focus on communications technology...

Ham Radio Magazine
October 1974

This month

- Log-periodic feed systems 30
- High-stability crystal oscillator 36
- Cubical-quad design 44
- Automatic reset timer 50

High-efficiency rf power amplifiers
Here is all the dynamic powerful performance needed to punch through QRMs, without an accessory amplifier. SWAN's 700CX Champion transceiver lets you enjoy a more responsive value-packed ham station, for less cost-per-watt, than any other rig in its class... less than 86¢ per watt if you have your own power supply... less than $1.05 per watt with SWAN's 117-XC deluxe AC power supply with matching cabinet and built-in speaker... and, less than 98¢ per watt with the 117-X AC power supply.

Quality is not sacrificed. Cross-modulation and front-end overload will not plague or frustrate your communications. This Champion delivers a full 700 watts P.E.P. input on 10, 15, 20, 40 and 80 meters with selectable USB, LSB, AM, or CW with sidetone. For extra frequency coverage, plug in an optional 510-X crystal oscillator. If you want separate transmit and receive frequencies, use a 508 VFO accessory. VOX? Yes, with SWAN's plug-in VX-2 option. You can also hook up an FP-1 telephone patch to the 700CX. Even if you insist on more power, you can obtain the maximum legal limit of 2000 watts by adding a SWAN Mark II linear amplifier.

Whatever your style, the Champion 700CX is a winner. Whether you select the 700CX for your home station, its portability, for mobile use, or for its many compatible accessories—you can count on this Champion to give superior performance — everyday!

With all this talk about cost per watt, you may be interested in SWAN'S WM-1500 In-Line Wattmeter. Read forward or Reverse power on four scales from 0 to 5, 50, 500 and 1500 watts. Accuracy is better than 10% full scale on frequencies from 2 to 30 MHz.

WM-1500 In-Line Wattmeter ............ $64.95

DEALERS THROUGHOUT THE WORLD
or order direct from SWAN ELECTRONICS

Home Office: 305 Airport Road • Oceanside, CA 92054 Telephone: (714) 757-7525

THE BEST PRACTICAL DEVELOPMENTS IN AMATEUR RADIO
Don’t let its size fool you. The ALPHA 374 is a BIG LINEAR in every respect except bulk . . . a high performance package all the way.

ALPHA 374 DELIVERS BRUTE POWER – Comfortably handles continuous maximum legal power in any mode . . . even FSK or SSTV.

HANDLING CONVENIENCE HAS A NEW MEANING – Just flip the bandswitch and start talking. Bandpass circuits do away with normal tune-up.

“PARKING” IS A SNAP – ALPHA 374’s lean 52 pounds won’t break your back and the sleek one-cubic-foot cabinet fits in anywhere.

ALPHA 374’s superb performance — state-of-the-art convenience — famous ALPHA quality and full-year warranty . . . all can be yours for years of operating pleasure at surprisingly reasonable cost.

WHAT ARE YOU WAITING FOR? Contact your dealer now (or ETO directly if more convenient), and start enjoying your own ALPHA 374 right away.

ETO
EHRHORN TECHNOLOGICAL OPERATIONS, INC.
BROOKSVILLE, FLORIDA 33512
(904) 596-3711
INTRODUCING THE

MODEL CX-11... Deluxe Integrated Station

9 New Features

New solid state broadband linear power amplifier 10-160 meters. 175 Watts DC output — requires no tuning, operates into any VSWR — continuous duty at full rated output.

New concept front-end design — utilizing double active balanced mixers for unmatched sensitivity, blocking and cross-modulation rejection.

Solid-state modular construction utilizing gold-plated, pins and plug-in sockets for all transistors, IC's, and circuit board connectors.

Five Bandwidths of selectivity are standard — 2.4, 1.5, 1.0, .4, .1 kHz.

Peak notch filter with adjustable frequency notch depth and Bandwidth controls.

RTTY narrow and wide shift FSK-LSB.

Built-in electronic Keyer with independent speed and weight control and partial or full dot memory.

Power supply completely self-protecting — both thermal and current overload, integrated circuit controlled.

New six-digit frequency counter utilizing new 1/2 inch amber or red LEDs optimized for a non-blinking, stable display.

ADDITIONAL FEATURES

Dual VFO's for transceive, split operation, or dual receive.

Adjustable IF shift.

Receive or transmit offset tuning.

Push Button spotting.

Adjustable R.F. clipping.

Instantaneous break-in CW.

Built-in Wattmeter.

Built-in noise blanker.

Adjustable R.F. power output.

Pre-IF, adjustable noise blanker.

Now in production at $2600

Distributed by

PAYNE RADIO

BOX 525, SPRINGFIELD, TENNESSEE 37172

Phone (615) 384-5573 — Nights (615) 384-5643

In Europe contact:

SB COMMUNICATIONS

Palmtorpsvagen 3

S-640 20 BJORKVIK, Sweden

Due to our tremendous growth — openings now available for communications design engineer, engineering aids and technicians.

Up date your CX7, CX7A to the CX7B with the all new 4-digit LED freq. counter and the new IC self-protecting CX7B power supply.

Complete Parts & Service At

Box 127 Franklin Lakes, NJ 07417
Tel: (201) 891-0459

2 October 1974
October, 1974
volume 7, number 10

staff
James R. Fisk, W1DTY
editor-in-chief
Joseph Schroeder, W9JUV
editor
Patricia A. Hawes, WN1QJN
assistant editor
J. Jay O'Brien, W6GDO
fm editor
Alfred Wilson, W6NIF
James A. Harvey, WA6IAK
associate editors
Wayne T. Pierce, K3SUK
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, worldwide:
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 WC1N 2AE, England

All European countries
Eskil Persson SM5CJP
Frotunagrand 1
19400 Upplands Väsby, Sweden

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

Copyright 1974 by Communications Technology, Inc.
Title registered at U.S. Patent Office
Printed by Wellesley Press, Inc.
Framingham, Massachusetts 01701, USA

Microfilm copies of current and back issues are available
from University Microfilms
Ann Arbor, Michigan 48103

contents

8 high-efficiency rf power amplifiers
Frederick H. Raab, WB8LQK

30 log-periodic feed systems
George E. Smith, W4AEO

36 high-stability crystal oscillator
Donald L. Stoner, W6TNS

40 simple vfo for fm transceivers
Paul O. Franson, WB6VKY

44 mechanical design of cubical-quad antennas
R.C. Golding, VE3II

50 automatic reset timer
Harvey N. Vordenbaum, W5ZHV

53 stereo technique enhances cw reception
Max Blumer, WA1MKP

56 storage-battery QRP power
Edward M. Noll, W3FQJ

4 a second look
94 advertisers index
83 flea market
62 ham notebook

66 new products
94 reader service
6 stop press

october 1974
In our ever more populated world, with its growing proliferation of electronic gadgets, it's the rare amateur who hasn't been bothered at one time or another by interference complaints. In the 1930s, as more and more broadcast stations came on the air, it was BCI. Then, in the late 1940s, it was TVI. Now, with exotic solid-state stereo and quadraphonic systems, the interference problem has become more widespread. It's also much more difficult to cure. Nor, as I pointed out in this column over a year ago, is the problem limited to amateurs. Consumers who live near high-powered television and fm broadcast stations regularly complain of unwanted interference. And the 900,000 or so class-D CB stations receive a share of the blame as well.

Clearly, the problem can be effectively solved only by proper design and construction at the manufacturing level. Why, you may ask, isn't this done now? Wouldn't it be a lot easier to properly design the equipment in the first place than to try to cure the problem piecemeal after the equipment is installed in the consumer’s home?

The answer lies in the economics of the design and sale of equipment in a highly competitive market. The manufacturers are obviously reluctant to add filtering or lead bypassing that would increase the size of the price tag. Until recently, in fact, they have contended that only 1% of home entertainment equipment operates in a strong rf environment which requires additional lead filtering or bypassing. However, an Electronics Industries Association spokesman acknowledged recently that the widespread growth of two-way radio systems, as well as higher-power a-m and fm broadcasting stations warrants another look at the manufacturers' present position. However, with dwindling profit margins brought on by inflation, I see little chance manufacturers will voluntarily do anything to solve the RFI problem.

What is needed is Congressional or FCC action to require all manufacturers of TV sets, stereo systems, and a-m and fm receivers to build interference suppression into their designs. Although the late Rep. Charles Teague of California introduced Congressional legislation in 1973 which would have required radio and television sets to meet FCC standards for filtering out interference, that bill, which is still pending, did nothing about radio interference to audio equipment. And, according to Rep. Torbert Macdonald of Massachusetts, Chairman of the House Commerce Subcommittee on Power and Communications, there is considerable legislative opinion that the FCC can require the manufacturers to put lowpass filters into TV receivers without additional legislation.

The ARRL Radio Frequency Interference Task Group, which has been working on the problem for over a year, has put together a packet of material which may prove helpful if you are experiencing rf interference problems. The packet, which includes a wealth of useful data, is available by sending a large (9x12-inch), self-addressed Manila envelope with $0.40 postage to Ted Cohen, W4UMF, 8603 Conover Place, Alexandria, Virginia 22308. Included is a questionnaire which will assist the ARRL RFI Task Force in its work with the FCC and representatives of the electronics industry. Let's all get behind this worthwhile effort.

Jim Fisk, W1DTY
editor-in-chief
Super Mast
Small in a big way.

For the low profile Ham operator.

It had to happen! The enormous success of Tri-Ex's original Sky Needle—by popular demand—has brought about the design of a miniature Sky Needle for the Tri-Band Beam. We call it Super Mast.


Shown here in its nested position at 21-feet, this Super Mast is supporting a three element 15 meter antenna & rotor assembly. Rush your order now. Visit or call your local Tri-Ex Tower dealer today. Price of this under-$300-tower, because of rising steel costs, is subject to immediate change.

7182 Rasmussen Avenue, Visalia, Calif. 93277

TOWER CORPORATION
Order now and save!
AMATEUR RESPONSE TO CURRENT FCC DOCKETS DISAPPOINTING as few amateurs take time to comment on the many important FCC actions now pending. Let's get with it!

Three Long-Awaited Repeater Actions (repeater linking, cross-banding and automatic control) have received a grand total of two comments thus far, both on automatic control (one wants rules tightened, other wants no rules at all!).

RACES Docket, on the other hand, has had lots of response -- 95% of it from RACES people, and almost 100% of that 'anti-ham!' Comments range from 'RACES needs paid professional operators -- hams are not competent emergency communicators' to one state organization that proposes taking the present RACES band segment away from the amateur service and reassigning it to state and local governments for full-time RACES use! One thing is certain: RACES has not received good amateur support in most areas.

REDUCED FEES FOR AMATEUR LICENSES offered in Docket 19658 issued August 12. License modification without renewal would be reduced to $5, renewal or new licenses to $6. Special calls remain at $25. Comments by September 20, replies by October 4.


ARRL ADVISORY COMMITTEE OPENINGS on the Contest, DX and VHF Repeater committees upcoming as many present appointments expire January 1, 1975. Nominations to fill the open slots are solicited, and the proper forms for making nominations are available on request from ARRL headquarters in Newington, Connecticut.

HAWAII SITE FOR NEW 1975 HAMFEST. Promoted by Leonard Norman of SAROC/Las Vegas fame, this new show is in addition to SAROC. A week-long affair is planned with package deals from all major U.S. cities. For developing details write to Leonard at SAROC, Box 945, Boulder City, Nevada 89005.

NATIONAL RADIO RIDES AGAIN. All assets of the former National Radio Company have been purchased by new National Radio Company, Inc., with plans to resume manufacture of most of the former company's product lines in Melrose, Mass.

PROBLEM WITH KEYBOARD CW BUFFS is proper IDing. FCC monitors are not set up to copy super-high-speed CW, so perhaps FCC rule limiting RTTY CW ID to 20 wpm should be extended to all modes. Forearmed is forewarned...

FCC COULD LICENSE ALIENS under provisions of Senate bill S.2457 now under consideration. This bill would enable many now prohibited to become licensed, and expedite licensing of others now eligible by bypassing considerable red tape.

ILLINOIS STATE POLICE APPLY FOR 2000 CB LICENSES, put FCC on spot as to whether this is "proper" CB use. Police/citizen groups are using CB in several areas, but question seems to be what impact CB licensing of a large force would have.

AT TEXAS VHF-EM SOCIETY CONVENTION in August FCC Amateur and CB Division Chief Prose Walker delivered a Special Temporary Authority for activation of TIRS (Texas Intercity Relay System) that permitted demonstration of the capabilities of this sophisticated multi-repeater linkup.

Prose also discussed restructuring of amateur radio, and reviewed a variety of possible approaches including a separate license for HF or VHF/UFH (with distinctive prefix -- AA-AL block is already ours, and attempts are being made to break N and NA-NZ prefixes loose from the Navy).

ARRL NEW ENGLAND DIVISION DIRECTOR CHAPMAN RETIRES effective December 31, but Bob, W1QV, plans to continue as President of the ARRL Foundation until the end of his term next March.
Instead of just saving QSL cards, you can help us save lives in the U.S. Coast Guard.

You could be the communications link between a freighter sinking in a raging storm and the Coast Guard’s search-and-rescue teams.

You could be radioing for supplies to feed the victims of a raging Mississippi River flood.

You could be sending pollution-control experts out to contain an oil spill off California.

In the Coast Guard, there’s nothing routine about being a radioman. When you’re doing the job you want to do, you’re helping others at the same time.

Last year we answered over 60,000 calls for help. Picked up signals from all over the world.

Even if you’re not yet an amateur, you could qualify for radioman school. If you do, we’ll pay you over $300 a month to start. Not to mention free food, housing, and medical care. And there’s an added benefit. One of our radiomen, in his free time, worked over 165 countries and all zones. In only three months.

We’ll build your code speed to 18-26 WPM. And teach you voice, teletype and radioteletype procedures on the most modern transceivers.

So if you’re between 17 and 26, send in the coupon. Find out about all the benefits of our guaranteed Radioman School Program.


Once you discover what a job as a Coast Guard radioman can do for you, we think you’ll get the message.

Help others/Help yourself.
Join the lifesavers.
The Coast Guard.

Commandant (G-PMR-4)
U.S. Coast Guard, Washington, D.C. 20590

I’d like to know more about the Coast Guard’s guaranteed Radioman School Program.

Name ___________________ Age _______
Street ___________________ Apt. # _______
City _______ State _______ Zip _______
Phone _______ Soc. Sec.# _______
Since the demise of the spark gap, radio amateurs have been plagued by inefficient transmitters. The transistor eliminated the power consumed by the filaments of vacuum tubes, but the inefficiency inherent in class-A, -B and -C amplifiers remained. Now class-D techniques (also called switched-mode or class-S) offer a means of eliminating some of the remaining inefficiency. These techniques can be applied to both audio and rf amplifiers, as well as to voltage regulators.

There are a lot of reasons an amateur might want to use class-D, including less input power for the same output, more output for the same input, smaller power supplies or batteries (lower energy consumption), and smaller heatsinks and transistors. In addition, the transistors don’t have to be linear.

You might use class-D to build a transmitter with a legal output of 900 watts. High-efficiency operation will keep this rig from heating your operating room at the same time. Class-D operation not only reduces your electric bill, it result in saving even more power at the generating plant (1 to 2 watts there for each watt saved in your transmitter).

Why are ordinary amplifiers inefficient, anyway? When used as a class-A, -B or -C amplifier, a transistor (or tube, fet etc.) sustains a non-zero voltage while it is conducting current. Whenever both voltage and current are present, power is consumed. The amount of power consumed depends on the class of operation—what portion of the time the active device is actually conducting current.

Class-A amplifiers conduct current all the time, and when amplifying a sine wave, efficiency is no greater than 50 percent. Since class-B amplifiers conduct current half the time, they can achieve 78.5% efficiency with sine-wave signals. Class-C amplifiers conduct current less than half of the time and do not, theoretically, have limited efficiency. However, practical limits (drive power, peak current, etc.) make it difficult to achieve very high efficiencies; maximum typical efficiency for class-C operation is 85 percent.

Class-D operation can provide more efficiency because it avoids the conditions of simultaneous non-zero voltage and non-zero current which cause power to be consumed in the transistor. The transistors act as switches. When the transistors are off (open), the current is zero, so no power can be dissipated. When the transistors are on (closed), the transistors have (nearly) zero voltage drop across them, so again no power is dissipated. So long as the transistors can be switched...
fast enough and saturated well enough, high-efficiency operation is possible.

The difference between linear and switched-mode amplifiers is best shown by an example. Suppose that you have a lamp which consumes 100 watts when connected to 100-volts dc, and that you want to dim it to 50 watts (fig. 1). The easiest way to reduce power is to insert a resistor in series with the lamp, adjusting its value to produce 50-watts dissipation in the lamp. If you go through the calculations, you will find that this class-A dimmer consumes about 20.7 watts, making its efficiency 70.7 percent.

To make a class-D dimmer, you would use a switching transistor instead of the resistor (fig. 1C). The transistor would be driven so that it is turned on 50% of the time and off the other 50%. The lamp will then consume an average of 50 watts and the transistor switch will consume (almost) nothing, thus having an efficiency of (almost) 100%. Note that the switch must operate fast enough so that you cannot see the lamp flicker.

A technique which is useful when designing linear high-efficiency rf amplifiers is envelope elimination and restoration. The EER technique (fig. 2) was developed by Kahn in the early 1950s as a means of adapting high-power a-m transmitters to ssb service.\(^1,2\) Basically, this technique treats a single-sideband signal as a carrier which is both amplitude and phase modulated. Before amplification, the envelope (amplitude) is detected and the carrier amplitude is limited. The phase-modulated, constant-amplitude carrier may now be amplified by nonlinear rf amplifiers. The envelope signal is an audio signal with frequency components from dc to about 10 kHz (four times the tone separation will do), and can be amplified by linear audio amplifiers. The two signals are combined by amplitude modulating the last stage of the rf amplifiers, producing an amplified ssb signal. This technique is useful in high efficiency amplification since it is generally much easier to build linear class-D audio amplifiers than linear class-D rf amplifiers.

In this article I will attempt to give you a basic understanding of what class-D operation is all about. Understanding class-D requires close attention to where current flows and why a voltage is what it is. Never assume a particular waveshape just because it seems reasonable; make sure something causes it.

**class-D audio amplifiers**

Class-D audio amplification is often referred to as pulse-width modulation (PWM) because this technique is used in class-D audio amplifiers. Applications include both amplitude modulators and loudspeaker amplifiers, and all power levels of interest to amateurs are feasible. The use of integrated circuits makes the modulation circuitry quite simple.

Audio-frequency PWM is somewhat similar to the class-D light dimmer. A combination of transistors and diodes acts as a switch which applies a voltage pulse train to the load through a lowpass filter.
filter. The pulse width determines the average voltage, which is the output of the lowpass filter. The output (average) voltage can be varied to reproduce a desired audio signal by varying the pulse width.

**a-m modulator**

When a class-D audio amplifier is used as an a-m collector modulator, both the voltage and current outputs will always be positive. The switch, composed of a transistor and a diode (fig. 3A), connects the inductor in the lowpass filter to either \( +V_{cc} \) or ground (zero voltage). The lowpass filter has a high input impedance at the switching frequency, but allows the desired audio frequencies to reach the load. Load resistor \( R \) represents the rf amplifier to be modulated.

If the pulse width is 50% of the period of the switching frequency, the average voltage is 50% of \( V_{cc} \). Since the lowpass filter allows only low-frequency voltages to reach the load, with a 50% pulse width a current of \( V_{cc}/2R \) flows in the load. As the pulse width is varied from zero to 100%, the load voltage varies from zero to \( V_{cc} \), and the load current varies from zero to \( V_{cc}/R \).

When the transistor is driven on, current flows through the inductor into the load; when the transistor is turned off it stops conducting current. The inductor resists any instantaneous change in current flow and draws what it needs through the diode. Therefore, the diode acts as part of the switch and cannot be eliminated from the circuit. Note that no current at the switching frequency flows into the load; hence, there is no power dissipated at the switching frequency. When the transistor or diode conducts current, the voltage across it is very small (saturation voltage), so the switch is very efficient.3.4.5

**loudspeaker amplifier**

If class-D is to be used in an audio power amplifier or other ac-coupled application, the output circuit becomes more complicated as shown in fig. 4. A blocking capacitor, \( C_B \), prevents dc current from flowing into the load but requires that current be able to flow from the load into the switch during any part of the ac cycle. This requires a second transistor-diode pair. A pulse width of 50% produces no current flow at all. As the pulse width is varied, low-frequency current flows into the load.

A third variation of the output stage is sometimes called the class-BD amplifier6 (the previous configurations are then called class-AD). The class-BD circuit is essentially both a positive and a negative voltage modulator (fig. 5). This configuration is very versatile because it can produce both ac and dc outputs. Also, when there is no signal input, the ampli-
CIRCUIT EQUIVALENT CIRCUIT

VOLTAGE PULSES

TRANSISTOR CURRENT

DIODE CURRENT

fig. 3. Basic audio-frequency pulse-width modulation circuit with voltage and current waveforms.

A Pulse-width modulation can be accomplished quite easily using only a couple of integrated circuits. Fig. 6 shows how a triangle wave can be compared to the audio input signal to generate pulses with harmonics. As the pulse width is modulated, the dc component is modulated linearly to produce the desired output signal. The switching frequency and its harmonics are also modulated, but their modulation is highly nonlinear, resulting in a large amount of splatter near these frequencies. When the switching frequency is much higher than the audio frequency the splatter is reduced to negligible levels at the passband of the output filter.

The input impedance of the low-pass filter should be much higher than the load resistance to prevent significant current flow at the switching frequency. A good way to accomplish this is to use a large inductor at the input of the filter — its reactance, at the switching frequency, should be ten times the load resistance.

If the class-D amplifier is used as a loudspeaker amplifier, the output filter should attenuate the switching frequency by at least 40 dB. If the circuit is used as an a-m modulator, the filter should attenuate the switching frequency 80 dB to prevent adjacent-channel interference. A two-pole, lowpass filter will provide 40-dB attenuation per decade; a four-pole filter will provide 80-dB per decade attenuation.

It is convenient to make the cutoff frequency of the filter equal to the highest audio frequency and the switching frequency ten times higher; this allows 40-dB attenuation of the switching frequency for each two poles (L-C pair) in the output filter. The inductor value is chosen to have a reactance of 10R at the switching frequency and the capacitor is chosen to resonate with the inductor at the cutoff frequency. The capacitor can be any good quality capacitor. The inductor should use a toroid which has relatively high Q at the switching frequency.

generating PWM

Pulse-width modulation can be accomplished quite easily using only a couple of integrated circuits. Fig. 6 shows how a triangle wave can be compared to the audio input signal to generate pulses with
Whenever the input audio signal is greater than the triangle signal, the output pulse amplifier is driven on.

A good triangle wave of about 1-volt peak-to-peak can be generated by integrating a 12-volt peak-to-peak square wave with a lowpass R-C filter. The square wave can be generated by a simple multivibrator built from CMOS NOR gates as shown in fig. 7. A high-speed comparator such as the 710 is then used to produce the pulses (fig. 8).

An alternative means of generating the pulses is to use a NE555 timer IC. The circuits are described in the applications notes. This modulator varies only the trailing edge of the pulse, but that really doesn't matter much. For linear PWM, however, you must charge the modulator capacitor from a current source rather than through a resistor. A recent paper by Subbarao describes a simple PWM circuit using a unijunction transistor to generate the triangle wave (if you try his circuit, I suggest using the diodes in the output as described here).

### Pulse amplifiers

Switching (pulse) amplifiers can be designed quite easily since there are only three basic considerations:

1. There must be enough base current to saturate the transistors.
2. There must be enough drive voltage to cut off the transistors.
3. Rise time must be much smaller than the switching frequency.

The third requirement is satisfied by using transistors with a gain-bandwidth product at least ten times the switching frequency (or transistors with a rise time no larger than 5% of the switching period). There are many inexpensive switching transistors suitable for low and medium power levels.

Pulse amplifiers are best designed by working from the output stage back to the pulse source. A sample design is shown in fig. 9. Assume that the peak output current is 1 ampere, and that the minimum current gain of transistor Q3 is 25 (from the data sheet). The base current required to saturate Q3 at all times is then

$$i_{b3} = \frac{ic3}{\beta} = \frac{1A}{25} = 40 \text{ mA}$$

The output transistor is to be driven by the complimentary transistor pair, Q1 and Q2. Under saturated conditions, silicon transistors have typical collector-emitter voltages of 0.3 volt and typical base-emitter voltages of 0.7 volt. Transistor Q2 must be on to turn Q3 on, so the voltage at point D will be 0.3 volt. The voltage on the base of Q3 (point E) will be 0.7 volt below $V_{cc}$, or 11.3 volts. The maximum value of $R_3$ is then

$$R_{3\text{ max}} = \frac{11.3 - 0.3}{0.040} = 275 \text{ ohms}$$

![fig. 4. Basic class-D audio power amplifier (also called class AD).](image)
A PWM signal can be generated by comparing a sinusoidal input signal to a reference triangle waveform. A suitable triangle waveform generator is shown in fig. 7; a PWM generator using an IC comparator is illustrated in fig. 8.

Use the nearest standard value (270 ohms). When transistor Q1 is on and Q2 is off, point D will be at 11.7 volts (12 - 0.3). Since this is greater than the 11.3-volt saturation voltage, transistor Q3 should be cut off.

A similar process is used to choose a value for R2 (6800 ohms), assuming that point A is also driven by a complimentary pair. Note that although transistor Q1 does not conduct any sustained current, it will conduct the same surge current while switching, so R1 should be the same value as R2. A complimentary pair (such as Q1 and Q2) will generally be necessary for high switching speeds. If you use a single transistor and collector resistor, turn-on will be fast. However, turn-off will be slow because the collector capacitance must discharge through the resistor.

An emitter follower pair cannot provide any voltage gain, and will produce a smaller voltage swing in the output, and thus be less efficient. For these reasons a voltage gain pair is usually better. However, there are disadvantages. If point A is disconnected from its drive, both Q1 and Q2 will turn on, causing a short circuit, probably destroying themselves and Q3 as well. During switching this same process can cause a large current spike, reducing efficiency. It is generally a good idea to put a small resistor (1% to 5% of R3) somewhere in the collector path to reduce these effects.

Transistor base capacitance can be a significant impediment to high-speed switching. Before a transistor can turn on, its base capacitance must be charged to 0.7 volt through the base resistor. This produces an output waveform delayed from the driving waveform. This effect can be overcome by using speed-up capacitors (C1, C2 and C3 in fig. 9). These capacitors have much the same effect as the trimmer capacitor in an oscilloscope probe. The correct capacitance value causes a square-wave voltage (rather than a damped voltage) to appear on the base.

It is probably possible to calculate the values of these capacitors, but it is much easier to find the values by trial and error. Use an oscilloscope to compare the rising edges of the square waves at points A and D. Install capacitors C1 and C2 and observe that the delay becomes smaller; increase the value of C1 and C2 until the delay is negligible. Do not use more capacitance than is necessary as this will load the driver and slow the amplifier. Base-to-emitter resistors (such as R5) may be added to provide return paths for the speed-up capacitors. This helps to keep the transistors off when not driven on.

Typical values (determined experimentally) are one-half to one-third of the corresponding base resistors.

One last comment on pulse amplifiers. Fixed voltage changes can sometimes be made by using diode drops. The diode(s) will conduct only when the applied voltage is large enough.

**Efficiency**

What efficiency can you actually expect? Both saturation voltage and non-instantaneous switching reduce the efficiency of the output stage, and these and current spikes reduce the efficiency.
of the driver stages. The driving resistors also consume power. Although exact calculation of efficiency requires some complicated formulas, here are some rules of thumb that give ballpark answers:

1. Decrease the efficiency of the output stage by subtracting the saturation voltage-to-$V_{cc}$ ratio from 1. If the saturation voltage is 0.3 volt and the supply is 12 volts,

   $$\eta = 1.00 - \frac{0.3}{12} = 1.0 - 0.025 = 97.5\%$$

2. Further decrease the efficiency by subtracting the ratio of the time spent in switching to the switching period. If the switching frequency is 100 kHz (10 $\mu$s) and the rise time is 100 nanoseconds,

   $$\eta = 0.975 - \frac{2 \cdot 100 \text{ nsec}}{10 \mu\text{sec}} = 95.5\%$$

3. Most of the power dissipated in the amplifier will be dissipated in the output stage and its base driving resistor(s). The power consumed in the base resistor is approximately equal to the output power reduced by the ratio of base current to output current. This decreases the efficiency by the ratio of $i_b$ to $i_c$ (or by $1/\beta$)

   $$\eta = 0.955 - \frac{41 \text{ mA}}{1 \text{ A}} = 91.4\%$$

Remember that these rules are only approximate, so the actual efficiency will be lower at less than peak output. Before you get discouraged, though, remember that saturation voltage and drive power reduce class-B efficiency, and that peak power contributes most to the average efficiency.

**power regulators**

Class-D operation can also be used for ac and dc power control. SCRs and triacs can be used to chop an ac waveform to produce the desired output power. These devices turn on when driven and stay on until the output current ceases (at the end of an ac half cycle). SCRs conduct current in only one direction, while triacs conduct current in either direction.

Dc voltages (or currents) can be regulated efficiently by switching regulators. A voltage-reducing regulator circuit looks like a simplified audio amplifier (fig. 10). The high-gain amplifier compares the output of the lowpass filter to the desired reference voltage. If the output voltage is lower than the reference by more than a small amount, transistor Q1 is turned on and the output voltage begins to rise. When the output voltage exceeds the reference by more than a small amount, Q1 is switched off and the output begins to fall. In this manner the output voltage is kept within a small fixed amount of the reference voltage. The switching frequency depends on the output filter and current, and varies with changing load conditions. The high-gain amplifier and voltage reference regulator circuit is discussed in the text.
are often available in a single IC such as the μA723.

**class-D rf amplifiers**

Class-D operation can also be used to build high-efficiency rf amplifiers. In this case the switching frequency component of the pulse train becomes the rf carrier and is coupled to the load through a bandpass filter rather than a lowpass filter. Fig. 11 shows the equivalent circuit of a simple class-D rf amplifier. Switches S1 and S2 (switching transistors in an actual circuit) are driven alternately on and off with a 50% duty cycle, producing a square-wave voltage, $V_s$. The square-wave voltage has components at the fundamental (switching) frequency and its odd harmonics. The peak-to-peak voltage of the fundamental component is $4/\pi (1.27)$ times the peak-to-peak voltage of the square wave. The series-tuned output circuit is resonant at the switching frequency, so it exhibits high impedance to the harmonics, but provides a direct connection to the load for the carrier. As a result, only current at the carrier frequency can flow into the load.

The output voltage and current are sine waves which are represented mathematically by

$$v_o = \frac{2V_{cc}}{\pi} \sin \omega t$$

$$i_o = \frac{v_o}{R} = \frac{2V_{cc}}{\pi R} \sin \omega t$$

When the output current, $i_o$, is positive, it flows through S1; when it is negative, it flows through S2. A single transistor switch cannot be used for class-D rf operation because the output current must be able to flow in both directions. The power output from this amplifier is given by

$$P_o = \frac{(V_{o \text{ peak}})(i_{o \text{ peak}})}{2} = \frac{2V_{cc}^2}{\pi^2 R}$$

The switches consume almost no power themselves because the voltage across them is nearly zero when they are conducting current.

**rf circuits**

There are a variety of class-D rf amplifier circuits (fig. 12) just as there are a wide variety of linear amplifiers. The equivalent circuit just discussed can be realized by any of the complimentary versions (figs. 12A, 12B or 12C). The input transformer secondary windings are connected so that the transistors turn on with opposite polarities of the drive signal. Complimentary class-D amplifiers have the advantage of requiring no output transformer, and hence no transformer losses.

The quasi-complimentary configuration (fig. 12C) uses only npn transistors which are both more abundant and less expensive than pnp types at high frequencies. This is a definite advantage of the quasi-complimentary circuit.

Transformer-coupled or push-pull class-D amplifiers are also possible. In the voltage-switching amplifier (fig. 12D), alternately driving the transistors causes their collector voltages to be square waves of zero to $2V_{cc}$ volts. The current which flows in either transistor is a half cycle of a sine wave, just as in the complimentary amplifiers. Power output depends on the turns ratio of the output transformer, as well as on the supply voltage and load resistance.

The total voltage swing on the transformer primary is $2V_{cc}$, so if there are four turns in the primary for each turn in the secondary, the output power will be
the same as that of a complimentary amplifier. Output voltage varies with the turns ratio, and output power varies with the square of the turns ratio. The turns ratio can be used as part of the matching and loading network. This configuration is particularly useful when the supply voltage is low since it provides a $2V_{cc}$

![Equivalent circuit of a class-D rf amplifier and ideal waveforms.](image)

Output voltage varies with the turns ratio, and output power varies with the square of the turns ratio. The turns ratio can be used as part of the matching and loading network. This configuration is particularly useful when the supply voltage is low since it provides a $2V_{cc}$

Another class-D rf circuit is the current-switching push-pull amplifier shown in fig. 12E. This circuit is a so-called “dual” of the voltage-switching amplifier because it features square-wave current and sine-wave voltages. The rf choke forces a constant current so the transistors conduct constant current while they are on. The parallel-tuned output filter conducts all of the harmonic currents but forces the carrier current into the load. Output voltage and power are somewhat different than those of the voltage-switching amplifier. Since there can be no dc voltage drop across a transformer winding, the total primary voltage must be

$$v_{pri} = \pi V_{cc} \sin \omega t$$

(The peak collector voltage is $\pi V_{cc}$ so the average or dc collector voltage is $V_{cc}$.) If the turns ratio is 1:1, the output power is

$$P_o = \frac{\pi^2 V_{cc}^2}{2R}$$

Output current is

$$i_o = \frac{\pi V_{cc}}{R} \sin \omega t$$

and the dc input current (and transistor peak current) is

$$i = \frac{\pi V_{cc}}{2R}$$

The current-switching amplifier offers an alternative way of fitting together power requirements, supply voltage and maximum transistor ratings. Also, it has the same configuration and the same output filters as class-B transistor power amplifiers. However, it will generally be less efficient than the voltage-switching amplifier because more current must be drawn through the same saturation voltage and large amounts of current must be switched (the voltage-switching amplifier switches at zero current points).

**Transformers and tuned circuits**

The transformers required in class-D rf amplifiers are essentially the same as
fig. 12. Practical class-D rf amplifiers can be built in various ways as shown here. The advantages and disadvantages of each of these circuits are discussed in the text.

those used in solid-state class-B rf amplifiers. They consist of several parallel wires wound on a stack of toroidal cores made of suitable material for the frequencies to be used. Building these transformers is a mixture of intuition and witchcraft and a lot of trial and error. However, here are some general rules:

1. Increasing the number of turns increases the series inductance, degrading the high-frequency response.

2. Paralleling two windings with the same number of turns decreases series inductance, improving high-frequency response.

3. Stacking several cores increases power handling capability and increases shunt inductance, improving low-frequency response.

The transformer parameters must be chosen to fit the application, and in class-D circuits it is necessary to pass a few harmonics of the carrier as well as the carrier itself. However, it is not difficult
to build transformers working over several octaves (up to 5 or 6).\textsuperscript{16,17}

The output filter need not be the simple tuned circuits used in the examples here. A T-network presents a high impedance to the harmonics of the carrier, and can be used where series-tuned circuits are shown. Pi-networks present low impedances to the harmonics through a hybrid transformer (fig. 13) as is done with linear amplifiers.\textsuperscript{18} Basically, a hybrid transformer prevents the two amplifiers from loading each other. The transformer has a 1:1 turns ratio which forces equal currents in each winding. If you wish, you can work out the details with a little algebra, but essentially, if the two amplifiers do not produce equal

<table>
<thead>
<tr>
<th>JEDEC number</th>
<th>type</th>
<th>maximum V_{CE}</th>
<th>maximum I_{C}</th>
<th>package</th>
<th>application</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N4123</td>
<td>npn</td>
<td>30</td>
<td>0.2</td>
<td>TO-92</td>
<td>(plastic) 100-kHz switch</td>
</tr>
<tr>
<td>2N4124</td>
<td>npn</td>
<td>25</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N4125</td>
<td>pnp</td>
<td>30</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N4126</td>
<td>pnp</td>
<td>25</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N2222A</td>
<td>npn</td>
<td>40/65**</td>
<td>0.8</td>
<td>TO-18</td>
<td>(metal) 1-MHz switch</td>
</tr>
<tr>
<td>2N2907A</td>
<td>pnp</td>
<td>40/65**</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N5190</td>
<td>npn</td>
<td>40</td>
<td>4.0</td>
<td>flat</td>
<td>100-kHz switch</td>
</tr>
<tr>
<td>2N5191</td>
<td>npn</td>
<td>60</td>
<td>4.0</td>
<td>(plastic)</td>
<td></td>
</tr>
<tr>
<td>2N5192</td>
<td>npn</td>
<td>80</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N5193</td>
<td>pnp</td>
<td>40</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N5194</td>
<td>pnp</td>
<td>60</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N5195</td>
<td>pnp</td>
<td>80</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N3262</td>
<td>npn</td>
<td>80/100</td>
<td>1.5</td>
<td>TO-39</td>
<td></td>
</tr>
<tr>
<td>2N3734</td>
<td>npn</td>
<td>30/45</td>
<td>1.5</td>
<td>TO-5</td>
<td>(metal) 30-MHz switch (high-speed switch)</td>
</tr>
<tr>
<td>2N3735</td>
<td>npn</td>
<td>50/70</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N5262</td>
<td>npn</td>
<td>50/70</td>
<td>3.0</td>
<td>TO-39</td>
<td></td>
</tr>
<tr>
<td>2N3961</td>
<td>npn</td>
<td>40/56</td>
<td>1.0</td>
<td>stud</td>
<td>30-MHz switch (400-MHz rf)</td>
</tr>
<tr>
<td>2N3553</td>
<td>npn</td>
<td>40/56</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N3375</td>
<td>npn</td>
<td>40/56</td>
<td>1.5</td>
<td>stud</td>
<td></td>
</tr>
<tr>
<td>2N3632</td>
<td>npn</td>
<td>40/56</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD-200</td>
<td>fet</td>
<td>25</td>
<td>0.05</td>
<td>can</td>
<td>100-MHz switch</td>
</tr>
<tr>
<td>1N4933</td>
<td>diode</td>
<td>50</td>
<td>1.0</td>
<td>DO-41</td>
<td>100-kHz switch (metal)</td>
</tr>
<tr>
<td>MR380</td>
<td>diode</td>
<td>50</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*When two values are shown they are V_{CEO}/V_{CEV}. The first is with base open, the second with reverse bias as in a push-pull amplifier.

**Without A suffix, 30/50.

and can be used in the place of paralleltuned circuits. Input impedance to the third harmonic should be at least ten times the load impedance at the carrier frequency, and the output filter should attenuate harmonics by 50 dB or more.

Two (or more) small amplifiers can be combined to obtain greater output power by connecting them to the load outputs, \textsuperscript{R2} consumes power and reduces efficiency. This means the two amplifiers must be closely matched or controlled.

Hybrid transformers are also used to divide drive power between two amplifiers whose outputs will be combined. This helps to keep phase relationships the same in each amplifier. If more than two amplifiers are to be combined, they must
be combined in groups of two. The drive signal is first split into two signals, then into four. Two pairs of outputs are combined to form two signals; these signals are then combined to form one high-power output. Note that the input impedance of the hybrid transformer and the difference load resistor are twice the output resistance.

![Hybrid transformer diagram](image)

**fig. 13.** Hybrid transformers, such as the one shown here, can be used to combine the outputs from two amplifiers.

class-D rf amplifier design

Designing a class-D rf amplifier is generally easier than designing a class-B or -C rf amplifier stage. There are no gain-variation, base-bias, neutralization or unequal-current problems to worry about. As with class-D audio amplifiers, you start at the output and work backwards.

I decided to try to design and build a 50-watt class-D power amplifier for 160 and 80 meters (and maybe 40). The circuit that resulted is shown in **fig. 14.** The first step is selecting the Q of the output circuit. I chose a Q of 5 which meant that L3 and C6 must have reactances of 250 ohms at the midband frequency. This value of Q reduces the third harmonic to 33 dB below the carrier.

The next step is to determine the output voltage and current. The peak voltage and peak current into the 50-ohm load are found from

\[
\begin{align*}
V_p &= \sqrt{2RP} = \sqrt{2 \times 50 \times 50} = 70.7 \text{ volts} \\
i_p &= \frac{V_p}{R} = \frac{70.7}{50} = 1.41 \text{ amp}
\end{align*}
\]

The peak value of square-wave voltage at the input of the tuned circuit which will produce this peak output is

\[
V_{swp} = \frac{\pi}{4} \cdot 70.7 = 55.5 \text{ volts}
\]

If no matching were used, the transistors would have to withstand 111 volts or...
more on their collectors. It is convenient to use a 4:1 matching transformer which reduces the square-wave voltage swing to 27.8 volts and increases peak current to 2.83 amps. These values are much more suitable for commercially available transistors.

I decided on the push-pull circuit rather than the quasi-complimentary configuration because I was already using a matching transformer and because a 28-volt power supply is easier to come by than a 56-volt supply. Capacitor C5 provides an ac ground for the transformer center tap,

If the saturation voltage is 1 volt, the collector supply voltage, $V_{cc}$, must be 28.5 volts, and the collector voltage will swing between 1 and 56 volts. The dc current required is

$$i_{dc} = \frac{2I_p}{\pi} = \frac{2 \cdot 2.83}{\pi} = 1.80 \text{ A}$$

and the L2-C4 combination keeps rf out of the power-supply wiring.

Now the driving circuitry must be designed. It is convenient to drive the bases of transistors Q3 and Q4 through a push-pull transformer to insure that they are driven out-of-phase with respect to

---

fig. 14. Class-D rf power amplifier for 160, 80 and 40 meters provides more than 35 watts output with collector efficiencies of 90% or more. Construction of transformer T3 is shown in fig. 15.
each other. It is best to drive the bases with sine-wave current.

While square-wave current might turn the transistors on a little more rapidly, it maintains a lot of charge in the base which must be removed before the transistors will turn off. A check of switching transistor characteristics will show that storage time (turn-off delay) is a much more serious problem than turn-on delay. Sine-wave current provides the base with only enough charge to sustain the collector current, greatly reducing storage-time effects.

If the output transistors have a current gain of 20, to insure saturation the base current in each transistor must be a half sine-wave with a peak value of

\[ i_{bp} = \frac{2.83}{20} = 142 \text{ mA} \]

The base voltage will rise to about 1 volt (or slightly less) when driven. When the current changes direction, the base becomes an open circuit and its voltage becomes -1 volt. This is a reflection of the +1 volt potential on the base of the other transistor through transformer T2.

The power which must be applied to the two transistor bases is then

\[ P_b = \frac{4}{\pi} \cdot \frac{1}{2} \cdot 0.142 = 90 \text{ mW} \]

This means that the power amplifier has a power gain of about 27 dB!

Since the drive power is only a small fraction of the total power this amplifier will require, driver efficiency is not too important. Almost any type of rf amplifier can be used for a driver — even untuned class-A. I found it more convenient to use a quasi-complimentary class-D amplifier. I used a pair of relatively new fets for Q1 and Q2. These have greater stability and faster switching speed than most bipolar devices, and are easier to drive as well.

The series-tuned circuit L1-C3 will allow only sinusoidal current to flow. Since harmonic suppression is not as important as in the power-amplifier stage, I used a Q of 2.5 for the driver. At the carrier frequency transistors Q3 and Q4 have a base resistance of

\[ R_b = \frac{(4/\pi) \cdot 1}{0.142} = 8.97 \text{ ohms} \]

It would be difficult to build a 90-mW amplifier without special components.
driver with a 9-ohm load line, so T2 has a
turns ratio of 4:1. This multiplies the
impedance by 16, resulting in a 145-ohm
load line. The ±1 volt base voltage will be-
come ±4 volts on the input of T2. The cur-
rent input to T2 has peaks of about 35 mA.

When saturated, the fets become
45-ohm resistors. This causes a voltage
drop. To correct for this voltage drop, it is
necessary to increase the supply volt-
age, $V_{DD}$. If there were no voltage drop
through the fets, $V_{DD}$ would be 8 volts
to allow a ±4-volt swing. With the correction,

$$V_{DD} = 8 \cdot \frac{145 + 45}{145} = 10.5 \text{ volts}$$

The driver dc input current is 11.1 mA
(351~) so the driver power input is

$$P_D = (10.5) (0.011) = 117 \text{ mW}$$

The driver efficiency is about 77%.

It is not a good idea to try to operate
the driver from a 10.5-volt power supply.
Remember that the value of 10.5 volts is
related directly to the nominal 1-volt base
saturation voltage. This was not an exact
value to start with, and even if it were, it
would vary slightly with temperature,
collector current, etc. If $V_{DD}$ were fixed at
10.5 volts and the base voltage decreased
slightly, only the fet saturation resistance
would limit the current. For this reason,
it is better to use a higher voltage supply,
$V_S$, and to provide a resistor to absorb
changes in the base voltage. I used a 1k
resistor and a 21.6-volt supply, which
made it easy to monitor drive current.
With this resistor the overall drive effi-
ciency is about 37%, but the 240-mW
total drive power is still less than one-
percent of the power-amplifier power.

The fets are saturated by applying a
15-volt peak sinusoidal gate-to-source
voltage. The 1:5 turns ratio of T1 permit-
ted driving them from a 3-volt source.
Since the fets have a very high input
impedance and require essentially no in-
put power, it was necessary to load the
secondary windings to produce an
approximate 50-ohm input impedance.

Transformers T2 and T3 are made by
running enameled wire through two par-
allel stacks of ferrite cores as shown in
fig. 15. Transformer T3 has four turns in
the output winding and two turns in each
side of the input; T2 has two turns in
each side of the output and eight turns in
the input winding. Since I had the smaller
size cores, twelve cores were required for

The Continental Electronics 314(E) is a 2-kW
CW/MCW all solid-state transmitter for 275 to
530 kHz. It uses a push-pull class-D rf amplifier,
and has an overall efficiency of 70% or better
with load vswr as high as 3:1. Photo courtesy
J.D. Rogers.
the 2N3632, an rf transistor. Either transistor should handle the required current and voltage. Since 2N5262s were considerably cheaper, I decided to use them. It's my guess that rf transistors would be less efficient but more rugged. Clip-on heatsinks will reduce thermal stress on Q3 and Q4.

My amplifier was built on a double-sided PC board to insure a good ground plane. Layout is not critical, but remember that a 1.8-MHz class-D amplifier contains energy at frequencies much higher than 1.8 MHz.

The driver and power amplifier tuning coils are wound on 0.680-inch (17-mm) OD rf toroid cores. All have a measured Q of 190 or more. The Q of these inductors is very important since it determines the amount of power they absorb from the output. The fraction of power lost to the coil is the ratio of circuit Q (5 for the output) to the inductor's unloaded Q. An inductor with a Q of 200, for example, causes a 2.5% reduction in efficiency. Remember that winding coils, like winding transformers, is a black art. Don't think you can improve the Q by using larger wire — you will decrease the self-resonant frequency and the Q because the interwinding capacitance is increased.

Test the driver first, with power removed from the power amplifier stage. Tune the driver for peak input current (if tuning for peak current seems strange, remember that this is series tuned, whereas most class-C power stages are parallel tuned). Input current should not exceed 16.6 mA, as this corresponds to the 50-mA peak current rating of the fet. Also, $V_s$ should be kept at 25 volts or less. If the bases of Q3 and Q4 suddenly open, $V_{DD}$ will go up to $V_S$. The driver should work on 160, 80 and 40 meters. It will also work on 20 if you reduce L1 to compensate for the series inductance of T2. You can tell when the input signal is large enough by whether any further increases produce increases in the dc current.

Now for the final. Always turn the driver on first (and off last). This circuit is not designed to have both Q3 and Q4 on at the same time, so it will oscillate, probably destroying the transistors. Start $V_{CC}$ at zero and bring it up to 3 or 4 volts so you can measure the output. In the absence of an output meter, tune for peak dc current. Tune the power amplifier only at very low voltages. When the

![fig. 15. Layout of the output transformer (T3 in fig. 14). Primary is 4 turns no. 20 enamelled, center-tapped to C5, wound through 12 CN-20 ferrite cores (two parallel stacks). Secondary is 4 turns no. 20.](image-url)
3 amps of collector current. On 80 meters an output of 32 watts required maximum drive. Winding T2 with a 5:1 turns ratio would probably provide enough drive for 50-watts output.

I tried the amplifier on 20 meters and this eventually resulted in two dead transistors. Although the bottom of the collector voltage waveform remains square, ringing due to transformer inductance and stray capacitance continues for most of the time the transistor is off. Although I measured 63% efficiency at about 1-watt output, the amplifier has a tendency to oscillate and to divide frequency. However, I think the circuit would work on 20 meters with different transformers. The series inductance can only be tuned out at the fundamental frequency, and the reactances at the harmonic frequencies make it difficult to obtain the half-sinusoidal current waveforms required in class-D operation.

The variation of output voltage with supply voltage is very linear, and driver feedthrough is only a few milliwatts, so the power amplifier should be suitable for a-m or ssb service (using the EER technique). It might be a good idea to include an automatic phase comparison circuit which would reduce the collector voltage when the output was mistuned (reactive). Such a circuit would be essentially the same as the vswr protection circuits used in early solid-state rf power amplifiers.

**Modulation**

All of the class-D rf amplifiers discussed so far are constant carrier (amplitude) types. If these amplifiers are to be used for a-m or ssb service, they must be modulated. Modulation is most easily accomplished by varying the collector supply voltage with a class-D audio amplifier. For ssb service, this is an application of the envelope elimination and restoration technique discussed earlier. The use of both class-D audio and rf amplifiers produces a highly efficient linear rf amplifier. Collector modulation of the class-D rf amplifier is very linear and there is no need to modulate the driver (in a class-B or -C amplifier, both the power amplifier and the driver must be modulated to prevent overdrive).\(^{14}\)

Pulse-width modulation can be adapted to produce a modulated rf carrier as shown in fig. 16. Because the carrier component of a pulse train is proportional to the sine of the pulse width, rf pulse-width modulation (PWM) must be generated by comparing the desired modulation to a full-wave rectified cosine wave at the carrier frequency. The output amplifier may be either monopolar or bipolar.\(^{13}\)

Bipolar rf PWM has essentially no splatter due to non-linear modulation of the harmonics of the carrier. Although the rise times required by rf PWM are no higher than those required by a constant-carrier class-D rf amplifier, rf PWM requires switching stages to be controlled as in audio PWM, and this makes it much more difficult to implement. You might be able to build an rf PWM amplifier for operation on 160 meters, but with present devices, it would be difficult to use at much higher frequencies.

**Vacuum-Tube Circuits**

If you are thinking about a legal limit transmitter, you might consider using vacuum tubes. Power handling capabilities are much greater than those of transistors, and filament power need not be counted as part of the input power. The same configurations apply to tubes as well as to transistors. A vacuum tube can be turned off quite efficiently by driving the grid negative, and this consumes very little power. Driving the grid positive forces the tube to saturate, causing it to act like a resistor. However, driving the grid positive causes grid current to flow and consumes drive power.

What you can obtain with tube switch-es must be determined by using the characteristic curves of the tubes you plan to use. Generally, the saturation losses will be greater than those of transistor amplifiers. However, the output matching networks may be more efficient, and saturation losses occur in class-B vacuum tube amplifiers as well as class-D amplifiers.
When an application calls for a power level or frequency where class-D operation is impractical, there are several other types of amplifiers which have efficiencies better than that of class-B. These include class-C, of course, and a couple of amplifier circuits which don’t really operate as class-A, -B, -C or -D. Since the envelope elimination and restoration amplifier has the same basic circuit (fig. 17) as a class-A or -B linear amplifier, but it is biased and driven so the transistor conducts current for less than half the time. Current is thus drawn through the transistor when the voltage is lowest, resulting in less power consumption.

The reduced conduction angle can be obtained at various combinations of bias and drive, and the current pulse need not be exactly sinusoidal. There are some general rules for class-C operation:

1. Any deviation from class-B (or class-A) produces a nonlinear amplifier.

2. Reducing the conduction angle will improve the efficiency, with efficiency approaching 100% as the conduction angle approaches zero.

3. As the conduction angle is reduced, either output power will decrease or peak collector current will increase.

4. The necessary increase in drive power is approximately inversely proportional to the conduction angle.

These rules will help you to estimate what performance can be obtained by technique makes it possible to use nonlinear rf amplifiers in linear service it is possible to design the rf amplifier for efficiency rather than linearity.

Class-C operation has been used for many years to build rf amplifiers with improved efficiency. A class-C

---

**fig. 16.** Radio-frequency pulse-width modulation system.
converting a class-B amplifier to class-C. Class-C can be used to obtain higher efficiency, but it won't be a panacea because drive requirements and peak current will increase with increasing efficiency.

**envelope feedback**

A technique called envelope feedback can be used to make a nonlinear rf amplifier operate as if it were linear, provided there is some sort of gain control which can be applied.\(^1\) Basically, this technique uses a feedback loop to look at the desired output and the actual output, and correct amplifier gain so the two are equal.

Envelope feedback is not a new idea, but today it is much easier to implement due to the abundance of integrated circuits. It is no different from other audio feedback and requires a frequency response from dc to about 10 kHz for ordinary ssb signals. To keep the feedback loop from oscillating, it is necessary that the open-loop gain (point A to point E in fig. 18) be zero for frequencies with 180° or more phase shift. Many books have been written on feedback theory, so I will not go into it any deeper.

Class-C amplifiers are an ideal application of envelope feedback. The bias network normally used to bias a class-B transistor amplifier slightly into conduc-

![fig. 18. The envelope feedback technique shown here can be used to make a non-linear rf amplifier operate as if it were linear (see text).](image)

![fig. 17. Basic solid-state class-C rf amplifier circuit.](image)
multiple-resonator class-C, single-ended class-D, and class-CD. My own name is class-E. This technique is particularly useful at vhf where driving a pair of transistors 180° out of phase becomes difficult.

A voltage-switching class-D amplifier has a square-wave voltage and half-wave rectified sine-wave current, arranged so that one or the other is always zero in each transistor. Examination of the waveforms reveals that the voltage waveform contains a fundamental and odd harmonics, while the current waveform contains a fundamental and even harmonics. To maintain both waveforms with a single transistor requires an output network which is resistive at the carrier frequency, a short-circuit to even harmonics, and an open-circuit to odd harmonics. The series of parallel-tuned circuits in fig. 19 pass even-harmonic current freely while preventing odd-harmonic current from flowing. The parallel-tuned output circuit passes the even-harmonic current to ground and forces the fundamental frequency current into the load. Ideally, the transistor consumes no power since it always has either zero voltage or zero current.

When this technique is used at lower frequencies, only resonators for the fundamental frequency and third harmonic are usually used, and the circuit is referred to as “third-harmonic peaking.” Efficiencies of 90-percent have been reported.

At higher frequencies the series of parallel-tuned traps can be replaced by a quarter-wavelength transmission line as shown in fig. 20. The parallel-tuned output circuit provides a short-circuit to all harmonics. The quarter-wave line transforms the short-circuit into an open-circuit for odd harmonics and a short-circuit for even harmonics. In addition, it can be used to transform the actual load resistance to the desired load line. If the characteristic impedance of the line is $R_0$,

The circuit shown in fig. 20 can be adapted to a 300-mW walkie-talkie for 10 or 6 meters (or 2 or 1½ meters, too, if you’re very careful about how you put it together). I tested it at 25 MHz and measured 73% efficiency.* The output circuit has a Q of 3, and the transmission-line transforms the 50-ohm output to a 300-ohm load line.

When saturated, the fet becomes a resistor (about 45 ohms in this case). Since the fet requires negligible drive power, it should be possible to obtain the 16-volt peak sine-wave drive directly from the oscillator tank circuit, eliminating the need for a driver. Remember that matching could also be accomplished with a pi-network—this would allow the use of other transmission-line impedances.

*This circuit was the author’s entry in Signetics’ D-mos fet contest and will be the subject of a future Signetics Applications Note.
capacitor-shunted switch

The capacitor-shunted switching (CSS) amplifier is another type of rf amplifier which uses a single switching transistor and doesn’t behave like any of the four standard amplifier classes. I sometimes call it class-F (for far-out). Instead of regarding collector capacitance as an impediment to its operation, the CSS amplifier uses it as an integral part of the circuit.

The shunt capacitor (fig. 21) provides a current path when the transistor is off. The rf choke acts as a constant dc current source. The series-tuned circuit forces sinusoidal current to flow into the load, and has a high input impedance to harmonic voltages. The difference between the current flowing into the circuit through the rf choke and that flowing in the output either flows through the transistor (when it is on) or charges the capacitor (when the transistor is off). The fundamental frequency component of the collector voltage is the voltage which appears across the load.

Any energy stored in the capacitor at the time the transistor switches on will be dissipated in the transistor. Recently, Sokal discovered that mistuning the resonant circuit so that it is inductive causes the capacitor voltage to drop to zero at the time the transistor switches on, producing 100% efficiency.

Analyzing this amplifier is fairly complicated, but the resulting design equations given by Sokal are fairly simple:

\[
\begin{align*}
L2 &= \frac{QR}{\omega} \\
C2 &= \frac{1 + 1/Q}{\omega QR} \\
C1 &= C2 \cdot Q/6.3 \\
P &= \frac{2V_{cc}^2}{\left(\frac{\pi^2}{4} + 1 + R\right)}
\end{align*}
\]

where \( Q \) is the \( Q \) of the output circuit. Adjustment for peak efficiency may be

---

C2 78-pF variable (E.F. Johnson 158-4)  
L1 2.2 \( \mu \)H rf choke (Delevan 1025-28)  
L2 106 nH (4 turns no. 26 wire on Perma-core 57-2656 or Micrometals T30-6 core)  
T1 11 turns no. 26 twisted pair on Perma-core 57-2656 or Micrometals T30-6 core  
T3 piece of 125-ohm coaxial cable (RG-63B/U), 112.2" (2.85 meters) long

fig. 20. This 300-mW multiply-tuned rf amplifier designed for operation on 25 MHz has efficiency of 73%. In this circuit transformer T3 is a section of coaxial transmission line.

fig. 21. Capacitor-shunted switching (CSS) amplifier can provide operating efficiencies of nearly 100%.
somewhat critical, and the amplifier will have inefficiency due to saturation voltage and rise time, just as a class-D amplifier does. However, the simplified output circuit (compared to multiple tuning) and reduced driving problems (compared to class-D) may be worth it, especially at vhf.

summary

In this article I have tried to give an overview of high-efficiency amplifiers, particularly class-D amplifiers, which might be useful to amateurs. There are a lot of variations beyond those mentioned here. Understanding how they work requires careful attention to voltage and current relationships and a little algebra. With a little luck, an enterprising amateur should be able to implement some of these ideas into his own equipment. I would like to hear from anyone who does.

I would like to thank my friends Rich Grimsley, WA3JEL, and Bob Calderwood, WA7ANT, for their very helpful comments on the rough draft of this manuscript.

references

How to find the optimum point for feeding a multi-band log periodic

Log-periodic antenna texts provide little information on methods of getting a practical transmission line matched to the antenna feedpoint. References 2, 5 and 7 describe methods of matching and feeding vhf log periodics by use of boom balun to coax matches, but most of these systems are not suitable for high-frequency log periodics.

The original log-periodic antennas built here were first fed by using a 1:1 balun with the balanced winding across the normal short-element feedpoint. Although the swr was relatively low across the 20-meter band and not too bad on 15, there was some variation between these two bands. On 10 meters there were some bad swr excursions when going from 28.0 to 29.7 MHz, some exceeding 2.5:1, showing a bad mismatch on these higher frequencies. Equipment was not readily available to make a complete swr run over the antenna’s entire bandwidth, 14 to 30 MHz.

Though some of the vhf references indicate that the swr could be expected to go up to 2.5:1 over a log periodic’s bandwidth, it was felt this could be improved by a better matching system between the transmission line and the antenna. Upon checking several log periodics at the normal short-element feedpoint using the Omega Antenna...
Noise Bridge, it was noted that there was considerable variation in impedance over the three bands.

**Analysis**

Upon analyzing this result it became evident that the active or driven elements (one-half wavelength long at a specific frequency) were at various electrical distances (1/4 wave-wise) from the feedpoint. In fig. 1 for example, the second element, which is the driven element on 20 meters, is 35 feet (10.7 meters) or approximately a half wavelength to the rear of the feedpoint at the front of the antenna. Since previous tests with the antenna bridge had indicated the driven element exhibited 30 to 33 ohms input impedance, it can be assumed that this impedance would be repeated at the feedpoint since the two are connected about halfway between a high- and low-impedance point on 15 meters.

Looking at 10 meters, element 9 is about 16 feet (5 meters) long so it is the active element on that band. It is about 6.5 feet (2 meters) to the rear of the feedpoint. A quarter-wavelength feedline on 10 meters is about 8.4 feet (2.6 meters) and a half wave, 16.8 feet (5.2 meters). Thus, the feedpoint is

![fig. 1. A 12-element three-band log-periodic antenna showing the electrical relationship of the extended feedpoint to the driven element on each of the three bands.](image)
meters). Again, the feedpoint is at an intermediate point with respect to the active element.

In summary, it will be noted that although the feedpoint at element 12 presents a fairly predictable impedance on 20 meters, it presents a highly variable match on 15 and 10. This was confirmed by SWR readings across each of the three bands.

**moving the feedpoint**

By extending the open-wire feedline toward the antenna apex as shown in Fig. 1, a point is reached near the apex where elements 2, 6 and 9 are all about 3/4 wavelength from this common, higher impedance, feedpoint for their respective bands. The impedance at this point appears to be on the order of 200 to 300 ohms, so it can be fed with 50-ohm coax through a 4:1 balun with a satisfactory match on all three bands. The 3/4-wavelength open-wire line acts as a matching transformer.

The low and high impedance points along the open-wire line for each of the three bands are shown in Fig. 1. Incorporation of this modification extends the feedpoint 17.25 feet (5.3 meters) forward of the short-element end of the antenna.

In Fig. 2 the same principle of an extended open-wire feeder is applied to matching a longer log periodic with a 70-foot (21.4-meter) boom length and 22-degree apex angle. This requires an open-wire feeder 5/8-wavelength long to reach the common-impedance feedpoint, also approximately at the apex angle. In this case the open-wire feeder has been extended 27 feet (8.2 meters) from the center of the short element. Note that these extended feeders can hang down from the short-element end of the antenna if necessary; they need not be extended horizontally as shown.

---

**fig. 2.** An extended 12-element three-band log periodic with a 5/8-wavelength extended-feed matching system.
fig. 3. A 5-element, 40-meter monoband log periodic. The center of the short element is just a quarter wavelength from the driven element, providing an optimum feed point.

The monoband log periodics of fig. 3, tested here on 10, 15, 20 and 40 meters in 5-element versions (some 4- and 6-element types were also tested) have all had element 2 exactly a quarter wavelength from the high-impedance, short-element feedpoint. These have worked extremely well using a 4:1 balun to match them to coaxial transmission lines. The swr has been relatively low across each band.

Similarly, the single-band vertical monopole log periodics of fig. 4, tested on 40 and 80, also used the quarter-wavelength feed and were similarly flat.\textsuperscript{15} The swr readings on the 80-meter version were:

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Swr</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0 MHz</td>
<td>1.25:1</td>
</tr>
<tr>
<td>3.9 MHz</td>
<td>1.4:1</td>
</tr>
<tr>
<td>3.8 MHz</td>
<td>1.2:1</td>
</tr>
<tr>
<td>3.7 MHz</td>
<td>1.1:1</td>
</tr>
<tr>
<td>3.6 MHz</td>
<td>1.2:1</td>
</tr>
<tr>
<td>3.5 MHz</td>
<td>1.2:1</td>
</tr>
</tbody>
</table>

\textbf{similar approach}

This system for feeding log-periodic antennas was believed to be original at
Table 1. Vertical monopole log-periodic antenna dimensions (5-element arrays).

<table>
<thead>
<tr>
<th>Element</th>
<th>Total Length</th>
<th>Frequency in MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>3.5-4.01</td>
<td>70' (21.4 m)</td>
</tr>
<tr>
<td>E2</td>
<td>3.8-4.02</td>
<td>67' (20.4 m)</td>
</tr>
<tr>
<td>E3</td>
<td>5.0' (15.3 m)</td>
<td>58' (17.7 m)</td>
</tr>
<tr>
<td>E4</td>
<td>4.0' (13.1 m)</td>
<td>50' (15.3 m)</td>
</tr>
<tr>
<td>E5</td>
<td></td>
<td>43' (13.1 m)</td>
</tr>
<tr>
<td>S1</td>
<td>3.0' (9.2 m)</td>
<td>30' (9.2 m)</td>
</tr>
<tr>
<td>S2</td>
<td>2.7' (8.2 m)</td>
<td>27' (8.2 m)</td>
</tr>
<tr>
<td>S3</td>
<td>2.4' (7.3 m)</td>
<td>24' (7.3 m)</td>
</tr>
<tr>
<td>S4</td>
<td>1.9' (5.8 m)</td>
<td>19' (5.8 m)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mast Height</th>
<th>Pole Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>80' (24.4 m)</td>
<td>45' (13.7 m)</td>
</tr>
<tr>
<td>75' (22.9 m)</td>
<td>40' (12.2 m)</td>
</tr>
<tr>
<td>50' (15.3 m)</td>
<td>25' (7.6 m)</td>
</tr>
</tbody>
</table>

1. Calculated design, not actually built and tested.
2. Built and tested design, with measured SWR under 1.5:1 over frequency range shown.

In any case, it is hoped the above information on improved methods of feeding log-periodic antennas will be helpful to amateurs using these interesting antennas. I would like to hear from anyone trying this technique.

The time I worked it out. However, after it was mentioned briefly in a previous article9 it was learned that Ray Rosenberry, K8EBF, developed a similar method that was described and covered by his patent of 16 February, 1971, which covers "Broad Band Transformer Antenna and Related Feed System." Therefore, I do not claim the odd quarter-wavelength feed method for log-periodics to be original. K8EBF and I have since exchanged several letters regarding these log-periodic feed methods.

Fig. 5. Construction details for a 5-element vertical monopole log periodic. Dimensions for 80, 75, 40 and 20 meters are given in Table 1.
references


"Ever since I bought that $450 receiver, I've had a communication problem — my XYL!"
high-stability

crystal oscillator

The Goral oscillator — a new high-performance crystal-oscillator circuit that features excellent load capacitance correlation and temperature stability

One of the most frustrating problems faced by a newcomer to the crystal manufacturing business is that of capacitance correlation of the oscillators. Although 32 pF has been the recommended standard for many years, few engineers seem inclined to use this value in their new circuits. In many cases the engineer gets the circuit working to his satisfaction and is reluctant to change any of the component values. Usually, the burden of correlation falls on the crystal supplier.

A second problem, which is no less irritating, is that of activity requirements. The crystal vendor may supply perfectly good crystals, only to find that many will not oscillate in the user's circuit.

While the crystal oscillator circuit to be described will not cure any of these past problems, it can certainly minimize them in the future. Although the oscillator configuration (which is an adaption of the basic Colpitts circuit) may not be new, I am unaware of any similar designs. It was developed independently in the quartz crystal laboratory at SGC, Inc., and has the following features:

1. The ability to correlate at virtually any capacitance between 5 and 50 pF. In fact, the crystal will oscillate very close to its series-resonance point in this circuit.

2. The ability to make crystals oscillate with equivalent series resistances (ESR) well above the Mil-spec maximum. The circuit is sufficiently active to oscillate quartz blanks which have not been plated during the manufacturing process.

3. The temperature stability is essentially independent of the solid-state devices used. Capacitance variations due to the semiconductor junctions are virtually swamped out due to the large shunt capacitance in the circuit.

4. The circuit is easily adapted to "rubber" the crystal with semiconductor variable-capacitance diodes and exhibits a very wide pulling range due to its high activity.

Colpitts oscillator

The simplified circuit for the transistorized Colpitts oscillator is shown in fig. 1. Note that the rf ground has been shifted from the customary position at the collector. Oscillation occurs due to the 180° phase-shift through the transistor and the additional 180° inversion across the tuned circuit represented by the crystal. The capacitor values are determined by the circuit impedance and frequency range.

The basic circuit for the fet Colpitts oscillator is quite similar and is shown in fig. 2. Note that the rf ground has been moved to its customary position by bypassing the source (collector), leaving the drain (emitter) at an rf potential above

Donald L. Stoner, W6TNS, Director of Marketing, SGC, Inc.*

*SGC, Inc., Frequency Control Division, 13737 SE 26th Street, Bellevue, Washington 98005.
Thus, one end of all crystals in a bandswitching circuit can be grounded. The fet Colpitts circuit is also very useful because the temperature characteristics are excellent. The fet causes virtually no drift with temperature.

Fig. 3 shows a practical application for the fet Colpitts oscillator. The values have been optimized for the 10-to-20-MHz range. Note that this circuit also incorporates a leveling diode, CR1, that rectifies the rf voltage across the crystal. Thus, the more active the crystal, the more negative bias which is produced. This, in turn, reduces the gain of the oscillator. Thus high and low activity crystals tend to produce the same output voltage at the drain of the fet.

Unfortunately, the fet Colpitts is not a particularly active circuit and seems to require lower resistance crystals than its transistor counterpart. Crystals with an ESR above 20 ohms appear to be quite sluggish. In this instance, the ESR referred to is measured at parallel resonance. This is the mode the crystals oscillate on in this circuit.

The sluggishness of the fet circuit is due primarily to the shunt loading placed across the crystal by the netting capacitor, C1, and the diode, CR1. If a variable-capacitance diode is used in the circuit (in addition to the netting capacitor), crystals with ESRs of less than 16 ohms are required for reliable starting.

Goral oscillator

Obviously, it is possible to make the basic fet Colpitts oscillator more active by operating it at higher drive levels. However, for best stability, the crystal drive level should be kept as low as possible, consistent with reliable starting. If the oscillator loop gain can be increased without increasing crystal current or substantially increasing drive level, the performance of

![fig. 1. Basic Colpitts oscillator using an npn transistor.](image)

![fig. 2. Basic Colpitts oscillator circuit using an fet.](image)

![fig. 3. Practical Colpitts oscillator using an fet. Component values have been optimized for the 10- to 20-MHz frequency range.](image)
ture stability of the circuit. Transistor Q3 is a simple buffer to prevent oscillator loading.

Don’t be concerned by the strange numbers associated with the transistors. Device Q1 is a Motorola jfet and was selected because of its low cost ($0.38 each). Practically any junction-type field-effect transistor will work in the circuit without affecting performance. The MPS-5172 may also be an unusual number. Again, it is the lowest cost Motorola rf small-signal device in their line ($0.21 each). There are HEP equivalents, but, frankly, they are more expensive because of the packaging. Again, transistors Q2 and Q3 are totally non-critical and virtually any general purpose npn rf type should work equally well. The agc diode, CR1, is a 1N914 or 1N4148.

Fig. 5 shows a simple variation to the basic Goral oscillator which incorporates a variable-capacitance diode. This allows the frequency to be varied with an external dc source (such as a clarifier on fixed-frequency ssb equipment) or modulated for fm applications.

Although the circuit of fig. 6 is untested, it should make an outstanding vfo. Any temperature instability and drift which occurs in this circuit is the result of the tank circuit and not the devices or components.

A printed-circuit board for a simple crystal test oscillator is shown in fig. 7. Note the only variation from fig. 4 is the

---

**fig. 5.** A varicap may be used in the Goral oscillator, as shown here, to vary the output frequency from a variable dc source.

---

**fig. 6.** Using the Goral oscillator as a highly stable vfo. The L/C values are chosen for the desired output frequency.

---

**fig. 4.** The Goral crystal oscillator circuit. Emitter follower Q2 provides power gain for the feedback energy, providing high crystal activity without affecting the crystal drive level. Transistor Q3 is the output buffer. Diode CR1 is a 1N914 or 1N4148.
fig. 7. Printed-circuit component layout for a simple crystal test set using the Goral oscillator. This same circuit board may be used for the circuit shown in fig. 4 (see text). Full-size PC board is shown in fig. 8.

fig. 8. Full-size printed circuit board for a simple crystal tester.

value of the gate resistor for Q1. Here it is reduced to 100k to permit reading the gate current (and, therefore, crystal activity) on the meter.

I wish to thank Pierre Goral, who developed the circuit, for his assistance in preparing this article.
Simple vfo adds all-channel receiving capability to two-meter fm transceivers

Vhf fm transceivers have become very popular for local communication, taking much pressure off the high-frequency bands, but the typical fm transceiver, with its limited number of channels, lacks the versatility that many hams desire. In Southern California, for example, every two-meter channel is occupied — some many times over — and trying to provide operating capability on each can be very expensive, whether the approach taken is multiple crystals or a frequency synthesizer. Yet most hams would like to operate, or at least have the capability to operate, on many channels. After operating for a while, mostly mobile, on a few channels that were already installed in the used rig I bought, I came to the conclusion that what I really needed was tunable receiving capability, not vast numbers of full channels. A tunable receiver permits me to listen in on other channels, perhaps finding one I’d like to try, or quickly eliminating others because of the geographical coverage, use of the repeater, or even the people on the channel. It’s obvious, I believe, that some repeaters welcome new blood, whereas others are occupied by users who prefer to talk to the same people, just as is true in any social organization.
A tunable receiver also permits tuning the input of repeaters when malicious or accidental interference disrupts the frequency, making a little transmitter hunting desirable.

I developed the simple variable-frequency oscillator shown in fig. 1 to give me the tunable receiving capability needed for the relevant upper two megahertz of the two-meter band. It replaces the first crystal oscillator in an fm transceiver, and tunes over the required range, generally one-third of the first injection frequency; i.e., it operates at approximately 45 MHz for popular fm transceivers, a frequency that can easily be changed if needed.

The vfo can either be built into an existing transmitter, or into an add-on enclosure. The circuit itself is very small, and the potentiometer used to tune it can be placed remotely.

circuit description

The vfo uses a field-effect-transistor oscillator tuned by a tuning diode (variously known as a Varicap, varactor or variable-capacitance diode). A source-follower output stage buffers the oscillator, and the supply voltage is regulated by a zener diode. Stability is certainly adequate for the usual fm receiver, but I haven’t checked it on one with a very narrow bandpass.

None of the parts in the vfo seem exotic, and it should be possible for any active building ham to put it together in a few hours out of parts in his collection.

The oscillator uses an inexpensive plastic field-effect transistor in a Colpitts circuit. The transistor is a member of the popular and large Motorola family whose Grandfather is the MPF102, but I recommend that you use one of the better specified versions rather than the MPF102, which has a very wide IdSS range. I used the MPF102, but ended up having to try different values of source resistance to get satisfactory results.

The oscillator tank coil is a simple four-turn coil of heavy silver-plated wire. The silver is obviously not needed, but I found it easier to unwind a short piece of World War II vintage tank-transmitter coil than find tinned number-16 copper wire. A toroidal coil would also be suitable,

---

**fig. 1. Schematic diagram of the receiving vfo for two-meter vhf-fm equipment. Fets Q1 and Q2 are MPF102 types (2N5668, 2N5669 are better). L1 is 4 turns no. 16, 3/8" (13 mm) in diameter.**
perhaps even necessary, for lower-frequency versions if you want to keep the vfo small.

The circuit is tuned by an inexpensive Motorola tuning diode in a plastic TO-92, D-shaped case like that used for the fet oscillator. The particular diode used, the MV2201, has a nominal capacitance of 6.8 picofarads, but any similar diode—even an expensive military type—is suitable. I used Motorola parts because they are widely available; the HEP versions are quite suitable with the sole warning that their HEP802 fet appears to be like the MPF102, so the same warning about the source resistor applies. If it doesn’t work, try another value of resistance.

The varactor tuning makes it simple to tune the unit remotely, and to pick restricted ranges, but a small trimmer capacitor could also be used. In this case, construction is more complicated and critical.

With a variable resistor for tuning, however, you can take a number of approaches. A simple 270° potentiometer will cover the band in one swing, but makes tuning a little tricky. One is easy to add to the front panel of a transceiver, however, and if the tuning range is restricted to part of the band, this should work. Use a composition pot, not a wirewound one, which tends to give step-wise tuning, and the steps aren’t likely to be the ones you want.

For best control and calibration, I recommend a ten-turn potentiometer and appropriate digital dial. With a 2000-kHz range, and close to 1000 divisions, repeatability and calibration is excellent. It won’t be linear calibration, of course, though if you’re a masochist, you could probably come close with proper selection of component values and padding. A wire-wound pot is fine for this use since the steps are much smaller.

It’s also possible to use a switch and multiple resistive trimming pots for selecting specific channels. I still recommend that you have provision for variable tuning, however.

You might notice the two diodes at the ground end of the potentiometer. These forward-biased silicon diodes raise the cold end of the pot about 1.4 volts above ground, ensuring that the varactor is reverse biased at any setting of the pot. They also help select the proper bandwidth (with the 1500-ohm resistor and 5000-ohm pot), and provide some temperature compensation for the varactor, at least in theory. I don’t have the facilities for checking the latter, and am not ambitious or curious enough to find them.

I highly recommend that you use quality mica capacitors in the frequency-determining tank circuit (and that includes all small value capacitors in the circuit except the 15-pF output capacitor). An unstable ceramic capacitor can be very frustrating, particularly if you use the unit in an unheated garage or automobile (admittedly not as big a problem in coastal Southern California as it is in Wisconsin or New Hampshire). The small rf choke, by the way, is not critical in value. The circuit works without it, but exhibits considerable amplitude variation across the tuning range.

The buffer output stage is straightforward, and uses the same type of transistor as the oscillator. The source follower configuration provides adequate drive for popular transistor rigs; if drive is inadequate, it might be necessary to
convert this stage to a tuned-drain version, as shown in fig. 2 (I haven't tried this, though). Even a broadly tuned rf choke might be adequate, but don't bother unless you try. Most quality rigs designed for fm don't require much drive; it would make the crystals drift. A converted military receiver might be another matter.

The vfo operates from about 12 volts, with a 9- or 10-volt zener diode regulating the voltage to the transistors and tuning diode. Little current is required, but if you operate from small batteries, you can dispense with the zener and operate directly from 9 volts or so. The short-term variations should be small enough for the intended use. That's not true in a car, however. The supply voltage there often varies from 11.5 to 14.5 volts.

construction

The easiest way to make the vfo is probably to use a small piece of perforated Vector board. An etched circuit board is prettier, but a lot of trouble if you're just making one. Do mount everything solidly, as in any vfo. I found fairly extensive filtering and shielding necessary, but this might not be critical out in the provinces. Before I shielded the unit, it received amateurs, Adam 12, aircraft and Alice Cooper, simultaneously. A shielded cable is vital for both remote control and output leads, also.

installation

The electrical installation is relatively straightforward; I'll leave the mechanical engineering to you. Simply unplug one crystal, and connect the output of the vfo to the hot end. In the Tempo FMP I use, the high end of the crystal is switched, and the low end is grounded through a small trimmer capacitor. Make sure that you connect the vfo and cable ground directly to the transceiver ground, not through this trimmer. Use the shortest lead possible, and a direct ground.

I recommend Teflon-insulated miniature cable, not RG-174/U with its soft plastic insulation. Most of the fm rigs are tiny, and burning plastic insulation looks and smells horrible. By the way, the battery compartment of my Tempo FMP has space for the vfo.

One warning: It is possible for the crystal oscillator in the rig to take off when you attach the input lead to it, but this can be prevented by installing a small rf choke in the lead from the vfo right at the crystal socket. A couple of small ferrite beads may do the job. If worst comes to worst, you might even have to ground the emitter of the crystal oscillator transistor through a bypass capacitor of, say, 470 pF, when using the tunable vfo. I didn't have any trouble with one vfo I built, but the other needed the rf choke.

calibration

I suggest that you make sure the vfo is working properly before you install it, as the installation will undoubtedly be a little tedious if you put it in a transceiver. The easiest way to check operation and range is with a suitable frequency counter. You can also use a monitor receiver, or a signal generator plus the receiver, but these can be confusing due to the numerous images possible. You'll need to touch up the tuning after installation. If the tuning range isn't correct, you can juggle component values. This technique is undoubtedly all too familiar to anyone who reads ham radio and has read this far.

final note

Just out of curiosity, I replaced the source-follower output stage with a tuned tank circuit on two meters (as in fig. 2), then introduced a small amount of audio into the varactor from a dynamic microphone. The combination transmitted good quality fm for a few blocks, but I can't really recommend the technique for general use, not with the sharp receivers (and tongues) found in most areas. I don't even recommend it as a crystal replacement for transmitters for the same reasons.

ham radio
After using a Yagi antenna for ten years with excellent results, the time came when it had to be replaced. I decided this was a good time to test the relative merits of the quad antenna. The following piece presents the results of four years of work dealing with construction problems of a cubical quad in a Canadian climate. Emphasis is placed on mechanical details such as clips and fasteners, joint interfaces, protection of wire elements and spreader design. On-the-air results are also reported, which are based on qualitative observations.

Electrically, the design is the same as that described by Lee Bergren in the May, 1963, issue of QST.1 The only claim I have to this design is the mechanical features described here.

**project objectives**

The quad has a bad reputation in Canada because of mechanical problems that occur during the severe winters. My first two models failed during successive winters; the third model survived three Toronto winters with no maintenance. It was designed with the following objectives:

1. Stronger joints between crossarms and boom.
2. Better clamps between spreaders and wire elements.
3. A means to avoid element breakage.

4. A better joint between spreaders and crossarms.

description

The boom is made of 3-inch (7.6-cm) aluminum irrigation pipe instead of the 4-inch (10.2-cm) diameter pipe used in Bergren's design and proved to be quite satisfactory. It is lighter in weight and crossarm-to-boom joints remained tight by minimizing sway in the spreaders, which could elongate the holes in the boom. In a commercially-built quad, the holes through the boom have additional bearing surfaces provided by sleeves shrunk onto the boom. This is difficult for the amateur to achieve, so it was necessary to make a tight fit with the materials available. If you have the means to shrink sleeves onto the boom at these points, the advantage is obvious. Aluminum irrigation pipe is not always perfectly circular, and this in itself presents a difficulty when making sleeves or spider clamps.

drilling the boom

As explained in the article by Bergren, holes are drilled at 90 degrees through the boom 1/8 inch (3 mm) apart. These holes are to accommodate the square aluminum plate used as a support. Certain precautions must be observed, however, in drilling the holes to make them accommodate a push fit for the 1/8-inch (32-mm) ID aluminum tubes used for crossarms, each of which is 4 feet (1.2 meters) long.

To avoid some of the weaker points in antenna construction much care must be used in marking the boom for drilling. Nothing but utmost pains is good enough. Circumscribe on the outside of the metal boom a circle that exactly defines the outside contour of the tube hole. If you are using 1/8-inch (32-mm) ID tubing, the circles will be 1.376 inches (35.0 mm) diameter (for a wall thickness of 0.063 inch, or 1.5 mm). A tube with a thicker wall will need holes slightly farther apart.

When correctly marked, the holes will be drilled to a diameter of 1/8 inches (32 mm). When using a large drill through a thin-wall tube, the inside of the holes will be rough and uneven. It is essential that the holes make a perfectly smooth fit for the tubing forming the antenna cross arms.

The hole now lies about 1/32 inch (1 mm) inside the circumscribed circle. A steel plug 1.413 inches (36 mm) in diameter is now prepared. File the rough-drilled hole carefully until it is perfectly circular, so that the steel plug fits the hole exactly.

measurement notes

You'll notice that dimensions for holes and parts are given quite exactly, and this is important. If the antenna is to withstand the weather, care in making measurements is imperative. Much care and patience at this point will pay off in a maintenance-free installation. It's surprising how exactly the fitting process can be done, especially if a jig or template is available.

The remaining 1/32 inch (1 mm) of the crossarm hole is now filed out, using the circumscribed circle on the metal and a piece of the crossarm tube as templates. A really tight fit is the objective here — a
The joint that will not work loose. The corresponding hole on the other side of the boom is similarly marked and drilled (don’t try to drill straight through the boom). By careful measurement, the holes will be so closely opposed to each other that the spreader tips, when assembled, will not be more than 1 inch (25 mm) out of alignment.

By careful measurement, the holes will be so closely opposed to each other that the spreader tips, when assembled, will not be more than 1 inch (25 mm) out of alignment.

138

139 14.0

142

148

165

14.3

144

14.4

101

FREQUENCY

IMHzI

Curve 1 Driven element only, 15 feet (4.6 m)
Curve 2 1st director added, 15 feet (4.6 m)
Curve 3 2nd director added, 15 feet (4.6 m)
Curve 4 Boom lifted to 30 feet (9.1 m)
Curve 5 Reflector added, 75 feet (22.9 m)

fig. 2. Standing wave ratio readings taken during assembly of the array. Bridge was located at the junction of the coaxial transmission line and the element except for curve 5, when the bridge was between the coaxial transmission line and the transmitter. Dimensions refer to boom heights above ground.

machining the boom

The only part of the work that required commercial help was turning a 24-inch (61-cm) length of aluminum tubing to join two 15-foot (4.6-meter) lengths of aluminum irrigation pipe used for the boom. The pipe arrived in two 20-foot (6.1-meter) lengths. However, the boom went together so easily, and was erected so simply, that if I did the job again, I’d have no hesitation at all in using a 40-foot (12.2-meter) boom.

If, as in my case, the pipe is not absolutely circular, carefully measure the maximum and minimum diameters, average them, and subtract 0.003 inch (0.1 mm) for clearance. Grease the pipe well (a good silicone grease is best), and hammer the two boom lengths onto the junction piece using a block of wood and a sledge hammer. This completes the boom except for minor details.

spreaders

Fiberglass tapered tubes are used for the spreaders, rather than aluminum, because the fiberglass causes less wind loading. The spreaders are 13 feet (3.96 meters) long, 1¼ inches (32 mm) in diameter, tapering to 3/8 inch (10 mm). This configuration presents a nicely balanced combination of adequate stiffness with light weight.

At a length of 13 feet (3.96 meters), the two spreaders in line need no separation to achieve the desired length, and so are simply moved down the 1¼-inch (32-mm) diameter crossarms until they meet at the center. They are fixed in this position by the bolts that secure each crossarm to the square plate, since these bolts pass through the aluminum tube, fiberglass tube and plate.

The only other adjustment is at the point where the spreader emerges from the crossarm. Since the spreader is tapered, some play will exist at this point. This play is taken up by inserting a neoprene O-ring just inside the end of the aluminum crossarm. It needs no holding in place, but the joint at this point can be covered by a machined aluminum sleeve, made to fit the two tubes, and secured by two self-tapping screws.

The size of the thick end of the spreader should be checked with the manufacturer before buying your crossarm material. Mine required a little work with an emery cloth to make a perfect fit.

clips and fasteners

The homemade clip shown in fig. 1 resulted from many experiments. The clamp is a commercially obtained item. The tube portion, which carries the wire element, is made from 1/8-inch (3-mm) 1D copper tubing. The tube radius should be 3 inches (76 mm). Sections of the copper tube are cut off so that the ends point at right angles to each other. The supporting band, to which the 3/8-inch (10-mm) diameter clamp attaches, is a
strip of copper cut to length, formed, and soldered to the copper tube as shown. The idea is to provide support to the wire elements through the entire radius of the bend, presenting no solid point where the wire could fracture from vibration.

When the wire loops have been fed through the tubing clamps, cut to length, and secured, the wire will be prevented from slipping through the clamps by solder dropped onto the wire just clear of the clamp ends. One or two turns of number-22 AWG (0.6-mm) wire at the desired point will assist in making a good solder joint. Note that cold solder jobs in this area are a definite "no-no" if your antenna is to withstand the elements.

Be certain the wire elements move freely within the copper tubing. Any sharp bends in the wire will defeat the entire idea of this project; remember, care in construction will pay off in maintenance-free operation.

rotator

The usual pressure-grip clamp arrangements used on the antenna rotator shaft (2 inches, or 51 mm) diameter are inadequate for an antenna of this size. If a HAM-M rotator is used, the ⅛-inch (6-mm) bolt that screws into the rotating shaft at top and bottom of the motor should be removed. This bolt should be replaced with a 3/8-inch (10-mm) high-tensile-strength bolt to avoid shearing under the stress involved.

performance

The curves in fig. 2 show the standing wave ratio of the antenna during assembly. Curve 5 shows swr with the complete array elevated to 75 feet (22.9 meters). Antenna bandwidth is 200 kHz with an swr of less than 2:1, which is to be expected. Qualitative tests indicated a front-to-back ratio of 28 dB. Not bad for a home-built antenna.

reference

Advance Registration, $11.00 per person, includes:
1. Advance Registration ticket.
2. Regular Registration ticket.
3. Admission ticket to Social Hour, hosted by T. P. L. Communications and TRI-EX Tower Corp. with SAROC on Friday.
4. Admission to Exhibit Area and Technical Sessions.
5. Ladies will receive an additional ticket.
6. Admission ticket to Social Hour, hosted by Ham Radio Magazine with SAROC on Saturday.
8. Tax and Gratuity on all items listed.

Advance Registration, with midnight show, $21.00 per person:
Includes all items 1 thru 8, plus Hotel Sahara's midnight show with two drinks in the Congo Room starring Totie Fields.

Advance Registration, with dinner show, $27.42 per person:
All items 1 thru 8, plus Hotel Sahara's Dinner Show, no drinks, in the Congo Room starring Totie Fields.

Mail your SAROC Advance Registration check now to SAROC, P. O. Box 945, Boulder City, Nevada 89005, must be received before 15 December 1974.

Full refund on advance registration if written request is received in SAROC, P. O. Box 945, Boulder City, Nevada before 2 January 1975.

Special airfares via United Airlines round trip to Las Vegas, Nevada from selected cities, includes three nights accommodations, SAROC Advance Registration, Dinner Show, Tax and Gratuity. Request complete details from SAROC, P. O. Box 945, Boulder City, Nevada 89005.

Call toll free 800-634-6666 for Del Webb's Hotel Sahara accommodations, for SAROC special room rate of $15.00 per night, plus room tax, single or double occupancy, effective January 2-6, 1975.
Explore the world of RTTY... with sophisticated equipment from HAL.

The RVD-1002. The silent, reliable RTTY video display unit from HAL.
The revolutionary HAL RVD-1002 RTTY video display unit "prints" an RTTY signal from any TU at the four standard data rates (60, 66, 75 and 100 WPM), using a TV receiver with slight modification. Or it will directly feed a TV monitor. Power consumption is low, thanks to the RVD-1002's solid-state construction. So turn on to silent, trouble-free RTTY — with the RVD-1002.
Price: $575 ppd, USA. Air shipment $10.

The silent RTTY keyboard — that's the HAL RKB-1.
The RKB-1 TTY keyboard is loaded with features to make sending RTTY easy and fun. You get automatic letter/number shift at all four speeds, typewriter keyboard layout, and no clatter. The loop keying transistor is isolated from other keyboard circuits — wire it into any convenient point in your loop. Plus TTL logic, glass epoxy PC board, commercial grade keyswitches and more.
Price: $250 Assembled, ppd USA. Air shipment $5.

RTTY — and CW on one keyboard! The HAL DKB-2010.
All solid-state. Transmit at data rates of 60, 66, 75 or 100 WPM at the flick of a switch. Complete alphanumeric keys, 15 punctuation marks, 3 carriage control keys, 2 shift keys, break key, 2 character function keys, a "DE-call sign" key, even a "Quick brown fox..." test key.
The DKB-2010 includes a three-character buffer operational in either the RTTY or CW mode. Optional 64 or 128 key buffer also available.
Price: $425 Assembled, $325 Kit, ppd USA. 64 key buffer $100, 128 key buffer $150. Air shipment $10.

Commercial quality on an amateur's budget — the HAL ST-6 TU
Every amateur who knows his RTTY respects the ST-6 terminal as being the best. Autostart operation, an antispace feature and switch selection of 850 and 170 Hz shifts are standard. Circuitry is state-of-the-art, including DIP IC's on plug-in PC cards. Filters and discriminators are designed for standard RTTY tones. A 425 Hz shift discriminator is an option which allows superior reception when copying commercial press transmissions. Another option is the AK-1 audio frequency shift keyer for input to an SSB transmitter. The ST-6 and its options are available in assembled or kit form. Cabinet not included in kit.
Price: ST-6 $310 Assembled, $147.50 Kit, ppd USA. 425 Hz Discriminator $40 Assembled, $29 Kit, ppd USA. AK-1 AF $90 Assembled, $29 Kit, ppd USA. Air shipment: Assembled ST-6 with any or all options $10, ST-6 Kit $4, 425 Hz Kit $1, AK-1 Kit $1.

HAL Communications Corp. Box 365, Urbana, Illinois 61801 Telephone: (217) 359-7373
Enclosed is $ for: [ ] RVD-1002 [ ] RKB-1 [ ] DKB-2010 [ ] ST-6
Please specify [ ] Assembled [ ] Kit [ ] Options
Please send me more information on the following HAL products:
[ ] RVD-1002 [ ] RKB-1 [ ] DKB-2010 [ ] ST-6
[ ] Complete HAL catalog

Name__________________________________ Address______________________ Call Sign____________________
City/State/Zip__________________________

Illinois residents add 5% sales tax.
automatic reset timer

Using the versatile NE555 timer IC as a ten-minute ID timer or repeater time-out timer

Recently, when a friend expressed a need for a timer with automatic reset or triggering capability, the NE555V integrated circuit came to mind. The NE555V is a versatile, inexpensive IC designed especially for timer and oscillator use. External components determine the time delay or oscillator frequency and duty cycle. The output is capable of sourcing or sinking 200 mA, adequate for most small relays.† Other basic timer circuits have been described previously,1,2 but all require triggering by a manually-operated switch or by relay contacts.

Fig. 1 shows the basic timer circuit. As shown, the relay or other load is normally off. For normally on operation connect the relay or other load between pin 3 and ground. The delay time constant is set by the simple RC product of R1 and C1. Pins 2 and 4 are grounded momentarily through switch S1, providing start or manual reset of the timer. Pin 2 is the trigger input; when it is grounded momentarily the timing interval is started. Once started it cannot be retriggered. Pin 4 is the reset input; when it is grounded momentarily the timing interval is ended (the output goes low). With pins 2 and 4 connected together both functions are obtained with one push of the switch. When the reset function is not wanted pin 4 should be connected to pin 8, VCC.

The NE555V IC can also be triggered by a negative-going pulse applied to pin 2. Thus, two or more timers can be cascaded for sequential timing as shown in fig. 2.

†Although a relay coil is shown as the load, the NE555V may be able to operate some loads directly. The 200-mA load current is for a supply voltage of 15 volts, however, and load current will be less for lower supply voltages.
When pin 3 goes low at the end of a timing interval, a negative pulse is generated by the .001-μF capacitor and 27k resistor. This pulse triggers the start of the second timer IC. If a similar pulse circuit is connected to the second timer, and its output is connected to the trigger input of the first timer, the second timer automatically triggers the first timer as shown in fig. 3.

The second timer can be set to determine the on time of the first timer. When the timing interval of the second NE555V is completed a negative pulse is generated from the second .001 μF capacitor and 27k resistor. This pulse triggers the first timer which turns off the relay. Thus, the first timer determines the delay time interval and the second timer determines the on time of the relay.

At the end of the on time the first timer is automatically triggered and starts another timing interval. If the start/reset switch is closed momentarily, both timers are triggered. This does not matter because the first timer cannot be reset or triggered by the trigger pulse from the second timer while the first timer is in its timing interval.

For time delays of more than a few minutes a good quality tantalum capacitor such as a Sprague 150D should be used. For example, a ten-minute time delay requires a 100-μF capacitor and a 6-megohm resistor. Two possible applications for this circuit are station ID timers and repeater time-out timers.

You might also consider using the astable multivibrator circuit (fig. 4). The charge and discharge times of the capacitor, C, are determined as follows: Discharge time (when the output, pin 3, is low) $t_2 = 0.685(R_b)C$. The charge time (when the output is high) $t_1 = 0.685(R_b+R_d)C$. This circuit has two main disadvantages for longer time delays. For one thing, the first timing interval is longer than subsequent ones. This is due to the fact that the capacitor's charge starts from zero for the first time interval but thereafter operates between 1/3 and 2/3 of $V_{cc}$. The second disadvantage is that there is no manual reset capability. Even if the reset pin is connected to ground through a switch the capacitor will not be completely discharged, due to the time constant of $R_b$ and $C$.

references
Shed unwanted QRM and Foreign Broadcast signals with a 25 db front-to-back. Work stations you never knew existed. Let the Hy-Gain 402BA help you make 5 Band DXCC and 5 Band WAS. Designed with only one objective... optimum performance in a small package, the 402BA offers mechanical and electrical superiority at an affordable price. A unique linear loading stub delivers maximum performance without the loss of center loading coils. Can be easily stacked with tri-band or 20 meter beams and requires only 10' separation. The exclusive Hy-Gain Beta Match gives positive DC ground to drain away precipitation static. For best results, use with Hy-Gain BN-86 Balun.

- 4.9 db forward gain.
- 12-25 db Front/Back ratio.
- SWR 1.5:1 or less at resonance.
- Takes maximum power.
- 1 KW AM, 2 KW PEP.
- Boom length 16', longest element 43'.
- Only 8.5 sq. ft. surface area.
- Weighs just 47 lbs.
- Turns in only 24' radius.
- DC grounded, driven element.
- Wind survival - 80 mph.

**Order No. 397**

For prices and information, contact your local Hy-Gain distributor or write Hy-Gain.


Branch Office and Warehouse: 8100 Sepulveda Blvd., #322, Van Nuys, CA 91401; 213/785-4532; Telex 65-1359.

Distributed in Canada by Lectron Radio Sales, Ltd., 211 Hunter Street West, Peterborough, Ontario.
enhancing cw reception through a simulated-stereo technique

A simple method for improving copyability of CW signals

A sharp audio filter is a great help in copying CW signals through noise and interference. A filter passband of 100 Hz will accommodate the keying bandwidth at 20 wpm and tolerate some short-term drift of transmitter and receiver. However, such a narrow filter makes scanning of the band slow and difficult, and with high skirt selectivity the character of the received signal and its attack and decay may become distorted from ringing.

threshold gating

Higher noise reduction than possible from a tuned filter can be accomplished through threshold-gating, a technique in which the received and filtered CW signal is used to key a relay or an electronic switch. In turn, the relay or switch feeds the received and filtered signal or a sidetone oscillator to the headphones or speaker. Threshold-gating achieves its selectivity through the switching process. No signal is heard off frequency or between the dots and dashes. However, the original signal is highly distorted, especially in its attack and decay, or is completely replaced by a sidetone. As a result, feel for band conditions and for the quality and “signature” of the signal are lost, and any reply slightly off the filter frequency will not be heard at all.

This discussion suggests that you cannot, at the same time, use high filter selectivity and retain an essentially unaltered CW signal and full feel for the signal and the band. Therefore, sharp filters seem to have little value in contests and net operations, where you want to respond rapidly, often to signals which
appear to one side of your receiver center frequency.

**another approach**

This is certainly true as long as you listen to the filtered signal only. However, if you were to listen simultaneously to one speaker fed with the processed signal and another speaker reproducing the “raw” CW signal, you could retain a feel for the band and would even hear chirp and clicks that extend beyond the filter passband. Also, if the received signal were drifting you would not lose it, and you could hear replies at some distance from the center frequency of your filter. Obviously, you would also lose some of the advantage of the filter and QRM and QRN would have returned to some degree.

To this end, you can be helped by the ability of the brain to discriminate between signals which appear at both ears or only at one. To do this, the incoming CW signal is divided into two channels as shown in fig. 1. Half of the signal goes through a sharp filter to one ear, and the other half is passed unfiltered to the other ear. The level or balance control in the unfiltered side compensates for any attenuation of the filter. It is set so that a tone centered in the filter passband is heard by both ears at the same loudness level. This tone is then perceived stereo-

*Because this effect may be enhanced or diminished by the phase relationship of the audio in the two earpieces, it would be desirable to try transposing the leads to one of the earpieces to see what happens.*

**results**

The effect of this simulated stereo reception of CW signals is dramatic. Interfering signals and broadband noise appear to come from a point off to one side of the head. The desired signal, centered in the filter passband, appears within or just in front of the head and assumes a transparent clarity that is hard to describe. The signal-to-noise ratio is much improved. The character of the signal is preserved and ringing is either absent or less apparent than in monaural reception with the same filter. Chirp and clicks are readily noticed, and even drifting signals or DX signals with multipath distortion are readily copied.

The mind seems to concentrate automatically on the desired signal and to be relatively unaware of and undisturbed by the signals outside the filter passband. Yet, that information is present and an off-frequency reply is heard just as well as if no filter were in use.

**practical considerations**

I have used this approach with a simple passive toroid filter and with a more complex filter and threshold-gate combination. Both are effective. The latter has an advantage on some occa-
sions, but for its simplicity and ease of adjustment the toroid filter is superior. The high-impedance audio signal from my HW101 is matched to the low impedance of the series-tuned toroid filter by a transformer, as shown in fig. 2. The center-tapped secondary provides two equal signals, one attenuated by the balance control and then fed to the right channel of a low-impedance stereo headset.

The toroid filter in the other half of the secondary resonates at 790 Hz and has a 3-dB bandwidth of 60 Hz; this frequency was chosen because the apparent stereo separation increases at lower frequencies. The output of the filter is fed directly to the left channel of the headset. The balance control should be adjusted on a moderately weak CW signal; a strong, steady tone, such as from a crystal calibrator, gives a slightly different balance.

First, peak the signal in the filter by listening only to the left earphone, then put on both phones and adjust the balance control until the signal appears centered. The range of the balance control is sufficient to move the signal from the far right across center to the left. Little further adjustment is required under differing band conditions.

The principle can be applied in various ways. Other input and output impedances can be accommodated with different transformers, or a parallel-tuned toroid filter (approximately 500 ohms) could be used. Other filters could be substituted, and instead of earphones a stereo amplifier and speaker combination used to give a good demonstration of simulated-stereo CW reception to interested listeners at a club meeting or hamfest.

references

DATA SIGNAL
the latest in station accessories

AUDIO AUTOMATIC GAIN CONTROL AMPLIFIER
Is your tone decoder having problems due to input signal variations? If so, eliminate these and other problems caused by weak, strong or varying input signals. The AAGC-1 will take signal levels between 50 mV to 5 Volts and feed a clean rock stable signal to any decoder for perfect operation. Give your decoder a chance to decode properly with our AAGC-1 amplifier.

Shipping Weight 3 oz. $14.95 kit $19.95 wired

DELUXE RECEIVER PREAMPS
Specially made for both OLD and NEW receivers. The smallest and most powerful single and dual stage preamps available. Bring in the weakest signals with a Data Preamp. Now with improved FET's for greater performance.

<table>
<thead>
<tr>
<th>BAND</th>
<th>STAGES</th>
<th>GAIN</th>
<th>NOISE FIGURE</th>
<th>KIT PRICE</th>
<th>WIRED PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 meter</td>
<td>Single</td>
<td>25 dB</td>
<td>2 dB</td>
<td>$15.50</td>
<td>$18.50</td>
</tr>
<tr>
<td>6 meter</td>
<td>Single</td>
<td>25 dB</td>
<td>2 dB</td>
<td>$15.50</td>
<td>$18.50</td>
</tr>
<tr>
<td>2 meter</td>
<td>Single</td>
<td>20 dB</td>
<td>2.5 dB</td>
<td>$15.50</td>
<td>$18.50</td>
</tr>
<tr>
<td>2 meter</td>
<td>Double</td>
<td>40 dB</td>
<td>2.5 dB</td>
<td>$30.50</td>
<td>$36.50</td>
</tr>
<tr>
<td>220 MHz</td>
<td>Single</td>
<td>17 dB</td>
<td>2.5 dB</td>
<td>$15.50</td>
<td>$18.50</td>
</tr>
<tr>
<td>220 MHz</td>
<td>Double</td>
<td>35 dB</td>
<td>2.5 dB</td>
<td>$30.50</td>
<td>$36.50</td>
</tr>
</tbody>
</table>

CRICKET 1 ELECTRONIC KEYER
A popularly-priced IC keyer with more features for your dollar. Cricket I is small in size and designed for the beginner as well as the most advanced operator. It provides fatigue-free sending and its clean, crisp CW allows for easy copying at all speeds. Turned on its side, the Cricket can be used as a straight key for manual keying. Right or left hand operation. AC/DC.

Shipping Weight 3 lbs. $49.95

OTHER EXCITING PRODUCTS INCLUDE
TOUCHTONE TO ROTARY CONVERTER
TOUCHTONE TO TOUCHTONE CONVERTER
TOUCHTONE PADS
AUTOMATIC DIALER
ANTI-FALSING TOUCHTONE DECODER
AGC AMPLIFIER

Write today for complete details

Data Signal, Inc.
Successor to Data Engineering, Inc.
2212 Palmyra Road
Albany, Ga. 31701
912-435-1764
In a self-sufficient QRP station the storage battery is king. Although battery power need not be limited to low-power stations, QRP operation does permit you to gain knowledge of the science, gradually weaning you away from plug-in power, and over a period of time you can make your amateur station reasonably independent of the power mains. Solar power, wind power, etc., can make it so. The wind and solar conversion combination is attractive because on very cloudy days when there is no bright sunshine, there often is wind. Initially it might be expedient to take some power from the mains with an efficient battery charger, particularly when power demand is above the QRP level and there is a sequence of dark, windless days.

The radio amateur may be able to make a considerable contribution by demonstrating how energy can be derived from light, wind and other means. A house that is partly or completely self-sufficient in terms of heat and electrical power is a worthy objective.

Battery power at kilowatt and higher levels requires a well-ventilated hut or battery room, if lead-acid wet batteries are to be used. During the charge cycle batteries release some hydrogen gas which, if permitted to accumulate, becomes explosive. More gas is released when charging at a high rate or when you permit batteries to overcharge. Normally there is no hazard if the hydrogen gas circulates and intermixes freely with the atmosphere.

A ventilated window box will do for somewhat lower power levels. However, batteries must be selected to withstand the weather extremes of the site or mounting position. Nickel-cadmium batteries have fewer such problems and can be operated in more confined areas but are considerably more expensive at the higher power levels as compared to lead-acid types.

Some of you who lived in farm country before rural electrification may recall the small battery room just away from or attached to farm houses. Remember the wind chargers, small gasoline engines and dc generators? This is not so much nostalgia as some very practical dreaming as to how to obtain at least some degree of self-sufficiency, avoiding some of our
enslavement to mass energy sources plus the high cost that shortages trigger.

small lead-acid batteries

In the realm of QRP operation there are a variety of small lead-acid types. Visit your local motorcycle shop or take a look at the variety of types listed on the motorcycle batteries list in the Sears catalog. Two- and four-ampere-hour (Ah) types can be purchased at low cost. A typical price for a 4-Ah, 12-volt battery is not much more than 10 dollars. Such a low-powered battery displaces very little hydrogen and can be brought into your radio shack with little hazard. It can be charged by the smallest of chargers or by a small solar energy converter. On the basis of a 20-hour discharge period, the 4-Ah battery can supply 200 mA continuously for a period of 20 hours (4/20). Based on amateur operating practice it would be no problem to supply up to 10 watts for almost 8 hours of continuous operation without requiring a recharge.

Power capacity and current capability can be increased by connecting two or more of these small batteries in parallel. Much depends on your operating practices. In most cases operating time is substantially less than the projected maximums suggested by the previous figures.

gelled-electrolyte batteries

There is an attractive newcomer on the scene. It is a lead-acid battery that uses a gelled electrolyte, fig. 1. It is truly a portable lead-acid battery that can be mounted at any angle and, in some models, even charged at any angle. Others charge more efficiently with the battery upright but can be charged at other angles with some limited decline in the total number of recycles. The electrolyte is unspillable and lasts for the full life of the battery, avoiding maintenance and handling problems. The battery has a one-way vent that serves as a release when there is undue gas pressure, although in this style of battery there is much less gassing.

The gelled-electrolyte battery handles...
temperature extremes very well and is capable of performing down to \(-76^\circ\text{F}\) \((-17^\circ\text{C})\). It is tolerant of both overcharge and a deep discharge and provides long, maintenance-free shelf life. Batteries may be connected in series, parallel or series-parallel combinations to obtain desired voltage and current capability. Case and

**GC 1245-1 Specifications**

<table>
<thead>
<tr>
<th>Nominal voltage</th>
<th>12 volts (6 cells in series)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal capacity at:</td>
<td>4.5 Ah</td>
</tr>
<tr>
<td>225 mA (20-hour rate) to 10.5 volts</td>
<td>4.3 Ah</td>
</tr>
<tr>
<td>430 mA (10-hour rate) to 10.26 volts</td>
<td>3.9 Ah</td>
</tr>
<tr>
<td>780 mA (5-hour rate) to 10.14 volts</td>
<td>2.4 Ah</td>
</tr>
<tr>
<td>2400 mA (1-hour rate) to 9.6 volts</td>
<td>0.96 watt-hours/cubic inch</td>
</tr>
<tr>
<td>Energy density (20-hour rate)</td>
<td>12 watt-hours/pound</td>
</tr>
<tr>
<td>Specific energy (20-hour rate)</td>
<td>approximately 60 milliohms</td>
</tr>
<tr>
<td>Internal resistance of charged battery</td>
<td>80 amperes</td>
</tr>
<tr>
<td>Maximum discharge current with standard terminals</td>
<td></td>
</tr>
<tr>
<td>Discharge</td>
<td>(-76^\circ\text{F} \text{ to } +140^\circ\text{F})</td>
</tr>
<tr>
<td>Charge</td>
<td>(-4^\circ\text{F} \text{ to } +122^\circ\text{F})</td>
</tr>
<tr>
<td>Charge retention (shelf life) at (68^\circ\text{F})</td>
<td></td>
</tr>
<tr>
<td>1 month</td>
<td>97%</td>
</tr>
<tr>
<td>3 months</td>
<td>91%</td>
</tr>
<tr>
<td>6 months</td>
<td>82%</td>
</tr>
</tbody>
</table>

charger are provided for some types as shown in fig. 2.

The characteristics of the Globe-Union 4.5 ampere-hour, 12-volt battery are given in fig. 3. This battery would be a good choice for up to 5-watts QRP operation. Typical capacity figures are shown in item 2 of the specifications chart (fig. 3). Note, under item 9, the charge retention ability of the battery. When sitting unused for six months the charge drop-off is only 82%.

The first graph shows battery capacity as a function of the discharge rate. When discharged at the 20-hour rate the battery provides 100% capacity if operated at normal room temperature (about \(69^\circ\text{F}\) or \(21^\circ\text{C}\)). The percentage is lower for faster discharge rates.

Curves for various discharge rates are shown in the second graph. The top curve, representing the 20-hour rate, indicates a voltage decline to about 10 volts when the current demand is a continuous 0.225 amperes for a period of 20 hours. The final power delivered under this situation is about 2.25 watts \((0.225 \times 10)\). If a current demand of 1 ampere is made, note that the battery will provide almost four hours of continuous operation. This is about 10 watts of power for a continuous 4 hours. Thus, the 5-watt rating is a very conservative one.

In normal amateur operations you would have no trouble supplying 10 watts input to a QRP transmitter, and perhaps even more if you take care of the battery, preventing it from overcharging or dis-

fig. 4. This charger for gelled-electrolyte batteries provides either fast or float charging (photo courtesy Globe-Union).
charging to too deep a level. You can protect the battery's welfare by keeping an eye on its output voltage under load.

Power demand can be stretched even further if the battery is kept on a continuous floating charge with the permanent connection of a small charger, fig. 4. Current demand in amperes can be made for short periods of time.

The above operation also applies for daytime operation when using a solar energy converter as a float charger. Battery charge must be restored before the end of the day if capacity for night-time operation at lower power level is required.

The rated capacities (20-hour basis) for various Globe-Union gelled-electrolyte batteries are shown in table 1.

Prices are higher than for comparable wet electrolyte lead-acid types, but substantially lower than the cost of nickel-cadmium batteries. The combination shown in fig. 2 is especially attractive for use with portable transceivers because it includes a battery-case and a charger. Batteries of this type do vent some hydrogen at the end of the charge cycle, or upon overcharge, and although they are less hazardous than wet electrolyte types, sensible ventilation and avoidance of sparks are advisable during the charging interval.

**solar power as a charger**

The solar energy converter has excellent battery charging capabilities. There are a number of ways in which you can use such a source. If the converter has adequate capacity it can even handle the initial charging of the battery. This is really not too much of a requirement if you are willing to charge the battery initially in a series of long-term steps.

The second technique is to use a conventional charger to obtain the initial charge. Then the solar energy converter can be pressed into service as either a float or trickle charge source. In this mode of operation the current demand is only one-quarter or even a smaller fraction of the initial charge current requirement. If the battery is critical of charge voltage or current it is possible to add a solid-state regulator to the output of the solar energy converter. Under less stringent requirements the protective diode that is a part of the solar device can prevent the discharge of the battery when the impinging light on the solar cells is inadequate to maintain the proper charge current.

**battery chargers**

There are several battery-charging arrangements relating to battery types and mode of operation. Insofar as the initial charge is concerned, some batteries can be charged quickly while others are preferably charged at lower current rates over a longer period of time. In general,

---

**table 1. Rated capacity of various Globe-Union gelled-electrolyte batteries.**

<table>
<thead>
<tr>
<th>part number</th>
<th>nominal capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GC 210</td>
<td>0.9 Ah</td>
</tr>
<tr>
<td>GC 410</td>
<td>0.9 Ah</td>
</tr>
<tr>
<td>GC 610</td>
<td>0.9 Ah</td>
</tr>
<tr>
<td>GC 1215</td>
<td>1.5 Ah</td>
</tr>
<tr>
<td>GC 620</td>
<td>1.8 Ah</td>
</tr>
<tr>
<td>GC 426</td>
<td>2.6 Ah</td>
</tr>
<tr>
<td>GC 626</td>
<td>2.6 Ah</td>
</tr>
<tr>
<td>GC 1245</td>
<td>4.5 Ah</td>
</tr>
<tr>
<td>GC 660</td>
<td>6.0 Ah</td>
</tr>
<tr>
<td>GC 280</td>
<td>7.5 Ah</td>
</tr>
<tr>
<td>GC 680</td>
<td>7.5 Ah</td>
</tr>
<tr>
<td>GC 12200</td>
<td>20.0 Ah</td>
</tr>
</tbody>
</table>
nickel-cadmium types are charged at a slower rate than lead-acid types. Gelled-electrolyte types are usually charged at a slower rate than wet electrolyte cells.

For practically all types of rechargeable batteries the slow charge is much preferred over the fast charge, although certain battery types are less ill-affected by a fast charge, and in some circumstances you may have to sacrifice some battery life in favor of fast charging. Regular amateur radio operations are such that you can usually take advantage of slow charging, and, therefore, gain an extension in battery life.

Batteries can be charged and then discharged to a specified end voltage. At this time the battery is again charged fully, discharged, etc. In this mode of operation the battery is on charge whenever it is not being discharged by a connected load. Two other arrangements keep the battery on continuous charge. These are known as a constant-voltage charger (float voltage charge) or a constant-current charger (trickle charge). In the float voltage system preferred for gelled-electrolyte batteries the charge voltage is held constant while the current is free to vary. In contrast, the trickle charge plan preferred for nickel-cadmium batteries maintains a constant charging current while the voltage is allowed to vary.

The chart of table 2 shows the initial charge current and fully charged current for the standard ratings of various Globe-Union gelled-electrolyte batteries. For example, the 4.5-Ah, 12-volt battery begins charging at a level of 700 mA. Full charge is indicated when the battery voltage reading is 14.4 volts and the charge current has dropped to a level between 50 and 100 mA. This corresponds to a final cell voltage of 2.4 volts.

When the same gelled electrolyte batteries are to be kept on continuous charge it is preferable that the charge voltage be held to 2.25 volts per cell, or for the 4.5-Ah version, a final voltage of 13.5 volts. Therefore, the charger must supply a constant 2.25 volts/cell (13.5 volts in the case of the 4.5-Ah, 12-volt battery).

To obtain the maximum number of recharge cycles the on-charge voltage initially should be such that the battery charge is brought up to 2.4 volts per cell. This charge should be continued until the current drops to the values shown in the tables. At this point the charger should be switched over to a float voltage of 2.25 volts per cell.

In practice as many as 200 to 400 full charge/discharge cycles are possible. If a float voltage charge is maintained, instead of permitting complete discharge, thousands of cycles of operation are feasible.

The charger shown in fig. 4 permits both modes of charging. Note the switch that can be used to select either float or fast charge. An indicator lamp is turned on when the battery reaches 80% of full charge.

An example of a constant-voltage

---

table 2. Charging-current values for Globe-Union gel-cells.

<table>
<thead>
<tr>
<th>battery rating</th>
<th>maximum initial charge current</th>
<th>approximate final current</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9 Ah</td>
<td>0.15 Amp</td>
<td>10-20 mA</td>
</tr>
<tr>
<td>1.5 Ah</td>
<td>0.25 Amp</td>
<td>20-40 mA</td>
</tr>
<tr>
<td>1.8 Ah</td>
<td>0.30 Amp</td>
<td>20-40 mA</td>
</tr>
<tr>
<td>2.6 Ah</td>
<td>0.40 Amp</td>
<td>30-60 mA</td>
</tr>
<tr>
<td>4.5 Ah</td>
<td>0.70 Amp</td>
<td>50-100 mA</td>
</tr>
<tr>
<td>6.0 Ah</td>
<td>0.90 Amp</td>
<td>60-120 mA</td>
</tr>
<tr>
<td>7.5 Ah</td>
<td>1.20 Amp</td>
<td>80-160 mA</td>
</tr>
<tr>
<td>20.0 Ah</td>
<td>4.00 Amp</td>
<td>100-300 mA</td>
</tr>
</tbody>
</table>

fig. 6. Battery charge data for the Eveready N86 nicad battery.
A basic charging circuit for nickel-cadmium batteries is shown in fig. 7. The circuit is fundamental although the values given are for the Eveready N86 battery. This circuit provides a charging current of 120 mA. After a battery has been fully charged, a trickle charge arrangement can be used to maintain full charge. Recommended trickle charge current for this battery falls between 24 and 40 milliamperes. This current value can be obtained by switching a higher value resistor into the constant-current charging current.

**Model HRT-2**

5 Channel, Narrow Band

2.2 watt FM Transceiver

This light weight, "take anywhere" transceiver has the "Regency-type" interior componentry to give you what others are looking for in portable communications. You get a heavyweight 2.2 watt signal . . . or if you want, flip the HI/LO switch to 1 watt and the receiver gives you 0.7 uv sensitivity and 0.5 watts audio. Both transmitter and receiver employ band-pass circuitry so that power and sensitivity are maintained across the entire band. Get one to go . . . only

$179.00

Amateur Net

Regency Electronics, Inc.

7707 Records Street

Indianapolis, Indiana 46226

An FM Model For Every Purpose . . .

Every Purse

- HR-2MS 8 Channel Transceiver
- HR-212 12 Channel-20 Watt
- AR-2 2 Meter FM Transceiver Power Amplifier

**HERE IS A FIRST FULL**

of 2 METER POWER

**NEW**

American Made

Quality at Import Price

**EVERY PURSE**

- HR-2MS 8 Channel Transceiver
- HR-212 12 Channel-20 Watt
- AR-2 2 Meter FM Transceiver Power Amplifier

**October 1974**
transmitter
fail-safe timer

This timer was designed to provide for the disabling of an automatic RTTY transmitter in the event of control failure. In particular, this station has features which allow control codes to be punched on tape. After starting a tape the operator may leave the room to work on one of the many unfinished projects always waiting in the basement. Another feature allows a remote operator to punch tape on the LRXB composite tape set and then have it automatically replayed at its completion (operator on premises, but not necessarily at the control console). In either case a tangled tape or a mispunched control code could leave the transmitter keyed. There is also the possibility of the operator leaving the switching set-up in such a way that the system can not function properly. In all such installations it is necessary to provide some sort of backup control so that the channel is not blocked by a stalled automatic system.

This system allows the transmitter to remain keyed no longer than ten minutes (five minutes for the replay). If the time limit is exceeded, the transmitter is removed from the air and cannot be re-keyed until reset by the control operator. The timer is reset by the CW identification device. Hence, it is possible to make transmissions longer than ten minutes, but only if the proper identification is given. Station control wiring prevents a remote station from inserting the CW ID sequence on a replay tape. However, such codes may be inserted when the control operator punches tape.

Originally I planned to use a NE555 timer IC to set the ten-minute time period. However, I found it impossible to reach the ten-minute limit with the capacitors I had on hand. Since such capacitors were also expensive and somewhat difficult to find, it was decided to go to a shorter period and use a 7490 divider to extend the period. This approach costs no more than the original plan with a high quality/cost capacitor, and it allows for other timing periods as well.

The NE555 oscillator is set at approximately one cycle every 1.4 minutes. The output is introduced to the 7490 decade divider. Pin 11 of the 7490 goes high on the eighth count (approximately 11.2 minutes) after the 7490 is enabled by U4B. Then the output of U3D goes low, forcing the output of U3C high. When pin 8 of U3C goes high, Q1 conducts, removing the base bias from Q2. When Q2 stops conducting, the disable relay opens, resetting a holding relay in the control unit and disabling the entire automatic system. The Q1, Q2 configuration was chosen so that the disable relay would be normally on and power supply failure would also reset the system.

When the replay is enabled U3A, pin 3, goes high. Pin 8 of U2 goes high on a count of four (approximately 5.6 minutes); U3B goes low, shutting down the disable relay as previously described.
The 7490 is enabled when the transmitter is on (U4D pins 12 and 13 low). If, however, pin 3 of U4A is forced low (by the CW ID device), then U4B pin 6 goes high, resetting the 7490 to its zero count. It has not been found necessary to reset the oscillator, but this may be done for increased accuracy in the timing periods.

If either the transmitter or the CW ID is keyed, Q3 conducts, keying the transmitter. Also, when the CW ID is keyed, Q4 conducts, keying the CW ID relay which is used to disable the station tape readers and keyboard during the identification sequence.

When the replay is keyed, Q5 pulls the transmitter line low (a single transistor was used here to eliminate the need for another IC package), enabling the 7490 and keying the transmitter. As mentioned above, keying the replay allows the four count from the 7490 to reach Q1 via U3, setting the time-out period for the replay function keys the transmitter, but does not allow any data to be sent.

The circuit described here has been in operation for a period of four months. It has never timed out a transmission of proper duration and on several occasions it has removed the transmitter from the air when transmissions were too lengthy (and a few times when the proper control codes were not received by the system).

The logic draws less than 100 mA at five volts. The relays are 24-volt P&B KH4703 and are operated from the un-
regulated dc supply. This supply is 18 volts under the load of the five-volt regulator, and is quite adequate for reliable operation of the relays. The unit is constructed on perf board and is enclosed with the CW ID device in an rf-proof enclosure. All leads entering or leaving the enclosure are bypassed.

Notice that since the timer is reset by the CW ID, the timer would not function properly if the CW ID were inserted automatically every eight to ten minutes. The CW ID must be inserted (possibly on tape) by the control operator for the transmitter to run longer than the limit set by the timer.

Robert Clark, K9HVW

waveguide klystron cooler

In many amateur microwave assemblies, it is impractical or even impossible to obtain adequate air flow around reflex klystrons or other signal sources. One solution is a simple water-cooled section of waveguide. Such a solution is more practical than fabricating a water jacket for the klystron itself because the guide section can be used with any flange-mounted klystron or Gunn diode. An example unit is illustrated in fig. 2. It was fabricated from a short section of WR-90 guide with UG-39/U flanges and 1/4-inch (6-mm) water lines. The klystron, a Varian 6975, was operating with a beam power of 9.0 W. The temperature reduction at the worst case was greater than 15°C (see fig. 3). The coolant flow rate was 0.6 liters/minute, coolant temperature was 25°C.

John M. Franke, WA4WDL

protector guards against auxiliary battery drain

The latest Sears catalog has an item which should be of interest to amateur operators who use multi-battery electrical systems for mobile, portable or repeater use. The Sears system, which sells for less than $15.00, charges the auxiliary battery, without switching, while the engine (or recharging system) runs. It also protects the engine-starting battery from discharging while the engine is not running such as when operating portable or camping. The system, which consists of a heavy-duty 50-amp circuit breaker and a solid-state switching arrangement, can be used with two or more batteries wired in parallel, 6 to 32 volts, negative ground. The Sears system can be ordered from your local Sears store or sales office; order catalog number 28T7105.

Jim Fisk, W1DTY
CALL BOOK

When you want an authoritative, up to date directory of licensed radio amateurs It's the CALLBOOK

Over 210,000 QTH's in the DX edition
DX CALLBOOK for 1974 $8.95

Over 285,000 QTH's in the U.S. edition
U.S. CALLBOOK for 1974 $9.95

See your favorite dealer or Send today to
(Mail orders add 50c per CALLBOOK for postage and handling)

WRITE FOR FREE BROCHURE

NEW AND DIFFERENT!!

“EBM”

The all new T_doc manual for electronics experimenters and hobbyists

More than two years in the making, T_doc has gathered the most practical and usable data from industry, the U.S. Patent Office, DOD, NASA, NTIS (National Technical Information Service) and others. Jam-packed with all the data needed for the hobby experimenter at the bench. From theory refresher to applications diagrams, device characteristics, tables and formulas, charts and graphs -- hundreds upon hundreds of illustrations.

A High-Density Modular Document

No wasted space or words. Separate sections are removable in loose-leaf fashion -- books within a book -- mounted in a rugged binder, big enough to hold other T_doc publications -- or your own notes.

Just by way of example, the section on hand soldering was boiled-down from the practices of the American Welding Society -- Committee on Soldering and Brazing; NASA, DOD, solder manufacturers, the Bell Telephone System and others. The section contains everything you need to know about solder, fluxes, soldering tools and techniques.

There are over 100,000 words covering theory and application of semiconductor devices -- diodes, transistors, the SCR/TRIAC, digital and linear integrated circuits, operational amplifiers, voltage regulators, counters and decoders, and much, much more.

Sections also treat the vacuum tube and CRT, capacitors and electrostatic devices, relays and switches, electromechanical devices and mechanical movements, energy sources, cable and wire.*****

Update Without Annual Replacement

No need to buy a whole new book every year to keep abreast of information in the field; the "book within a book" style permits you to update only as needed.

There has never been another manual like it. That's why we undertook to put it together! Once you have had a chance to put the manual to use, you'll start enjoying electronics as a hobby, with fewer unfinished projects that could have been completed had there not been an information gap.

Electronics Bench Manual

Introductory Price: $17.95 Postpaid In U.S.A.

Send check or money order marked "EBM" with your name and address to:

TECHNICAL DOCUMENTATION
BOX 340
CENTREVILLE, VA 22020

703-830-2535

Virginia residents please add 4% sales tax.
The new Ascom ASMR100 transmitter/antenna system tester is a three-way test instrument which provides a constant monitor of transmit/antenna functions in any vhf system. When installed in the transmission line between the antenna and transceiver, it provides an accurate check of power output with settings of 25- or 50-watts full scale. Accuracy is ±5 percent. The second inline function of the instrument measures the standing wave ratio of the antenna circuit to assure optimum efficiency. The instrument can also be used as a field-strength indicator.

Attractively packaged in an all-aluminum case to resist rust or corrosion, the Ascom system tester is designed to mount permanently or for use by servicemen as a precision test unit. Frequency range is 144 to 174 MHz. Suggested resale price is $69.95. For more information write to Antenna Specialists Company, 12435 Euclid Avenue, Cleveland, Ohio 44106, or use check-off on page 94.

The new Quick-Op Amplifier now available from Hildreth Engineering provides an easy way for you to experiment with a wide range of operational amplifier circuits. Solderless connectors are provided on the front panel of the device so you can easily install resistors, capacitors and diodes, building any op-amp circuit you wish. The internal 741C op amp IC has been tested for gain and dc offset adjustment. Two standard 9-volt transistor-radio batteries mount inside the case, making a completely self-contained unit. If you've been wanting to use op amps, but haven't yet, here's a good way to get started. $11.95 each, less batteries, first-class postage paid, from Hildreth Engineering Company, Post Office Box 3, Sunnyvale, California 94088. For more information, use check-off on page 94.

A free conversion scale is available from Singer Instrumentation that converts microvolts to dBm and vice versa. High resolution is afforded by the 10-inch (25-cm) scale length. The scale is printed on silver foil with adhesive backing suitable for permanent attachment to any instrument.

Write to Singer Instrumentation, 3211 South La Cienega Boulevard, Los Angeles, California 90016, or use check-off on page 94.
Don't Miss That CW QSO!!

**CW TRANSMITTER MODEL 50**

- Built-in Antenna Relay
- 160, 80, or 40M Plug-in Coil
- Crystal Control
- Zener Regulated Chirpless Keying
- Clean Output — "T" Network
- Built-in 115 VAC Supply

**MODEL 50K - BASIC KIT** $39.95

ADD-ON OPTIONS:
- SIDETONE 200-21K $5.95
- KEYER 200-22K $13.95

**MODEL 50W - BASIC WIRED** $49.95

ADD-ON OPTIONS:
- SIDE-TONE $59.95
- KEYER $69.95
- SIDE-TONE & KEYER $79.95

ORDER DIRECT OR WRITE FOR BROCHURE AND NAME OF NEAREST DEALER.

PHONE: 814-432-3647
BOX 158-A FRANKLIN, PA 16323

BATTERY BOX
High quality American made. Aluminum battery box. All terminals insulated. Made to hold 2 "C" cells.

High quality 3" Square Frame PM Speaker, 4 ohm impedance...

$1.25 ea. ppd.

**UNUSED PRINTED CIRCUIT BOARD ASSEMBLY.**
Manufactur-ers overrun. His loss your gain.

Consists of: 5 - ½ Watt resistors. 3 - Silicon Diodes. 2 - Transistors. 80Ω. 2 - 100Ω. 16 Volt Caps. 1 - DPDT 12 Volt Guardian Relay, 1 - SPDT High Current Relay.

**Price:** $3.25 ea. ppd.

**NEW NEW NEW**

**GNAT'S EYE LED PILOT LITE.** miniature led bulb. Diameter is only .100 inch. Your choice of RED, YELLOW, GREEN. Price is a low 3 for $1.00 ppd.

Use Standard 7447 Decorder-driver. Seven Segment Readouts. All tested and guaranteed. Specifications included. Full 335 inch high. Color, RED.

Less Decimal $2.00 ppd.
With Decimal $2.25 ppd.
With Colon $2.50 ppd.

Each unit contains numeral 1 and plus and minus sign. $2.25 ppd.

JUST ARRIVED - Transformer, 115 VAC primary, 18 volt, 5 amp intermittent duty secondary $6.00 ea. ppd.

Transformer - American Made — Fully shielded. 115 V Primary, Sec. — 24-0-24 @ 1 amp with tap at 6.3 volt for pilot light.

Price — A low $2.90 each ppd.

400 Volt PIV at 25 Amp. Bridge Rectifier.

$4.00 ea. or 3 for $10.00 ppd.

**NEW NEW NEW NEW**

Factory New Semtech Bridge Rectifiers

**ALL 10 AMPS**

50 Volt PIV $1.75 ea.
100 Volt PIV $2.00 ea.
200 Volt PIV $2.25 ea.
400 Volt PIV $2.50 ea.

All Postpaid USA

**NEW NEW NEW**

3/16 inch Dia. LED Lites
- Red $2.25 ea. ppd.
- Green $4.00 ea. ppd.
- Yellow $4.00 ea. ppd.
- Super Bi-LED — Lites red with polarity one way and green when you reverse the polarity. Neat for many things. Price is a Low $1.75 ea. ppd.

SEND STAMP FOR BARGAIN LIST
Pa. residents add 6% State sales tax
ALL ITEMS PPD. USA
Add $1.00 postage for Canadian orders.

m. weinschenker

K 3 DPJ BOX 353 IRWIN, PA. 15642

For FREQ. STABILITY

Depend on JAN Crystals. Our large stock of quartz crystal materials and components assures Fast Delivery from us.

CRYSTAL SPECIALS

2-METER FM for most Transceivers ea. $3.75
144-148 MHz — 0025 Tol.
Frequency Standards
- 100 KHz (HC 13/U) 4.50
- 1000 KHz (HC 6/U) 4.50

Almost all CB Sets, Tr. or Rec.

(CB Synthesizer Crystal on request)

Any Amateur Band in FT-243 1.50

(80-meter, $3.00 - 160-meter not available) 4 for 5.00

For 1st class mail, add 20¢ per crystal. For Airmail, add 25¢. Send check or money order. No dealers, please.

Division of Bob Whan & Son Electronics, Inc.
2400 Crystal Drive
Ft. Myers, Florida 33901

All Phones (813) 936-2397

Send 10¢ for new catalog with 12 oscillator circuits and lists of frequencies in stock.
SOLD STATE 2M AMPLIFIER
50 ohms input/output; 1-3 watts in, 10 watts out; automatic solid state switching
12 VDC

Kit Less Case $24.95 Kit Less Case $25.95
Kit With Case $27.95 Kit With Case $29.95
Assembled, Tested 39.95 With Meter, Add 10.00
Allow $2.00 postage — VA residents, add 5% tax.

Radio Transmitter on a Chip!
- Oscillator
- Buffers
- Modulator
- Controlled Power Output Stage

NA2000 100mW AM on 10 Meters 9.95
NA2001 250mW AM on 10 Meters 14.95
in stud mount package
Both types usable at reduced output at 6 Meters and above. Requires external crystal and two tuned circuits. With Data/applications.

TERMS:
Prepaid U.S. orders over $10.00, we pay shipping.
Prepaid U.S. orders under $10.00, add $1.00 chg.
Prepaid Foreign orders over $10.00, add postage.
Prepaid Foreign orders under $10.00, add $1.00 postage.
COD U.S. orders over $10.00, add $1.50 chg.
COD U.S. orders under $10.00, add $2.50 chg.
No Foreign COD orders.
California residents add 6% sales tax.
Confused? Please read again before ordering.

NASEM, Box A1, Cupertino, Ca. 95014
Don't settle for second. Get the best...

hy-gain Antennas!

TH6DXX
6-Element Super Thunderbird DX
Superior Performance TriBander!

Impressive coverage 10-15-20 meters. Separate, improved Hy-Q traps for each band...SWR less than 1.5:1 on all bands. Takes maximum legal power, up to 1 kw AM, 2 kw PEP. Exclusive Beta Match. Factory pre-tuned. Feeds with 52 ohm coax.

TH3Mk3
3-Element Super Thunderbird Popular TriBand Beam Improved!
Outstanding performance 10-15-20 meters at reasonable cost. Separate, matched Hy-Q traps for each band. Exclusive Beta Match for tapered impedance, DC ground. SWR less than 2:1 at resonance. Accepts maximum legal power and feeds with 52 ohm coax.

18AVT/WB
The Great Wide Band Vertical Super Performer 80 through 10 meters!

18 HT
Incomparable Hy-Tower Finest Multiband on the Market!
Automatic band selection 80 through 10 meters. Unique stub decoupling system isolates electrical 1/4 wavelengths for each band. Takes maximum legal power. Feeds with 52 ohm coax. 24' tower is entirely self-supporting, virtually indestructible. Requires only 4 sq. ft. for installation.

GECC revolving credit available
Use your BankAmericard or Master Charge

ELECTRONIC DISTRIBUTORS, INC.
Communications specialists for over 35 years.
1960 Peck Street, Muskegon, MI 49441 616/726-3196 Telex 228-411
DENTRON 160 XV TRANSVERTER

Get in on the excitement on 160 meters the easy way with Dentron Radio Company's Model 160 XV Transverter. No need to buy a new transceiver. This low cost, easy-to-use, new accessory quickly connects to your existing SSB station with just two simple connections and you are ready to join in on the fun on top band. With sunspots at their low, there will be a lot of good action in the months ahead and you'll want to be ready.

- 5 watts drive ample for full output
- 100 watts DC input
- Full 1.8 - 2.0 MHz coverage
- 3.8 to 4.0 MHz input
- Matches 50 ohm antenna
- Built in power supply for 110/220V 50/60 Hz.
- No modifications to existing equipment
- Operates in both transmit and receive modes

Denton 160 XV Transverter $199.50 ppd. U.S.A.

Also the 160 AT antenna tuner matches your 160 Meter, 50 ohm exciter to almost any random length or existing antenna — just $49.95 postpaid.

All units in stock for immediate delivery

Order from
Denton Radio Co.
27587 Edgpark Drive, North Olmstead, Ohio 44070
216-734-7388
West Coast: 11591 Rabaul Ave., Cypress, CA 90630

- PCB KITS -

RTTY SPEED CONVERTER/Drilled PCB 5 & 11 VDC $42.00
RTTY PCB ONLY $ 6.50
RTTY AFSK Gen. All Shifts & CW I.C. 9 VDC @ 2ma $ 7.25
100 kHz XTAL CALIBRATOR Less XTal 9 VDC @ 2ma $ 5.25
POWER SUPPLY — 28 VDC @ 650 mA output $9.85
PREAMP MICRONEPHRON 26 dB Gain 9 VDC @ 1ma $3.85
LIMITER PREAMP For High Z Mike 9 VDC @ 1ma $ 5.30
PRODUCT DETECTOR For Your Receiver 9 VDC @ 1ma $3.95
"S" METER KIT Less 1ma Meter $ 6.35
SWR METER, Stripline, Less 200ua Meter $ 3.25
WWV CONVERTER 3.5-4.0 MHz Output 9 VDC @ 5ma $ 5.75
Requires 6-5.5MHz Crystal
6 METER CONVERTER FET Front End 9 VDC @ 5ma $ 6.50
7-11 MHz Output, Less 43 MHz XTal $ 6.50
CW KEYING MONITOR, RF Keyed, Less 5k $ 5.20
POWER SUPPLY -9 VDC @ 50ma Output $ 115VAC $5.35
6 METER CASCADE PREAMP 80 VDC @ 4.5ma $5.45
Wired & Tested Less 2 ea 40W4 Resistors
DRILLS, #54, 56, 58 or 60 (each) $5.50
Finest Quality for PCB's Made in USA Three For $1.25

EXCEPT AS NOTED ABOVE, ALL KITS ARE NEW, 100% SOLID STATE, AND COMPLETE WITH AN UNDRILLED G-10 PCB (PRINTED CIRCUIT BOARD) AND ALL PCB MOUNTED COMPONENTS. KITS ARE LESS POWER SUPPLIES, CHASSIS, AND ENCLOSURE HARDWARE. SEND SELF-ADDRESSED, STAMPED ENVELOPE FOR COMPLETE DATA SHEET AND SCHEMATIC.

SATISFACTION GUARANTEED. RETURN IN 30 DAYS FOR REFUND. ALL KITS POSTPAID, INCLUDE 50¢ HANDLING CHARGE. WASHINGTON RESIDENTS ADD 5.3% SALES TAX.

Martex Corporation
519 S. AUSTIN, SEATTLE, WASH. 98108

Radio Amateurs Reference Library of Maps and Atlas

WORLD PREFIX MAP — Full color, 40" x 28", shows prefixes on each country . . . DX zones, time zones, cities, cross referenced tables $1.25


RADIO AMATEURS MAP OF NORTH AMERICA! Full color, 30" x 25" — includes Central America and the Caribbean to the equator, showing call areas, zone boundaries, prefixes and time zones. FCC frequency chart, plus useful information on each of the 50 United States and other Countries $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" $2.50

Complete reference library of maps — set of 4 as listed above $3.75

See your favorite dealer or order direct. Mail orders please include 50¢ per order for postage and handling.

WRITE FOR FREE BROCHURE! RADIO AMATEUR CALLBOOK INC.
Dept. E 925 Sherwood Drive
Lake Bluff, Ill. 60044

70 october 1974
The TRITON is a One-of-a-Kind HF transceiver, totally solid state including the final amplifier. The new generation that does more things better than ever before.

One, you can change bands instantly. Just turn the band switch—and go!

Two, there is less internal heat to prematurely age components and no high voltage to break down insulation or cause accidental shock.

Three, it has ample reserve power to run at full rating even for RTTY or SSTV without limit. Great for contests or emergency service.

Four, it is light and compact with a detachable AC power supply to work directly from 12 VDC—for mobile operation without tedious installation.

Five, the TRITON is a delight to operate. SSB is clean, crisp and articulate. Amplified ALC puts all available speech power into the antenna without splatter. CW is wave-shaped to cut through QRM and pile-ups. Instant break-in (not "semj" which really isn't break-in) lets you monitor the frequency while transmitting. And six, a lot more goodies such as excellent dial illumination, plug-in circuit boards, offset tuning, built-in SWR bridge, speaker, crystal calibrator, snap-up anti-parallelax front feet, light indicators for offset and ALC, direct frequency readout, WWV, entire 10 meter band coverage—and a lot more.

The TRITON brings together all that is new and exciting in Solid State for your greater enjoyment of Amateur Radio.

TRITON I 100 watts input.............. $579.00
TRITON II 200 watts input............ 669.00
Model 251 Supply for TRITON I... 79.00
Model 252 Supply for TRITON II.. 99.00

We'll be happy to send you full information.

TEN-TEC, INC.
SEVIERVILLE, TENNESSEE 37862

More Details? CHECK—OFF Page 94
For your operating pleasure - A NEW TUNABLE ACTIVE FILTER

In addition, Peak-N-Notch can be used as a versatile test instrument in harmonic and intermodulation distortion measurements. Battery power eliminated now and other.

OVER-CONCERNS: SIGNALS. POWER, A SPEAKER, AND HIGH-POWERED LOUDSPEAKERS MAY BE USED WITH THE FILTER.

Silicon integrated circuits and a precision, built-in voltage divider provide a louds, noise-free output. It's TO GOOD TO PASS UP.

Radiation Devices Co., P.O. Box 8650, Baltimore, MD 21234

RTTY VIDEO DISPLAY UNIT

VIDI-TYPE MODEL 872 $550
WRITE FOR BROCHURE

LELAND ASSOCIATES
18704 Glastonbury Rd.
Detroit, MI. 48219

GT-HR2
6 FREQUENCY CRYSTAL DECK, REGENCY H.R.-2 OR H.R.-2A, IMPROVED CIRCUIT BOARD, LAYOUT AND FOIL.

KIT $9.95
WIRED $13.95

HF144U MOS FET PREAMP
OUR FAMOUS 2-METER PREAMP GIVES 17dB OF AMPLIFICATION WITH ONLY 3dB OF NOISE INSERTION.

KIT $11.95
WIRED $17.95

The Hy-Gain 550A is the complete amateur system. Designed from the ground up to work together for total performance. Each element is matched to the system.

GT-550A TRANSCEIVER The matchless heart of the 550A System. No other transceiver can give you this performance for the price. Operating fixed station or mobile, the GT-550A is guaranteed to have top frequency stability after warm-up. 25 KHz calibrator and VOX, optional.

RF550A CONTAINS HIGH ACCURACY WATT METER; SWITCH FOR FORWARD OR SELECTED POWER; SWITCH TO SELECT 5 ANTENNAS OR DUMMY LOAD.

SC550A SPEAKER CONSOLE WITH HEADPHONE JACK. AC400 POWER SUPPLY WILL MOUNT INSIDE.

AC400 POWER SUPPLY IS HEAVY DUTY SOLID STATE TO OPERATE GT-550A AT FULL POWER FROM 115/230 VAC 50/60 HZ.

G-1000 12V D.C. MOBILE POWER SUPPLY WITH CABLES.

Electronics Center carries complete lines of Ham equipment, accessories and antennas. Write or call W5ZYA or W5PAX for your HAM needs.

electronics center, inc.
2929 N. Haskell • Dallas, TX 75204 • 214/526-2023

Home of the world's largest Electronic Flea Market. It's FREE! First Saturday of each month.

More Details? CHECK-OFF Page 94
CROWDED BANDS GOT YOU DOWN? . . . DO YOUR 2 METER CHANNELS SOUND LIKE THE RECEIVING END OF A 20 METER DX PILE UP? . . . DO YOU HAVE TO WAIT IN LINE TO USE THE LOCAL REPEATER? . . . IF THE ANSWER IS YES (OR IF YOU'RE JUST LOOKING FOR A LITTLE PRIVACY) HERE IS YOUR CHANCE TO GETAWAY TO THE LESS CROWDED BANDS THAT ARE JUST ITCHING TO BE UTILIZED.

---

**2 METER TYPE COVERAGE & SIMPLICITY ON 220 MHz**

**COBRA**

**VHF 200**

- 10W & 1W OUTPUT
- 12 CHANNELS
- LESS THAN .5uv RCVR
- 223.5 SIMPLEX SUPPLIED
- HAS ACCESSORY JACK FOR TONE INPUT & DISCRIMINATOR OUTPUT
- 220-225MHz RANGE

**ONLY $229.00**

ASK ABOUT SPECIAL CLUB GROUP PURCHASE PLAN

---

IF YOU WOULD LIKE TO COMBINE PRIVACY WITH A LITTLE DX ONCE IN A WHILE . . .

---

**MOTOROLA MOBILES CONVERTIBLE TO 6 OR 10 METERS**

- **T41GGV** 25-watt VIBRATOR POWERED - WAS $75.00-NOW $59.00
- **T51GGV** 50-watt VIBRATOR POWERED - WAS $75.00-NOW $59.00
- **U41GGT** 30-watt T-POWER - WAS $100.00-NOW $79.00

---

**TERMS OF SALE:** Sales to licensed Radio Amateurs for use on Amateur freqs only. All prices FOB Oak Park, IL. Check with order, COD or you can charge to your BankAmericard or Master Charge.

**STORE HOURS:** Mon-Thurs. 9:30-6:00, Fri. 9:30-8:00, Sat. 9:30-3:00. Closed Sun. & Holidays

**WANTED:** Good used FM & test equipment. No quantity too large or small. Finders fees too.

---

**SPECTRONICS INC.**

1009 GARFIELD STREET
OAK PARK, ILL. 60304
(312) 848-6778
CRYSTAL FILTERS and
DISCRIMINATORS
1 27/64" x 1 3/64" x 3/4"

9.0 MHz FILTERS
XFG-A 2.5 kHz SSB TX $31.95
XFG-B 2.4 kHz SSB RX $45.45
XFG-C 3.75 kHz AM $48.95
XFG-D 5.0 kHz AM $48.95
XFG-E 12.0 kHz NBFM $48.95
XFG-M 0.5 kHz CW $34.25

9.0 MHz DISCRIMINATORS
X90-01 ± 5 kHz RTTY $24.10
X90-02 ± 10 kHz NBFM $24.10
X90-03 ± 12 kHz NBFM $24.10

9 MHz CRYSTALS (Hc25/u)
XF900 9000.0 kHz Carrier $3.80
XF901 8998.5 kHz USB $3.80
XF902 8991.5 kHz LSB $3.80
XF903 8990.0 kHz BFO $3.80
F-05 Hc25/u Socket .50

(Export Inquiries Invited)

VHF CONVERTERS

RF Freq. (MHz) +
50-54 144-148
28-32 120-124
25-28 100-104
20-24 80-84
15-19 60-64
10-14 40-44
5-9 20-24

Power 12V D. C.
1 1/4" x 1 3/8" x 1 1/2" + connectors

Very low N. F. units on special order.

+Other ranges, amateur & commercial, to order.

Shipping: Filters, $.50; Converters, $1.00

USED TEST EQUIPMENT

All checked and operating unless otherwise noted. Send SASE for complete list.

Boonton 190 A Q-mtr 20-260 MHz Q5-1200 $345
Boonton 202 B Sig. Gen. AM-FM 54-216 MHz $325
Boonton 202 D (sim. to above) 175-250 MHz $225
HP 1000 D Freq. stand w/scope Acc. 1 ppm $85
HP 185A Scope w/185B amp sampling 10 kHz $335
HP 202 A Function Gen. 008-1200 MHz $195
HP 205 A8 Audio Gen. 02-20 kHz-metered $195
HP 1208B Dist. anal 20 Hz-20 kHz 1% $195
HP 524 D Freq. Counter. Basic unit 10 Hz-10 MHz $185
HP 540 B Trans osc. for 524 to 124 Hz $185
HP 560 B (TS510A/U) sig. gen. 10-420 MHz $450
HP 616 B10 Sig. Gen. 0.5-1.2 GHz calib att. $365
HP 630 A Imp. Bridge 50-500 MHz 2-200 ohm $195
Panoramic SPA-4 Spec. Anal. Bandwidth 10 MHz-44 GHz 5 or 70 MHz sweep width $985
Polaroid MS 34-Sig. Gen. 4.2-11 GHz calib att. $495
Polaroid R uwave rcrv .4-8 GHz with plug-in AM, FM, CW, Pulse - less plug-in $225
Polaroid TSA Spec. Anal. 0.1-44 GHz with plug-in $125
Soliton 200 A SCR tester-checks anode, gate volts. current, leakage and holding $165
Stoddart NM 10 A (URM-6) RF ints. mtr 10-25 kHz complete with acc. $650
Stoddart NM 20 A (PRM-1) RF ints. mtr 15-25 MHz. complete with acc. $650
Stoddart NM 50 A-RFI mtr. 375-1 GHz, w/acc. $985
Tek RM 15-DC-15 MHz GP scope $265
Tek 181 Time mark generator $95
Tek 190A Const. Ampl. Sig. Gen. 35-50 MHz $125
Tek 565 dual beam 10 MHz scope, less plug-ins $625
TS 4013A-Sig. Gen. (HP 166) 1.8-4 GHz $335
URM 7 RFI Mtr. (sim. NF-105) 20-400 MHz $750

ECHO}

SPECTRUM INTERNATIONAL
BOX 1084 CONCORD MASSACHUSETTS 01742

LEARN RADIO CODE

THE EASY WAY!

$9.95
Album contains three 12"
LP's 2 1/2 hr. instruction

EPSILON RECORDS
508 East Washington St., Arcola, Illinois 61910

RTTY PICTURE
PERF TAPES

5-LEVEL • CHAD TYPE
11/16" WIDE • ERROR FREE
3 Min. to 7 Hours Long
Send 16 cents in
STAMPS for list

JOE DICKENS, WA9UGE, 601 S. Dodson
Urbana, IL 61801

More Details? CHECK-OFF Page 94

GRAY Electronics
P. O. Box 941, Monroe, MI 48161
(Send SASE for complete list)
Specializing in used test equipment

by
K.V.G.

october 1974

74
NEW

HT-144B

TWO METER FM PORTABLE

CRYSTAL SOCKETS INCLUDED!
IMPROVED TRANSMIT AUDIO!
UP TO 6 KC DEVIATION!
.35 uV SENSITIVITY OR BETTER!
.25 SQUELCH SENSITIVITY!
IMPROVED INSTRUCTION MANUAL!
F.C.C. TYPE APPROVAL PENDING!

KIT ONLY $129.95 COMPLETE less batteries
AND for a limited time only we will furnish
ONE SET OF CRYSTALS FREE!
Your choice of 94-94; 52-52; or 34-94.

IT'S AN EVEN BETTER BUY NOW!!!!!!!!!

ACCESSORIES: “Rubber Duckie” Antenna (BNC Connectors) $12.95
Nicad Battery Charger $ 4.95
Sealed 12v Nicad Battery Pack $29.95

Please include $1.00 for Shipping and Handling - N.Y.S. residents add sales tax

VHF ENGINEERING
DIV. OF BROWNIAN ELECT. CORP.
320 WATER ST. POB 1921 BINGHAMTON, N.Y. 13902 607-723-9574

More Details? CHECK-OFF Page 94
HI THERE
MEET THE AMAZING NEW
SABA-5
PREAMPLIFIER

WB4TPI (Jerry) says "'/#@?,
does that thing work?"

W4HLS (Hugh) says "Couldn't have made
weak station contacts without it."

WAVE (Frank) says "Will enhance any
station's capabilities."

W4FIC (Mac) says "Well worth while."

Note: Above evaluations on Collins 75A4.
S-Line Drake F4-B, R4-C, Signal One. FPM 300

Specifications
- Solid State Circuitry MOS-FET
- 80-40-20-15-10 Meters NO TUNING
- Ultra Low Noise-High Useful Gain
- Gain: 20 db min. Typical 25 db
- Noise Figure: Less than 2.5 db
- High Quality Communications Design
- Broadband with adequate MARS
- Overlap
- Minutes to install on Receivers
- Battery or External Power Operation
- No Strong Signal Overloading
- Allows reduced RF Gain on receiver
- for improved cross modulation
- Attractive Black textured and gray
- Cabinet 3X4X5
- Low Current drain (Approx. 15ma @ 18V)
- LED Indicator light

Mfg. by,
SYMTEK INC.
4805 N. HESPERIDES
TAMPA, FL. 33614

C F P ENTERPRISES
866 RIDGE ROAD, LANSING, N. Y. 14882

Whether you extend the range of your VHF
FM station with the new Ringo Ranger or
rotate your house with full size HF Mono-
beam. It's hard to beat CUSHCRAFT for
the very best in antennas.

Contact CFP today for the CUSHcraft an-
tenna of your choice. You'll be glad you did.

Office & Salesroom Hours by Appointment Only
24-Hour Phone: 607-533-4297
Send SASE for Monthly Listing of
Used Equipment and Bargain Goods

FM Schematic Digest
A COLLECTION OF
MOTOROLA SCHEMATICS
Alignment, Crystal, and Technical Notes
covering 1947-1960
136 pages 11½" x 17" ppd $7.50
S. Wolf
P. O. Box 535
Lexington, Massachusetts 02173

3-D MAGNETIC CALL SIGNS
3 inch letters
Your choice of colors —
Black, Red, Blue or Green
Adherence to metallic surfaces test up to 180 MPH
$4.00 each — 2 for $7.00 (same call)
ALSO
RUBBER STAMPS
Made to order — 3 lines - $4.00
Preinked stamp pad $1.35
(please print or type all copy)

WB8OTV SPECIALTY PRODUCTS
P. O. Box 187 • Grasslake, Michigan 49240

SPACE SAVER TOWERS & MASTS
CZ series towers, cranks up, installs
without guy wires. New lacing design
creates greater strength.
Mini and Magna rotating masts ... high
strength galvanized tubing, self support-
ing crank-up.
For complete details and prices please
check your local dealer or write
Certified Welders L.A. City License #634
TRISTAO TOWER CO.
P.O. Box 115, Hanford, California 93230

3 inch letters
Your choice of colors —
Black, Red, Blue or Green
Adherence to metallic surfaces test up to 180 MPH
$4.00 each — 2 for $7.00 (same call)
ALSO
RUBBER STAMPS
Made to order — 3 lines - $4.00
Preinked stamp pad $1.35
(please print or type all copy)

WB8OTV SPECIALTY PRODUCTS
P. O. Box 187 • Grasslake, Michigan 49240

SPACE SAVER TOWERS & MASTS
CZ series towers, cranks up, installs
without guy wires. New lacing design
creates greater strength.
Mini and Magna rotating masts ... high
strength galvanized tubing, self support-
ing crank-up.
For complete details and prices please
check your local dealer or write
Certified Welders L.A. City License #634
TRISTAO TOWER CO.
P.O. Box 115, Hanford, California 93230

3 inch letters
Your choice of colors —
Black, Red, Blue or Green
Adherence to metallic surfaces test up to 180 MPH
$4.00 each — 2 for $7.00 (same call)
ALSO
RUBBER STAMPS
Made to order — 3 lines - $4.00
Preinked stamp pad $1.35
(please print or type all copy)

WB8OTV SPECIALTY PRODUCTS
P. O. Box 187 • Grasslake, Michigan 49240

SPACE SAVER TOWERS & MASTS
CZ series towers, cranks up, installs
without guy wires. New lacing design
creates greater strength.
Mini and Magna rotating masts ... high
strength galvanized tubing, self support-
ing crank-up.
For complete details and prices please
check your local dealer or write
Certified Welders L.A. City License #634
TRISTAO TOWER CO.
P.O. Box 115, Hanford, California 93230
Come Face to Face with the facts...

IC-21A... 24 channel capability, with 7 channels supplied. It’s MOSFET front end provides better than 0.5 db sensitivity at 20 db quieting. 5 HELICAL FILTERS virtually eliminate intermodulation. Built in AC and DC power supplies. Modular construction, of course. Many other features make the IC-21A a great two meter transceiver. The IC-21A is capable of using our new digital VFO.

...and choose ICOM

IC-22... 22 channel capacity, with 5 supplied. Solid state T-R switching, and an extra large speaker. All the great quality features that label it as one of the truly fine ICOM transceivers. 10/1 watt power saving option. Trimmer caps on all 22 channels for both transmit and receive, plus a built in discriminator jack to let you get on and stay on frequency.

The IC-3PA is a regulated DC power supply for all the INOUE mobile transceivers. Use it with your IC-230 for base operation. It’s completely regulated and gives you an indication of it’s operating condition: normal, excessive current, or if the protection circuit is working. These are shown through the use of eye catching indicator lamps. There is also a built in speaker in the cabinet.

ICOM
Distributed by
ICOM WEST, INC.
Suite 232 - Bldg H
300-120th Ave. N.E.
Bellevue, Wash. 98005
(206) 454-2470

ICOM EAST Div. ACS Div.
Suite 501
13777 N Central Expwy.
Dallas, Texas 75231
(214) 335-0479
KEYBOARD AND ENCODER KIT

★ 48 Keys
★ ASC-II Encoder
★ For: Terminals
  TV Typewriters
  Calculators
  RTTY Displays
  CATV and more

At long last—a top quality fully professional data entry keyboard at a sensible price. Keyswitches are full typewriter travel and response type, arranged in a modified ANSI layout. Full length spacebar with equalizer. Keyswitches are mounted on a double sided fiberglass circuit board with plated through holes. The encoder provides a standard ASC II output and includes a debouncer circuit. ASC II code includes shift and control functions with two user defined keys available. Keytops are first quality double-shot molded types for permanent good appearance. Gold plated contacts on keyswitches. NEW—no surplus parts. Typewriter style—NOT a modified keypunch board.

KDB-1 Kit $39.95 ppd

Southwest Technical Products Corporation
DEPT. H
219 W. Rhapsody
San Antonio, Texas 78216

LOW PRICES ON POPULAR COMPONENTS

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

SEMICONDUCTORS
- 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, INC.
P. O. BOX 624, MARION, IOWA 52302
(319) 377-7927 or (319) 377-2638

radio communication

Great Britain's most popular amateur magazine. The official publication of the RSGB. Learn what English amateurs are building, learn what they are doing.
$12.50 per year (12 issues)
Includes RSGB Membership

HAM RADIO
GREENVILLE, NH 03048

NEW HOT SUGGESTED GIFT ITEM
DIGITAL CLOCK KIT $34.95
Full 6 digit LED display
Complete with anodized alum. case. All parts and P.C. board. With complete assembly drawings. Ship wt. 1 1/2 lbs.
SLA-1 7 SEG READOUT $2.25 EA. 6/$12.50
12 ASST'D LEDS, RED, GREEN, AMBER, MOSTLY JUMBO 12 FOR $2.50
Orders over $10.00 ppd. Others add 50¢ handling & mailing.

HAL-TRONIX
P. O. BOX 1101 SOUTHGATE, MICH. 48195
(313) 285-1782

HAM RADIO
GREENVILLE, NH 03048

Circuit Britain's most popular amateur magazine. The official publication of
the RSGB. Learn what English amateurs are building, learn what they are doing.
$12.50 per year (12 issues)
Includes RSGB Membership

HAM RADIO
GREENVILLE, NH 03048

NEW HOT SUGGESTED GIFT ITEM
DIGITAL CLOCK KIT $34.95
Full 6 digit LED display
Complete with anodized alum. case. All parts and P.C. board. With complete
assembly drawings. Ship wt. 1 1/2 lbs.
SLA-1 7 SEG READOUT $2.25 EA. 6/$12.50
12 ASST'D LEDS, RED, GREEN, AMBER, MOSTLY JUMBO 12 FOR $2.50
Orders over $10.00 ppd. Others add 50¢ handling & mailing.

HAL-TRONIX
P. O. BOX 1101 SOUTHGATE, MICH. 48195
(313) 285-1782

78 October 1974 More Details? CHECK-OFF Page 94
15-watt, 12-channel 2-meter mobile transceiver has multiple FET front end. Instantaneous final protection circuit. Crystals for .16/.76, .34/.94, .94/.94. And R.S.V.P. Ask for Model 13-500 at $249.95.

30-watt, 12-channel 2-meter mobile transceiver with dual channel selectors, Discriminator and S/RF/SWR meters. Crystals for .16, .34, .94 TX plus .76, .94 RX. And R.S.V.P. Ask for Model 13-505 at $299.95.

With Midland, R.S.V.P. means Repeater Service Voucher Program. Midland's new way to help support non-profit 2-meter repeater services across the United States through you, the active radio amateur. Your Midland amateur radio dealer has all the details, and your purchase of one of these high performance Midland 2-meter mobile transceivers will include an R.S.V.P. certificate. Simply complete and return this—Midland will see that the qualifying repeater installation you choose receives a cash contribution in your name. Offer void where prohibited by law.

Write for Midland's free Amateur Radio Catalog—Dept. H, P.O. Box 10932, Kansas City, Missouri 64141

More Details? CHECK—OFF Page 94
Outstanding performance makes the difference in Hy-Gain's popular 3 element TH3MK3 tri-band beam. Superior construction makes it the best. The Hy-Gain TH3MK3 superior construction includes a cast aluminum, tilt head, universal boom-to-mast bracket that accommodates masts from 1 1/4" to 2 1/2". Allows easy tilting for installation, maintenance and tuning, and provides mast feedthru for beam stacking. Taper swaged slotted tubing on all elements. Taper swaged for larger diameter tubing at the element root where it counts, and less wind loading at the element tip. Slotted for easy adjustment and readjustment. Full circumference compression clamps at all joints are mechanically and electrically superior to self-tapping metal screws. Extra heavy gauge machine-formed, element-to-boom brackets with plastic sleeves used only for insulation. Bracket design allows full support. "Hy-Q" traps for each band are tuned at the factory. You can tune the antenna, using charts supplied in the manual, for optimum performance on your preferred mode, phone or CW. Hy-Gain's exclusive Beta Match for optimum matching, balanced input on all 3 bands and DC ground to eliminate precipitation static. For best results, use with Hy-Gain BN-86 balun is recommended.

- Up to 8 db gain.
- 20-25 db front-to-back.
- VSWR less than 1.5:1 at resonance.
- 1 KW AM, 2 KW PEP power capability.
- Turning radius...15.7'.
- Net weight...36 lbs.
- Boom length...14'.
- Longest element...27'.
- Surface area...5.1 sq. ft.
- Nominal 50 ohm input.

And send it with your check for $189.95 for your Hy-Gain TH3MK3, 100' of free RG-8/U foam cable and prepaid shipping!
OUR DIGIPET 60 IS A GENERAL-PURPOSE FREQUENCY COUNTER WITH A RATING OF 1 kHz TO 60 MHz.

(PLUS 130 MHz TO 160 MHz)

Perfectly designed for the radio amateur who wants quality, accuracy and economy.

If you operate around the 50 MHz band, we can offer you the Digipet 60—it measures a range of 1 kHz to 60 MHz—and it costs less than $300.

However, if you operate up around 140 MHz, you'll want the Digipet 160 converter. It costs an additional $50 and, mated-up with the Digipet 60, measures the critical range from 130 MHz to 160 MHz.

Its AC or DC operable with complete overload protection, plus being stable (aging rate: 1 part in $10^6$/week), small (7" deep x 2½" high), sensitive (50 mV/m's), flexible (five numerical-tube digits) and accurate (resolves to 1 kHz or 1 Hz, depending on gate time selected).

Write immediately for more information.

T.R.I. CORPORATION
505 West Olive Avenue • Sunnyvale, CA. 94086 • (408) 733-9080
**ALL MERCHANDISE IS NEW Unused Surplus**

**AND IS SOLD ON A MONEY BACK GUARANTEE.**

<table>
<thead>
<tr>
<th><strong>LED 7 SEGMENT READOUTS</strong></th>
<th><strong>EACH 10 PAK</strong></th>
<th><strong>TTL</strong></th>
<th><strong>EACH 10 PAK</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>MAN-3 .115&quot; w/RH decimal (claw)</td>
<td>$ .90</td>
<td>$ 8.00</td>
<td>7400 HN</td>
</tr>
<tr>
<td>MAN-3 .115&quot; w/RH decimal (flat leads)</td>
<td>$ .80</td>
<td>$ 7.00</td>
<td>7401</td>
</tr>
<tr>
<td>MAN-4 .115&quot; w/RH decimal (DIP)</td>
<td>$ 2.00</td>
<td>$ 17.50</td>
<td>7402</td>
</tr>
<tr>
<td>DL 33 .1&quot; 3 digits in one 12 pin DIP</td>
<td>$ 2.50</td>
<td>$ 22.00</td>
<td>7403</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>LED DISCRETE DEVICES</strong></th>
<th><strong>EACH 10 PAK</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>MV50 axial micro-mini red</td>
<td>$ .15</td>
</tr>
<tr>
<td>MV5021 diffused dome red</td>
<td>$.25</td>
</tr>
<tr>
<td>MV4 2 WATT hi-pwr red (STUD)</td>
<td>$ 2.25</td>
</tr>
<tr>
<td>MV4H 2 WATT hi-pwr red (hi-domo)</td>
<td>$ 2.50</td>
</tr>
<tr>
<td>M5 2 WATT hi-pwr INFRA-RED</td>
<td>$ 2.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>LINEARS</strong></th>
<th><strong>EACH 10 PAK</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>LM301 MINI-DIP Hi perf. AMPL</td>
<td>$ .50</td>
</tr>
<tr>
<td>LM307 MNZ-DIP Op AMP (super 741)</td>
<td>$.50</td>
</tr>
<tr>
<td>LM309H T05 5V Regulator</td>
<td>$.90</td>
</tr>
<tr>
<td>LM309K T03 5V IA Regulator</td>
<td>$ 1.75</td>
</tr>
<tr>
<td>LM311 8DIP hi perf. Volt. Comparator</td>
<td>$ 1.00</td>
</tr>
<tr>
<td>LM320 T03 5V Negative Regulator</td>
<td>$ 1.90</td>
</tr>
<tr>
<td>LM320 T03 12V Negative Regulator</td>
<td>$ 1.90</td>
</tr>
<tr>
<td>LM320 T03 15V Negative Regulator</td>
<td>$ 1.85</td>
</tr>
<tr>
<td>LM380 14DIP 2 WATT Audio AMPL</td>
<td>$ 1.70</td>
</tr>
<tr>
<td>LM381 16PI Low noise Stereo Amp.</td>
<td>$ 1.75</td>
</tr>
<tr>
<td>9601 DIP Monostable Multivibrator</td>
<td>$.55</td>
</tr>
<tr>
<td>9602 DIP Dual 9601</td>
<td>$.65</td>
</tr>
<tr>
<td>555 8MINI-DIP TIMER</td>
<td>$ 1.20</td>
</tr>
<tr>
<td>723 DIP Precision Voltage Regulator</td>
<td>$.90</td>
</tr>
<tr>
<td>741 8MINI-DIP Hi perf. Op Amplifier</td>
<td>$ .45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>CMOS</strong></th>
<th><strong>EACH 10 PAK</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CD 4016 Analog Switch</td>
<td>$ 1.20</td>
</tr>
<tr>
<td>74C74 Dual D FF</td>
<td>$ 1.20</td>
</tr>
<tr>
<td>74C76 Dual JK FF</td>
<td>$ 1.30</td>
</tr>
<tr>
<td>74C195 4 bit Shift Register</td>
<td>$ 2.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>CT5001 CALCULATOR CHIP SPECIAL!</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Forty-pin calculator chip will add, subtract, multiply and divide: 12-digit display and calculate; chain calculations; true credit balance sign output; automatic overflow indication; fixed decimal point at 0, 2, 3, or 4; leading zero suppression.</td>
</tr>
<tr>
<td><strong>$ 5.95 EACH 10 FOR $ 49.00</strong></td>
</tr>
</tbody>
</table>

**OPTO ISOLATOR SPECIAL!**

**MONSANTO MCT26**

**6 PIN MINI-DIP**

**$ 1.25 EACH 10 FOR $ 10.00**

**FLIP FLOP SPECIAL!**

Dual low power RST flip flop DIP package similar to SIGNETIC #8424. With data & application notes.

**10 FOR $ 2.50**

**FIVE DOLLAR MINIMUM ORDER. FREE FIRST CLASS POSTAGE ON ALL ORDERS. CALIFORNIA RESIDENTS PLEASE ADD SALES TAX.**

SEND STAMP FOR FREE FLYER. WRITE TO: VALU-PAK

box AF Carmichael, Ca. 95608
WANTED: ARC-51.

ROCHESTER, N. Y. - Hamfest date of 1975 - RESISTORS: Carbon composition brand new. All standard values stocked. Minimum order $5.00. 15W RMS power dualmeter bridge 24.95; Hygain 49d; CDE Ham-2 109.00; Belden 8448 coax: new Raytheon, GE 811A 7.95; many new Sprague capacitors, write needs; ICS. 8012 Coax: free flyers. All items new.

MEMPHIS AREA HAMFEST, Sunday, October 6 at State Technical Institute, conveniently located at Interstate 40 and Macon Road (Exit 11). Demonstration, for late model transceiver. Write George Keys. TRADEX: Collins 390A & 6541, 224-2668, Nite Resort, Terre Haute, Indiana 47802. (812)-894-2397.

RTTY EQUIPMENT FOR SALE including machines, parts, gears. Send us a list of your teletype needs.

NORTHWESTERN HAMFEST - Quartermaster Park, @ 2400, 9260 East Lake St., Minneapolis, Minn. October 19. Dealer registration now open. Send for details. Bob McFadden, KD5AMQ, 1300 Grand Ave., N.E., Kirkland, Wa. 98033.

WANTS TO TRADE: Calrad KW relative power dualmeter bridge 24.95; Hygain TH6DXX serial this December; CA8000, $175.00; Belden 8448 8-wire rotor cable 12'/ft.; #22GA/7ST phosbronze longwire-rhombic antenna wire, plastic coat, high tensile 2.50/1000-ft.; Belden 8448 RG8 coax: new Raytheon, GE 811A 7.95; many new Sprague capacitors, write needs; ICS. 8012 Coax: free flyers. All items new.

MIS 384. Where to compute square roots, cube roots, trigonometric functions, logarithms, exponentials, and more! Quickly. Accurately. Easily! Send today for the Improved and Expanded Edition of the First and Best Calculator Manual that you can use throughout the world . . . still only $2.00 Postpaid with Unconditional Money-Back Guarantee! Mail your Playly Optics and Electronics Dept.-M3, 836 South 113, West Allis, Wisconsin 52134.
# for the EXPERIMENTER!

**INTERNATIONAL EX CRYSTAL & EX KITS**

- OSCILLATOR
- RF MIXER
- RF AMPLIFIER
- POWER AMPLIFIER

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. MXM-1 TRANSISTOR</td>
<td>RF MIXER&lt;br&gt;Single tuned circuit intended for signal conversion in the 3 to 170 MHz range. Harmonics of the EX oscillator are used for injection in the 60 to 170 MHz range. Lo Kit 3 to 20 MHz, Hi Kit 20 to 170 MHz (Specify when ordering)</td>
<td>$3.50</td>
</tr>
<tr>
<td>2. SAX-1 TRANSISTOR</td>
<td>RF AMP&lt;br&gt;A small signal amplifier to drive MXM-1 mixer. Single tuned input and link output. Lo Kit 3 to 20 MHz, Hi Kit 20 to 170 MHz (Specify when ordering)</td>
<td>$3.50</td>
</tr>
<tr>
<td>3. PAX-1 TRANSISTOR</td>
<td>RF POWER AMP&lt;br&gt;A single tuned output amplifier designed to follow the EX oscillator. Outputs up to 200 mw, depending on the frequency and voltage. Amplifier can be amplitude modulated. Frequency 3,000 to 30,000 KHz</td>
<td>$3.75</td>
</tr>
<tr>
<td>4. BAX-1 BROADBAND AMP</td>
<td>General purpose unit which may be used as a tuned or untuned amplifier in RF and audio applications 20 Hz to 150 MHz. Provides 6 to 30 db gain. Ideal for SWL. Experimenter or Amateur</td>
<td>$3.75</td>
</tr>
<tr>
<td>5. OX OSCILLATOR</td>
<td>Crystal controlled transistor type. Lo Kit 3,000 to 19,999 KHz. Hi Kit 20,000 to 60,000 KHz. (Specify when ordering)</td>
<td>$2.95</td>
</tr>
<tr>
<td>6. TYPE EX CRYSTAL</td>
<td>Available from 3,000 to 60,000 KHz. Supplied only in HC 6/U holder. Calibration is ±0.02% when operated in International EX oscillator or its equivalent. (Specify frequency)</td>
<td>$3.95</td>
</tr>
</tbody>
</table>

---

# 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 temperature tolerance requirements.
FOR SALE: MOTOROLA MODEL C74BBY 90 watt compa station with blower, 450 MHz repeater with 6 dB gain antenna $350.00 as is, (working while pulled from service). Also available: 125 ft. 7/8" Heliax @ $.60/ft. and UHF fittings @ $7.50 each. F.O.B. Topeka, Kansas.

PACKRAT HAMARAMA is Sunday, October 6th at the Bucks County Drive-In Theater on Rt. 611 in Warrington, Pa. This is near exit 27 of the Pa. Turnpike and north of Willow Grove, Pa. Huge flea market, auction. Festivities begin at 9:00 a.m. and auction starts at 2 p.m. — RAIN or SHINE. Registration is $1.00 and tail gate selling $2.00. Talk-in 146.52, 52.525 and the club repeater WRSACD 222.98 and 224.58 out. For further information and flyer with map, SASE to K3XKM, Lee A. Cohen, 8242 Brookside Rd., Elkins Park, Pa. 19117.


VEry in-ter-est-ing! Next 5 big issues $1. “The Ham Trader,” Sycamore IL 60178

FAX PAPER, 19½" wide. Good for weathermap and desk fax recorders, $2.95/box, 4 for $9.00. 12/$25. Fax and RTTY list free. Jim Cooper, W2BVE, 651-H Forest Avenue, Paramus, N. J. 07652.

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

VOLUNTEER needed in Orange, California area to handle traffic for Bible translators. Also need RTTY gear, ham gear; tax deductible. Write Mike Naruta, WA8BHR, 4466 Burcht, North Street, MI. 48049.

QUALITY CABLE TIES (6" nylon), half price, $2.75/100 postpaid. Joe Ottinger, 106 Sheridan Ct., Leavenworth, KS 66048.

CANADIANS — We carry a broad line of electronic parts, including most solid-state devices, LEDs, ICs. Send for free flyer to: Ken, VE1AOU, Dartek Electronics, Dept. H, Box 2460, Dartmouth, Nova Scotia B2C 4A5.


FOR SALE: MOTOROLA TLN 6185A Quik Call Decoder with reeds. $20 each. Various Motorola and G. E. micros, control leads, cables, manuals, and tubes. W7PUD, 503-252-0303.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines in assembled or kit forms, plus many other suppression accessories. Free literature. Estes Engineering, 543-H West 184th, Gardena, California 90248.

WORLD QSL — See ad on page 93.

FM YOUR GONSET
(or your Clegg 22'er, Poly Comm 2, PC-62, Johnson
GN2, Aerotron 500, HA-460 TX 62 or VHF 1)

- New! Plug-in modulator puts the Communicator transmitter on FM.
- No modification or rewiring on your Communicator. Just plug into mike jack and crystal socket.
- Compact self-contained modulator measures 4" x 3" x 1½".
- Works with Communicator II, III, IV and GC-105, and other riggs listed.
- FM at a tenth the cost of a new rig.
- Frequency adjust for netting built in.
- $34.50 postpaid, U.S.A. $36.50 for PC-2, PC-62, HA-460. Specify transmitter model. California residents add 5% sales tax. (HC-6/U crystal and 9 volt transistor battery not supplied.)
- Send for free descriptive brochure.
ATTN. FT-101 MARK 2/B OWNERS

5:10 dB extra talk power, better RX gain and selectivity, no circuit modifications, better than a linear. Intro. price $99, post paid, $110 from October 1st. Details Holdings Ltd., 39-41 Mincing Lane, Blackburn BB2 2AF, England

NEW "JUNQUE" Limited Supplies — ALL BRAND NEW
JENNINGS' VACUUM VARIABLE CAPACITORS.
±5 TO ±25 PF, 20 to 100 KV. 1/4" dia. x 3/4" for mounting +1/2" for control. 0.4-200 MA DC. Each $3.00.
±4 TO ±56 PF, 10 to 50 KV. ±4-200 MA DC. Each $3.00.
±3 TO ±1 1/2" for control, + 1/2" for 1/2" shaft. 12 lbs each. $27.50.

METERS — all fit 7/8" hole. ALL BRAND NEW.
WESTON ±1941. 4 1/2" x 4" wide view plastic. 100 MV F.S., calibrated 0-4000 amp; or 50 mv F.S. scale calibrated 0-2000 amp NO SHUNTS. Choice each $8.50.
0-200 MA DC. API #430-274. Mirror scale. 5" x 3 1/2" each $8.50.
0-500 MA DC, 3 1/2" sq. SIMPSON, gray plastic case, wide view, each $6.50.
0-50 UA DC, 3 1/2" sq. SIMPSON, plastic case, wide view. Scale 0-360W. For Motorola Motrac base station transmitter. Each $6.50.
0-50 UA DC. 3 1/2" sq. SIMPSON, Dual scale 0-50 ua & 0-250 ma (no shunt) 4/20; ea. $5.50.
0-200 UA DC. BURLINGTON fan style, 4 1/2" x 2 1/2" scale each $4.50.

PLEASE — include sufficient to cover postage. any excess returned in order. Illinois shipments, add 5% for "sales tax". Store 5659 N. Ridge Ave., Chicago, Ill. 60660. Hours: Wed. 11:00 a.m. to 2:30 p.m.; Sat. 10:00 a.m. to 2:30 p.m. MAIL ADDRESS: 1249 W. Rosedale Ave., Chicago, Ill. 60650. Phones: (312) 334-4463 & 784-4426. BC ELECTRONICS
SURLUS TEST EQUIPMENT, VHF and microwave gear; write for bulletins. David Edsall, 2843 St. Paul, Baltimore, Md. 21218.

QSL's, Sample catalog 20¢. N & S Print, P. O. Box 11184, Phoenix, Ariz. 85061.

MANUALS for most ham gear made 45/65, some earlier. Send SASE for specific quote. Hobby Industry, WOJK, Box H-864, Council Bluffs, Iowa 51501.

WANTED: GENERAL CLASS (or higher) hams to join 4,500 member Morse Telegraph Club. Hundreds of hams already belong. Send modest $3 annual dues (includes subscription to great slick paper newsletter, "Dashes & Dots"). GST 5 J. Long. 520 West Schwartz Street, Salem, Ill. 62881 for membership card and assignment to nearest chapter.

EXCLUSIVELY HAM TELETYPE 21st year. RTTY Journal, articles, news, DX, VHF, classified ads. Sample 30¢, $3.00 per year. Box 837, Royal Oak, Michigan 48068.

PC's, Send large S.A.S.E. for list. Semtronics, Rt. #3, Box 1, Bellaire, Ohio 43906.


NEED PARTS? We carry parts for R-388-390-390A-391-392-1051-51S1, Nems Clark-Racal-Pack sets, PRC-25-41-87, 397-70-71-73-74-77. If you need a part no matter what you have, if its U.S. government we have it or can get it. Also we want to buy or trade all aircraft communications. All ground radio communications. All plug-in modules control heads. No matter what cond. they are in - bent or busted ok. We will buy or trade. We have R-390-389-390A-392-1051-51S1. Nems Clark - Racal - and new ham gear for trade. D & R Electronics, R. D. #1, Box 56, Milton, Pa. 17647. Phone 1-717-742-4604 after 6:00 P.M.

SIGNAL ONE OWNERS, expert and prompt service. High and low power, high and low band equipment. Same day service. Same day delivery. Also will purchase your gear for trade. SIGNAL ONE OWNERS, expert and prompt service. High and low power, high and low band equipment. Same day service. Same day delivery. Also will purchase your gear for trade. SIGNAL ONE OWNERS, expert and prompt service. High and low power, high and low band equipment. Same day service. Same day delivery. Also will purchase your gear for trade.

WANTED - USED FM 2-way radio communications equipment and test equipment. Mot., GE and RCA etc. No doggies please, CAL-COM Systems, Inc., 701-51A Kings Row, San Jose, Calif. 95112, Tel. 408-998-4444.

YAESU TRANSCEIVER OWNERS — Present and prospective owners of Yaesu communications equipment to GST J. Long. 520 West Schwartz Street, Salem, Ill. 62881. Send business-size SASE or two IRC's for complete information and sample of monthly FT newsletter. Milton Lowens WAZAQQ, 3977-F Sedgwick Ave., Bronx, N. Y. 10463.

VHF-UHF PRE-AMPS. 432 MHz receive and transmit. We will buy or trade. We have SIGNAL ONE OWNERS, expert and prompt service. High and low power, high and low band equipment. Same day service. Same day delivery. Also will purchase your gear for trade.

FREE IC With Every $10 Order*

- REDUCE YOUR PROJECT COSTS
- MONEY-BACK GUARANTEE
- 24-HOUR SHIPMENT
- ALL TESTED AND GUARANTEED

TRANSISTORS:
- NPN
  - 2N3563 TYPE RF Amp & OSC to 1 GHz (p/ 2N3565) $6.00
  - 2N3565 TYPE Gen Purpose High Gain (TO-106) $6.00
  - 2N3691 TYPE GP Amp to 25 mA and 50 MHz $6.00
  - 2N3886 TYPE RF Per Amp 1 W 600-600 MHz $1.50
  - 2N3903 TYPE GP Amp & Sw to 100 mA and 30 MHz $6.00
  - 2N3904 TYPE GP Amp & Sw to 100 mA (TO-92) $5.00
  - 2N3919 TYPE RF Per Amp 3 W 5 330 MHz $3.00
  - Assort NPN GP TYPES, 2N3565, 2N3641, etc (15) $2.00

PNP
- 2N3638 TYPE Gen. Per. Amp & Sw $4.00
  - 2N4749 TYPE Low Noise Audio Amp 1 uA in 50mA $4.00

FET'S:
- N CHANNEL (LOW NOISE)
  - 2N4115 TYPE RF Amplifier to 450 MHz (TO 72) $2.00
  - 2N5485 TYPE RF Amp to 450 MHz (plastic 2N4416) $3.00
  - 2N5163 TYPE Gen. Purpose Amp & Sw (TO 106) $3.00
  - 2N4091 TYPE RF Amp & Switch (TO 106) $3.00
  - 1N4148 TYPE Ultra Low Noise Audio Amp $2.00
  - Assort RF & GP FET'S, 2N5163, 2N5486, etc (8) $2.00

P CHANNEL
- 2N3460 TYPE Gen. Purpose Amp & Sw (TO 106) $3.00
  - M104 TYPE MOS FET (On-specified) 0.3 pF $3.00

LINEAR IC'S:
- 555X Timer 1-2.1 Us, Op. (p/ 555) $9.00
  - 709 Universal OP AMP (DIP TO-5) $3.00
  - 723 Voltage Regulator 3.3 V (1 250mA) (DIP TO-9) $3.00
  - 739 Dual Low Noise Audio Preamplifier OP AMP (DIP TO-5) $9.00
  - 741F, 741T Freq. Compensated OP AMP (DIP TO-5/9) $4.00
  - 2556 Dual 555 Timer 1 per. to 100 Hz (DIP TO-5) $1.50
  - LM309 Posture Voltage Regulator (TO-9) $1.25
  - MC1558 Dual 741 OP AMP (MINI DIP) $9.50
  - Assorted Linear 741(109/123, etc) 14 $2.00

DIODES:
- 1N914 TYPE Gen Purpose 100V/10mA 10/$1.00
  - 1N3600 TYPE Hi Speed Sw 75V/200mA 6/$1.00
  - 1N4608 TYPE GP & SW 80V/400mA 6/$1.00
  - 1N8393 TYPE RECIFIER Stud Mount 400V V/12 2/$1.00
  - 1N495 ZENER 3.5 Volt 400mW 3/$1.00
  - 1N753 ZENER 6.2 Volt 400mW 4/$1.00
  - 1N755 ZENER 7.5 Volt 400mW 4/$1.00
  - 1N757 ZENER 9.1 Volt 400mW 4/$1.00
  - 1N756 ZENER 10 Volt 400mW 4/$1.00
  - 1N495 ZENER 15 Volt 400mW 4/$1.00
  - 1N686 ZENER 20 Volt 400mW 4/$1.00
  - D5 VARIATOR 5 50W Output 20-30 250/70 70$5.00
  - F7 VARIATOR 1.5 W Output 100 500 MHz 5 30$1.00

*MAIL NOW! With every order of $10 or more, postmarked prior to 1/1/60, FREE 739 Low Noise Dual OP AMP included.

ORDER TODAY — All items subject to prior sale and prices subject to change without notice. DATA SHEETS included with most items.

WRITE FOR FREE CATALOG offering hundreds of semiconductor parts not listed here. Send 10¢ stamp.

TERMS: All orders prepaid. We pay postage. $1.00 handling charge on orders under $10. Calif. residents add 6% sales tax.

ADVA ELECTRONICS

BOX 4181-F, REDWOOD CITY, CA 94062
Tel. (415) 851-0455

More Details? CHECK-OFF Page 94
THREE QUARTER INCH DIGITS
BY OPCOA
$4.95
* 0.7 character
* 0 to 7 Segments
* 30 miles
* Order by type number
* Plus or Minus one

CRYSTAL OSCILLATOR

8 WATT STEREO AUDIO AMP

The factory "skipped" most of these. A 8 WATT STEREO amplifier, complete with power cord, controls, and wood box. Panel dimensions: 8 x 2.5 x 3.5. $4.95

PROFESSIONAL 8-TRACK TAPE TRANSPORT

CLOCK CHIPS as Low as $4.95

INTEGRATED CIRCUIT SOCKETS

SANKEN HYBRID AUDIO POWER AMPS

CAKULATOR

DIGITAL BASICS

BASIC K12

BASIC K22

BASIC K32

12 DIGIT BASIC 24

12 DIGIT BASIC "MEMORY" K25

PRECISION CRYSTAL

EPOXY FILLER

SILICON BOND

RECIPTIVES

INTEGRITY

20-Years of Business

20-Years of Money-Back GUARANTEE

20-Years of Economy! LOWEST PRICES!

48-HR. SERVICE

OPCIA SLA-1

6-DIGIT KRONOS CLOCK

Money-Back on all items

$29.95

$1.95

$2.50

$5

$25

$4.95

$5.95

$0.95

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5

$25

$2.50

$5
There's nothing amateur about our radios.
Deluxe "101 Series"... The ultimate base station combination.

FR-101 Digital
SOLID-STATE RECEIVER
- Total coverage capability: 160 thru 2 meters + 12 major S.W. bands.*
- Direct frequency readout to 100Hz.
- Provision for all-mode reception: SSB, CW, AM, RTTY & FM.**
- Reliable, plug-in, modular circuitry.
- Compatible transceive operation with 101 series.
* Six and two-meter converters and crystals optional. ** Filters and FM detector optional.

FL-101
SOLID-STATE TRANSMITTER
- 240 Watts PEP.
- 160 thru 10 meter coverage + 2 optional auxiliary bands.
- All-mode operation: SSB, CW, AM & FSK.
- Reliable, plug-in, modular circuitry.
- Provision for RF speech processor.

Specifications subject to change without notice.

Visit your dealer for details or write for our new catalog.
All Yaesu products warranted by the selling dealer. Complete after-warranty service available in Paramount, Calif.

YAESU MUSEN USA INC.
7625 E. Rosecrans Avenue, Unit #29 Paramount, California 90723 (213) 633-4007
LOW COST DIGITAL KITS

NEW BIPOLAR MULTIMETER: AUTOMATIC POLARITY INDICATION

Model ES 210K

Displays Ohms, Volts or Amps in 5 ranges • Voltage from 100 Microvolts to 500 V • Resistance from 100 Megohms to 1 Megohm • Current from 100 Nanoamps to 1 Amp . . . . . . . $82.00 Case extra: $12.50
(Optional probe) $5.00

40 MHz DIGITAL FREQUENCY COUNTER:
• Will not be damaged by high power transmission levels.
• Simple, 1 cable connection to transmitter's output.

ES 220K - Line frequency time base.
1 KHz resolution . . . 5 digit: $79.50 Case extra: $10.00
ES 221K - Crystal time base.
100 Hz resolution . 6 digit: $109.50 Case extra: $10.00

DIGITAL CLOCK:

ES 112K/124K • 12 hour or 24 hour clock: $46.95.
Case extra: • Metal $7.50

CRYSTAL TIME BASE:

ES 201K - Opt. addition to ES 112K, 124K or 500K
Mounts on board. Accurate to .002% . . . . . . . $25.00

I.D. REMINDER:

ES 200K - Reminds operator that 9 minutes and 45 seconds have passed. Mounts on ES 112 or 124 board. Silent LED flash: $10.95. Optional audio alarm $4 extra.

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:

40 MHz DIGITAL FREQUENCY COUNTER:
The New Hy-Gain 270 brings state-of-the-art design to 2 meter mobile.

The Hy-Gain 270 is specifically designed to solve the problems of gain 2 meter mobile antennas...hard tuning, high VSWR, poor pattern due to irregular ground plane, and fade from whip flex.

The all white fiberglass and chrome design develops 6 db gain through the use of 2 stacked 5/8 wave radiators with a self-contained 1/4 wave decoupling system. Because the Hy-Gain 270 operates independent of the car body ground, you get minimum pattern distortion for maximum range in all directions. Independence from the car body also means the end to tune-up problems. The fiberglass design solves the fading problem due to upper whip flex.

Since the antenna and feedpoint are sealed in fiberglass, the Hy-Gain 270 will deliver top performance year after year without loss due to corrosion. The Hy-Gain 270 can be mounted anywhere ...bumper, cowl, deck or mast ...for fixed, land mobile or marine service using Hy-Gain mounts listed below.

- 6.0 db gain.
- 250 watt rated.
- 144-148 MHz.
- VSWR less than 1.5:1 at resonance, 6 MHz Bandwidth.
- 96" whip height.
- No pruning required, completely factory tuned!
- 50 ohm input.
- 3/8 x 24 standard mobile thread.
- Comes with 18' coax and PL-259 connector.

Order No. 270

Mounts—Universal No. 271
Flush Body No. 499
Bumper No. 415

Get maximum range ...get a Hy-Gain 270!

For prices and information, contact your local Hy-Gain distributor or write Hy-Gain.

Hy-Gain Electronics Corporation; 8601 Northeast Highway Six; Lincoln, NE 68507; 402/464-9151; Telex 48-6424.
Branch Office and Warehouse; 6100 Sepulveda Blvd. #322, Van Nuys, CA 91401; 213/765-4532; Telex 65-1969.
Distributed in Canada by Lectron Radio Sales, Ltd., 211 Hunter Street West, Peterborough, Ontario.
Aha, the SECRET of PC Board success finally revealed. A perfectly balanced lighting tool combining magnification with cool fluorescence. Excellent for fine detail, component assembly, etc. Lens is precision ground and polished.

Regularly $55.00. Now, over 30% discount (only $38.00) to all licensed Hams, verified in Call Book. Uses T-9 bulb (not supplied).

Include $2.00 U.S. postage, or $3.00 in Canada. $4.00 elsewhere. California Residents include 6% sales tax.

Or send stamped envelope for free brochure of other incandescent or fluorescent lamps suitable for all engineers, architects, students, etc.

D-D ENTERPRISES
DEPT. A, P.O. BOX 7776
SAN FRANCISCO, CA 94119

YOUR GEAR WANTED!
WE PAY TOP DOLLAR OR TRADE!
We are looking for: MD/83A/ARN Modulator . . . PRC-668 . . . ARC-115 . . . TS-683/TSM Crystal impedance meter.

If you hate money, we'll trade for NEW ham gear!

COLUMBIA ELECTRONICS SALES, INC.
Box 9266-C, No. Hollywood, CA. 91609
Phone: (213) 764-9030

KW BALUN KIT STILL ONLY $5!
The AMIDON Toroid Balun Kit makes a modern, compact antenna transformer that can be wired for either 4:1 or 1:1 impedance ratio. The balun is ideal for use between a coaxial feedline and 50 ohm antenna. It reduces coax radiation and properly balances the energy for application to the antenna's feedpoint. The balun also acts as a isolation device and removes the capacity of the coax from the antenna which reduces the high SWR frequency range of the array. Baluns made from this kit can be used to advantage on these antennas: cross dipole, Quad, Beam, inverted Vee, Windom and Folded Dipole.

SEND FOR FREE FLYER!

AMIDON Associates
12033 Otsego Street . NORTH HOLLYWOOD. CALIF. 91607

THE ULTRA-BAL 2000

NOW . . . An extremely rugged, weather-proof BALUN!
• Full 2KW, 3-30 MHz, 1:1 or 4:1 ratios.
• Special Teflon insulation. May be used with tuned lines and tuners.
• With dipole insulator and hang-up hook.

ONLY $9.95 ppd. (state ratio)
At your dealer or order direct
K.E. Electronics Box 1279, Tustin Cafl. 92680

RADIO & ELECTRONS CONSTRUCTOR

• Audio Construction Projects
• Receiver Construction Projects
• Transmitter Construction Projects
• Test Equipment Projects
• Radio Control Projects

and much more

ONE YEAR SUBSCRIPTION — $7.00
12 MONTHLY ISSUES
Write
RADIO CONSTRUCTOR
Greenville, N. H. 03048

COMPLETE ANTENNA SYSTEMS
A complete ready-to-use antenna system designed for your favorite frequency. Includes No. 12 copperweld wire element dipole, 100 ft. of coax with connector, and 100 ft. of 3/4 inch diameter dacron halyard at each end of dipole. No "diddling" or trimming required. You furnish the supports, plug the feedline into your xmt and start operating. Power ratings — 2KW, VSWR 1.5:1 or less.

75/80M Monoband . . . 130 Ft. . . . $74.75
40M Monoband . . . 65 Ft. . . . 69.75
80/40M Dualband . . . 130 Ft. . . . 99.95
80/40/20M Triband . . . 130 Ft. . . . 114.00

Descriptive literature available. State desired frequency. Postpaid contiguous USA.

HOUSE OF DIPOLES
Box 8484
Orlando, Fla. 32806

WEBSTER radio

2602h E. Ashlan
Fresno, Calif. 93726
Phone (209) 224-5111

QUALITY • THE SIZE • THE FEATURES • CHECK CTCSS — MINI ENCODER
6-10 Cal epoxy circuit board. Precision grade American components. 3/4" x 1-1/4" (single freq.). Fits with ease into handheld units. Multi-freq. units avail. Low power consumption (less than 2mA). Single Freq. Unit Only $14.95. Each Additional Freq. Only $2.00.

COMMUNICATION PRODUCTS & ENGINEERING
P. O. Box 261 • Milford, Michigan 48042

THE PRICE

92 october 1974
NEW
ELECTRONIC KEYER KIT

Features:
- TTL Circuitry
- Sends perfect code including overwound trace between dot and dash where a space is one time element; a dot is one time element, and a dash is three time elements.
- Actual keying element is 250 V transistor
- Side tone generator (adjustable frequency and volume)
- Speed adjustable 5 - 50 WPM
- A - C Operated
- One year guarantee

Kit includes everything necessary except key and enclosure
- Etched and drilled PCB
- All PCB mounted parts
- Transformer
- Speaker
- Potentiometers
- Complete detailed assembly instructions and schematic.

KIT PRICE $39.95  Kit with PCB Assembled and Tested $49.95

ANACOM ENGINEERING CO.
POST OFFICE BOX 12005
DALLAS, TEXAS 75223

Cash for any Collins military or commercial equipment or parts, especially 618 T Transceivers, 490 T antenna couplers. AN/ARC-102. AN/ARC-96.
CASH
AN/MRC-96, SPACE ELECTRONICS CO.,
78 Brooklaine Drive, Upper Saddle River, N.J. 07458
(201) 307-7540

WORLD QSL BUREAU
THE ONLY QSL BUREAU to handle all of your QSLs to anywhere; next door, the next state, the next country, the whole world. Just bundle them up (please arrange alphabetically) and send them to us with payment of $1 each.
5200 Panama Ave., Richmond, CA USA 94804

GROTH-Type
COUNTS & DISPLAYS
YOUR TURNS

- 99.99 Turns
- One Hole Panel Mount
- Handy Logging Area
- Spinner Handle Available

Case: 2x4": shaft 1/2"x3"  
Model TC2: Skirt 2¼"; Knob 1¼"  
Model TC3: Skirt 3"; Knob 2¼"  

R. H. BAUMAN SALES
P.O. Box 122, Itasca, Ill. 60143

Like everything else in these mixed-up times, the price of Ham Radio, whether by subscription or newsstand, is going to be raised.

You can SAVE by subscribing or extending your existing subscription at today's low rates, but you must do it before the end of the year when our new rates take effect.

Remember, you can save even more with our low priced three year subscriptions where you get three years for the price of two.

Please enter my

\[\square\] new \[\square\] extension subscription
\[\square\] 1 YEAR \[\square\] $7.00 These rates expire
\[\square\] 3 YEARS \[\square\] $14.00 Dec. 31, 1974
\[\square\] LIFE \[\square\] $99.00

Name \[\square\] Call

Address

City \[\square\] Zip

ham radio magazine
GREENVILLE, NH 03048

More Details? CHECK-OFF Page 94
Advertisers

check-off

... for literature, in a hurry — we’ll rush your name to the companies whose names you “check-off”

Place your check mark in the space between name and number. Ex: Ham Radio / 234

INDEX

ATV Research ............................................... 86
Adva Electronics .......................................... 85
Amidon Associates ......................................... 92
Antech ......................................................... 78
Anacom Engineering Co. ............................... 93
BC Electronics .............................................. 96
Barry ............................................................ 97
Bauman ........................................................ 93
Budwig Manufacturing Co. ............................ 86
C.F.P. Electronics .......................................... 87
Caddell Corp ................................................. 86
Columbia Electronics ...................................... 92
Communication Products & Engineering .......... 92
Craig Radio ................................................... 86
Cush Craft .................................................... 95
D-D Enterprises ............................................ 82
Data Signal, Inc ............................................ 55
Denton Radio Co ............................................ 70
Dickens, Joe WAWUGE .................................... 74
Dynamic Electronics, Inc ............................... 86
E S Enterprises ............................................. 90
Ehrhorn Technological Operations .................. 1
Elmac, Div. of Varian Assoc ............................. Cover IV
Electronics Center, Inc ................................. 72
Epsilon Records ............................................. 74
Erickson Communications .............................. 68
Epsilon Electronics ........................................ 45
Gray Electronics .......................................... 74
Hal Communications Corp .............................. 49
Hal-Tronix ..................................................... 78
Ham Radio .................................................... 78
Hamtronics, Inc ............................................ 86
Henry Radio Stores ........................................ Cover III
Holding Photo Audio Centre ........................... 85
House of Dipoles ......................................... 92
Hy-Gain Electronics Corp ............................... 52, 69, 80, 91
Icon ............................................................ 7
International Crystal Mfg. Co. Inc ..................... 84
Jan Crystals .................................................. 67
Janel Labs ..................................................... 86
K. E. Electronics .......................................... 92
Leland Associates .......................................... 72
Logic Newsletter ........................................... 72
Madison Electronic Supply .............................. 85
Martex Corporation ........................................ 70
Matric ......................................................... 67
Midland Electronics Co ................................. 79
Nascom ....................................................... 68
Nurmii Electronics Supply .............................. 47
Oneida Elect. Mfg. Co. .................................. 86
Palomar Engineers ........................................ 85
Poly Paks ..................................................... 88
RMS Corporation .......................................... 86
Radio Devices Co .......................................... 72
Radio Amateur Callbook, Inc. .......................... 65, 70
Radio Constructor ......................................... 92
Regency Electronics, Inc ............................... 51
SAROC ......................................................... 48, 90
Signal One ................................................... 2
Southwest Technical Products .......................... 78
Space-Military Electronics .............................. 93
Speciality Products ........................................ 76
Spectronics FM ............................................. 73
Spectrum International ................................... 55
Swan Electronics .......................................... Cover II
Symtek, Inc .................................................. 76
T. R. I. Corporation ........................................ 81
Technical Documentation ................................ 65
Tekpro Design Systems .................................. 68
Ten-Tec, Inc ................................................ 71
Topeka FM Communications & Electronics ......... 72
Tri-Ex Tower Corp ......................................... 5
Tri-Tek, Inc ................................................ 76
Tristao Tower Co .......................................... 76
VHF Engineering, Div. of Brownian Elect. Corp. ... 75
Valu-Pak ...................................................... 82
Webster Radio ............................................. 92
Weinschenker, M. ......................................... 69
Wolf, S. ....................................................... 76
World QSL Bureau ........................................ 93
Yaesu Musen USA ......................................... 89
BUY OUR ANTENNA...TAKE IT OUT OF BOX...ASSEMBLE IT EASILY

IT WORKS

No Professional Help Required!
If I (an ad man) can put one together in minutes, anyone can!
And then...
IT WORKS BEAUTIFULLY!

FM 2 METER ANTENNAS
FROM THE WORLD'S LEADING MANUFACTURER OF VHF/UHF COMMUNICATIONS ANTENNAS

NEW FM GAIN RINGO RANGER — Get extended range with this exciting new antenna. A one eighth wave phasing stub and three half waves in phase combine to concentrate your signal at the horizon where it can do you the most good. Your present AR-2 can be extended with a simply installed RANGER KIT.

<table>
<thead>
<tr>
<th>Model</th>
<th>Power</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARX-2</td>
<td>100   watts</td>
<td>146-148 MHz</td>
</tr>
<tr>
<td>ARX-220</td>
<td>100   watts</td>
<td>220-225 MHz</td>
</tr>
<tr>
<td>ARX-450</td>
<td>100   watts</td>
<td>435-450 MHz</td>
</tr>
<tr>
<td>ARX-2K</td>
<td></td>
<td>RANGER KIT</td>
</tr>
</tbody>
</table>

NEW FM MOBILE — Fiberglass 5/8 wave professional mobile antenna for roof or trunk mount. Superior strength, power handling and performance.
AM-147T 146-175 MHz mobile

NEW 4 POLE — A four dipole gain array with mounting booms and coax harness 52 ohm feed, 360° or 180° pattern.
AFM-4D 1000 watts 146-148 MHz
AFM-24D 1000 watts 220-225 MHz
AFM-44D 1000 watts 435-450 MHz

IN STOCK WITH YOUR LOCAL DISTRIBUTOR

Cushcraft CORPORATION
621 HAYWARD ST., MANCHESTER, N.H. 03103

More Details? CHECK-OFF Page 94

October 1974
SEE BARRY FOR THE EXCITING NEW DENTRON
160 Meter Transceiver. Just plug into your existing 80 meter transceiver and you’re on the air .......................................................... $199.50

From VHF Engineering
HT Kit 2 watts out, 4 channel 2 meter transceiver kit $99.95
RX-144C 2 meter receiver kit, 3 mV Sens, 2 watt audio $69.95
TX-144 or 220 Transmitter kit $29.95

IC-230 by Inoue
 Completely synthesized with phase locked loop, Single Knob Control, Smart compact styling. $489.00

From Drake
Drake T-4XC $580.00
TR-22C Transceiver $229.95
Drake AA-10 Amplifier for TR-22 $49.95
Drake AC-10 Pwr. Sup. for TR-22, AA-10 or TR-72 $44.00
DC-4 Write

VENUS
SS-2, SLOW SCAN MONITOR - $349.00
Hood & $15, CG Test Tape $9.50
SS-2K, SLOW SCAN MONITOR KIT $269.00
C-1, FAST SCAN/SLOW SCAN CAMERA & CONVERTER - $469.00

NPC Power Supplies
115 VAC input - 12 VDC 4 amps out $29.95
Same as above but regulated $47.95
Model 108R - 115 VAC/13.6 VDC 12 amps max. REGULATED $64.95

BARRY has Antennas
CushCraft A-147-4 $13.50
CushCraft A-147-11 $21.95
Hustler 4 BT-V Vertical Antenna $56.95
HyGain 18V 10-80 m. vertical $33.00
Newtronics GT-144-5 2 dB gain, Trunk lid mount $39.95
Gold Line Single Pole, 5 position coaxial switch, wall bracket or panel mount, 1 KW AM $17.95

Courrier ML-100 Mobile Linear Amp. 1000 watt input, 200 watts out, 10 meter operation: New $120.00
CONSTANT VOLTAGE TRANSFORMER. Input 115 VAC @ 60 Hz output, 24 Volts @ 15 amps regulated (plus or minus 1%) requires 6 mfd, 600 VAC capacitor add $4.95 $60 value $14.95 ea.
Malory UHF Inducton 200va-250va $9.95 ea
SWR Bridge less meter by Automatic Electric, To 800 Mcs, see July 74 CQ pg. 43, TNC connectors, $30 value $10.95
Same 300ft. as above $149.50

Clegg FM-27B, 146-148 Mc coverage without buying a crystal. Fully synthesized 25 w. out $479.95
Shipping prepaid on all FM-27B's $309.95

Tube Headquarters. Diversified Stock. Heavy Inventory of Elmac tubes, chimney seals, etc. 3-500Z or 3-400Z Specify $42.50

Bird
We are official distributors for all Bird products
Bird Model 43 Wattmeters $100.00
HQ-145 - Gen'l coverage on Ham bands $125.00
2-30 MHz Slugs $35.00 Most VHF Slugs $32.00

C.D. Ham II Rotator
New Improved $149.95
write or call for introductory offer
TR-44 complete with control box $69.95
8 conductor cable for HAM II & TR-44 Rotators 15¢/ft.

FM from Barry
Drake TR-72, 2-meter FM transceiver, 23 channels, 1 or 10 watts output, 13.8 volts $320.00
Deluxe Headsets, excellent for ham radio or visual labs: 600 ohms, vinyl cushioned: $9.95
With volume control $11.99
Collins 152-J1 Phone Patch, good, removed from equipment $24.95
DYCOMM Block Booster "D" Kit, 10-15 watts in 45-55 watts out continuous $15.95
DYCOMM Brick Booster "E" Kit, 1-3.5 watts in 12-30 watts out $59.95

CHECK BARRY FOR FAMOUS BASSETT ANTENNAS
Complete packaged multiband wire antennas including special Bassett helium filled sealed resonators.
DGA-204075 $79.50
DGA-152040 $79.50
Also the Bassett DGA-2M high gain 2-meter collinear featuring fiberglass construction and polished chrome brass ½-24 thread mounting, 6 dB gain $29.95

HF Gear from Barry
Swan Cygnet 260, Good but need wafer switch for DC operation $250.00
Famous Triton-II by Ten-Tec. Fully solid-state, 20 watts transceiver. 5 bands - full break in on CW $606.00
Ten-Tec 252 AC Power Supply with VOX $119.00
Drake TR-4C Transceiver new, $599.95
Drake AC-4 Power Supply $120.00
R-392/URR by Collins & others, 500 kc to 31.99 Mc, digital readout similar to R-390, 24 volts dc at 3 amps. Very good condition. Introductory offer subject to change. As is $150.00
Good tested $195.00
Heath SB-301 with SB-600 Speaker, Exc. $250.00
R-399/URR 15 to 1500 kc. Manual or motor tuned with digital readout. Very good $495.00
Servo Corp. R-5200 Receiver 50 to 250 Mv continuous CW, FM, AM, adjustable selectivity, 115 volt AC $50.00
Hunter Bandit Linear Amplifier, Exc. Cond. $495.00
HQ-170 - Hammarlund 170-6-1600 meter with clock exc. $195.00
HQ-215 - Hammarlund Solid State Amateur Receiver
Very Good $245.00
Drake 2NT Transmitter New cond. $125.00
Collins MP-1 Mobile 12 VDC Power Supply: Good Cond. $89.00

BARRY
512 Broadway
NY, NY 10012

DEPT. H-10
212-WA-5-7000
TELEX 12-7670

More Details? CHECK-OFF Page 94
Suddenly... the answer is KENWOOD

TS-900 Kenwood's superb state-of-the-art SSB transceiver

... the ultimate transceiver. The promise of the transistor has been fulfilled. Here is the transceiver you will want to own... whatever you now have, get ready to trade up. Its important features are far too numerous to list. Its specifications are superb. The TS-900 is unquestionably the best transceiver of its kind ever offered.
The price.............................. $795.00

PS-900 (AC Supply) $120.00, the DS-900 $140.00

TS-520 Kenwood's go every place... do everything transceiver

The new TS-520 is the transceiver you have wanted, but could not buy until now. It is a non-compromise, do everything, go everywhere 5 band transceiver for SSB or CW that performs equally well at home, in an automobile, airplane, boat or trailer. The TS-520 features built-in AC power supply, built-in 12 volt DC power supply, built-in VOX with adjustable gain delay and anti-VOX. The price ................. $629.00

The "Twins" by Kenwood

The R-599A is the most complete receiver ever offered. It is solid state, superbly reliable, small and lightweight, covers the full amateur band... 10 thru 160 meters, CW, LSB, USB, AM, AM-N and FM.
The price.............................. $459.00

The T-599A is mostly solid state... only 3 tubes, has built-in power supply, full metering (ALC, Ip. RF output & high voltage), CW-LSB-USB-AM operation.
The price.............................. $479.00

See the Kenwood line at the following dealers:

- ALABAMA / L & T Electronic Specialties, Birmingham
- ALASKA / Service Electric Co., Inc., Ketchikan
- ARIZONA / Elliott Electronics, Tucson
- Ham Shack (The), Mesa
- Orbit Electronics, Tucson
- CALIFORNIA / Communications Headquarters, San Diego
- Electronics Emporium Int'l., San Diego
- Gary Radio, Inc., San Diego
- Ham Radio Outlet, Burlingame
- Henry Radio, Anaheim
- Henry Radio, Los Angeles
- Webster Radio, Fresno
- COLORADO / Radio Communication Company, Arvada
- FLORIDA / Amateur Electronic Supply, Orlando
- Amateur Radio Center Inc., Miami
- Amateur Wholesale Electronics, Miami
- Grice Electronics Inc., Pensacola
- Hollister Electronic Supply, Jacksonville
- GEORGIA / Clayton Communications, College Park
- IDAHO / United Electronics Wholesale, Twin Falls
- ILLINOIS / Klaus Radio, Inc., Peoria
- INDIANA / Graham Electronics, Indianapolis
- Hoosier Electronics, Terre Haute
- Radio Distributing Company, South Bend
- IOWA / Hobby Industry, Council Bluffs
- KANSAS / Associated Radio Communications, Overland Park
- MAINE / Down East Ham Shack
- MARYLAND / Electronic International Service Corp., Wheaton
- Professional Electronics, Baltimore
- MICHIGAN / Electronic Distributors, Muskegon
- Radio Supply & Engineering Company, Detroit
- MINNESOTA / Electronic Center, Minneapolis
- MISSOURI / Ham Radio Center, St. Louis
- Henry Radio, Butler
- MONTANA / Conley Radio Supply, Billings
- NEW MEXICO / Gene Hansen Company, Corrales
- NEW YORK / Adirondack Radio, Amsterdam
- Harrison Radio Corp., Farmingdale, New York City
- Ohio / Amateur Electronic Supply, Cleveland
- NORTH CAROLINA / Vickers Electronics, Durham
- OHIO / Amateur Electronic Supply, Cleveland
- Communications World, Cleveland
- Queen City Electronics, Cincinnati
- Srpco Electronics, Dayton
- OKLAHOMA / Derrick Electronics, Broken Arrow
- Radio, Inc., Tulsa
- OREGON / Portland Radio Supply, Portland
- PENNSYLVANIA / Electronic Exchange, North Wales
- JRS Distributors, York
- Kass Electronics, Drexel Hill
- SOUTH CAROLINA / Accutek, Inc., Greenville
- SOUTH DAKOTA / Burghardt Amateur Center, Watertown
- TEXAS / Douglass Electronics, Corpus Christi
- Electronics Center, Inc., Dallas
- Ed Juge Electronics, Inc., Fort Worth
- Madison Electronics, Houston
- UTAH / Manwill Supply Company, Salt Lake City
- WASHINGTON / Amateur Radio Supply Company, Seattle
- WISCONSIN / Amateur Electronic Supply, Milwaukee

Prices subject to change without notice.
For years, the industry-wide standard warranty for power grid tubes has been 1,000 hours. For years, the operating lifetimes of EIMAC tubes have exceeded this warranty — reducing down-time and boosting on-the-air time in thousands of transmitters. So, EIMAC offers a new warranty policy for 81% of all standard power grid tubes: 3,000 hours/1 year, with prorated adjustment from 300 to 3,000 hours. Failure during the first 300 hours results in complete replacement.

This warranty is a direct result of reliability that has been built into every EIMAC product for the past 40 years. Our 3,000 hour warranty stands as proof.

For details about which tube types are covered by the new warranty, contact EIMAC, Division of Varian, 301 Industrial Way, San Carlos, California 94070. Or any of the more than 30 Varian/EIMAC Electron Device Group Sales Offices throughout the world.