206) 353-6616

**WEST VIRGINIA**
Progress Electronics
852 Commerce Street
Longview, Wash. 98632
(206) 636-5100

**ICOM WEST**
1251 - 170th St. N.E.
Bellevue, Wash. 98006
(206) 641-0554

**ICOM EAST**
Div AOS, Inc.
Box 331
Richardson, Tex. 75080
(214) 235-0479

Distributed by: ICOM

ICOM DEALERS!
GET WITH THE SATISFERS!
WRITE TODAY FOR DETAILS!!!
CRISTAL BARGAINS

Depend on...

We supply crystals from 16kHz to 100MHz. Over 6 million crystals in stock.

SPECIAL

Crystals for most amateur 2-Meter F.M. Transceivers:

$3.75 Each

Inquire about quantity prices. Order direct. Send check or money order.

For first class mail add 15c per crystal...for airmail add 20c ea.

SPECIALS! Crystals FOR:

Frequency Standards
100 KHz (HC/12) $1.50
1000 KHz (HC/6) $4.50
Almost All CB Sets, Trans. or Rec.
(CB Synthesizer Crystal on request) $2.50
Any Amateur Band in FT-243 $1.50
(Except 80 meters) 4 for $5.00
80 Meters Range in FT-243 $2.50
Color TV 3578.545 KHz (wire leads) $1.50
4 for $5.00

DIPPED MICRA CAPACITORS

CAPACITY CASE TANTALUM CAPACITORS
45pf CMO4 0.47uf @ 6V 12/$1.00
100pf CMO4 4.7uf @ 6V 10/$1.00
180pf CMO4 6.8uf @ 6V 8/$1.00
Glass sealed, axial leads
2000pf CMO4 Coaxial visible red, 3/16 dia.
3900pf CMO6 Catalog # LED1216..., 2/31
2/25c, 10/80c, 25/$1.50
Coaxial miniature coaxial red.
Catalog # LED1218..., 3/31

5 VOLT COMPUTER GRADE CAPACITOR
Just right for IC circuits
5400uF, 5V, 2/1.00

NEW AND SURPLUS ELECTRONIC COMPONENTS FOR THE PRO
AND SERIOUS AMATEUR, AN ORDER OR 8c STAMP PUTS YOU
ON OUR MAILING LIST, MINIMUM ORDER $3.00 U.S., $15.00
FOREIGN, ALL ORDERS POSTPAID, PLEASE ADD INSURANCE
FREE: Apply for your personal SWAN Credit Card simply by completing and mailing this form to SWAN ELECTRONICS, 305 Airport Road, Oceanside, CA 92054.

SWAN REVOLVING CREDIT SERVICE APPLICATION H
(PLEASE PRINT)

Name: ____________________________ (First Name) ____________________________ (Middle Name) ____________________________ (Last Name)

Mailing Address: ____________________________ (Street) ____________________________ (City) ____________________________ (State) ____________________________ (Zip Code)

How long at this address: _______ Phone: ____________________________ (Area Code) (Number)

Former Address ____________________________ (If less than two years at present address:)

____________________________ How Long: ______

Occupation: ____________________________ Birthdate: ____________________________

Social Security #: ____________________________ Amateur Radio Call: ____________________________

Employer: ____________________________ How Long: ______

Company Address: ____________________________ (Street) ____________________________ (City) ____________________________ (State) ____________________________ (Zip Code)

Former Employer: ____________________________ How Long: ______

Name of Your Bank: ____________________________

Address: ____________________________ (Street) ____________________________ (City & State)

Savings ______ Checking ______ Loan ______ Home Loan Account No.: ____________________________

Bank Loans, Finance, etc.: ____________________________

(Name of Firm) (Address) (City & State) (Account #)

Current Credit Cards:

(Name) (Account No.) (Name) (Account No.) (Name) (Account No.)

Relative or Personal Reference:

(Name) (Address) (City) (State)

The above information is true and correct. I/We will make no charge purchase until reading the Swan Credit Service Agreement and Disclosure to be provided.

Your Signature: ____________________________ Date: ____________________________

Signature of Spouse: ____________________________ Date: ____________________________

More Details? CHECK—OFF Page 110
A COMPLETELY PORTABLE FREQUENCY COUNTER WITH . . .

- 10 HZ to 65 MHz range
- Full six digit readout (L.E.D.)
- Sensitive front end (LESS THAN 10 MV.)
- Only $199

FEATURES

- High capacity rechargeable Ni Cd batteries
- Crystal controlled time base (can be field calibrated)
- Convenient 3-position range select switch allows:
  1. Readout always in MHZ.
  2. Eight digit resolution by range selection
  3. Direct reading pre-scalar operation to 999,999 MHZ.
- 'Battery save' switch for spot checks
- Less than 5 watts power consumption (5 volts @ 0.9 AMPS)
- Dimension 6" x 3.5" x 2.3"
- TTL input for use with pre scalar
- Can be operated on internal or external power, with trickle charge and full charge positions
- Sample control lets operator determine how often the readout is updated. Can "hold" present count without being updated

Mail orders directly to:
Great American Miniatures, Inc.
P. O. Box 10990
Midwest City, Okla. 73110

Model C-85 Freq. counter $199.00
Battery charger 8.00
Battery charger & eliminator 18.00

DIGIPET-60
See Nov., '72 CQ & Apr., '73 QST reviews

Freq. Counter
1 KHz-60 MHz
(130-160 MHz with optional converter)
Reg. $299

A frequency counter with a range of 1 kHz to 60 MHz (130-160 MHz when used with our Digipet-166 converter). With a resolution of 1 kHz or 1 Hz (or 1/1,000 kHz or 1/1,000 Hz). It can be operated on either ac or dc, with complete overload protection. Plus a stability of 1 part in 10^6 per hour. The whole unit is a mere 7" deep by 2½" high. Superb precision quality at LESS THAN KIT PRICES. Can be used for literature and trade in our LOW INTRODUCTORY PRICE. 1 year warranty.

AMATEUR-WHOLESALE ELECTRONICS
5 W.W. 79 Territorial Miami, Fl. 33156

Andy Electronics Co., Inc.
Department 23, 6551 Spruce, Houston, Texas 77007
All prices FOB Houston, Texas

CIRCUIT BOARD KIT (LESS CASE) $12.95
KIT (LESS BATT) $21.95
WIRED (LESS BATT) $26.50
SIDETONE KIT $4.95, WIRED $6.95

PADDLE MODEL 11

★ ADJUSTABLE TRAVEL
★ NON-SKID WEIGHTED BASE
★ FULLY ASSEMBLED

ONLY $9.95

SEE YOUR DEALER
OR ORDER DIRECT. PRICES F.O.B. FRANKLIN, PA.

RD 1, POKE LANE
BOX 185A
FRANKLIN, PA. 16323
PHONE: AREA CODE (814) 432-3647
NURMI ELECTRONIC SUPPLY
1727 Donna Road · West Palm Beach, Florida 33401 · Phone — (305) 686-8553

DELUXE Equipment Enclosure
Great for Linears, SSTV Monitors, Station Controls, etc.

FEATURES:
- Rubber Feet
- Cream/Lt. Green Textured Finish
- Heavy Steel Construction
- ½” Felt Lining for Quiet
- Holds Over 80 Lbs. of Equipment
- Heavy Duty Piano Hinges
- Cabinet & Base Bolt to Pedestal
- Cabinet Can Be Used Alone
- All Wires Including Line Cord Can Be Routed thru Pedestal & Out Grommeted Hole in Base.
- Front Panel 9”x19”

LIMITED SUPPLY
THIS OFFER CANNOT BE REPEATED — LESS THAN 100 LEFT!!!!

DIMENSIONS: CABINET: 21”W x 16”D x 11”H
BASE: 18”W x 14”D x 2”H
PEDESTAL: 6”W x 6”D x 36”
OVERALL HEIGHT: 49”

SHIPMENT: Shipped in Two Heavy Triwall Cardboard Cartons.
Shipped VIA Motor Freight. Freight Charges will be Collected upon Delivery. Florida Residents, Please Enclose 4% State Sales Tax.

ALL THIS ONLY
$39.00

A Real Beauty!

july 1973
NEW RX-144C RECEIVER KIT
For Repeaters or Those Who Need The Best

$69.95
WITH 10.7 CRYSTAL FILTER

- Low cross modulation front end
- 10.7 MHz crystal filter
- Sensitive noise squelch
- COR output for control
- 2 watts audio output
- Less than .2 μV sensitivity
- Measures 4 x 6 x 1 inches

ALSO AVAILABLE
TX-144 Transmitter Kit $29.95 — RX-144 Receiver Kit $59.95 — PA-144 Amplifier Kit $29.95
Add $1.00 shipping per kit ordered. New York Residents add sales tax.

We are now in our new location, please note the new address.
The most popular three band beam in the world!

INTERNATIONALLY superior

RESPECTED for performance

Superior construction and performance make the difference in Hy-Gain's popular 3-element Thunderbird.

- Thunderbird's "Hy-Q" traps provide separate traps for each band. "Hy-Q" traps are electronically tuned at the factory to perform better at any frequency in the band—either phone or CW. And you can tune the antenna, using charts supplied in the manual, to substantially outperform any other antennas made.

- Thunderbird's superior construction includes a new, cast aluminum, tilt-head universal boom-to-mast bracket that accommodates masts from 1½" to 2½". Allows easy tilting for installation, maintenance and tuning and provides mast feed-thru for beam stacking.

  Taper swaged, slotted tubing on all elements allows easy adjustment and re-adjustment. Taper swaged to permit larger diameter tubing where it counts! And less wind loading. Full circumference compression clamps are mechanically and electrically superior to self-tapping metal screws.

- Thunderbird's exclusive Beta Match achieves balanced input, optimum matching on all 3 bands and provides DC ground to eliminate precipitation static.

  - Up to 8 db gain
  - 25 db front to back ratio
  - Power capability 1Kw AM, 2Kw PEP
  - SWR less than 2:1
  - Extra heavy gauge, machine formed, element to boom brackets with plastic sleeves used only for insulation. Bracket design allows full mechanical support.

Model 388 $144.95

Other tri-band beams to choose from:

-  6-element Super Thunderbird TH6DXX
-  3-element Thunderbird Jr. TH3JR
-  2-element Thunderbird TH2Mk3

Model 389 $179.95
Model 221 $ 99.95
Model 390 $ 99.95

AVAILABLE FROM AMATEUR DEALERS THROUGHOUT THE WORLD

HY-GAIN ELECTRONICS CORPORATION
8601 Northeast Highway 6 Dept. WG Lincoln, Nebraska 68507
402/434-9151 Telex 48-6424
URC-11
WALKY TALKY
243 MC 2 way radio, hand held, measures 3 x 4 inches. Used for survival in downed aircraft. May be converted for other frequencies.
URC-11 $15 each or 3 for $40.00

GIANT LED 83¢
Price break at last on these giant LED with 1,000,000 hours of life. Measure full ½ by ½ inch. First time offered.
RED $1.00
GREEN $1.25
SUPER BRIGHT collimated RED with parabolic reflector, measures 3/16 diameter. A real hi-intensity red visible over 100 ft.
SUPER RED $1.25
All above LED's 12 for the price of 10

7 SEGMENT LED
Hobby craft due to being factory rejects. Most have a segment or decimal inoperative. Still a great "buy" for the experimenter. What an unusual tie clip you can make with pocket battery ... demo displays, etc. Many applications you don't need full 7 segments. $1.00 each or $10 the dozen. 0.333 inches high character.

GIANT 7 SEGMENT
As above only this one is the giant display 13/16 inches hgt. of character. First time offered and as far as we know, offered no where else. This one is quite an attention getter. Also available in this giant display numeral "one" with "plus" and "minus" sign. Again, these are rejects. Giant display $1.50 each 12 for $15.00

JOHN MESHNA JR. ELECTRONICS

"INTRODUCTORY PRICES"
ST-5 KIT OF ELECTRONIC PARTS $ 47.50
ST-5A KIT OF ELECTRONIC PARTS $ 52.50
ST-5A KIT OF ELECTRONIC PARTS $ 54.00
ST-6 KIT OF ELECTRONIC PARTS $128.50
ST-5A KIT OF ELECTRONIC PARTS $9.00

Pemco Model 50A Frequency Counter Semi-KIT $125.00
This is a fully assembled and tested board, you add only your own power supply and cabinet, etc. Write for details.
You must supply the cabinet, A.C. cord, meter, switches, etc. on all kits except where noted otherwise. (All prices are postage paid (we pay shipping).
We will do most any printed circuit board for individuals or prototypes. If required we will also do the layout of the boards. All our boards are G-10 glass-epoxy solder plated and come drilled only. At present time we can do only simple sided. All component parts used in our kits are new manufacturers stock. We Do Not Use Any Used or Surplus Parts. All inquiries are answered promptly.
Pemco Electronics Manufacturing
422 18th St., N.E., Salem, Ore. 97301, (503) 585-1641

WANTS TO BUY
All types of military electronics equipment and parts. Call collect for cash offer.
Space Electronics Division of Military Electronics Corp.
76 Brookside Drive, Upper Saddle River, New Jersey 07458 (201) 327-7640

ACTIVE AUDIO FILTERS
1% FOR SUPER HIGH PERFORMANCE

CW FILTER (CWF-2)
Get razor sharp selectivity; No impedance matching; BW 80 Hz, 110 Hz, 180 Hz; Center frequency F=750 Hz; Skirt 60 dB down at 1/2 F and 2F; 4 op amps; 2" x 3" PC board; $4.95 wired, tested, guaranteed; $7.95 kit.

CW MINI FILTER (CWF-3)
1 1/4" x 2" PC board; Center frequency F=750 Hz; 30 dB down at 1/2 F and 2F; BW 110 Hz, 180 Hz; 2 op amps; $8.95 wired, tested, guaranteed; $7.95 kit.

LOW PASS FILTER (LPF-1)
Resistors set cutoff 500 Hz to 20 kHz; Factory set to 2.5 kHz; Roll off 48 dB per octave; Input imp 1 M; Gain=1; 5 op amps; 2" x 3" PC board; $16.95 wired, tested, guar.; $14.95 kit. Please include $5 postage on all orders.

MFJ Enterprises
P.O. Box 494-A, Miss. State, MS 39762

SAROC
9th annual fun convention
Best of Las Vegas — Best of Amateur Radio
January 3-6, 1974
SAROC Box 73 Boulder City, Nev. 89005

P.O. Box 62 E. Lynn, Mass. 01904
Then you’ll love Data Engineering’s new catalog
Write for your free copy today!

**TOUCH TONE PADS**
More features than any other pad including built-in monitor speaker and latest Phase-Lock loop circuitry.
- TTP-1 Standard pad for portable transceiver mounting.
- TTP-2 Standard pad in attractive case for home or mobile use.
- TTP-3 Mini-pad in attractive case for home or mobile use.
- TTP-4 Mini-pad for portable transceiver mounting.

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Sh. wt.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTP-1, 2, 3 &amp; 4</td>
<td></td>
<td>1 lb.</td>
<td>$44.50</td>
</tr>
<tr>
<td>TTP-1K, 2K, 3K &amp; 4K</td>
<td></td>
<td>1 lb.</td>
<td>$34.50</td>
</tr>
</tbody>
</table>

**AUTO-PATCH CONSOLE**
This mobile or home console includes all the features you need for complete auto-patch operation. A Touch-Tone Pad: an automatic dialer for sending one access code plus five Touch-Tone phone numbers; a single/dual tone burst encoder adjusted to your choice of frequency above 500 Hz, a continuous sub-audible tone encoder, and a built-in monitor. Complete PTT operation with one second transmitter hold. Sh. wt. 2 lbs.

- APC-4K Comp. Kit $84.50
- APC-4 Assembled $98.50

**2-METER PREAMP**
Specially made for both OLD and NEW receivers. The smallest and most powerful preamp available. Provides 20dB gain at 2.5 N.F. to bring in the weakest signals.

<table>
<thead>
<tr>
<th>Description</th>
<th>Sh. wt.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 oz.</td>
<td>9.50 kit</td>
<td>$9.50</td>
</tr>
<tr>
<td>Wired</td>
<td></td>
<td>$12.50</td>
</tr>
</tbody>
</table>

Please include sufficient postage for shipping.

DATA ENGINEERING INC.
Ravenswood Industrial Park, Springfield, Va. 22151
5554 Port Royal Road • 703-321-7171

More Details? CHECK-OFF Page 110
<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW MINIATURE CRYSTAL FILTERS</td>
<td>$1.00</td>
</tr>
<tr>
<td>- Made U.S.A.</td>
<td></td>
</tr>
<tr>
<td>WHEATLAND ELECTRONICS</td>
<td></td>
</tr>
<tr>
<td>P 0 BOX 343</td>
<td></td>
</tr>
<tr>
<td>ARKANSAS CITY KANSAS 67005</td>
<td></td>
</tr>
<tr>
<td>Include $.75 for postage and handling.</td>
<td></td>
</tr>
</tbody>
</table>

- NEW MINIATURE CRYSTAL FILTERS
  - Made U.S.A.
  - WHEATLAND ELECTRONICS
  - P 0 BOX 343
  - ARKANSAS CITY KANSAS 67005
  - Include $.75 for postage and handling.

**NEW MINIATURE CRYSTAL FILTERS**
- Made U.S.A.
- Wheatland Electronics
- P 0 Box 343, Arkansas City, Kansas 67005
- Include $.75 for postage and handling.

**Radio Communication**

Many thousands of you have become very familiar with the numerous Radio Society of Great Britain books and handbooks. We offer the excellent magazine, Radio Communication. It includes numerous technical and construction articles in addition to a complete rundown on the month's events in amateur radio. Surely a most interesting addition to your amateur radio activities.

For the Radio Society of Great Britain books and handbooks, use of their outgoing QSL Bureau for $12.95 a year.

Greenville, New Hampshire 03048

**Radio Communication**

Many thousands of you have become very familiar with the versatile Radio Society of Great Britain books and handbooks. We offer the excellent magazine, Radio Communication. It includes numerous technical and construction articles in addition to a complete rundown on the month's events in amateur radio. Surely a most interesting addition to your amateur radio activities.

For the Radio Society of Great Britain books and handbooks, use of their outgoing QSL Bureau for $12.95 a year.

Greenville, New Hampshire 03048

**Radio Communication**

Many thousands of you have become very familiar with the versatile Radio Society of Great Britain books and handbooks. We offer the excellent magazine, Radio Communication. It includes numerous technical and construction articles in addition to a complete rundown on the month's events in amateur radio. Surely a most interesting addition to your amateur radio activities.

For the Radio Society of Great Britain books and handbooks, use of their outgoing QSL Bureau for $12.95 a year.

Greenville, New Hampshire 03048

**Radio Communication**

Many thousands of you have become very familiar with the versatile Radio Society of Great Britain books and handbooks. We offer the excellent magazine, Radio Communication. It includes numerous technical and construction articles in addition to a complete rundown on the month's events in amateur radio. Surely a most interesting addition to your amateur radio activities.

For the Radio Society of Great Britain books and handbooks, use of their outgoing QSL Bureau for $12.95 a year.

Greenville, New Hampshire 03048
Your assurance of Performance and Quality

FTdx401 Transceiver

More For Your Money

<table>
<thead>
<tr>
<th>Feature</th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-in AC Power Supply</td>
<td>No charge</td>
</tr>
<tr>
<td>Built-in WWV 10 MHz Band</td>
<td>No charge</td>
</tr>
<tr>
<td>Built-in Noise Blanker</td>
<td>No charge</td>
</tr>
<tr>
<td>25 and 100 KHz Calibrators</td>
<td>No charge</td>
</tr>
<tr>
<td>VOX</td>
<td>No charge</td>
</tr>
<tr>
<td>Clarifier</td>
<td>No charge</td>
</tr>
<tr>
<td>Break-in CW with Sidetone</td>
<td>No charge</td>
</tr>
<tr>
<td>600Hz CW Filter</td>
<td>No charge</td>
</tr>
<tr>
<td>1 KHz Readout</td>
<td>No charge</td>
</tr>
<tr>
<td>Selectable SSB</td>
<td>No charge</td>
</tr>
<tr>
<td>6 Month Warranty by Dealer</td>
<td>No charge</td>
</tr>
<tr>
<td>Cooling Fan</td>
<td>No charge</td>
</tr>
</tbody>
</table>

Total only $599.00

Amateur Price Net
Price Subject To Change

Tomorrow's Transceiver Today: 20 tubes plus 50 silicon semiconductors, passive crystal filter (6 pole), velvet smooth tuning, superb noise blanker, standard electrical parts. This is truly the best buy in the amateur field today. See your local dealer for brochure & demonstration.

Factory Service is available even after your warranty has expired for the cost of labor and parts.

YAESU DEALERS:
HENRY RADIO STORES / 213-477-6701
Los Angeles, Anaheim, Ca., Butler, Mo.
HAM RADIO OUTLET / 213-272-0861
Burlingame, Ca.
RACOM ELECTRONICS / 206-255-6656
Renton, Wash.
WILSON ELECTRONICS / 702-457-3596
Pittman, Nev.

ED JUGE ELECTRONICS / 817-926-5221
Fort Worth, Tex.
AMATEUR ELECTRONICS SUPPLY / 414-442-4200
Milwaukee, Wis., Cleveland, Ohio, Orlando, Fla.
FRECK RADIO & SUPPLY / 704-254-9551
Asheville, N. Carolina
HARRISON RADIO / 516-293-7990
Farmingdale, L. I., Valley Stream, L. I., New York City, N. Y.

YAESU MUSEN USA INC.
7625 E. Rosecrans Avenue, Unit #29
Paramount, California 90723
Phone 213-633-4007

More Details? CHECK-OFF Page 110

july 1973
BARRY HAS ANTENNAS

Cush-Craft Trick Stick, universal dipole, 10-2 meters. 1.5 db gain at 146 MHz .......... $ 8.95
English power, 9.50
W2AU 10/15/20 Quad, bamboo ................. $ 49.00
Joy Stick (English) with original tuner ........ $ 29.00
RG-58 AR-2 3.75 db gain .................. $ 12.50
BBTL-144 Trunk Lip, 3.75 db gain ............. $ 34.95
Newtonics CG-144 mobile 5.2 db gain ........ $ 37.75
Quick Disconnect by Newtonics for COT, etc. $ 9.95
CG-1 Gutter Clip by Newtonics .......... $ 1.25
2M MAGNETIC MOUNT w/RG58 & PL-259 with 10 ft. RG 58 ready to go ........ $ 9.95
14AVQ/WS VERTICAL .................. $ 47.95
18AVT/WS VERTICAL .................. $ 69.95
HY GAIN 2 METER, 15 element beam ......... $ 35.00

NEW ULTRA BALUN 1:1 .......................... $ 9.95
C.D. HAM "M" ROTATORS, new, complete $ 99.95
HAM "M" CABLE ........................................ $134/ft.
C.D. TR-44 ROTATORS, new, complete $63.95
CABLE FOR TR-44 ......................... 6 ft./ft.
RG-58A/U 100 ft. rolls, VHF connector PL-259 one end Type "N" (UG-21E/U) other end $ 12.50
RGBA/U — 65 feet with PL-259 connectors on each end $ 95.00
B & W Vacationer apartment house antenna, 2, 6, 10, 15 & 20 meters. Hang out your window.
Take along on your vacation ................... $ 24.95
Authorized factory dealers for Antenna Specialists, CushCraft, Gam, Heights Towers, Hy Gain, Mor-Gain, Antenna, Mosley, Newtonics, Tri-Ex, Rohn, E-Z Way, Times Wire

TOWER PROBLEMS? Let Barry get factory engineering answers from TRI-EX on your new installation.

NEW! VENUS SSTV MONITOR. Advanced features. Late Summer availability.

BIRD
4350 80-10M 2KW Ham Mate ................. $ 79.00
43 Wattmeter ................................ $100.00
BIRD 43 SLUGS, spec. freq./power, HF $35.00 ea.
VHF, $32.00 ea.

SWR BRIDGE COUPLER, DC-800 MHz
(no indicator) full amateur power $90.00 Value $10.95

MISC.
Gonset 900A 2 meter Sidewinder with 901A AC power supply. 144-148 MHz SSB, AM & CW, 20w. PEP, 6w. AM — mint, $250.00
Gonset 903A 2 meter amplifier, 5 watts in, 500 watts out all modes $375.00
HQ-180 with clock. Mint condition, professionally calibrated. Needs new RF gain control $275.00
Mollen magnetic shields for 2" C.R. scope tubes with brackets
Brand new $ 6.95
TP-9 Similar to EE-8 field telephone with built-in amplifier. Up to 50 ml. Less easily obtained $35.00
Magnetic shields for
Brand New $ 7.50
Power Supply for BC-221, slips into battery compartment $29.50
ALUMINUM DIE CAST BOXES in many different sizes. Doy boxes. Details in New Green Sheet No. 23
2 METER VHF DUMMY LOAD/WATTMETER
Good up to 15 watts — w/SO-239 CONNECTOR $19.95
Jackson G80 brass 50:1 anti-back dieh drive 1/16" to 1/4", $12.00 value $5.50

INVERTER/CONVERTER:
MODEL 612 provides 12 VDC neg. ground power in automobiles with either 6 v. neg. ground or 12 v. pos. ground. 10 amp surge, 3 amp continuous supply, new $229.50
INVERTER, 12 volt DC input, 115 volt AC out. Model 12-115 solid state power supply, 200 watts continuous new, $ 59.95

GE INDUSTRIAL SILICON RECTIFIER
1400 PIV
250 amp., GE #41A281049-11. Quantities in stock. $90.00 value, brand new $22.50

BARKER & WILLIAMSON
 Dummy Load - Wattmeters ........................ 529
 333 DC - 300 MHz, 1000 watts int. .......... $139.95
 334A DC - 230 MHz, 1500 watt ............. $169.00
 374 DC - 300 MHz, 250 watt int. .......... $ 79.95
 850A, 85 Inductors ............................... $ 59.95
 851 Inductor ..................................... $ 29.95
 425 Low Pass Filter, 10-80 meters .......... $ 24.95
 210 Audio Osc., ideal for lab & broadcast $329.95
 410 Distortion Meter, ideal for lab & broadcast $369.95
 AM-141 Amplifier, 2000 watts RF output, continuous 2-18 MHz, complete with coils and 833-A's. Built-in 115 VAC Supply, unused $950.00

E. F. JOHNSON
Matchbox complete with directional coupler and indicator, 10-80 meters. 1-2KW PEP, 1 KW AM — new, $154.50
275 watts — new, $ 94.95
151-4 Variable Capacitor, 250 pf, medium Xmitting type ................................ $2.95 ea.

Tube Headquarters. Diversified Stock. Heavy inventory of Eimac tubes, chimeys, sockets, etc.

CASH PAID . . . FAST! For your unused TUBES, Semiconductors, RECEIVERS, VAC. VARIABLES, Test Equipment. ETC. Write or call Now! Barry, W2LN1. We Buy!
We ship all over the World.
Send 10c plus 40c postage & handling (refund 1st order).

GE INDUSTRIAL SILICON RECTIFIER
1400 PIV
250 amp., GE #41A281049-11. Quantities in stock. $90.00 value, brand new $72.50
for the EXPERIMENTER!

INTERNATIONAL EX CRYSTAL & EX KITS
OSCILLATOR • RF MIXER • RF AMPLIFIER • POWER AMPLIFIER

1. MXX-1 TRANSISTOR
   RF MIXER
   A single tuned circuit intended for
   signal conversion in the 3 to 170
   MHz range. Harmonics of the OX
   oscillator are used for injection in
   the 50 to 170 MHz range. Lo Kit 3
   to 20 MHz, Hi Kit 20 to 170 MHz
   (Specify when ordering)........$3.50

2. SAX-1 TRANSISTOR
   RF AMP
   A small signal amplifier to drive
   MXX-1 mixer. Single tuned input
   and link output. Lo Kit 3 to 20
   MHz, Hi Kit 20 to 170 MHz
   (Specify when ordering)........$3.50

3. PAX-1 TRANSISTOR
   RF POWER AMP
   A single tuned output amplifier
   designed to follow the OX oscil-
   lator. Outputs up to 200 mw.
   depending on the frequency and
   voltage. Amplifier can be ampli-
   tude modulated. Frequency 3,000
   to 30,000 KHz....................$3.75

4. BAX-1 BROADBAND
   AMP
   General purpose unit which may
   be used as a tuned or untuned
   amplifier in RF and audio appli-
   cations 20 Hz to 150 MHz. Pro-
   vides 6 to 30 db gain. Ideal for
   SWL, Experimentor or
   Amateur............................$3.75

5. OX OSCILLATOR
   Crystal controlled transistor type.
   Lo Kit 3,000 to 19,999 KHz, Hi Kit
   20,000 to 60,000 KHz. (Specify
   when ordering)....................$2.95

6. TYPE EX CRYSTAL
   Available from 3,000 to 60,000 KHz.
   Supplied only in HC 6/U holder.
   (Specify frequency)..............$3.95

for the COMMERCIAL user...

INTERNATIONAL PRECISION RADIO CRYSTALS

International Crystals are available from 70 KHz
   to 160 MHz in a wide variety of holders.
   Crystals for use in military equipment can be
   supplied to meet specifications MIL-C-3098E.

CRYSTAL TYPES:
   (GP) for "General Purpose" applications
   (CS) for "Commercial Standard"
   (HA) for "High Accuracy" close tem-
   perature tolerance requirements.

write for CATALOG

INTERNATIONAL CRYSTAL MFG. CO., INC.
10 NO. LEE • OKLA. CITY, OKLA. 73102

More Details? CHECK-OFF Page 110

july 1973 97

RATES Commercial Ads 25¢ per word; non-commercial ads 10¢ per word payable in advance. No cash discounts or agency commissions allowed.

COPY No special layout or arrangements available. Material should be type-written or clearly printed and must include full name and address. We reserve the right to reject unsuitable copy. Ham Radio can not check out 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 is 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

WE BUY ELECTRON TUBES, diodes, transistors, integrated circuits, Semiconductors, Astral Electronics, 150 Miller Street, Elizabeth, New Jersey 07207, (201) 354-2420.

NEW JERSEY QSO PARTY from 1900 GMT, Aug. 18 to 0600 GMT Aug. 19 and from 1200 GMT on Aug. 19. Phone and CW are the same contest. A station may be contacted once on each band — phone and CW — and contact is counted only once per contest. N.J. stations may work other N.J. stations. N.J. stations are to identify by signing “DE NJ” on CW and “New Jersey calling” on phone. Suggested frequencies are 14035, 3735, 5900, 7035, 1335, 7265, 14035, 14280, 21100, 21355, 28100, 28600, 50-50.5, 144-146. Suggest phone activity on even hours.

EXCHANGES of QSO's: Number of N.J. stations worked by the number of N.J. counties worked. N.J. stations: W-K-VE-VQ QSOs count 1 point; DX stations 3 points. Multiply total points by number of QSL cards (including N.J. and SNJ). KP4, KH6, KL7, KZ5 count both as DX contacts and as station multipliers. Logs must show GMT, date and county and received by Sept. 15, 1973. The first contact for each multiplier must be indicated and numbered. A check list of contacts and multipliers should be attached. Multiple-operator entries should be noted and calls of operators listed. Logs and comments should be sent to Englewood Amateur Radio Association, Inc., 503 Tenafly Road, Englewood, N. J. 07631. A copy of SASE should be included for results. Stations planning participation in N. J. are requested to advise the EARA by Aug. 4th so that we may plan for coverage from all counties.

REPAIR TV TUNERS — High earnings, complete course details, 12 repair tricks, many plans, two lessons, all for $1. Refundable. Frank Bocek, Box 9236 (Enterprise Branch), Redding, Ca. 96001.


USED MYLAR TAPES — 1800 foot, Ten for $8.50 postpaid. Freemeran, 4041 Central, Kansas City, Mo. 64111.

ON SALE Drake ML-2. For details write K9DHD, 1006 Wilson, St. Louis, Mo. 63117.

FOR SALE: Drake 2C. For details write K9DHD, 1006 Wilson, St. Louis, Mo. 63117.

27TH ANNUAL VHFC Picnic and Hamfest on Sunday, July 29, 1973, at Turkey Run State Park near Marshall, Indiana. Registration $1.50 or 4 for $5.00. There will be prizes, huge flea market, XYL Bingo, and pleasant good fellowship. Talk in on .94 and 52.525 MHz.

BECKMAN MDL. 1453 recorder vg., $90.00; Beckman 1453 with 4005 scanner vg., $120.00; HP/Sanborn two tube, vg., $15.00; antenna tuners in cabinet, $130.00; WE RO97/FA-14 oscillograph, g.v., $24.00; Cleary printers 16 column, £25.00. Hamfest held Sunday, Sept. 15, 1973, at the new, $20.00. Douglas Craton, 5625 Balfrey Dr., W. Palm Beach, Fla. 33406.


CANADA'S MOST UNUSUAL Surplus and Parts Catalog. Jam packed with bargains and unusual items. Send $1. ETCO-HR, Box 741, Montreal, Canada.

VERY in-ter-est-ing! Next 6 big issues $1. "The Ham Trader." Sycamore IL 60178

SOUTH DAKOTA HAM PICNIC, August 4, 1973 at Wylie Park, Aberdeen, from 10:00 to ??? Prizes, flea market, activities for XYL and Jr. ops. Limited camping available. For information or tickets contact: WQOGS, 1017 7th Ave. S.W., Aberdeen, S. D. 57401. Talk in on 3955 kHz and 146.54 MHz.

Plastic Engraved Call Plates, w/pin $1.25. WA2UUY, 15 Vincent St., Parlin, N. J. 08859.
YAESU FT-101
now with 160 meters
SEE WILSON
for your Yaesu products
FTDX 401 Transceiver
FL2100 Linear Amplifier
FL2000B Linear Amplifier
Interested in trading Tempo One's
and other Yaesu equipment.

WILSON ELECTRONICS
BOX 794 HENDERSON, NEVADA, 89015
702-451-5791

WE PAY HIGHEST
PRICES FOR ELECTRON
TUBES AND SEMICONDUCTORS

H & L ASSOCIATES
ELIZABETHPORT INDUSTRIAL PARK
ELIZABETH, NEW JERSEY 07206
(201) 351-4200

WANTED
HIGHEST PRICES EVER
Needed immediately. Hundreds of dollars paid.
Want complete units or parts in any condition.
AN/APN-84 consists of IP-186/APN-84 Receiver-
Indicator and T-342/APN-84 Transmitter. AN/
CPN-2A consists of IP-68/CPN/2A Receiver-
Indicator, T-230 A Transmitter and 0-18 Oscilla-
tor. Wire collect immediately for top prices.
Also wanted: RADIO SETS: RT-581/URC-9; AN/GRC-106;
AN/ARC-51 AX; AN/ARC-102; AN/ARC-94; AN/ARC-
131; AN/ARC-133; RECEIVERS: R-1388/ARN-82; R-
1393/ARN-83; TACAN: AN/ARN-52; Plotting Tables:
PT-434/ASA-13; AN/ARM-22; MD-83A/ARN; SG-2A/
GRM; SG-1A/ARN. We also purchase all Collins Modules
and Plug in Units as well as Indicator and Controls. What
have you got in Military equipment?

SPACE ELECTRONICS
Div. of Military Electronics, 76 Brookside Drive,
Upper Saddle River, N. J. 07458; (201) 327-7640
TELEX 134-599

LEARN RADIO CODE
THE EASY WAY!
• No Books To Read
• No Visual Gimmicks To
Distract You
• Just Listen And Learn
$9.95
Based on modern psychological
techniques—This course will take
you beyond 13 w.p.m. in
LESS THAN HALF THE TIME!
Available on magnetic tape
$9.95 — Cassette, $10.95

Epsilon Records
508 East Washington St., Arcola, Illinois 61910

WHY FIGHT QRM?
Win the battle against CW QRM with the new DE-101
using advanced integrated circuit design. Connect it
between your receiver and high impedance earphones
for a guaranteed superior CW reception. Operate your
receiver the same way as before except now you can
discriminate against QRM. No adjustments, the DE-101
is factory tuned and complete with built in ac supply.
One year warranty. 4" x 2 1/2" x 6" $29.95 plus $2.00
shipping. Ala. residents add 5% sales tax.

DYNAMIC ELECTRONICS INC.
BOX 1131 DECATUR, AL. 35601
THE MT. AIRY VHF RADIO CLUB (Pack Rats) will hold the 18th annual family day and picnic, Sunday, August 12 (rain date August 19) at the Fort Washington State Park, Flourtown. The event features games, entertainment, and free soda. Talk-in sessions will be scheduled for 16.2 MHz AM, 52.525 MHz FM, and 146.52 MHz FM.

15TH ANNUAL PICN  IC AND HAM FEST, on Sunday August 5th at the Frankfort Picnic Grove, 1 mile north of U. S. 30 on U. S. 45, Frankfort, Ill. Food and Drinks. Snack bar. 11th Shop. Admission $1.50. Payment due at gate. For further information and advance tickets contact Val Hellig, K9ZW, 3420 South 60th Court, Cicero, Ill. 60650.

FOR YOUR FUTURE ROBYN RADIOS send your order to, Two Way Radio Sales, 1501 Monroe Street, Bogalusa, La. 70427 or 202 Farrell Street, Picayune, Miss. 39466.

W9OG, will be on the air daily during the Evansville Freedom Festival, June 29 through July 4, 1973. This year will mark the fourth annual Freedom Festival, a six day celebration, ending with the Mansfield Festival. The event features many special events station W9OG, Drake, Shakespeare, and C.B. amateur Community. 1169 N. Military Highway, Norfolk, Virginia 23502.

TO CELEBRATE the 350th Anniversary of the first settlement in the State of New Hampshire, the special events station WP10RT will operate during the period August 28-29, 1973. Mode of operation will be CW, multibeam. Probable phone frequencies will be 14.230, 14.300, and 14.525 MHz. QSL card will be sent to all stations worked.


MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines in bulk. for sale. For complete details and prices please check your local dealer or write Certified Welders L.A. City License #643.

CRISTAO TOWER CO.

P. O. Box 115, Hammond, California 93230

AM/FM P.C.B. Unused rejects, some with broken connections, broken resistors, etc. AS IS. With AM/FM loop stack: 2 gang, AM/FM tuning capacitor; 8 transformers, miniature, RF, IF, etc. (IF's 455 KC & 10.7 MC); transistors, diodes, resistors, capacitors; etc. On brown, bakelite box, 7/4" x 3" x 1/2". Priced at $1. Each 10/$7.50; 5/$3.75; ea. 79c.

CO-AX CONNECTORS. ALL BRAND NEW, individually packed. Some are unused, bulk, some discoloration.

N TYPE.

UG-21/U, cable male for RG8 or RG9/U $10.50; 5/$3.10; each 97c.

UG536/U, cable male for RG58/U or RG55/U. 4/$3.00; each 97c.

UG-27/A, rt. angle adapter, 1" dia. x 8.5" long. 10/$4.00; 5/$2.25; each 50c.

UG-27/A, as above but 1 1/4" each side; 5/$3.50; each 75c.

UG-997/A, rt. angle chassis receptacle. 10/$5.70; 5/$4.80; each 97c.

UG-201/A, adapter; fits N type chassis receptacle, takes BNC plug. 10/$9.25; 5/$4.75; each 97c.

BNC TYPE.

UG999/U, bulkhead receptacle for RG55 & RG58/U. 50c.


UG253/U, bulkhead receptacle for RG-253/U. 50c.

CH-420, mini and Magna rotating masts, high with all parts. 250c.

CH-239, mast, 750v with all parts. 1000v.

CH-129, mast, 750v with all parts. 1000v.

CH-423, mast, 750v with all parts. 1000v.

CH-424, mast, 750v with all parts. 1000v.

CH-425, mast, 750v with all parts. 1000v.

CH-426, mast, 750v with all parts. 1000v.

CH-427, mast, 750v with all parts. 1000v.

CH-428, mast, 750v with all parts. 1000v.

CH-429, mast, 750v with all parts. 1000v.

CH-430, mast, 750v with all parts. 1000v.

CH-431, mast, 750v with all parts. 1000v.

CH-432, mast, 750v with all parts. 1000v.

CH-433, mast, 750v with all parts. 1000v.

CH-434, mast, 750v with all parts. 1000v.

CH-435, mast, 750v with all parts. 1000v.

CH-436, mast, 750v with all parts. 1000v.

CH-437, mast, 750v with all parts. 1000v.

CH-438, mast, 750v with all parts. 1000v.

CH-439, mast, 750v with all parts. 1000v.

CH-440, mast, 750v with all parts. 1000v.

CH-441, mast, 750v with all parts. 1000v.

CH-442, mast, 750v with all parts. 1000v.

CH-443, mast, 750v with all parts. 1000v.

CH-444, mast, 750v with all parts. 1000v.

CH-445, mast, 750v with all parts. 1000v.

CH-446, mast, 750v with all parts. 1000v.

CH-447, mast, 750v with all parts. 1000v.

CH-448, mast, 750v with all parts. 1000v.

CH-449, mast, 750v with all parts. 1000v.

CH-450, mast, 750v with all parts. 1000v.

CH-451, mast, 750v with all parts. 1000v.

CH-452, mast, 750v with all parts. 1000v.

CH-453, mast, 750v with all parts. 1000v.

CH-454, mast, 750v with all parts. 1000v.

CH-455, mast, 750v with all parts. 1000v.

CH-456, mast, 750v with all parts. 1000v.

CH-457, mast, 750v with all parts. 1000v.

CH-458, mast, 750v with all parts. 1000v.

CH-459, mast, 750v with all parts. 1000v.

CH-460, mast, 750v with all parts. 1000v.

CH-461, mast, 750v with all parts. 1000v.

CH-462, mast, 750v with all parts. 1000v.

CH-463, mast, 750v with all parts. 1000v.

CH-464, mast, 750v with all parts. 1000v.

CH-465, mast, 750v with all parts. 1000v.

CH-466, mast, 750v with all parts. 1000v.

CH-467, mast, 750v with all parts. 1000v.

CH-468, mast, 750v with all parts. 1000v.

CH-469, mast, 750v with all parts. 1000v.

CH-470, mast, 750v with all parts. 1000v.

CH-471, mast, 750v with all parts. 1000v.
Summertime is Ten-Tec time...

Wherever you go, take Ham Radio with you. A TEN-TEC solid-state transceiver will keep you in touch with old and new friends.

Enjoy the out-of-doors, operate on vacation, mobile or portable, with a rig you will use year around.

ACCESSORIES

Model 210
115/230V AC to 12V DC, for Argonaut only ............Price $24.95

Model 250
115/230V AC to 12V DC, for Argonaut and "405" Linear...Price $49.00

Model 215
Ceramic microphone for Argonaut .....................Price $17.00

Model KR5
Keyer ........................................Price $34.95

Model 206
Calibrator. 100 kHz .........................Price $23.95

Argonaut
80-40-20-15-10 meters SSB/CW.
5 Watts input .......................Price $288.00

Model 405 Linear
Solid-state, 100 watts input.
12V DC. ..................................Price $149.00

PM3A
40-20 meters. VFO CW. 5
Watts input .........Price $89.95

PM2B
80-40-20 meters. VFO CW. 3
Watts input ..................................Price $65.95

WRITE FOR DETAILS
See the TEN-TEC line of solid state transceivers at any of these stocking distributors:

**ALABAMA**
- James W. Clary Co. Birmingham
- Alabama

**CALIFORNIA**
- Yokon Radio Supply Anchorage Fairbanks
- M-Tron Oakland Communications Headquarters San Diego
- Quement Electronics San Jose
- L.A. Electronix Sales Torrance

**COLORADO**
- CW Electronics Denver
- CONNECTICUT
- Datron Electronics Hartford

**FLORIDA**
- Amateur-Wholesale Electronics Miami
- Amateur Electronic Supply Orlando
- The Ham Shack Sarasota
- GEORGIA
- Johnson Electric Sales Griffin
- ILLINOIS
- Spectronics, Inc. Chicago
- Trigger Electronics River Forest
- INDIANA
- Graham Electronics Indianapolis
- Radio Distributing Co. South Bend

**IOWA**
- Hobby Industry Council Bluffs

**KANSAS**
- Kansas Electronics, Inc. Salina

**MICHIGAN**
- Mail Publisher Radio Supply Co. Ann Arbor

**MINNESOTA**
- Electronic Exchange Minneapolis
- Missouri
- Amateur Radio Center, Inc. St. Louis

**NEW HAMPSHIRE**
- Evans Radio, Inc. Concord

**NEW JERSEY**
- Atkinson & Smith, Inc. Eatontown

**NEW MEXICO**
- Lelectronix Supply Farmington

**NEW YORK**
- Adirondack Radio Supply Amsterdam
- Arrow Electronics

**OHIO**
- Amateur Electronic Supply Cleveland

**PENNSYLVANIA**
- Electronic Exchange Pittsburgh

**TEXAS**
- Bayside Communications, Inc. Houston
- Texas

**VIRGINIA**
- Atwood Radio Supply Co. Norfolk

**WASHINGTON**
- Amateur Radio Supply Co. Seattle

**WISCONSIN**
- Amateur Radio Supply Milwaukee

**WISCONSIN**
- Ed Juge Electronics, Inc. Fort Worth

**WISconsin**
- Ed Juge Electronics, Inc. Fort Worth

See the TEN-TEC line of solid state transceivers at any of these stocking distributors:

**ALABAMA**
- James W. Clary Co. Birmingham

**CALIFORNIA**
- Channel Systems, 3563 Conquista, Long Beach, Texas 77002 (713) 224-2668.

**CLEANING OUT SHACK**
- Eico 753 Transceiver with AC supply, $100.00; Motorola 41 TRU, 2 meter FM Transceiver with accessories, $50.00; Viking Admiral new Novice Transmitter, $25.00; Lafayette Communications Receiver HA-225, $40.00. Barry Fluze, WB8LX, 32 Willow Spring, Wheeling, W. Va. 26003.

**WANTED**
- Hammarlund SP-600UX2 Receivers — Need 20 or more. P. O. Box 4039, Foster City, California 94404.

**FINDLAY ANNUAL HAMFEST**
- Riverside Park, Findlay, Ohio, Sunday, Sept. 9. Advance donation tickets $1.00 from C. Foltz, WBUN, W. Hobart, Findlay OH 45840.

**CLEANING OUT SHACK**
- Eico 753 Transceiver with AC supply, $100.00; Motorola 41 TRU, 2 meter FM Transceiver with accessories, $50.00; Viking Admiral new Novice Transmitter, $25.00; Lafayette Communications Receiver HA-225, $40.00. Barry Fluze, WB8LX, 32 Willow Spring, Wheeling, W. Va. 26003.

**WANTED**
- Hammarlund SP-600UX2 Receivers — Need 20 or more. P. O. Box 4039, Foster City, California 94404.

**CLEANING OUT SHACK**
- Eico 753 Transceiver with AC supply, $100.00; Motorola 41 TRU, 2 meter FM Transceiver with accessories, $50.00; Viking Admiral new Novice Transmitter, $25.00; Lafayette Communications Receiver HA-225, $40.00. Barry Fluze, WB8LX, 32 Willow Spring, Wheeling, W. Va. 26003.

**WANTED**
- Hammarlund SP-600UX2 Receivers — Need 20 or more. P. O. Box 4039, Foster City, California 94404.

**FINDLAY ANNUAL HAMFEST**
- Riverside Park, Findlay, Ohio, Sunday, Sept. 9. Advance donation tickets $1.00 from C. Foltz, WBUN, W. Hobart, Findlay OH 45840.

**CLEANING OUT SHACK**
- Eico 753 Transceiver with AC supply, $100.00; Motorola 41 TRU, 2 meter FM Transceiver with accessories, $50.00; Viking Admiral new Novice Transmitter, $25.00; Lafayette Communications Receiver HA-225, $40.00. Barry Fluze, WB8LX, 32 Willow Spring, Wheeling, W. Va. 26003.

**WANTED**
- Hammarlund SP-600UX2 Receivers — Need 20 or more. P. O. Box 4039, Foster City, California 94404.
### LED SEGMENT READOUTS

<table>
<thead>
<tr>
<th>MAN-4 EQUIVAL 3.95</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9 plus letters, single lead, 1-pip DIP socket, $1.49, no, with decimal point. Like MAN-1.</td>
</tr>
<tr>
<td>Socket for above, 50c.</td>
</tr>
</tbody>
</table>

**INTEGRATED CIRCUIT SOCKETS**

Buy Any 3 - Take 10c.

- 16-Pin, dual in line .45
- TO-5, 8 or 10 pins .29

**LINEAR OP AMPS**

- **FACTORY GUARANTEED**
- **FACTORY VACUUM TIGHT**

<table>
<thead>
<tr>
<th>Mfr. Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>532</td>
<td>Micro power 741 (TO-5)</td>
</tr>
<tr>
<td>533</td>
<td>Micro power 709 (TO-5)</td>
</tr>
<tr>
<td>537</td>
<td>Precision 741 (TO-5)</td>
</tr>
<tr>
<td>555</td>
<td>Low-drift 555 timer (TO-5)</td>
</tr>
<tr>
<td>556</td>
<td>Precision 723 voltage reg. (DIP)</td>
</tr>
<tr>
<td>560</td>
<td>Precision 723 voltage reg. (DIP)</td>
</tr>
<tr>
<td>561</td>
<td>Phase lock loop (DIP)</td>
</tr>
<tr>
<td>562</td>
<td>Phase lock loop (DIP)</td>
</tr>
<tr>
<td>563</td>
<td>Phase lock loop (DIP)</td>
</tr>
<tr>
<td>564</td>
<td>Phase lock loop (DIP)</td>
</tr>
<tr>
<td>565</td>
<td>Phase lock loop (DIP)</td>
</tr>
<tr>
<td>566</td>
<td>Tone generator (DIP)</td>
</tr>
<tr>
<td>567</td>
<td>Tone generator (DIP)</td>
</tr>
<tr>
<td>702C</td>
<td>High-gain, DC amp (TO-5)</td>
</tr>
<tr>
<td>709C</td>
<td>Operational amplifier (TO-5)</td>
</tr>
<tr>
<td>709D</td>
<td>Operational amplifier (TO-5)</td>
</tr>
<tr>
<td>710C</td>
<td>Differential amp (TO-5)</td>
</tr>
<tr>
<td>711C</td>
<td>Dual diff. amp (TO-5)</td>
</tr>
<tr>
<td>714C</td>
<td>Frequency comparator 707 (A)</td>
</tr>
<tr>
<td>717C</td>
<td>Dual 741C (A)</td>
</tr>
<tr>
<td>744CV</td>
<td>Freque. adj. 741C (A)</td>
</tr>
<tr>
<td>747C</td>
<td>Dual 741C (A)</td>
</tr>
<tr>
<td>7480</td>
<td>Dual operational amplifier (DIP)</td>
</tr>
</tbody>
</table>

**HOT MOS FETS**

- **2-MOS FETS**, 10k ohms 1N4119, TO-18, 10c (3) |
- **2-MOS FETS, DUAL GATE**, 1N4104, TO-18, 35c (3) |

**NATIONAL-EQUALS ON "DIGITAL CLOCK on a CHIP"**

*Money Back Guarantee!* Any "Chip" with Spec Sheet! **$12.88**

**LED MITY DIGITS**

**"DCM'S"**

**9.99**

**Digital Connector**

INCLUDES P.C. EDGE CONNECTOR - FREE!

<table>
<thead>
<tr>
<th>Code</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Digit-A</td>
</tr>
<tr>
<td>B</td>
<td>Digit-B</td>
</tr>
<tr>
<td>C</td>
<td>Digit-C</td>
</tr>
<tr>
<td>D</td>
<td>Digit-D</td>
</tr>
<tr>
<td>E</td>
<td>Digit-E</td>
</tr>
<tr>
<td>F</td>
<td>Digit-F</td>
</tr>
<tr>
<td>G</td>
<td>Digit-G</td>
</tr>
<tr>
<td>H</td>
<td>Digit-H</td>
</tr>
<tr>
<td>I</td>
<td>Digit-I</td>
</tr>
<tr>
<td>J</td>
<td>Digit-J</td>
</tr>
<tr>
<td>K</td>
<td>Digit-K</td>
</tr>
<tr>
<td>L</td>
<td>Digit-L</td>
</tr>
<tr>
<td>M</td>
<td>Digit-M</td>
</tr>
<tr>
<td>N</td>
<td>Digit-N</td>
</tr>
<tr>
<td>O</td>
<td>Digit-O</td>
</tr>
<tr>
<td>P</td>
<td>Digit-P</td>
</tr>
<tr>
<td>Q</td>
<td>Digit-Q</td>
</tr>
<tr>
<td>R</td>
<td>Digit-R</td>
</tr>
<tr>
<td>S</td>
<td>Digit-S</td>
</tr>
<tr>
<td>T</td>
<td>Digit-T</td>
</tr>
<tr>
<td>U</td>
<td>Digit-U</td>
</tr>
<tr>
<td>V</td>
<td>Digit-V</td>
</tr>
<tr>
<td>W</td>
<td>Digit-W</td>
</tr>
<tr>
<td>X</td>
<td>Digit-X</td>
</tr>
<tr>
<td>Y</td>
<td>Digit-Y</td>
</tr>
<tr>
<td>Z</td>
<td>Digit-Z</td>
</tr>
</tbody>
</table>

**POLY PAKS**

**P.O. BOX 842 H. LYNNFIELD, MASS. 01940**

WANTED: tubes, transistors, equipment, what have you? Bernard Goldstein, W2MNP, Box 257, Canal Station, New York, N. Y. 10013.


GONSET Communicator III 2 meters $100. Gonset 3063 2 meter power amplifier $75, package $150; Motorola FJ-1114B, with NiCad 94’s $90. Heath TX-110 $110, HR-20 $75, HP-20 $25, HP-10 $35, Hustler 80-10 mobile antennas, mast mount $35, package $245; you pay shipping — W5PNY, 2506-A 35th St., Los Alamos, New Mexico 87544.


VICTOREEN SURVEY METER for sale, Model 440 — RF/C New, $50 or best offer. Bayard Rowan, W5FK, 55 Runnymede Road, Berkeley Heights, N. J. 07922.

AMERICAN PRODUCTS WANTED for sales in the Far East. W5PHA, Global America Corp., Box 246, El Toro, Calif. 92630.

RESISTORS: Carbon composition brand new. All standard values stocked. 1/2 W 40/10 $0.00; 1/2 W 10% 30/1 $1.00 — 10 resistors per value, please. Minimum order $5.00. 15W RMS IC Audio Amplifier. Panasonic, Frequency response 20-10,000 kHz, 1/2% distortion. Price $6.95 Postpaid. Pace Electronic Products, Box 161-H, Ontario Center, New York 14520.

THE TIPPECANOE ARA and the Indiana Radio Club Council is again sponsoring the Annual Indiana Club Council Picnic and Hamfest at the Tippecanoe County Fairgrounds, located at 1100 Teal Road (Indiana Route 25), Lafayette, Indiana. This is a family hamfest. Flea market, games, trailer parking, awards, and more. Tickets from any IRC club by mail, or at the gate. Tickets by mail from W89FOT, 2233 Delaware Drive, West Lafayette, Indiana 47906. All tickets $2, but if purchased by August 1, owner is eligible for pre-registration prize of a Motorola HT 220.

FOR SALE — Must sell brand new C7X4 Signal/One, $1600.00. Contact Lewis Grigsby Jr., Farmers State Bank, Pittsfield, Ill. 62363, 217-285-2194.

HOOSIER ELECTRONICS — Your ham headquarters in the heart of the Midwest where only the finest amateur equipment is sold. Individual, personal service by experienced and active hams. Factory—authorized dealers for Regency, Genave, Drake, Standard, Clegg, Ten-Tec, Kenwood, Tempo, Midland, Galaxy, Hy-Gain, Heathkit, Mort, Ham-M, Hustler, plus many more. Orders for in-stock merchandise shipped same day. Write or call today for our complete line of new and used equipment. Friendly Hoosier service. Hoosier Electronics, R. R. 25, Box 403, Terre Haute, Indiana 47802. (812) 894-2397.

QSLs. Second to none. Same day service. Samples 25¢. Ray, K7HRL, Box 331, Clearfield, Utah 84015.

YOUR AD belongs here too. Commercial ads 25¢ per word. Non-commercial ads 10¢ per word. Commercial advertisers write for special discounts for standing ads not changed each month.

More Details? CHECK-OFF Page 110

july 1973
WE’LL PUT YOU 20 FEET ABOVE THE ROOF

No Matter How High Your Home May Be

There’s a Heights tower to fit every need and every budget. Crank ups, foldovers, TV stand-alones -- we’ve got ‘em all.....and they’re all aluminum. You can make sure your antenna is mounted at the maximum legal limit the right way, the Heights way. And remember, Heights towers are all aluminum, Heliarc welded for light weight. They’re extremely rugged, and very easy to erect.

Write for 12 page brochure giving dozens of combinations of height, weight and wind load. We think you’ll be setting your operating conditions to new heights.

HEIGHTS MFG. COMPANY
Almont Heights Industrial Park “AT”
Almont, Michigan 48003

GATEWAY ELECTRONICS
8123 PAGE AVENUE
ST. LOUIS, MISSOURI 63130
314-427-6116

L. E. D. 7 SEGMENT READOUT — MAN 1
TYPE — NEW $2.75
L. E. D. SINGLE SEGMENT — STANDARD SIZE — RED — NEW $2.50
5 MHz CRYSTAL — Miniature size w/wire leads 3/$1.00
10 MHz CRYSTAL — Standard HC-6/U in 24 volt oven $2.50
HEP 411 MOTOROLA DATA LIBRARY SET — $6.50
contains data on transistors and diodes — both
house numbers and registered — 8 lb.

THUMBWHEEL SWITCHES
— 0.5 x 2.125 x 1.78 — 10 position decimal $3.00
— 10 position BCD & Compliment $4.00
— End Plates (per pair) $1.45

MINIATURE SIZE
— 0.312 x 1.3 x 1.3 — 10 position decimal $2.50
— 10 position BCD & Compliment $3.75
— End Plates (per pair) $1.00

$5 Minimum Order.
Visit us when in St. Louis.
Please include sufficient postage.

Radio Amateurs Reference Library of Maps and Atlas

WORLD PREFIX MAP — Full color, 40º x 28º, shows prefixes on each country. . DX zones, time zones, cities, cross referenced tables . . . postpaid $1.25

RADIO AMATEURS GREAT CIRCLE CHART OF THE WORLD — from the center of the United States! Full color, 30º x 25º, listing Great Circle bearings in degrees for six major U.S. cities, Boston, Washington, D. C., Miami, Seattle, San Francisco & Los Angeles... postpaid $1.25

RADIO AMATEURS MAP OF NORTH AMERICA! Full color, 30º x 25º — includes Central America and the Caribbean to the equator, showing all areas, zone boundaries, prefixes and time zones, FCC frequency chart, plus informative information on each of the 50 United States and other Countries. . . . postpaid $1.25

WORLD ATLAS — Only atlas compiled for radio amateurs. Packed with world-wide information — includes 11 maps, in 4 colors with zone boundaries and country prefixes on each map. Also includes a polar projection map of the world plus a map of the Antarctica — a complete set of maps of the world, 20 pages, size 8½” x 12” . . . . . . . postpaid $2.50

Complete reference library of maps — set of 4 as listed above . . . . . . . . . . . . . . . . . . . postpaid $3.75

See your favorite dealer or order direct.

More Details? CHECK-OFF Page 110
The most powerful signals under the sun!

Hy-gain

Redesigned

HAMCAT

Out-hustles them all!

The famous HAMCAT... now redesigned for greater performance... equals or exceeds the performance of any other Amateur Mobile antenna. We guarantee it! And you need buy only one mast... whether you mount it on fender, deck or bumper. There's just one set of coils and tip rods... and they all stand up to maximum legal power. That's performance, that's value... THAT'S HY-GAIN!

Original Hy-Q "quick changer" coils wound on tough fiberglass coil forms for greater heat resistance, less RF absorption / Fiberglass shielded coils can't burn up, impervious to weather / Shake-proof, rattle-proof, positive lock hinge now even stronger... eliminates radio noise / All stainless steel tip rods won't bend or break / Full 5' mast gives you 10% more radiating area than the competition / Rugged swivel-lock stainless steel base for quick band changes, easy garaging.

Get the Hamcat... from Hy-Gain

Order No. 257 All new design 5' long heavy duty mast of high strength heavy wall tubing $16.95
Order No. 252 75 meter mobile coil $19.95
Order No. 256 40 meter mobile coil $17.95
Order No. 255 20 meter mobile coil $15.95
Order No. 254 15 meter mobile coil $12.95
Order No. 253 10 meter mobile coil $10.95
Order No. 499 Flush body mount $ 6.50

HY-GAIN ELECTRONICS CORPORATION
P. O. Box 5407-WG, Lincoln, Nebraska 68505

More Details? CHECK-OFF Page 110
March 1968 (first issue)
FEATUREING: 5-band SSB exciter, IC-regulated power supply, remotely-tuned 10-meter beam, Transistor curve tracer, double-balanced mixers.

May 1969
FEATUREING: Potpourri of integrated-circuit applications, FM repeater receiver performance, RTTY converter, IC noise blanker, The ionospheric layer.

June 1969
FEATUREING: Solid-state single-band SSB transceiver, External-anode tetrodes, FM communications receiver, RTTY tuning unit, Top-loaded vertical.

August 1969
FEATUREING: Homebrew Parasitic Reflector, Solid-state Q-5er, Frequency calibrator with mos IC's, New multiband quad antenna, Troubleshooting with a scope.

September 1969
FEATUREING: FM techniques and practices, IC power supplies, 1296-MHz varactor trip lever, Tunable bandwidth filters, Amateur microwave standards.

October 1969
FEATUREING: Hot Carrier Diodes, Low-cost linear IC's, Diversity antennas, solid-state 432-MHz exciter, Tropospheric duct communications.

November 1969
FEATUREING: Op Amps... theory, selection & application, WWV receiver, Multiband antenna, Electronic key, Six-meter collinear.

June 1970
FEATUREING: Communications experiments with light emitting diodes, FM modulation standards, Designing phase-shift networks, Transistor frequency multipliers, RTTY frequency-shift meter.

July 1970
FEATUREING: Inductively tuned high frequency tank circuit, Solid-state receiver, Digital frequency counter, Two-meter kilowatt, SCR-regulated power supplies, High-frequency hybrids and couplers.

August 1970
FEATUREING: High-performance filter/preamplifier for vhf-uhf receivers, 100 MHz digital frequency scaler, Tunable audio low filter, Stable solid-state info, Cubical-quad antenna design.

October 1970
FEATUREING: An swr meter for accurate rf power measurements, Direct-conversion receiver, IC voltage regulators, 432MHz converter, Introduction to thyristors.

December 1970
FEATUREING: SSB generator, RF interference, Antenna bridge, QRP transmitter, AFSK oscillator.

April 1971
FEATUREING: Inductors, VHF and UHF coil-winding data, Using ferrite and powdered cores, FM control head, Power fets, Five-band linear amplifier.

June 1971
FEATUREING: A practical approach to 432-MHz SSB, FM carrier-operated relay, Audio agc systems, Practical IC's, Low-noise 1296-MHz preamp.

September 1971
FEATUREING: Practical Photofabrication of Printed-circuit boards, Injection lasers, FM sequential encoder, Multimode I-f system, RTTY aic, IC phase-locked loops.

March 1972
FEATUREING: Remotely switch ed broadband HF linear, 2500 MHz converter, FM I-f filter, reciprocating detector, digital integrated circuits.

April 1972
FEATUREING: 2 meter FM transmitter, SSB two-tone tester, direct conversion receiver, audio-actuated squelch, tuning toroidal inductors.

June 1972
FEATUREING: 5 Band solid-state communications receiver, FM repeater control, SSTV synch generator, microwave experimenting.

August 1972
FEATUREING: Frequency synthesizer for Drake R.4, 2304 MHz preamp, audio filters, RTTY Monitor scope, mobile touch-tone.

September 1972
FEATUREING: HF power amplifier, RTTY receiver, FM channel measure, RTTY distortion, frequency scaler, repeater timers.

October 1972
FEATUREING: 4 channel spectrum analyzer, HF frequency synthesizer, all-band dipole, 150 meter vertical, multi-function IC's.

December 1972
FEATUREING: Satellite communications, UHF swr bridge, RTTY monitor, receiver, FM channel elements, helical mobile antenna.

There's no place like a good collection of HAM RADIO back issues to find answers you're looking for. Go over the list above and find the ones you need.

Enclosed is... for the issues I have checked.

Name
Address
City, State
Zip

Call

104 HAM Radio july 1973

More Details? CHECK-OFF Page 110
The best antenna of its type on the market. Four wide spaced elements (the longest 36’6”) on a 26’ boom along with Hy-Gain’s exclusive Beta Match produce a high performance DX beam for phone or CW across the entire 20 meter band.

- 10 db forward gain
- 28 db F/B ratio
- Less than 1.05:1 SWR at resonance
- Feeds with 52 ohm coax
- Maximum power input 1 kw AM; 4 kw PEP
- Wind load 99.8 lbs. at 80 MPH
- Surface area 3.9 sq. ft.

The 204BA Monobander is ruggedly built to insure mechanical as well as electrical reliability, yet light enough to mount on a lightweight tower. (Recommended rotator: Hy-Gain’s new Roto-Brake 400.) Construction features include taper swaged slotted tubing with full circumference clamps; tiltable cast aluminum boom-to-mast clamp; heavy gauge machine formed element-to-boom brackets; boom 2” OD; mast diameters from 1½” to 2½”; wind survival up to 100 MPH. Shipping weight 51 pounds.

See the best distributor under the sun...the one who handles the Hy-Gain 204BA Monobander.

Model 204BA (4-element, 20 meters) ........................................... $149.95
Model 203BA (3-element, 20 meters) ........................................... $139.95
Model 153BA (3-element, 15 meters) ........................................... $ 69.95
Model 103BA (3-element, 10 meters) ........................................... $ 54.95

FERRITE BALUN MODEL BN-86
Improves transfer of energy to the antenna; eliminates stray RF; improves pattern and F/B ratio. $14.95

HY-GAIN ELECTRONICS CORPORATION
BOX 5407 - WG / LINCOLN, NEBRASKA 68505
Check-off...

INDEX

Amateur-Wholesale
Amtech
Andy
Antenna King
Antenna Specialists
B&G
Babylon
B・Y
Bird
Bitec
Carville
Clegg
Command
Communications
Specialists
Comtec
Control Signal
Cursons
Data
Gateway
Gray (V)
Great American
H & L
HAL
Ham Radio
Ham Radio Center
Heath
Hevac
Hy-Gain
Icon
International Crystal
International Field Day
Jan
Janel
KRP
KW
Knight Raiders
L. A. Electronix
Larsen
MPJ
Matric
Meshna
Mor-Gain
Motorola
Nurmi
Olin
Palomar
Pemco
Poly Paks
RP
Recam
Radio Shack
Regency
Sams
Saroc
Savoy
Signal Systems
Solid State
Space-Military
Spectrum
Swan
Tecno
Ten-Tec
Tri-Ex
Tristao
VHF Communications
VHF Engineering
Vintage
Weinschenker
Wheatlands
Wilson
World QSL
Y & C
Yaesu

Limit 15 inquiries per request.

July 1973

Please use before August 31, 1973

Tear off and mail to
HAM RADIO MAGAZINE — “check-off”
Greenville, N. H. 03048

NAME

CALL

ADDRESS

CITY

STATE

ZIP

ATV Research 101
Amateur-Wholesale Electronics 88
Amteck 88
Andy Electronics 88
Antenna King 56, 57
Antenna Specialists Co. 2
B & G Electronics 101
Babylon Electronics 94
B-A 96, 112
Carroll 82
Carroll International Corp. 84
Clegg Division of ISC 67
Command Productions 84
Communications Specialists 84
Comtech 94
Control Signal Corp. 105
Curtis 105
Data Engineering, Inc. 93
Drake, Co., R. L. 81
Dycom 80
Dynamic Electronics, Inc. 100
Eimac, Div. of Varian Assoc. 100
Emporium Sounds of Pompano 80
Epsilon Records 100
Fair Radio Sales 94
Frank Electronics 94
G & G Radio Supply Co. 77
Gateway 106
Goodheart Co., Inc. R. E. 86
Gray Electronics 84
Great American Miniatures 88
H & Associates 100
HAL Communications Corp. 83
Ham Radio 108
Ham Radio Center, Inc. 78
Heath Company 73
Heights Manufacturing Co. 106
Henry Radio Stores 101
Hi-Gain Electronics Corp. 51, 91, 107, 109
Icom 85
International Crystal Mfg. Co. Inc. 97
International Field Day 105
Jan Crystals 86
Jan Labs 80
KRPElectronic Supermarkt, Inc. 66
KW Electronics 78
Knight Raiders Hamfest 82
L. A. Electronix Sales 111
Larsen Electronics, Inc. 63
Logic Newsletter 77
MPJ Enterprises 92
Matric 88
Meshna, John, Jr. 92
Mor-Gain, Inc. 92
Nurmi Electronic Supply 79, 89
Olson Electronics 5
Palomar Engineers 78
Payne Radio 86
Pemco, Inc. 92
Poly Paks 103
RP Electronics 80
Raccon Electronics, Inc. 77
Radio Amateur Callbook 76, 106
Regency Electronics, Inc. 15
Saroc 92
Savoy Electronics 82
Signal Systems 82
Solid State, Inc. 98
Space-Military Electronics 92, 100
Spectrum International 92
Swan Electronics 87
Teco Electronics 90
Ten-Tec, Inc. 102, 103
Tri-Ex Tower Corp. 85
Tristao, Inc. 86
VHF Communications 84
VHF Engineering, Division of Brownian 90
Weinschenker, M. 89
Wheatlands Electronics 94
Wilson Electronics 100
Wolf, S. 100
World QSL Bureau 105
Y & C Electronics 60
Yaesu Musen USA Inc. 95

110 AT July 1973
“2” Rigs in one!

No longer is it necessary to choose between AM and FM on two meters. Now you can have both in one compact unit. Join the gang on the new FM repeaters yet still be able to "rag chew" with old friends either AM or FM anywhere in the two meter band.

ALL SOLID STATE - NO TUBES
MADE IN AMERICA

Compare These Features

TRANSMITTER:
- Built-in VFO (Frequency converted for stability)
- AM and FM both crystal and VFO
- Four transmit crystal positions (8 MHz)
- 12 watt input AM and FM
- High level transmitter modulation on AM
- Bandpass coupled transmitter requiring only final tune and load
- Three internal transmit crystal sockets with trimmers for netting
- One transmitter crystal socket on the front panel
- Deviation limiting
- 146.94 MHz crystal included

RECEIVER:
- Double conversion
- Crystal controlled first conversion
- MOS FET receiver front-end
- Integrated circuit limiter and discriminator for FM
- Envelope detector and series gate noise clipper for AM
- Built-in squelch for both AM and FM

GENERAL:
- Separate transmitter and receiver tuning
- Built-in 115VAC power supply
- Direct 12VDC operation for mobile or portable operation
- Optional portable rechargeable snap-on battery pack available
- "S" Meter also used for transmitter tune up
- Military style glass epoxy circuit boards
- Anodized lettering and front panel
- Baked epoxy finish on the cabinet
- 47 transistors, 22 diodes, 1 integrated circuit
- Dimensions: 10¼"W x 6½"H x 7½"D

All this for just $489.95

plus

FREE SHIPPING IN U.S.A.
5 FREE CRYSTALS ($29.50 VALUE)

Electronix Sales
23044 S. CRENSHAW BLVD., TORRANCE, CALIF. 90505
Phone: (213) 534-4456 or (213) 534-4402
CLOSED SUNDAY & MONDAY
See LA for your SWAN needs

July 1973 111

More Details? CHECK-OFF Page 110
BARRY presents
CLEGG FM-27B

Total 146-148 MHz coverage without buying a crystal. Latest model 25w. out, fully synthesized.
$479.95
Clegg FM-27B Regulated AC power supply $79.95

DYCOMM
2 Meter Repeater — Deluxe model $600.00
2 Meter Amplifiers (Power ratings approx.)
BRICK BOOSTER, 2w in 35w out $79.95
BLOCK BOOSTER, 10 in 50w out, new, $99.95
$79.95

DRAKE
TR-22, in stock $219.95
TR-72 2 meter FM transceiver, 23 channel, 1 & 10 watts, 13.8 VDC $299.95
AC-10 AC Supply for TR-72 $39.95
TR-4/C new, $599.95 W4 new, $61.95
R4C Rec. $499.95 T-4XC Trans. $529.95
AC-4 Drake A.C. Power Supply $99.95
MN-2000 — 2 KW PEP antenna tuner $195.00
AA-10 2 meter 10 watt linear amp. for use with $49.00
TR-22, etc.

COLLINS
F455F15 1.5 kc mechanical filter, unused $25.00
F455F60 6.0 kc mechanical filter, unused $19.95

TEN TEC
ARGONAUT MODEL 505, 5 band, SSB, 5 watt $288.00
ARGONAUT 405 LINEAR AMP. 100w. PEP, 50w. out $149.00
210 POWER SUPPLY for Argonaut 505 only $249.50
250 POWER SUPPLY, powers 505 & 405 $49.00
315 RECEIVER 10-80 meters SSB, AM, CW $229.00
CW FILTER FOR 315 $14.95
AC4 SWR Bridge $89.95
AC4 $12.95
AC5 Tuner $8.95

Large stock of inductors by B & W and Air Dux. Write or Order.
Barry has lots of James Millen and some National Radio parts in stock.

ETO
ALPHA-77. The finest amplifier ever offered for amateur, commercial or military service. 3000 watts PEP continuous duty. Perfect companion to CX-77A $1,495.00 net
1 CX7A brand new, latest version, trade or cash. RTTY Filters & CW Filters for CX7 & CX7A, write

INSTRUMENTS
Pan Adapter BC-1031A $1000 unused with spare parts & book $75.00

12 VOLT DC POWER SUPPLIES:
110 AC OUTPUT, all with full factory warranty
MODEL 102, is a 4 amp overloaded power supply that automatically resets itself when the overload is removed $24.95
MODEL 104R, is a regulated power supply with the same electronic overload protection as the model 102. MODEL 104R — new, $34.95
MODEL 107M is a heavier duty supply with the same features as the model 102 but puts out 6 amps, useful for Clegg 27 series, etc. new, $27.95

HALLICRAFTERS
SR-150 Transceiver 10-80 meters AC or DC power supplies. $479.95
SR-160 Transceiver 80, 40, 20 meters write
SR-150-R DC power supply for SR-150 $109.50
SR-160 new, $109.50
FPM-300 new, $95.00

STANDARD
SRC-146A 2 meter handheld transceiver $289.00
SRC-SA Desk Battery Charger $33.50
NiCad Batteries for SRC-146A (Set of 10 American made) $25.00

LITTLE LULU
Your chance to build a high quality deluxe AM, CW 6 meter transmitter. Can be converted to FM. See Aug. '63 QST, page 45 for complete details. 115 VAC and 12 VDC power. Parts and information available. Call or write for further details.

TEMPO
2 Meter Linear Amplifiers, 502, 5-12 watts input, 35-55 watts output $105.00
802-B 1-1/2 watts input, 80-90 watts output $195.00
TEMPO FMI 2 Meter Transceiver, 2 watt, 6 channel, handheld new, $189.00

MARINE
Barry stocks Sonar, Pearce-Simpson, SBE and Antenna Specialists VHF Transceivers, Antennas and Depth Finders.

DX ENGINEERING
SPEECH COMPRESSORS
DIRECT PLUG-IN FOR COLLINS 325 $79.50 ppd. U.S.A.
DIRECT PLUG-IN FOR KWM-2 $79.50 ppd. U.S.A.

Pay us a visit when you are in New York. Thousands of unadvertised specials.

BARRY ELECTRONICS
512 Broadway NY, NY 10012
212-WA-5-7000
See Page 96 for more from Barry

BARRY ELECTRONICS
DEPT. H-7
512 Broadway NY, NY 10012
212-WA-5-7000
See Page 96 for more from Barry

112 JULY 1973
More Details? CHECK-OFF Page 110
THE TEMPO ONE

SSB TRANSCEIVER

Look at the specifications... look at the price tag... ask any of the thousands of Tempo ONE owners about its reliability... and the reason for its unparalleled popularity will be obvious. The Tempo ONE is now the proven ONE.

FREQUENCY RANGE: All amateur bands 80 through 10 meters, in five 500 khz ranges: 3.5-4 mhz, 7-7.5 mhz, 14-14.5 mhz, 21-21.5 mhz, 28.5-29 mhz. (Crystals optionally available for ranges 28-28.5, 29-29.5, 29.5-30 mhz.)

SOLID STATE VFO: Very stable Colpitts circuit with transistor buffer provides linear tuning over the range 5-5.5 mhz. A passband filter at output is tuned to pass the 5-5.5 mhz. range.

RECEIVER OFFSET TUNING (CLARIFIER): Provides ±5 khz variation of receiver tuning when switched ON.

DIAL CALIBRATION: Vernier scale marked with one kilohertz divisions. Main tuning dial calibrated 0-500 with 50 khz. points.

FREQUENCY STABILITY: Less than 100 cycles after warm-up, and less than 100 cycles for plus or minus 10% line voltage change.

MODES OF OPERATION: SSB upper and lower sideband, CW and AM.

INPUT POWER: 300 watts PEP, 240 watts CW

ANTENNA IMPEDANCE: 50-75 ohms

CARRIER SUPPRESSION: -40 db or better

SIDEBAND SUPPRESSION: -50 db at 1000 CPS

THIRD ORDER INTERMODULATION PRODUCTS: -30 db (PEP)

AF BANDWIDTH: 300-2700 cps

RECEIVER SENSITIVITY: X-ray input S/N 10 db

AGC: Fast attack slow decay for SSB and CW.

SELECTIVITY: 2.3 khz, (-6 db), 4 khz, (-60 db)

IMAGE REJECTION: More than 50 db

AUDIO OUTPUT: 1 watt at 10% distortion.

AUDIO OUTPUT IMPEDANCE: 8 ohms and 600 ohms

POWER SUPPLY: Separate AC or DC required. See AC "ONE" and DCT-A.

TUBES AND SEMICONDUCTORS: 16 tubes, 15 diodes, 7 transistors.

TEMPO "ONE" TRANSCEIVER $349.00

AC/ONE POWER SUPPLY 117/230 volt 60 cycle $99.00

DC/1-A POWER SUPPLY 12 volts DC $110.00

VF-ONE EXTERNAL VFO $99.00

Tempos one can supply the complete line of Yaesu equipment.

Henry Radio line has established a solid reputation for first rate performance at a reasonable price. Whether your interests lie in high frequency SSB or VHF/UHF FM, Tempo deserves your serious consideration. You will never be sorry.
EIMAC super-power tetrodes provide transmitter "building blocks" up to 10.4 megawatts, 100% modulated.

1.3 megawatt carrier 100% modulated

Draw your own 10.4 megawatt transmitter here.

For information on the X-2159 and X-2170 super-power tetrodes, contact the EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070. Or any of the more than 30 Varian /EIMAC Tube and Device Group Sales Offices throughout the world.