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ham radio magazine

MARCH, 1971

a PHASE-LOCKED local oscillator

this month

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- RTTY signal generator 23
- fm repeaters 38
- rating tubes for linear amplifiers 50

More Details? CHECK—OFF Page 94

Versatility plus! ... in a
2 Meter FM Transceiver

. . . IN THE FIELD
IN THE CAR
IN THE HOME . . .

DRAKE MODEL TR-22
$199.95 Amateur Net*

The TR-22 is a 2-meter VHF-FM completely transistorized, compact, portable transceiver with capacity for six channels. It can be used over the shoulder, mobile, or in your home. Has a built-in telescoping antenna, and SO-239 connector provided for external antenna. May be used barefoot or with accessory two-way amplifier. Operates on external 12 VDC or on internal rechargeable nickel-cadmium batteries. Has built-in 120 VAC 50-60 Hz battery charger.

SPECIFICATIONS

GENERAL • **Frequency Coverage:** 144-148 MHz • **6 channels, 3 supplied:** **(1)** Rcv: 146.94 MHz, Xmit: 146.34 MHz; **(2)** Simplex: 146.94 MHz; **(3)** Rcv: 146.76 MHz, Xmit: 146.34 MHz • **Frequency modulation** • **Push-to-talk** Xmtr Control • **DC Power Drain:** Rcv: 45 mA, Xmit: 450 mA • **Power Source:** 12 VDC ± 20%; 120 VAC 50-60 Hz (for recharging nickel cadmium batteries only.) • **Size:** 5⅜" x 2$^{5}/_{16}$" x 7⅛", **Wt:** 3¾ lbs.

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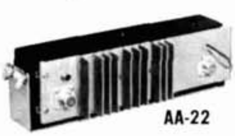
TRANSMITTER • **RF Output Power** over 1 watt • **Frequency Deviation** adjustable to 15 kHz maximum; factory set to 5 kHz.

***PRICE OF TR-22 INCLUDES:** Dynamic Microphone, Over-the-Shoulder Carrying Case, 120 VAC and 12 VDC Power Cords, Speaker/Headphone Plug, and 10 Nickel-Cadmium Batteries.

AT YOUR DEALER'S!



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Model AA-22 Accessory Amplifier $149.95. Improves receiver sensitivity and rejection of undesired signals. Provides at least 25 watts output with ½ to 3 watts drive. Fully automatic.

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More Details? CHECK—OFF Page 94

March, 1971
volume 4, number 3

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ham radio *magazine*

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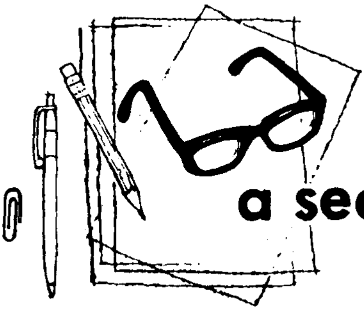

a second look

by jim fisk

Within the next 20 years the world's power needs may be supplied by huge solar power stations in synchronous orbit around the earth. Diminishing fossil-fuel reserves, doubts about the practicality of nuclear power and problems of air and water pollution have led scientists to develop a plan for a system of orbiting solar-power stations.

The satellites would collect solar energy with huge arrays of solar cells, and convert the resulting dc into microwave energy for transmission to the earth. On the earth large rectifier-antennas (rectennas) would convert the received microwave energy back to direct current for distribution to the user.

Each power satellite in the system would consist of a solar array about five-miles square, a parabolic transmitting antenna 1.5 miles in diameter and 10,000 microwave transmitting tubes, with an output of 1000 kW each. The transmitting antenna and solar array would be connected with a super-conducting cable 2 miles long. Total power of the proposed system is 100-million kilowatts.

A large rectenna on the earth, several miles square, would convert the received microwave energy back into dc power for distribution. Each element of the large receiving array would consist of a half-wave dipole with its own four-diode bridge. Since the individual dipole-diode combinations (dipodes) are independent, the overall beam pattern is essentially nondirectional, so it eliminates the necessity for precise aiming at the satellite.

An operating frequency of 3000 MHz was chosen to minimize the effects of atmospheric attenuation. Higher frequencies would be attenuated by the trophoshere while lower frequencies suffer from ionospheric attenuation. In addition, in complete cloud cover and moderate rainfall attenuation is lowest around 3000 MHz.

Many people, when first hearing of this plan, imagine that the microwave beam would virtually be a death ray that could cause great damage. Actually, with the proposed 100-million kW system, power density within the beam would only be 10 mW per square centimeter near the earth. This is the official Air Force maximum exposure level, and is a conservative limit with a built-in buffer factor, so it should not be hazardous for living things.

Although 20 years is a reasonable estimate for getting the satellite solar power system into operation, some scientists predict that the system could be working in 10 years if the government were willing to initiate a crash program similar to the nation's moon-landing program. In any event, this is the kind of planning we need to solve the increased demands for electric power in the future.

Jim Fisk, W1DTY
editor

New FM for '71
Standard's SR-C826M

professional quality, solid state, two-way radio, designed and sold exclusively for amateur use in the United States and Canada.

Standard Communications Corp., the world's largest manufacturer of marine V.H.F. equipment, has just developed a new industrial quality, high performance 2-meter unit. This rugged, compact transceiver is available only in the U.S. and Canada thru an authorized Standard dealer. The "826" is so compact that it makes mobile installation practical in almost any vehicle or aircraft, it becomes fully portable with the addition of Standard's battery pack.

GENERAL

Freq. Range — 143 to 149 MHz, 2 MHz spread

Supply voltage — 11 to 16 VDC. Negative Ground 13.8VDC nominal

Current Consumption — .15 amp receive standby. 2.4 amp transmit

Number of channels — 12- Supplied with 4 channels

1) 146.94 Simplex
2) 146.34/94
3) 146.76 Simplex
4) 146.34/76

Microphone — Dynamic

Dimensions — 6⅞"w x 2½"h x 9⅞"d

Weight — 4½ lbs. max.

Frequency stability—.001% (−10 to +60°C)

TRANSMITTER

RF power output — .8 or 10 watts

Output impedance — 50 ohms nominal

Deviation — Internally adjustable to ±10 kHz min. factory set to ±7 kHz

Spurious and harmonic attenuation — 50dB below the carrier power level

Type of modulator — Phase

RECEIVER

Sensitivity — .4 or less microvolts for 20 dB quieting

Squelch sensitivity — Threshold — .2 microvolts or less

2 MOSFET RF Amplifiers
1 MOSFET Mixer

Deviation acceptance — Up to ±15 kHz deviation

Spurious and image attenuation — 65 dB below the desired signal threshold sensitivity

Adjacent channel selectivity (30 kHz channels) — 60 dB attenuation of adjacent channel

Type of receiver — Dual conversion superheterodyne

Audio output — 5 watts For external speaker

$339.95 (complete as shown with microphone, built-in speaker and external alternator whine filter.)

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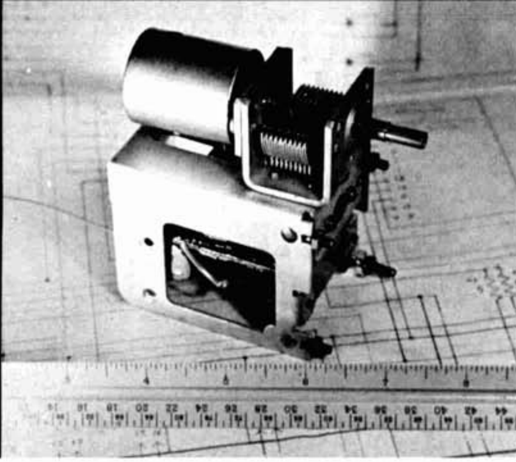


phase-locked local oscillator

A practical solid-state phase-locked local oscillator that covers the range from 14 to 50 MHz

J. A. Koehler, VE5FP, 2 Sullivan Street, Saskatoon, Saskatchewan, Canada

This oscillator was built to satisfy the requirement for the first local oscillator in a receiver. The design called for a number of stable frequencies separated by exactly 1 MHz over as wide a frequency range as possible – at least 30 MHz. One obvious solution would have been to use separate crystals for each frequency. However, this was not economical because of the large number of frequencies. An alternative would have been to build a frequency synthesizer using somewhat fewer crystals (twelve in this case), and produce the required outputs by mixing. I have gone this route before and it is extremely difficult to get all the frequencies precisely where required. The problem of suppressing unwanted mixing products is also formidable. For these reasons I decided to build a variable-frequency oscillator which covered the desired frequency range and which could be phase locked to the harmonics of a 1.0-MHz crystal-controlled oscillator.

Although phase-lock systems are not uncommon in commercial equipment, there has not been a great deal written about them in the ham literature; probably because a rigorous analysis of the process is mathematically complex. However, it is relatively easy to understand their operation and to build systems which work.

The phase-lock system is basically a servo system where the difference between the variable-oscillator frequency and a *reference* frequency produces an *error* signal which is used to alter the frequency of the variable oscillator. The process is similar to automatic frequency control (afc) except for one major difference which makes it far superior.

phase-lock operation

A conventional afc system is shown in block form in **fig. 1.** The discriminator produces an output which is proportional to the difference between the frequency of the voltage controlled oscillator (vco) and a reference frequency (the center frequency of the discriminator). The system is designed so that the overall feedback is negative. For example, if the discriminator output is zero volts for the desired frequency, positive for higher frequencies, and negative for lower frequencies, and if the vco moved up in frequency for positive control voltages and down for negative control voltages, then the amplifier must invert as well as provide gain. Then, if the vco drifted up in frequency for some reason, the discriminator output would become positive; the amplifier would amplify this voltage and would make it negative. This negative voltage, applied to the vco, would cause its frequency to decrease, thus counteracting the drift. The problem with an afc system is that frequency drift cannot be compensated for exactly; there is *always* some frequency error.

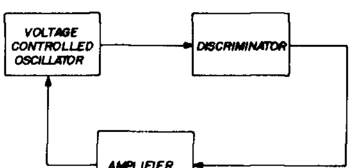


fig. 1. Basic parts of the automatic frequency control circuit.

This can be proved by the following argument. Suppose the vco were originally set exactly at the desired frequency. And furthermore, at that frequency, the discriminator output were exactly zero volts. Therefore, the control voltage to the vco would also be exactly zero volts. Now suppose that the vco drifted slightly upward in frequency. To bring it back to the original frequency requires a negative control voltage. This control voltage could only be produced if the discriminator output were somewhat more positive than zero; i. e., the vco frequency could not be exactly its original value.

This requirement for an error signal is characteristic of any servo system. The error can be reduced by tightening the control loop; in the case of afc this is done by increasing the gain of the amplifier so the control output would be very sensitive to small frequency changes. However, the frequency error cannot be eliminated entirely. In practice, the vco would be designed to be very stable so that frequency drift would be small. The afc system would then reduce drift even further.

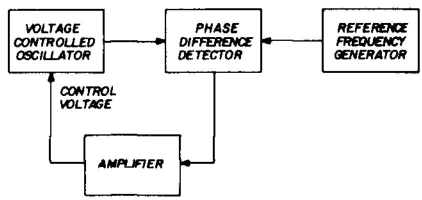


fig. 2. Block diagram of the basic phase-lock system.

A phase-locked system (pls) can produce an output frequency which is exactly the same as the reference frequency. This is done by deriving the error signal not from a frequency difference but from a phase difference. The block diagram of a pls is shown in **fig. 2.** Note that the afc discriminator has been replaced by a phase-difference detector. A reference frequency oscillator is also required, the discriminator performed this function in the afc system.

Fig. 3 shows a hypothetical time sequence of two input voltages (one at the reference frequency and the other at the vco frequency) and the output of the phase-difference detector. Initially the two voltages are in phase (the phase difference was zero) so the output of the phase detector is zero. However, because the two frequencies are different, the phase difference increases steadily with time until it reaches 360°. At that point the output of the phase difference drops back to zero since 360° phase difference is equal to zero phase difference.

Now suppose the output of the phase detector were connected to the vco control line. The ramp voltage would sweep the vco frequency. For the system to work properly, the control-voltage would sweep the vco frequency in a direction so as to decrease the frequency difference. Then, as the vco frequency approached the reference frequency, the rate of change of phase difference would decrease, and the vco would sweep more slowly. When the vco exactly reached the reference frequency, the phase difference between the two would be constant in time, so the vco frequency sweep would stop; the vco frequency would be phase-locked to the reference frequency.

The error signal in this loop is due to the phase difference between the vco and the reference frequency while they are locked together. This phase difference can be made arbitrarily small, just as the frequency difference in an afc can be reduced, but it cannot be entirely eliminated. However, for purposes of frequency control it is immaterial because the frequency error will be zero regardless of the phase error. If the vco frequency tended to drift, the phase detector would produce an output voltage which would

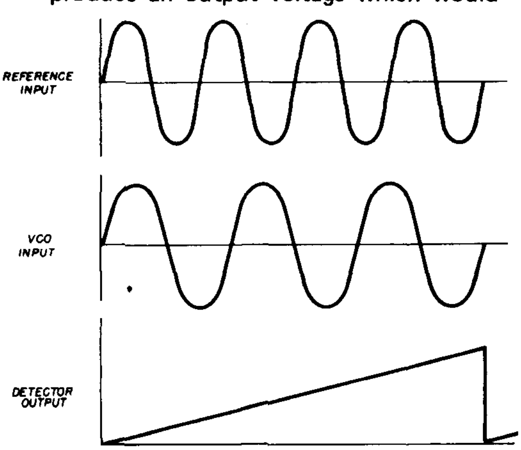


fig. 3. Waveforms in the phase-difference detector.

keep the vco locked to the reference frequency. After the drift, the phase difference between the two oscillators would, of course, be different from its original value, but the two frequencies would still be identical.

In practice, it is difficult to build a phase-difference detector with characteristics exactly as outlined above, and the devices used are called phase-sensitive detectors. The output of phase-sensitive detectors are usually only approximately

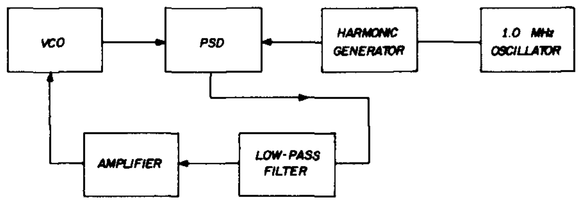


fig. 4. Proposed phase-locked oscillator for receiver local oscillator.

proportional to phase difference, and then only over a restricted range of phase difference. Also, there will also be a low-pass filter of some sort following the detector.

The lock-in range of the system, the range of vco frequency variation over which it can be locked onto the reference frequency, depends in a complicated way upon total loop gain and low-pass filter band-width. If you are interested in pursuing the topic, there are a surprising number of papers in technical journals on the subject. One of the more readable explanations I have seen appeared in the *Proceedings of the IRE*[1].

practical phase-locked oscillator

For my requirements, the vco had to have as wide tuning range as possible. Fair Radio has been selling a surplus tuning unit with a ganged capacitor and slug-tuned coil that covers the frequency range from 14 to 50 MHz, and I bought one of these.* I wanted to use this mechanism as the basis for a variable oscillator for this frequency range and

*$1.25 from the Fair Radio Sales Company, Post Office Box 1105, Lima, Ohio 45802. *Order RT-45 tuner. Shipping weight: 1 pound.*

phase lock it to the harmonics of a 1-MHz oscillator.

The system is shown in **fig. 4.** The surplus tuning unit was made into a Hartley oscillator using an fet. With no padding capacitor, the frequency range extended from about 15 to 80 MHz – this was more than adequate, and a padding capacitor was added to reduce the range somewhat, and to lower the low-frequency limit to a bit lower than 14 MHz. Frequency stability was quite good. Normally the oscillator should be as stable as possible so that it does not readily drift out of the lock-in range. A varicap across the tank circuit was to be used as the frequency controlling element.

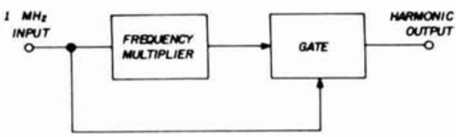


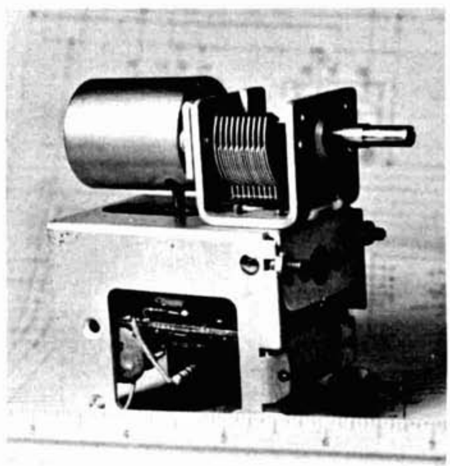
fig. 5. Harmonic generator.

The 1-MHz crystal-controlled oscillator also used an fet. The harmonic generator was more complicated than the type usually seen in the amateur magazines. A phase-look system requires that some power must be supplied to the reference frequency input to the phase detector at all frequencies where phase lock is required. To lock at 50 MHz, for example, requires appreciable amplitude of the 50th harmonic of the 1-MHz oscillator. Harmonics were originally generated by squaring the 1-MHz waveform and applying it to a diode – and later, other non-linear devices.

However, after a few experiments, it was apparent that the amplitudes of the higher harmonics generated in this way were too small. Step-recovery diodes probably would have been excellent; however, I didn't have any, so I built the harmonic generator outlined in **fig. 5.**

The output of the multiplier was keyed on and off at a 1-MHz rate by the gate. Assume that the frequency multiplication factor were ten and that it was somewhat non-linear; the output of the multiplier would then contain energy not only at 10 MHz, but also its harmonics, 20, 30, 40 MHz, etc. The gate can be thought of as a modulator which overmodulates. Consider for example the signal from the multiplier at 10 MHz. This would be modulated at a 1-MHz rate so the output of the gate would contain the carrier at 10 MHz as well as sidebands 1 MHz to each side of it (9 MHz and 11 MHz).

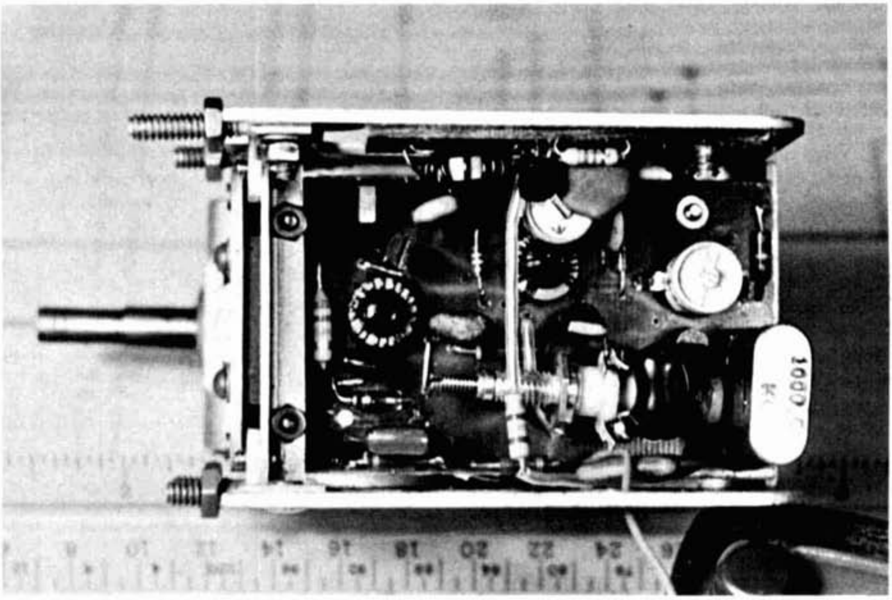
Because of overmodulation, there would also be other sidebands 2, 3, 4, and 5 MHz on either side of 10 MHz. The output of the gate would contain all the carriers (spaced at 10 MHz intervals) plus all the sidebands (spaced at 1 MHz intervals) between the carriers. This type of harmonic generator can be very efficient. The simple version I built produced sufficiently strong harmonics up to 70 or 80 MHz.


Miniature phase-locked local oscillator.

Since any mixer is, in fact, a phase-sensitive detector of sorts, my phase detector was a simple diode double-balanced mixer. I didn't have any hot-carrier diodes, so four 1N270s were selected by matching them on a curve tracer. The low-pass filter was an RC type, and the amplifier was a μA741 integrated circuit.

Unfortunately, when the system was built, it would not work properly over the entire range of the vco. Despite careful diode matching, the double-balanced mixer was not well enough been to provide some amplitude limiting of the vco output. However, the system was beginning to get too complicated, and the whole approach was abandoned.

After considerable experimentation,



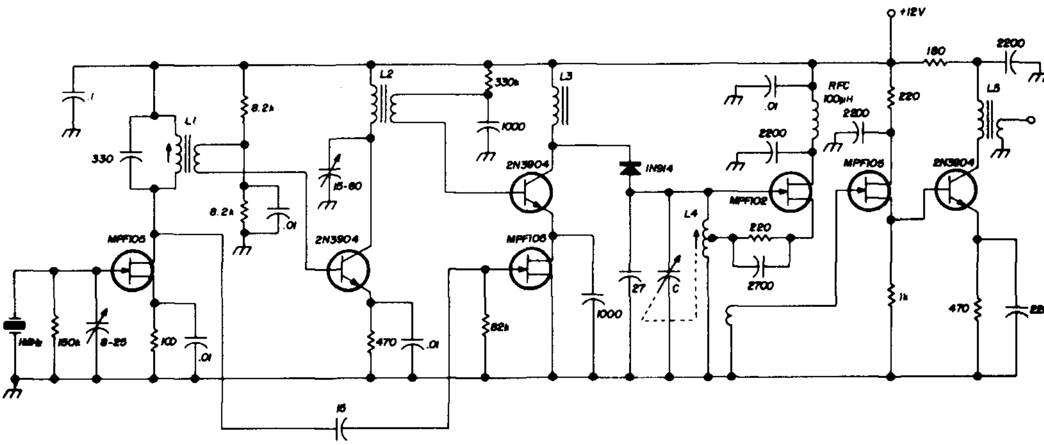
Complete phase-locked oscillator circuit is built on small board that is mounted in the surplus LC tuner.

balanced. The output of the mixer must be coupled directly to the amplifier input. Ideally, the output of the mixer should be at zero volts dc when the two inputs are not harmonically related. However, due to diode unbalance, there will always be a small dc component as well as the desired signal which offsets the amplifier input.

The problem was that the offset depended on vco amplitude. The system could, for example, be adjusted to work near 14 MHz by compensating for dc offset. However, when the vco was tuned to higher frequencies, the output amplitude changed, causing the dc offset to change and saturate the amplifier. If the gain of the amplifier were reduced so that it did not saturate anywhere over the vco range, then the lock-in range became unacceptably small at the higher frequencies. A possible solution might have the final solution required very few components. The oscillator fet itself was used as a mixer by coupling the harmonic generator output into the oscillator tank circuit with a varicap. The signal at the gate of the fet contained the oscillation frequency as well as all the 1-MHz harmonics. The instantaneous voltage at the gate depended on the phase difference between the oscillation frequency and the harmonics. Because the varicap was connected to the gate, the oscillation frequency therefore depended on this phase difference – thus satisfying the requirement of a phase-locked loop.

This system worked very nicely when I used a 1N914, a silicon planar switching diode, for the varicap. Normal varicaps with capacitance of 10 pF at 4 volts resulted in lock-in ranges which were too large, and which overlapped. With the 1N914, the lock-in range was about 100 kHz at 14 MHz and somewhat lower at the higher frequencies.

The final circuit is shown in **fig. 6.** The oscillator transistor was mounted on small terminal strips next to the coil. The factory, and it is anticipated that when the system is incorporated into the receiver, it will not be necessary because considerable wideband noise will be generated when the system is not locked.



C1, L4 Part of surplus tuner, Fair Radio RT-45 (see text)

L1 100 — 125 µH (J. W. Miller 42A104CBI) with 20-turn link

L2 25 turns no. 28 on Phillips 2P65347 toroid core, 7-turn link

L3 18 turns no. 28 on Phillips 2P65347 toroid

L5 15 turns no. 28 on Phillips 2P65347 toroid, 4-turn link

Phillips toroids are 0.375 inch in diameter. Ferroxcube 266CT125 toroids made of 4C4 material are identical to the Phillips units; Indiana General type CF102-Q1 are virtually the same.

fig. 6. Circuit of the practical phase-locked oscillator that tunes from 14 to 50 MHz.

1-MHz oscillator and harmonic generator was built on a printed-circuit board which fit nicely inside the framework of the surplus capacitor-coil framework as shown in the photograph. The smaller board on the side of the frame is the output buffer amplifier.

The frequency multiple in the harmonic generator need not be ten but can be any multiple. In the final version, it was sixteen.

The only remaining detail was to determine whether the vco was free running or whether it was phase locked at any point on the dial. This was done by connecting a diode detector and audio amplifier in parallel with the output. As the vco was tuned through its range, it was possible to hear it snap in and out of lock.

This method is not particularly satisfactory, and it is anticipated that when the system is incorporated into the receiver, it will not be necessary because considerable wideband noise will be generated when the system is not locked.

As an interesting side effect I found that it was possible to lock the vco on to harmonically related frequencies other than the 1-MHz points. For example, the vco could be locked to exactly 14.3333 MHz because the mixer detected the phase difference between the third harmonic of the vco at 43 MHz and the 43rd harmonic of the 1-MHz oscillator with sufficient amplitude to cause locking. However, the lock-in range for these frequencies is quite small and there is no difficulty in determining whether or not the output frequency was on one of these points or on the desired frequency.

reference

1. H. T. McAleer, "A New Look at the Phase-Lock Oscillator," *Proceedings of the IRE,* June, 1959, p. 1137.

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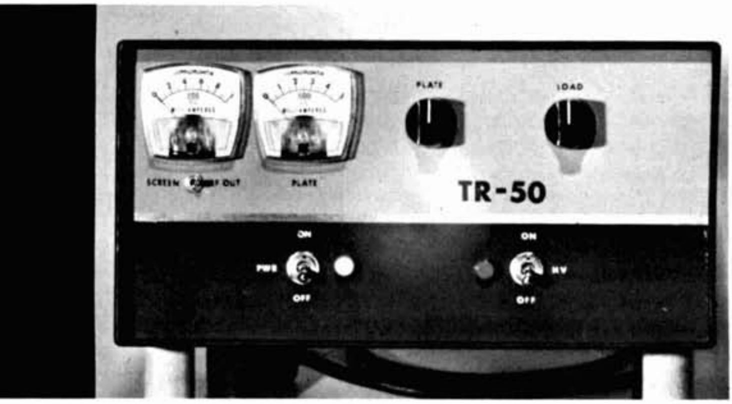


TR-50 customized six-meter transverter

A compact 300-watt transverter featuring high efficiency and a low-noise mosfet front end

Louis E. Savoie, K1RAK, 29 Hillsdale Road, Holbrook, Massachusetts 02343

The 50-MHz transverter described in this article was built to satisfy a specific purpose: to provide a medium power, tabletop transverter which was compatible, both electronically and in styling, to the Drake TR-3. A secondary object was cost. The result is a 300-watt ssb transverter that uses a low-noise mosfet receiving converter, and includes built-in solid-state power supplies. Efficiency of the output stage is 64%.

cabinet

My first order of business was to select a suitable enclosure for the unit. The Drake TR-6 cabinet matches the TR-3 in styling and offers the advantage of not having additional cutouts as do other cabinets of the TR-4 line. Cabinet measurements indicated a 10-1/2 x 13-1/4-inch chassis and 10-1/2 x 5-1/4-inch front panel were optimum. Considering the weight of the power-supply components, 0.047 steel was chosen for the chassis to provide strength and rigidity.

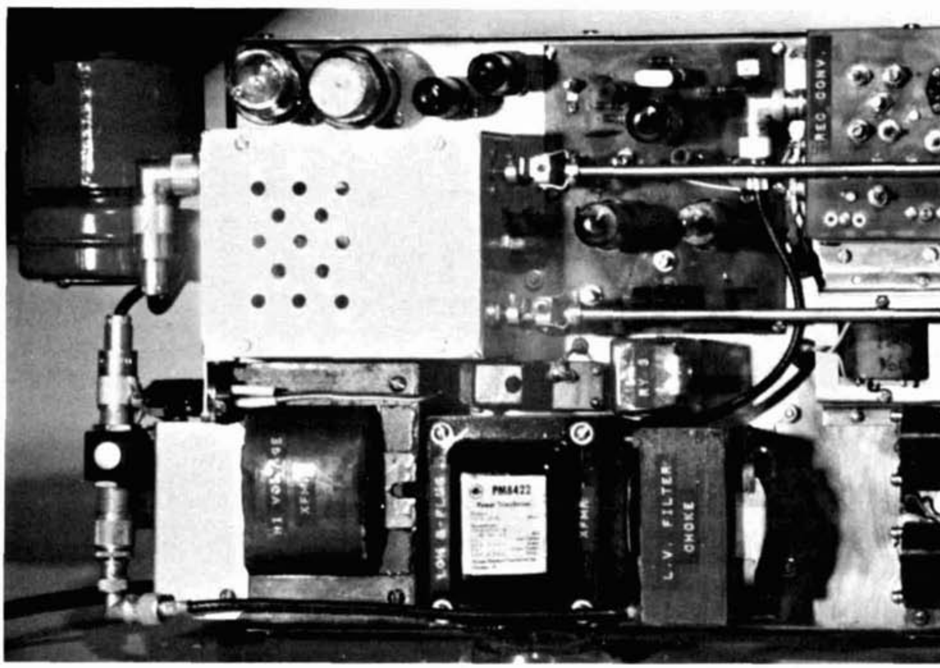
The chassis and front panel were purchased from a local metal shop for $9. This included bending and corner welding. The chassis, front panel and cabinet were then mated, and the chassis drilled for the captive hardware I wanted to use *to hold the system together. The captive* nuts should be riveted in place to provide a smooth, flush outside surface.

circuit

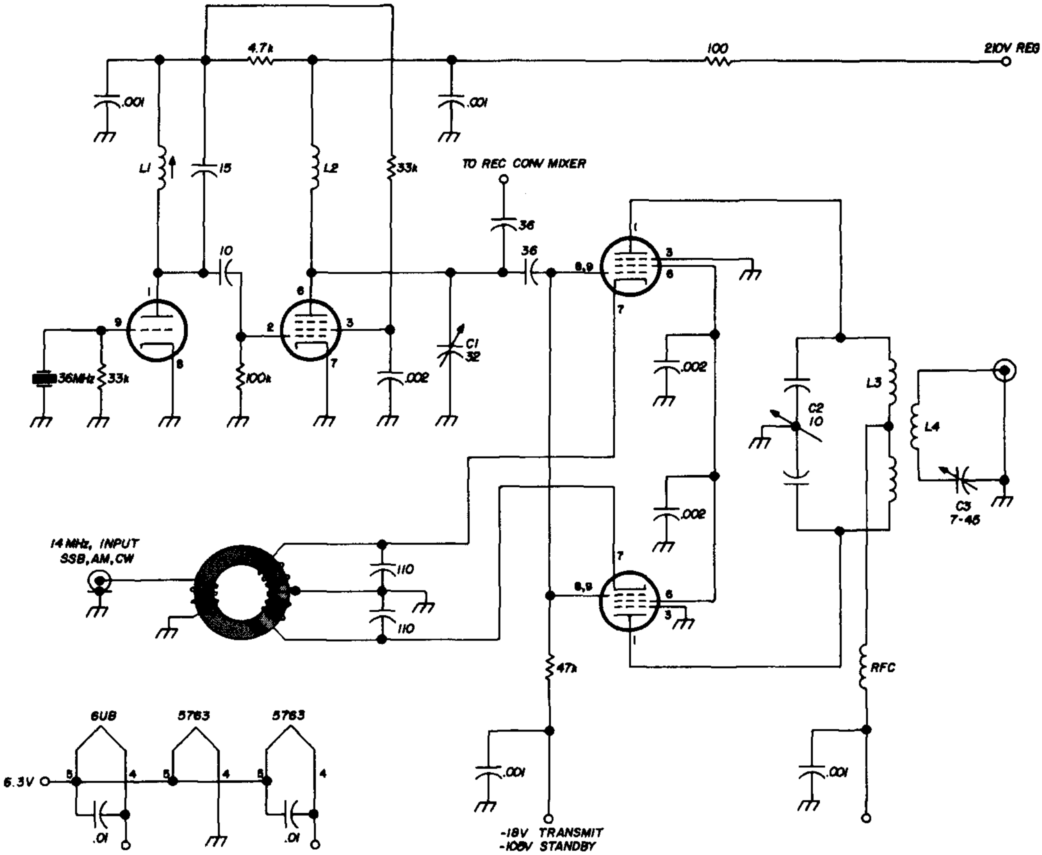
In the next phase of the design I considered both the mechanical and electrical requirements of the transverter. I have found it useful to first decide upon the circuit and power-tube requirements, and then search the literature for commercial transformers that will do the best possible job. Since I wanted the design to be as close to the state-of-the-art as possible, I decided on printed-circuit construction; solid-state would be used *where feasible.*

A recent article by K2ISP[1] described *printed-circuit transmitting mixers* for both six and two meters. Local experience with the two-meter unit suggested similar possibilities for the six-meter mixer. K2ISP's mixer features a conventional 6U8 buffer/amplifier that feeds a push-pull 5763 mixer/driver stage; the low-frequency ssb signal is injected at the cathodes of the 5763s. Although the original circuit was designed for a 43-MHz local oscillator and 7-MHz ssb, it seemed reasonably easy to convert to the more popular 36-MHz local oscillator, 14-MHz ssb system (**fig. 1**).

The printed-circuit board used in the K2ISP transverter, shown in **fig. 3**, can be used in the TR-50 without modifica-



Top view of the TR-50. The coaxial cable on the bottom goes to the receiving converter.



C1 32-pF variable (E. F. Johnson 160-110)

C2 10-pF butterfly (E. F. Johnson 160-211)

C3 7 — 45 pF ceramic trimmer

L1 12 turns no. 24, close wound on 1/4" slug-tuned form

L2 12 turns no. 20, air wound, 1/4" diameter, 1/2" long

L3, L4 7 turns no. 20, air wound, 1/2" diameter, 9/32" long

L5 4 turns no. 20, air wound, 1/2" diameter, 5/32" long

RFC Ohmite Z-50

Xtal 36-MHz third overtone

fig. 1. Six-meter transmitting mixer uses 14-MHz ssb input.

tion — although a few component values must be changed to accommodate the new mixing frequencies. The oscillator and buffer coils were re-designed to cover 36 MHz, and the input toroid was wound for 14-MHz injection.

After all the components were mounted on the printed-circuit board, the unit was tested on the bench. Using a TR-3 for injection, through a 10-dB pad, the transmitting mixer worked well into a 50-ohm load. A Heath Monitorscope indicated good quality ssb. Power output was calculated to be slightly more than 1.5 watts — more than enough to drive a power amplifier stage.

power amplifier

The available chassis space dictated a power tube that would combine ef-

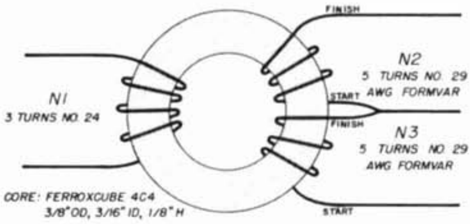


Fig. 2. Toroid transformer for 14-MHz input. Core is Ferroxcube 4C4 3/8" OD, 3/16" ID, 1/8" thick. Winding N1 is 3 turns no. 24 enameled: Winding N2 and N3 are each 5 turns no. 29 enameled. Windings N2 and N3 must be wound in same direction. Primary and Secondary winding should use full circumference of the core.

ficiency with small size. The 4X150/4CX250B power tetrodes offer a power-output-to-size ratio that seemed ideal for this application. These tubes require forced-air cooling, but commercial squirrel-cage blowers are available in small sizes and at low cost. A schematic of the six-meter power amplifier is shown in **fig. 4.**

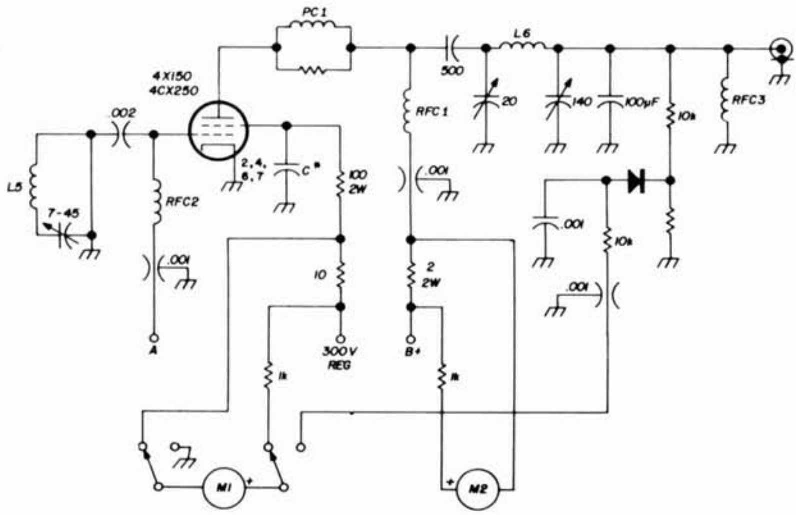
Rough sketches indicated that the pi-network coil, variable capacitors, plate choke and bypasses would easily fit into a 3x4x5-inch aluminum utility box. This made a suitable rf compartment which would fit into the vertical space between the cabinet and the top of the chassis.

The grid compartment box was made from 0.047-inch steel and mounted upside down under the chassis. By mounting this box against the back edge of the chassis, and including a rubber-gasketed cover, a plenum chamber was created. Cooling air is provided by a Dayton 21-cfm blower mounted to the chassis and sealed with rubber gaskets. A 1½-inch diameter hole through the back of the chassis and the grid compartment provides for air flow.

All power and filament connections are fed to the grid compartment through, .001 μF feedthrough capacitors. Coupling

fig. 3. Full-size printed-circuit board for the transmitting mixer.

from the mixer output link is fed to the 4CX250B grid through a ceramic feed-through connector. I believe this setup provides the input-output isolation which resulted in an exceptionally stable power amplifier that needs no neutralization.



C1 Eimac SK600 socket bypass capacitor

L5 Link on transverter board (L4 in fig. 1)

L6, 5 turns 1/8" copper tubing, 1" diameter

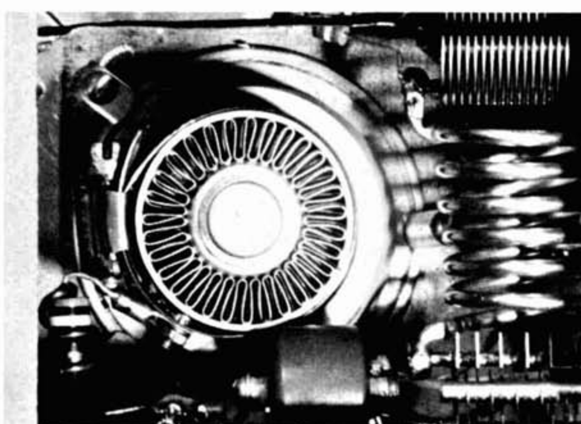
PC1 3 turns no. 14 around 47-ohm, 2-watt resistor

RFC1,2,3 Ohmite Z-50

fig. 4. 4X150 power amplifier stage operates at 64% efficiency and requires no neutralization.

I used low-cost surplus transformers and chokes for the various power supplies, although suitable commercial transformers are available. Separate transformers were fused for the high- and low-voltage supplies. A Stancor PS8415 was used for the bias supply, and a small 24-volt electric-train transformer provided power for the miniature coaxial relay and 15-volt zener-regulated receiving-converter power supply.* Power supply circuits are shown in **figs. 9, 10** and **11**.

*Shortly after completing this project, I uncovered a small bonanza. Jim Reeves, WA9HKE, 2207 Columbus Avenue, Anderson, Indiana purchased the closing stock of an electronics manufacturer, and included in this stock were a number of multiple-winding power transformers yielding 1100 to 1200 volts, 300 volts, 130 volts, 6.3 volts and 5 volts. The price is $12 each. These transformers are ideal for transverter projects such as the TR-50; I bought several for future projects.



Power-amplifier compartment. The 4CX250B is mounted to the rear of the compartment. Tube clamp is a stainless-steel heater-hose clamp.

switching and controls

Since the power output of the TR-3 is much higher than that needed for the 5763 mixer circuit, it must be attenuated. The 10-dB pad shown in **fig. 5** is somewhat over-designed, since the resistors specified will permit 220 watts dissipation. It is built into a 3x4x5-inch minibox and connected to the transverter input with short length of RG-58/U coaxial cable.

The switching relays consist of one three-pole, double-throw unit (K3), a standard Dow-Key antenna changeover relay (K1), and a miniature surplus coaxial relay (K2). K3 is the main control relay and is actuated by extra contacts in the ssb exciter (**fig. 6**); it actuates K1 and K2, and grounds the two bias lines. One multiple-pole relay would probably do the job, but these three relays were already in my junkbox.

metering

The meter circuits were designed with two factors in mind: low cost and easy-to-calculate meter shunts for the scales I wanted. By using low-cost imported meters in series with 1000-ohm resistors, all shunts are multiples or submultiples of 10 ohms. For example, with a 1-ohm shunt, this system will read 1 ampere full scale: for 500-mA full scale a 2-ohm shunt is required, and for 100-mA full scale, a 10-ohm shunt.

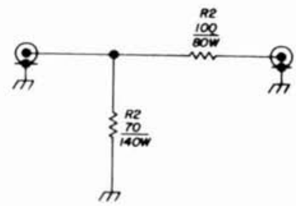
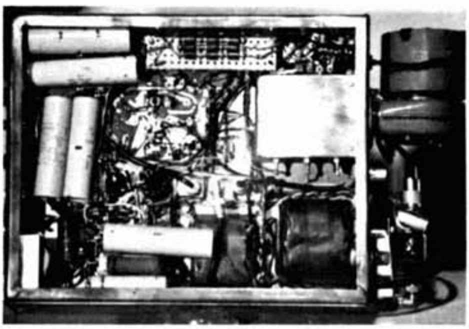
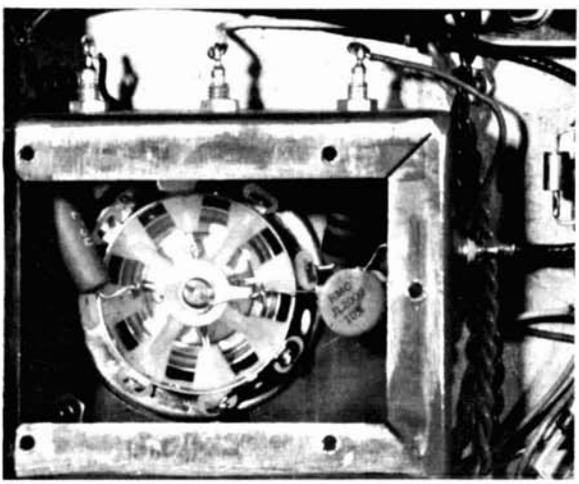


fig. 5. 10-dB pad must be used to lower output of ssb exciter. 100-ohm resistors consist of six parallel-connected 600-ohm 14-watt resistors (Sprague 459E7015). 70-ohm resistor consists of 7 parallel-connected 700-ohm, 14-watt resistors (Sprague 459E6015).



Bottom view of the TR-50. Bias transformer is mounted in lower left corner. Diodes in upper center are the high-voltage bridge rectifiers. BNC fittings in center are from the miniature coax relay.



Power-amplifier grid compartment. All connections are fed through .001 μF feedthrough capacitors.

The meters are used in the plate and screen circuits of the power-amplifier stage; these are the most critical measurements in 4X150 tetrodes. In addition, the screen-current meter is switched to read relative power output. The scale numbers on the original Micronta* meters were erased and replaced with press-on numbers to indicate the desired ranges.

*Micronta meters are $2.98 from Radio Shack.

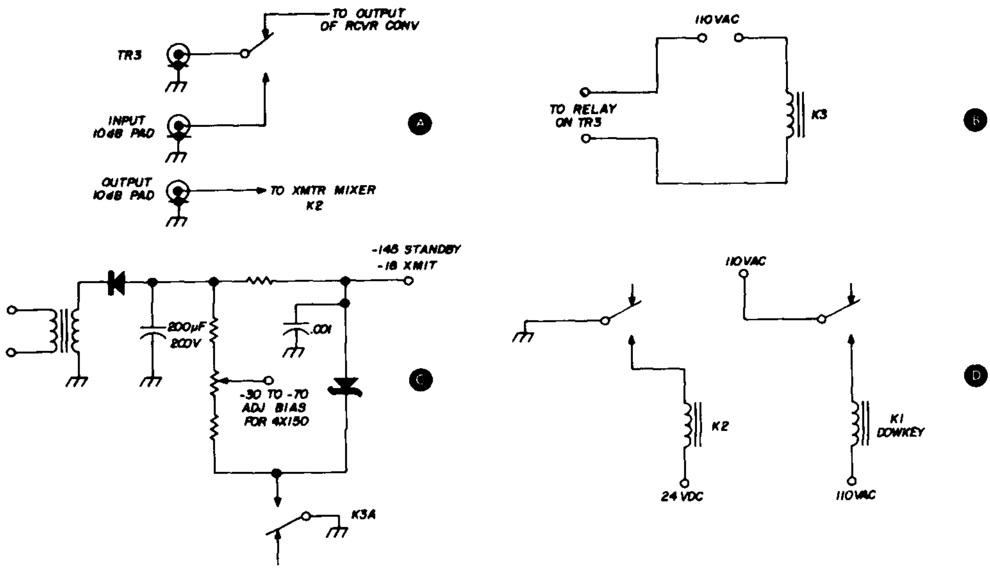


fig. 6. Switching and control circuitry. Relay K3 is a multiple-contact unit actuated by TR relay in the exciter. K2 is a miniature coax relay. K1 is a Dow-Key antenna changeover relay.

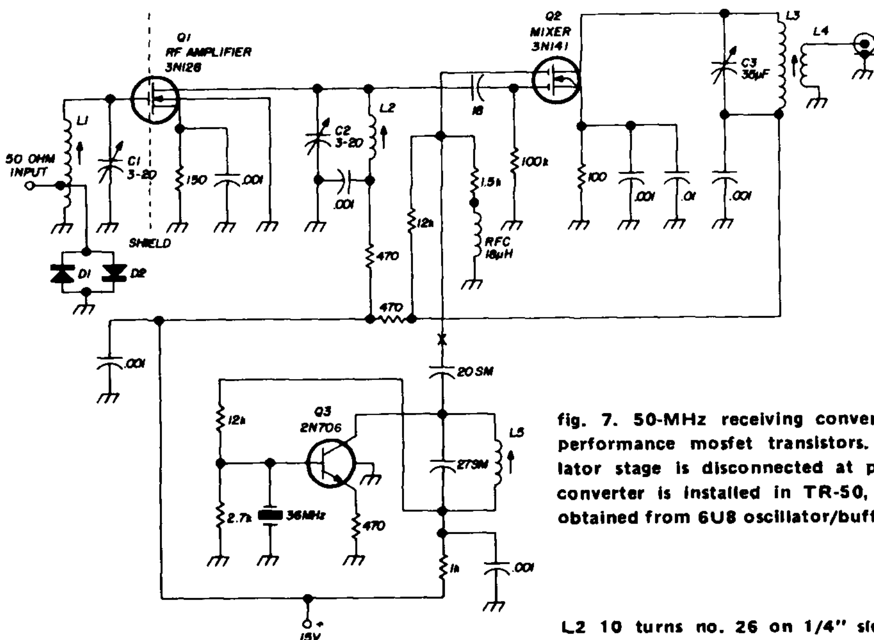


fig. 7. 50-MHz receiving converter uses high performance mosfet transistors. 2N706 oscillator stage is disconnected at point X when converter is installed in TR-50, and injection obtained from 6U8 oscillator/buffer.

C1,C2 3-20 pF air variable

C3 7-35 pF air variable

D1,D2 1N100 or equivalent

L1 10 turns no. 30 on 1/4" slug-tuned form, tap at 3 turns (J. W. Miller 20A000-2 form)

L2 10 turns no. 26 on 1/4" slug-tuned form (J. W. Miller 20A000-2 form)

L3 24 turns no. 26 on 1/4" slug-tuned form, secondary 3 turns no. 26 (J. W. Miller 20A000-2 form)

L4 9 turns no. 26 on 1/4" slug-tuned form (J. W. Miller 20A000-2 form)

RFC 18 µH (J. W. Miller 9310-42)

receiving converter

The receiver converter is based on a design by WB2EGZ originally published in *ham radio.*[2] The modified converter in the TR-50 uses a high-gain single-gate 3N128 mosfet as an rf amplifier; the mixer is a dual-gate 3N141 mosfet. To provide full transceive ability, oscillator injection is taken from the transmitting mixer. This circuit exhibits an excellent noise figure, and has high resistance to cross modulation.

I had originally planned to build the receiving converter into a commercial cast-aluminum box. However, there was not enough space between the top of the chassis and the final-amplifier tuning shafts to accommodate the commercial box. The box I finally used was made from double-sided printed-circuit board. The top and sides of the box were fixed in a holding jig and joined by solder fillets on all interior seams. This chassis is mounted next to the transmitting mixer board for direct capacitance coupling to the output of the 36-MHz oscillator/ buffer.

Placing of components in the receiving converter is not critical with the exception of the interstage shield in the 3N128 rf amplifier. The transistor socket should be mounted so the shield can be soldered across the width of the box, isolating the input to a small compartment on one end of the chassis. Ceramic feedthrough connectors are used for oscillator injection and i-f output. A BNC coaxial connector is used at the input.

The converter circuit shown in **fig. 7**

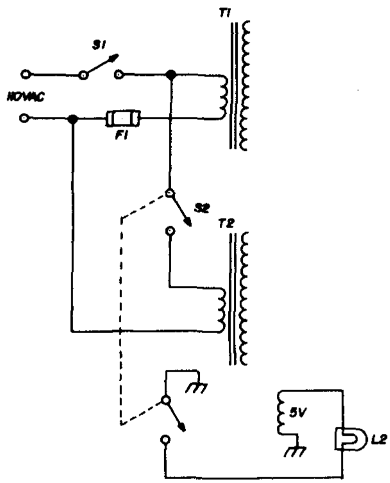


fig. 8. Ac control wiring for the TR-50. Fuse F1 is a 5-amp slo-blow unit.

has a 36-MHz oscillator stage that was included so the converter could be bench tested before putting it into the TR-50. When the receiving converter is installed in the transverter, the oscillator injection line is disconnected from the 20-pF capacitor and connected to the output of the transmitting-mixer buffer. The built-

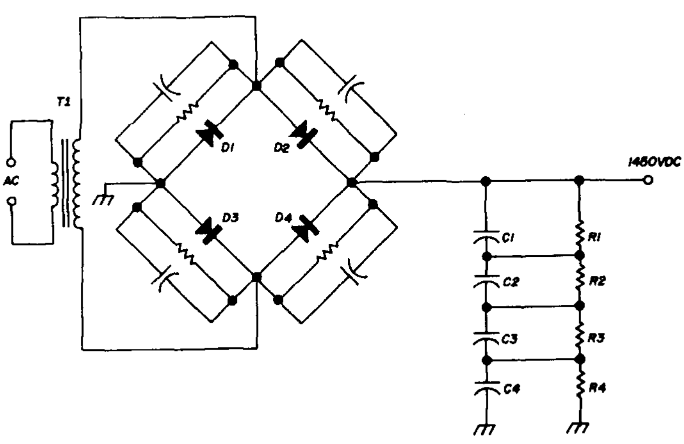


fig. 9. High-voltage power supply for the TR-50.

in receiving-converter oscillator stage is left on the board for future trouble-shooting and maintenance.

alignment and test

After all the wiring and assembly were completed, the unit was given a good shaking out and cleaning to remove all the bits of wire that had become lodged in the crevices. Next, I carefully inspected all the tube sockets, tie points and cable terminations for miswiring, shorts and unsoldered joints. This is time well spent, and it pays to do some careful circuit tracing. Do not short change yourself – a simple wiring mistake can become very costly when the power is turned on.

Before applying power for the first time, remove all the tubes from their sockets. Then turn on the power and measure the voltages. The voltages will tend to be on the high side, but will confirm that connections have been made to the right places.

Test the transmitting mixer first. Connect the output of the exciter through the pad to the mixer. Plug the mixer tubes in, along with the OB2 regulators and relay keying circuit. Adjust all tuned circuits to the correct frequency with a grid-dip meter. Temporarily connect a 51-ohm, 2-watt resistor from the output link of the mixer to ground; *do not* install the 4X150 yet.

Tune the ssb exciter for normal output, and using the grid-dipper as a wavemeter, adjust the 6U8 tuned circuits for maximum output to the 5763. Adjust the 5763 tuned circuits for maximum indication at 50 MHz. Be careful not to exceed the tune-up limitations of the exciter.

Turn off the exciter, disconnect power, discharge all the filter capacitors and install the 4X150. Remove the 51-ohm resistor from the mixer output. Connect a 50-ohm non-inductive load to the output of the power amplifier. Apply power and allow a normal warm-up period. Turn the exciter gain control down, key the exciter and adjust the bias on the 4X150 for resting current of 50 mA.

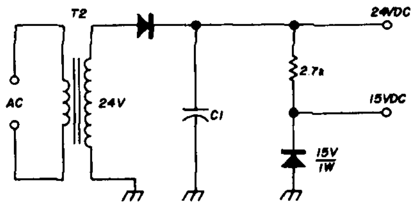


fig. 11. Receiving-converter and relay power supply.

Now turn up the exciter gain control and resonate the final. With 1400 volts on the plate, I could load my unit to 200 mA plate current; screen current was 30 mA. This corresponds to 280 watts dc input – power output, measured with a Bird thru-line wattmeter, was 178 watts, representing 64% efficiency.

Although I have not experienced any

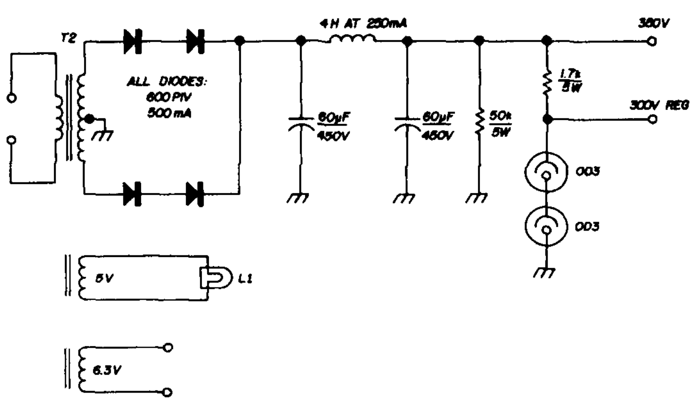


fig. 10. Low-voltage power supply.

instability in my unit, if you should run into this problem, conventional stub neutralization should cure it.

Alignment of the receiving converter is simple and straightforward. Since the mosfets are high-impedance devices, the resonant circuits can be dipped before the transistors are put in their sockets. When the converter is installed in the TR-50, only slight touchup is required to peak all the tuned circuits for maximum output.

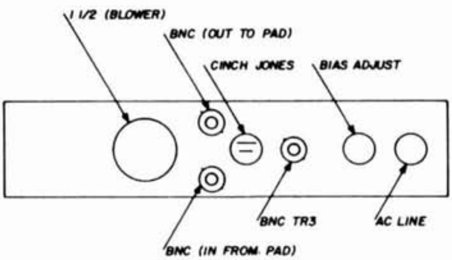


fig. 12. Rear panel layout of the TR-50.

painting

After all the checks and tests were completed and the transverter was fully checked out on the air, the front panel was removed. The steel panel was sanded with fine sand paper using *only* horizontal strokes, followed by a thorough cleaning with a degreasing solvent. *Rust-O-Leum* Dove Gray and Equipment Gray enamel were chosen as the closest match to the Drake TR-3 panel colors. A 3/16-inch wide piece of masking tape on the bare steel divided the panel into vertical halves. Each half was alternately masked while the other half was sprayed. Repetitive light coats of paint are preferred over one heavy coat.

Each color was baked for 30 minutes in the hot-air plenum chamber of a forced hot-air home furnace. After each half of the panel was baked, the 3/16-inch masking strip was carefully removed, leaving a bright steel dividing line that matches the decorative strip on the TR-3.

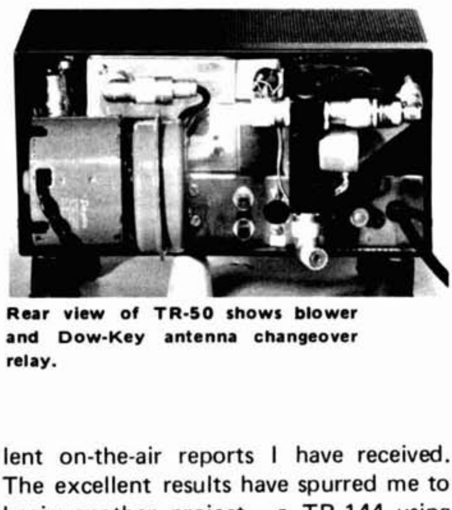
For lettering on the front panel I used *Prestype* transfers – black letters on the light gray upper half, and white lettering on the lower dark-gray half. Three coats of clear acrylic lacquer spray, baked for 30 minutes, protect the lettering.

The elevation legs for the TR-50 were made from 1-inch dowel rod, capped with rubber crutch tips.

conclusion

The original design was recently modified when I acquired a 4X250R from a friend. The 4X150 was replaced, and the bias readjusted for 125 mA idling current. No other modifications were necessary. An immediate increase of 20 watts was noted in output power. This tube, although expensive, is designed specifically for class-AB linear service, and the increase in power and efficiency was well worthwhile.

The pleasure I have derived from designing and building the TR-50 has been multiplied many times by the excellent on-the-air reports I have received. The excellent results have spurred me to begin another project – a TR-144 using K2ISP's printed-circuit two-meter mixer.



Rear view of TR-50 shows blower and Dow-Key antenna changeover relay.

I would like to express my thanks to Dick McGinn, WA1IMS, for providing the excellent photographs of the TR-50.

references

1. D. W. Bramer, K2ISP, "Heterodyne Transmitting Mixers for Six and Two Meters," *ham radio*, April, 1969, p. 8.
2. D. W. Nelson, WB2EGZ, "Six-Meter Mosfet Converter," *ham radio*, June, 1968, p. 22.

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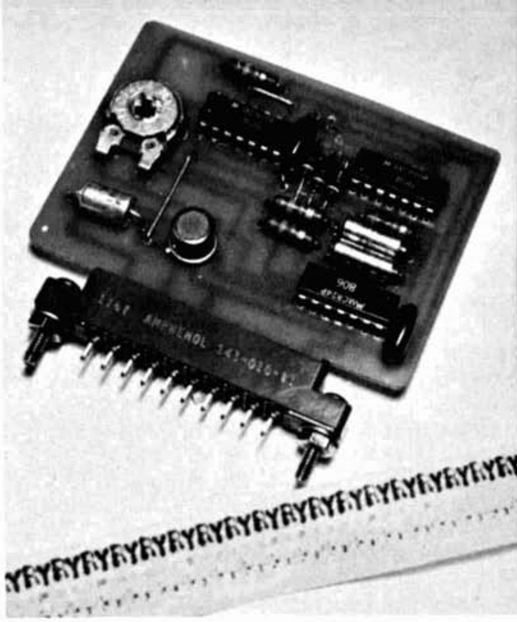


RTTY signal generator

This integrated-circuit RTTY reversal generator produces an RYRYRY signal for testing teleprinters

Vic Shinsel, W7ZTC, 2116 Oak Street, LaGrande, Oregon 97850

Teleprinter range adjustments and other performance checks are usually made while the machine is printing the standard RY test signal. *R* signals select even mark and odd space pulses, then *Y* signals reverse everything and select even space and odd mark. The result is a maximum amount of slipping and sliding of adjacent parts within the machine, and conditions which are likely to cause misprint are readily observed.

Bias and distortion measurements are ordinarily taken during reception of *reversal* square-waves or continuous space-bar signals. Reversal signals alternately open and close the machine loop, simulating a succession of mark and space pulses. Space-bar signals perform the same job if a keyboard of known quality is available. Use of the reversal square-wave or keyboard space-bar signal to a questionable RTTY transmission unit promptly turns up any bias distortion – as evidenced by alteration of the pulse duty cycle. This is the electronic *counterpart* of the *mechanical slipping* and sliding check.

Here's a low-cost reversal generator which also sends repetitive, zero-bias, RYRYRY test signals to the printer or transmitter loop. An electronic clutch is included, making the unit a self-contained solid-state transmitter-distributor. A *clutch keyer* circuit may be added later if desired. This enables the generator to send "... RY (pause) RY (pause) RY ...," leaving both hands free for stubborn machine adjustments. A multipurpose RTTY bias and loop test meter will also be described.

In order to be useful in distortion tests, reversal square-wave pulses must be of accurate length, with reasonably fast rise and fall times, and of especially accurate duty cycle. The square-wave works out to be 22.5 Hertz for the 45.5 baud (60 wpm) standard system. Mark and space pulses are of equal duration, so the duty cycle is exactly 50 percent.

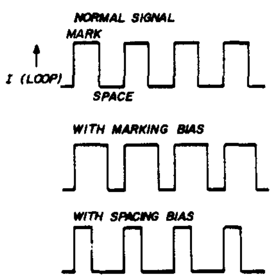


fig. 1. Bias distortion.

theory of operation

Consider a defective demodulator or terminal unit which changes the duty cycle by lengthening the mark pulses and shortening the space pulses. The demodulator is said to cause "marking bias" and it degrades system performance according to the severity of the condition. This kind of distortion **(fig. 1)** may be one reason why two teleprinters are unable to communicate through a radio system, while both print fine on local loops. The effects of bias distortion may be additive.

Quantitative bias measurements are expressed as percentages. Distortion which lengthens a 22-millisecond mark pulse by 11 milliseconds is described as 50% marking bias.

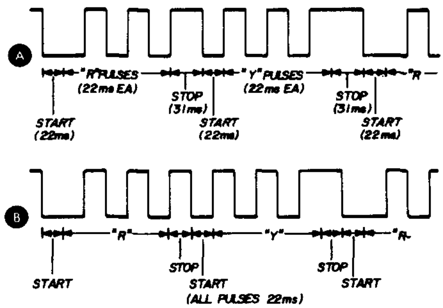


fig. 2. Teletype Corporation RY signal is shown in A; Western Union RY signal is shown in B.

The RY generator takes advantage of a compatibility scheme to develop a signal which prints RY while maintaining the perfect 50% duty cycle of the reversal square-wave. As such, this generator can be *a very useful standard for RTTY* system tests.

Fig. 2A shows the waveform of a Teletype Corporation model-14 distributor sending RY at the usual 61.3 words per minute. **Fig. 2B** shows the waveform of a surplus Western Union distributor sending RY at the compatible speed of 65 words per minute. Both machines are usable in the amateur bands, but 65 wpm is right at the upper speed tolerance limit set by FCC.

Note that the only difference between the two signals is the duration of the stop pulses. The Western Union machine sends a shorter (22 millisecond) stop pulse. The two machines operate compatibly because the *selecting* pulses are all the same length, i. e. both units use a 45.5 baud code.

Even with the shorter stop pulse, synchronization is assured. The nominal (420 rpm) receiving shaft speed of the Teletype machine is still faster than the

(390 rpm) transmitting shaft speed of the Western Union machine.

The Western Union RY signal in **fig. 2B** may be used as a reversal signal, because each mark has a space counter-

from the ic logic. The remainder of the circuit is used to invert two out of every fourteen square-wave pulses to form the RY test signal.

Flip-flops A, B, C and D form a

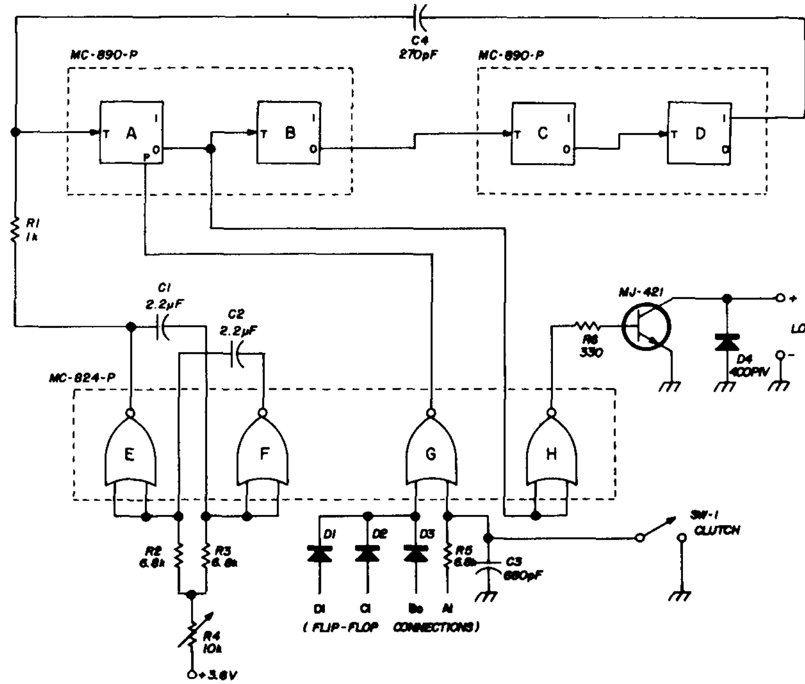


fig. 3 Solid-state RY generator. Diodes D1, D2 and D3 are germanium computer types. Silicon diodes may be used with higher supply voltage (3.5 to 4.5 volts). Resistor R4 is a Mallory MTC1414.

part of equal duration. The duty cycle is exactly 50 percent.

circuit

The circuit of **fig. 3** generates the RY waveform of **fig. 2B.** Gates E and F of the MC824P quadruple-two-input gate are connected as an astable multivibrator. The negative slopes of the multivibrator output trigger flip-flop A (MC890P) to form a perfect square-wave. Gate H is used as a buffer to drive the base of the Motorola MJ421 transistor with the square wave. The MJ421 is rated at 350 volts V_{cb} and makes an excellent loop driver. Diode D4 is for inductive transient suppression. Resistor R6 (not shown on the photo) was added to decouple transients scale-of-sixteen counter. Feedback capacitor C4 inverts one pulse by causing count 2 to be skipped. This occurs during the decay of the positive pulse fed through the capacitor from flip-flop D, which retriggers A and causes an immediate advance to count 3. Gate G inverts the other pulse by presetting count 15 to count zero. In other words, count 15 is also skipped. The truth table of **fig. 4** summarizes generator operation.

When S1 is closed, the circuit advances to the mark pulse of count 14. Gate G recognizes this count because all inputs are zero. The output of gate G goes positive and presets flip-flop A to mark. The circuit holds the mark as long as S1 remains closed, because the preset line will not allow flip-flop A to toggle. This provides the clutch action for the generator.

When S1 is opened, the positive voltage at R5 (from A1) pulls down the

G rapidly reactivates the preset line and forces the circuit on to count zero. Gate G has no further influence until count 15 is reached again, (or count 14 if S1 gets closed). Capacitor C3 adds a delay of 0.5

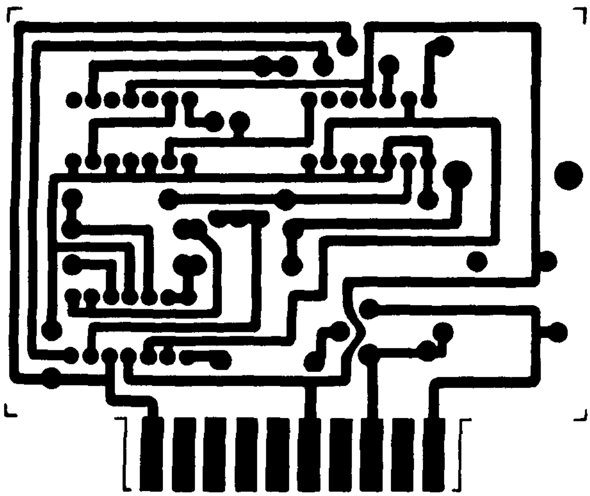


fig. 5. Full-size printed-circuit board layout for the RTTY generator.

output of gate G and removes the preset condition from the first flip-flop. The next trigger from the multivibrator momentarily advances the circuit to count 15. Then the positive voltage disappears from R5, causing the output of gate G to rise. The positive output from

fig. 4 Truth table for RTTY generator.

Count	Ao	Bo	Co	Do	Output
0	0	+	+	+	Mark (Stop)
1	+	+	+	+	Space (Start)
2	0	0	0	0	pos. transient — 0.5 μsec.
3	+	0	0	0	Space
4	0	+	0	0	Mark
5	+	+	0	0	Space R
6	0	0	+	0	Mark
7	+	0	+	0	Space
8	0	+	+	0	Mark (Stop)
9	+	+	+	0	Space (Start)
10	0	0	0	+	Mark
11	+	0	0	+	Space
12	0	+	0	+	Mark Y
13	+	+	0	+	Space
14	0	0	+	+	Mark
15	+	0	+	+	neg. transient — 0.3 μsec.
0	0	+	+	+	

microsecond to ensure that the preset pulse is of sufficient duration to do its job.

The overall effect is that only complete RYs are sent. The circuit action is always stopped in the proper state to begin another RY. If S1 is opened, then closed, a single RY will be sent. If S1 is opened, and remains open, a continuous train of RYs is sent. If S1 is eventually closed, the unit finishes its last RY, then stops ready to send another.

construction

Construction of the RY-reversal generator is simplified by the full-size etched-circuit layout of **fig. 5.** Component locations are given in **fig. 6.** This is a compact board, and every caution must be taken to avoid solder bridges and excessive heat. It is recommended that all hole locations be dimpled with a sharp scriber, then drilled out to no. 60 holes. Enlarge the pot mounting holes to no. 40 and 50, as required. Brighten the copper with steel wool or SOS pad just prior to soldering.

Surplus flatpack ics worked fine on

the original breadboard, but layout clearances were bothersome. This board uses popular plastic dual-inline RTL ics. The pattern was designed to match an Amphenol 143-010-01 connector. Three to multivibrator. Use 60-Hz line sweep and set the speed pot for minimal motion of the Lissajous pattern. This will be a slight adjustment! The Lissajous ratio is 22.5 : 60, or 3/8.

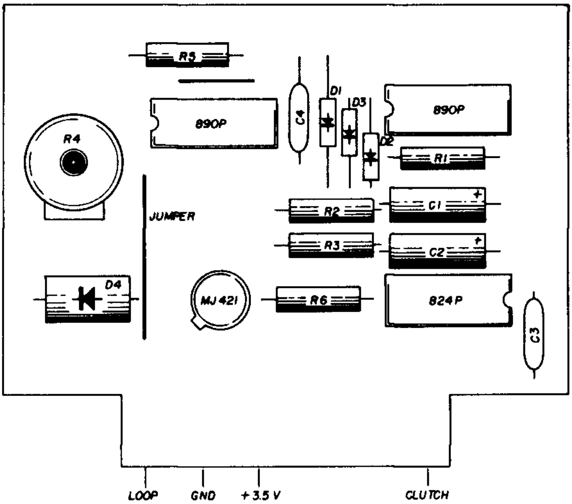


fig. 6. Component placement on the printed-circuit board.

four volts at about 75 milliamperes are required to power the unit; two flashlight cells are fine!

Ham printer loops are capable of some pretty wild transients. Some may develop spikes as high as 800 volts. Avoid ground loops and long leads common to the loop and board supply. A particularly noisy loop may require an 0.1 μF disc-ceramic capacitor from the board +3V to ground right at the Amphenol connector. This was not required on the original unit. Be sure to observe polarity when connecting the generator into a loop, or it will fail to print. No damage should result from a reverse connection.

adjustment

Only one adjustment is necessary. Open S1 and set the speed control (R4) for an approximate 22.5 Hz square-wave at the output of the multivibrator. The printer will start typing RYRY as the proper frequency is approached. Then, for precise adjustment, connect an oscilloscope probe to the output of the

Other speeds may be set on the pot for local machine tests, but it is wise to observe the FCC limits of 55-65 wpm for on-the-air tests.

There is a certain comfort in having nice, clean zero-bias RYs available at the flick of a switch. Automatic carriage-return shows its worth with this unit slamming out continuous RYs.

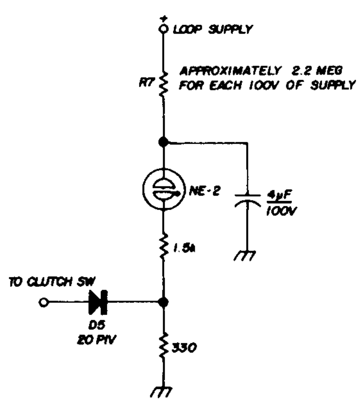


fig. 7. Clutch-keyer circuit.

clutch keyer

The clutch keyer of **fig. 7** was an afterthought. Note that the RY generator's clutch-control line is grounded through the diode and 330-ohm resistor. The ground inhibits generator operation. Every few seconds the neon relaxation oscillator fires and momentarily reverse-biases the diode, which effectively removes the ground from the clutch. As a result, one single RY is sent at a time – every two seconds. R7 is about 2.2 meg for each 100 volts of loop supply.

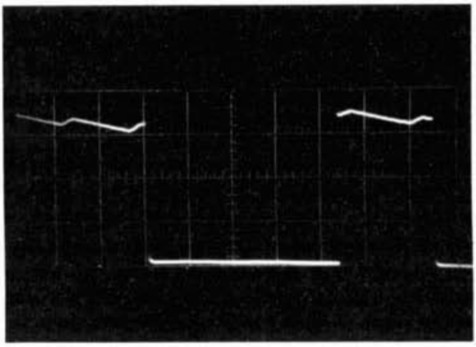


fig. 8. Poor regulation of loop current into resistive load. Droop above 60-mA value looks like marking bias to milliammeter. (Vertical scale, 20 mA per division; horizontal scale, 10 msec per division.)

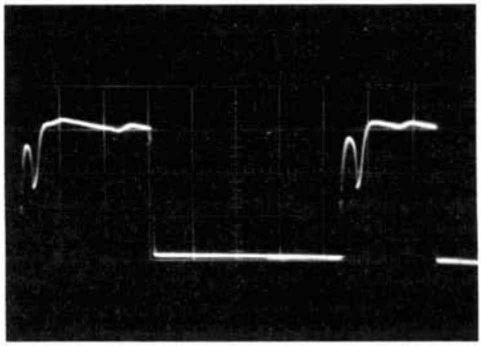


fig. 9. Inductive transients from selector magnet may also fool the bias milliammeter. (Vertical scale, 20 mA per division; horizontal scale, 10 msec per division.)

measuring distortion

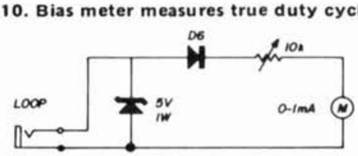
A common scheme for measuring bias distortion is as follows. First, close the loop (steady mark) and measure the loop current. Then apply reversal signals to the unit under evaluation, and again measure loop current. Since the reversal signal is half mark and half space, the meter will flutter slightly – but its average indication should be exactly half of the closed loop reading. This corresponds to zero bias, and any variation indicates the presence of gremlins. This seems to be a popular method because just about any loop milliammeter is suitable for the test. But there is a pitfall.

The regulation of the loop supply may influence the bias reading. This difficulty popped up in my Mainliner. The mark pulses had a high instantaneous current when first keyed on. Then the current drooped down slightly to the steady-mark value. **Fig. 8** shows the loop current waveform through a resistive load. With this condition, the meter errantly indicated a duty cycle change. The triangular "droop" portion of the signal above the steady-mark (60 mA) value appeared as marking bias. In this particular case, adjustment of a slicer or polar relay to reduce the apparent bias would have introduced about 8% distortion.

The situation worsens as inductive loads are switched into the loop. **Fig. 9** shows the effect of switching in a model-26 selector magnet.

A better bias measuring scheme is given in **fig. 10.** The zener diode clips at 5 volts and standardizes the mark pulses. Now the meter shows true duty cycle, and the reading is not appreciably affected by poor regulation, loop transients, loop resistance or supply voltage.

fig. 10. Bias meter measures true duty cycle.



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The pot is set once and for all at full scale on steady mark. Diode D6 assists in transient suppression.

The meter may be calibrated directly in bias percentage if desired. Zero current for the Western Union machine. Potentiometer R8 translates a compromise duty cycle of 33% to center scale on the multimeter for bias-distortion measurements where no reversal generator is

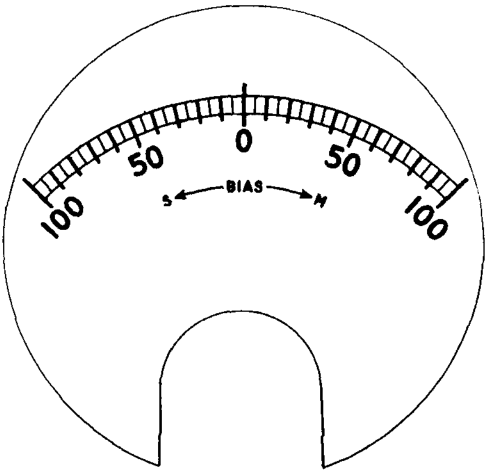


fig. 11. Full-scale bias scale for 3-inch Simpson meter.

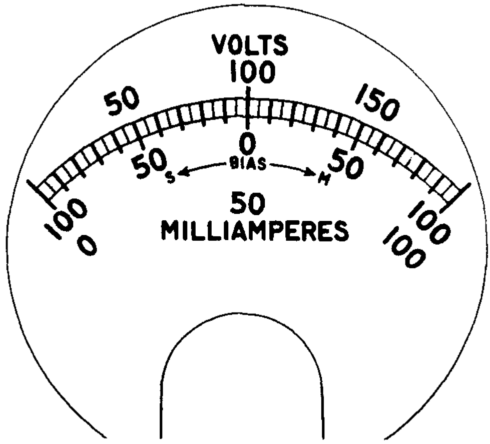


fig. 12. Full-scale RTTY multimeter scale for 3-inch Simpson meter.

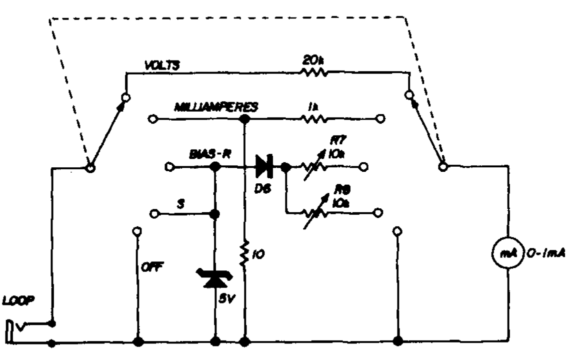
available. If the distributer is known to be free of bias, simply send successive keyboard-space signals at full speed. Read the bias at the printing end for an overall check.

corresponds to 100% spacing bias; half scale is zero bias; and full scale is 100% marking bias. **Fig. 11** is a suitable scale for a three inch Simpson movement. The scale of **fig. 12** was developed for the multi-purpose RTTY meter shown in **fig. 13.** It measures loop current, loop supply voltage and bias.

A steady stream of keyboard-space signals has a duty cycle of 31% for the standard Teletype equipment, and 35%

For calibration: Set R7 to full scale on steady mark. Then set R8 to 66% of the resistance or R7. As an alternative, R8 may be set to zero bias on a good, synchronous transmitter-distributor. When R7 is in the circuit, the meter reads bias from reversal signals. When R8 is in the circuit, the meter reads bias from keyboard-spaces.

fig. 13. Circuit for RTTY multimeter.



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ham radio

tabulated characteristics

of vacuum-tube and transistor amplifiers

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Although there are many active devices that are used for generating or amplifying af and rf signals, only two, vacuum tubes and transistors, are of great interest to radio amateurs. These two can be split into many sub-categories. However, only the conventional vacuum tube in the common-cathode configuration and the bipolar transistor in the common-emitter configuration will be considered in this article.

Transistors are finding great favor among both manufacturers and amateurs for use in receivers and low-level stages of transmitters. The vacuum-tube amplifier, however, still ranks as the best choice for moderate and high-power stages in radio transmitters.

Intelligent use of either device requires that the user have a clear concept of the device's capabilities, especially the limitations of these capabilities. Then, too, the FCC likes to ask rather searching questions concerning both vacuum tubes and transistors in its amateur license examinations. With the upsurge of interest in qualifying for higher-grade licenses, these active devices are having a new and inquiring look taken at their characteristics and capabilities.

Many books and magazine articles have been published on the characteristics and applications of vacuum tubes; almost as many have been written on transistors. Most of these are very good for the study of a particular aspect of the subject. A tabulation of the relative characteristics of the three major classes (A, B, and C) of amplifier operation has not had the emphasis that interest demands. This aspect must be understood clearly if an amateur is to make knowledgeable use of such amplifiers, whether in equipment of his own design or in the correct adjustment of manufactured equipment.

This article is written to provide a simple but complete comparison of the operating characteristics of class-A, class-B, and class-C amplifiers, listed under one heading for vacuum tube amplifiers and under another for bipolar transistors. Class AB1 and class AB2 operation may be interpolated between class A and class B.

This tabulation makes no pretense of being an in-depth exposition of the behavior of vacuum-tube amplifiers, and most certainly, not of transistor amplifiers. The facts, however, concisely state the more important factors that determine the use to which we put such amplifiers, and how we operate them in those applications.

table 1. Characteristics of vacuum-tube amplifiers.

	Class-A Operation
Distinguishing property	Ability to amplify signals without distortion.
Desired effect	To have the waveform of the output signal be identical, except for amplitude, to the waveform of the input signal.
Method	Quiescent grid-bias voltage is set to establish the operating point midway on the straight portion of the $E_c I_b$ characteristic curve.
	Grid signal voltage is limited so it never goes beyond the straight portion of the $E_c I_b$ characteristic curve in either the negative- or positive-going extremes of signal voltage.
	For triode vacuum tubes, for maximum undistorted output, the plate load resistance is set at twice the dynamic plate resistance of the tube.
	Plate voltage is limited to a value that will ensure the tube's rated plate dissipation will not be exceeded.
Distinguishing characteristics	Voltage gain is very high
	Power gain is very high
	Grid drive power requirement is extremely low
	Plate current, as measured with a dc meter with signal present, remains constant
	Plate current flows 360° during an input signal cycle
	Input impedance is very high
	Output impedance is not critical; however, distortion increases more for too-low than for too-high mismatch
	No grid current flows
	Grid-bias voltage source does not have to have low impedance or good voltage regulation
	Plate voltage source does not need to have good voltage regulation
	The stage may be used either single-ended or push-pull for either af or rf signals
	Stage can not be used as a frequency multiplier
	Oscillators can be forced, by limitation of grid swing, to operate in this class
	Efficiency is approximately 20%

Class-B Operation

Distinguishing property

Ability to amplify amplitude-modulated signals without distortion of the modulation characteristics.

Desired effect

To have the output signal power vary as the square of the input signal voltage.

Method

Quiescent grid-bias voltage is set to establish the operating point just short of the cut-off point on the E_cI_b characteristic curve.

Grid signal voltage may be great enough to drive the grid into the positive region. The less it is driven into the positive region, the lower will be the distortion of the output signal.

Plate load resistance is adjusted to the value required to attain the desired effect. Normally, it is adjusted for very heavy plate current loading.

Plate voltage is limited to a value that will ensure the tube's rated plate dissipation not being exceeded even when the plate current is set high to attain the desired effect.

Vacuum tube is selected to have ample cathode emission to meet heavy peak current demands.

Distinguishing characteristics

Voltage gain is moderate

Power gain is moderate

Plate current, as measured with a dc meter with signal present, may vary in relation with signal voltage amplitude. This is the condition when amplifying af or ssb rf signals. When amplifying a-m (double sideband with carrier), fm, or key-down cw signals, the plate current remains constant

Plate current flows for approximately 180° during an input signal cycle

Input impedance varies from high, when the grid is not excited into the positive region, to low, when the grid is driven into conduction

Output load impedance is quite critical, as its optimum adjustment is an important factor in achieving the desired effects

Grid current may flow; when it flows, it varies in the same manner as does the plate current

Grid-bias voltage source needs low internal impedance and good voltage regulation

Plate voltage source needs good voltage regulation

Stage makes a moderately good frequency multiplier

Stage must have push-pull configuration for af use but may be either single-ended or push-pull for rf

Oscillators can be forced to operate in this class

Efficiency is approximately 30% to 33% for steady-state rf (double sideband with carrier, fm, or key-down cw) and may go as high as 66% for af or ssb rf

Class-C Operation

Distinguishing property	Ability to respond linearly to amplitude modulation of the plate circuit
Desired effect	To have the plate current vary directly with the plate voltage. (The plate current, for example, will double when the plate voltage is doubled)
Method	Quiescent grid voltage is set to establish the operating point at approximately two-and-one-half times the negative potential required to cut off plate current flow. A portion of this voltage may come from a fixed source; part, however, must come from the IR drop across a grid resistor
	Grid signal voltage must be great enough to drive the grid far into the positive region, preferably into saturation
	Plate load resistance is not critical; it usually is set by complying with the requirement for moderate plate loading
	The vacuum tube is selected to have ample cathode emission to meet heavy peak current demands
	Plate voltage is limited to a value that will hold the plate dissipation to well within its rated capabilities, preferably to not over 60% of the rate capability; also, the plate voltage must not exceed one-half the flash-over voltage rating for the tube
Distinguishing characteristics	Voltage gain is very low
	Power gain is low, averaging about 10
	Grid drive power requirement is high
	Plate current, as measured with a dc meter under modulation conditions, remains constant
	Plate current flows between 60° and 90°, depending on bias and drive, during an input signal cycle
	Input impedance is low
	Output impedance is not critical; generally it is established by the requirement that the plate current should not exceed about 60% of the tube's rated capability
	Heavy grid current flows
	Grid-bias voltage source does not need good voltage regulation
	Plate voltage source needs good voltage regulation
	Efficiency is approximately 65% to 75%
	The stage may be used in either single-ended or push-pull configuration
	The stage makes an excellent frequency multiplier
	Oscillators normally operate in this class

table 2. Characteristics of bipolar transistor amplifiers.

Class-A Operation

Distinguishing property	Ability to amplify signals without distortion
Desired effect	To have the waveform of the output signal to be identical, except for amplitude, to the waveform of the input signal.
Method	Quiescent base current is set to establish the operating point midway between the cut-off and saturation points on the ac loadline
	Base signal voltage is limited to produce equal variations of collector current for both positive- and negative-going excursions of base-emitter signal voltage
	Load resistance is made equal to the value of the collector-emitter voltage divided by the collector current
	Collector-emitter voltage is limited to a value that will not permit the transistor's dissipation to exceed the rated power under any condition of signal voltage
Distinguishing characteristics	Voltage gain is very high
	Power gain is high
	Base-emitter drive power is moderate
	Collector current, as measured with a dc meter with signal present, remains constant
	Collector current flows 360° during an input signal cycle
	Input impedance is quite low
	Output impedance is not critical
	Base-emitter current flows 360° during an input signal cycle
	Collector voltage source does not need good voltage regulation
	The stage may be used either single-ended or push-pull for either af or rf signals
	The stage cannot be used as a frequency multiplier
	Oscillators can be forced, by limitation of base-emitter voltage swing, to operate in this class
	Efficiency is low, running from 20% to 30%

Class-B Operation

Distinguishing property Ability to amplify amplitude-modulated signals without distortion of the modulation characteristics

Desired effect To have the output power vary as the square of the input signal voltage

Method Quiescent base-emitter current is set to establish the operating point just short of collector current cutoff

For rf linear-amplifier service, a transistor is selected to have:

1. A flat beta curve
2. Multiple emitters, each with an integral bias resistor
3. High second-breakdown characteristic
4. Power dissipation at least twice the power at which it will be operated

For rf linear-amplifier service, the peak collector current swing is limited to only 30% of the rated maximum current

Collector load resistance is adjusted to the value required to attain linearity; normally, it is adjusted for very heavy collector current loading

Distinguishing characteristics Voltage gain is moderate

Power gain is moderate

Collector current, as measured with a dc meter with signal present, may vary with signal voltage amplitude

Collector current flows for approximately 180° during the input signal cycle

Input impedance is low

Output impedance is quite critical, as its optimum adjustment is an important factor in achieving the desired results

Base-emitter current will flow during slightly over 180° of the input signal cycle

Base-bias source must have low internal resistance

Collector voltage source must have good voltage regulation

The stage makes a good frequency multiplier

The stage must have push-pull configuration for af use but may be either push-pull or single-ended for rf use

Oscillators can be forced to operate in this class

Efficiency varies from 30% to 66%

Class-C Operation

Distinguishing property	Ability to respond linearly to amplitude modulation of the collector circuit
Desired effect	To have the collector current vary directly with the collector voltage. (The collector current, for example, will double when the collector voltage is doubled)
Method	Quiescent base-emitter current is zero; the base-emitter voltage is biased so that a small signal voltage is required to cause base-emitter (and collector-emitter) current to flow Input signal voltage must be great enough to drive the transistor to collector saturation. Because of the decreasing efficiency of a transistor under high excitation, the input signal also must be amplitude modulated. This serves two purposes: it supplies the extra peak excitation to keep the output power up during upward modulation peaks, and decreases the excitation to lessen feed-through during downward modulation swings Collector load resistance is not critical Collector voltage must be limited to not over one-half, and preferably not over one-fourth, the rated maximum voltage
Distinguishing characteristics	Voltage gain is very low Power gain is low, from 3 to 10 dB Base-emitter drive power is quite high Collector current, as measured with a dc meter under voice modulation conditions, remains constant Collector current flows between 90° and 160°, depending upon base bias and drive, during an input signal cycle Input impedance is very, very low Base-emitter current is high under signal conditions Base-bias source does not need good regulation Collector voltage source requires good regulation Efficiency is approximately 65% to 75% The stage is useful only in rf service and may be used either single-ended or push-pull The stage makes an excellent frequency multiplier Oscillators normally operate in this class

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More Details? CHECK—OFF Page 94

plain talk about repeater problems

Intermodulation and desensitization are the two most serious problems faced by repeater users — here is a discussion of some solutions

Vern Epp, VE7ABK, 203 View Street, Nelson, British Columbia, Canada

There are presently over 300 vhf amateur repeaters in use in the USA and Canada. Although a number of articles have been written on the subject, very little has been published about some of the problems. Basically, a repeater receives a signal on one frequency and transmits it on another. A carrier-operated relay is normally used to turn on the transmitter with an incoming signal. One of the biggest repeater problems is desensitization intermodulation and transmitter noise in the receiver. With proper design this problem can be alleviated.

The transmitter interferes with the receiver in two ways. First, the high signal power overdrives the grids of the receiver rf mixer or i-f tubes and causes grid current to flow. This grid current produces bias voltages which reduce receiver gain; this is desensitization. Secondly, the output of the transmitter consists of a carrier, sidebands and noise. Since the noise spreads to either side of the carrier, a portion of this noise spectrum falls on the receiver frequency, causing further receiving problems.

For successful operation, the following items must be kept in mind when designing a repeater: frequency spacing, antenna separation and transmitter power.

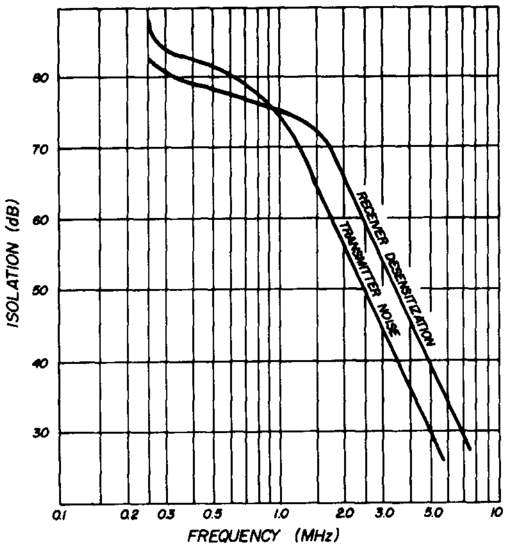


fig. 1. Isolation between transmitter and receiver to protect the receiver from transmitter noise and desensitization.

ceiver desensitization. With very little separation, the effect of transmitter noise is predominant. At greater frequency separations, the effect of receiver desensitization becomes greater (**fig. 1**).

It is generally agreed that the minimum frequency spacing should be 550 kHz if equipment is physically in one location and two antennas are used. The most common amateur repeater receives on 146.34 MHz and transmits on 146.94 MHz, a separation of 600 kHz. An even larger frequency separation is desirable to reduce the problems discussed.

antenna separation

Antenna separation is a very important factor. Most repeaters use vertical polarization since the mobile stations use vertical antennas. One solution to this problem is shown in **fig. 2A** where the transmit and receive antennas are physically remote from each other. An interconnecting link on 220 or 450 MHz connects the units together. This system is expensive but antenna isolation is nearly ideal.

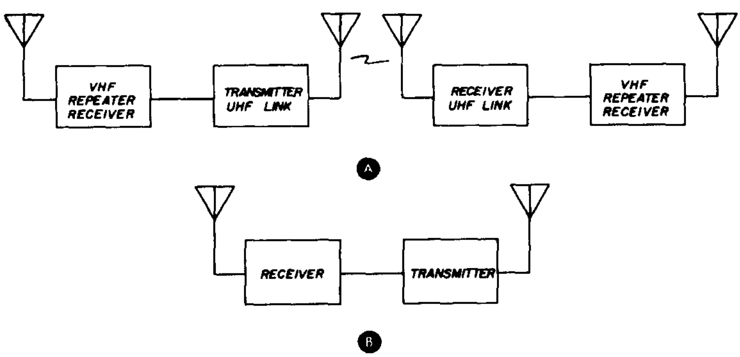


fig. 2. Use of separate antennas for transmitter and receiver.

frequency spacing

The closer the frequency of the transmitter is to the receiver, the more severe the effects of transmitter noise and re-

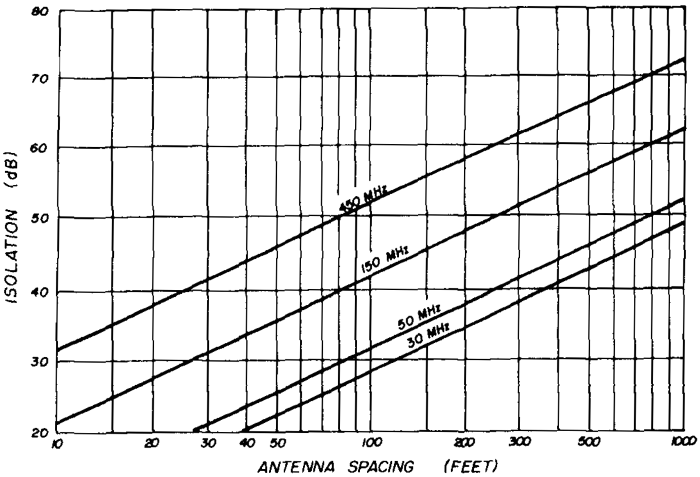


fig. 3. Attenuation provided by horizontal separation of dipole antennas.

The more common, less expensive method uses one location (**fig. 2B**). The antennas are separated vertically or horizontally from each other. **Figs. 3** and **4** show relative attenuation using vertical or horizontal separation. Vertical separation provides better isolation and is recommended for repeater operation. The top antenna is normally used for receiving while the lower one is used for transmitting.

transmit power

Interference problems increase as the power is increased. Most repeaters operate in the 25 to 50 watt range since mobiles use about the same power outputs. There is no point in running high power unless the mobile and base stations are also high powered. Obviously, a repeater gains little with a transmit range that is much greater than its received range.

cavity filters

Cavity filters are excellent devices for reducing interference problems. Loops are used to insert and extract energy from the cavity. The degree of coupling can be controlled by rotating the loops; this

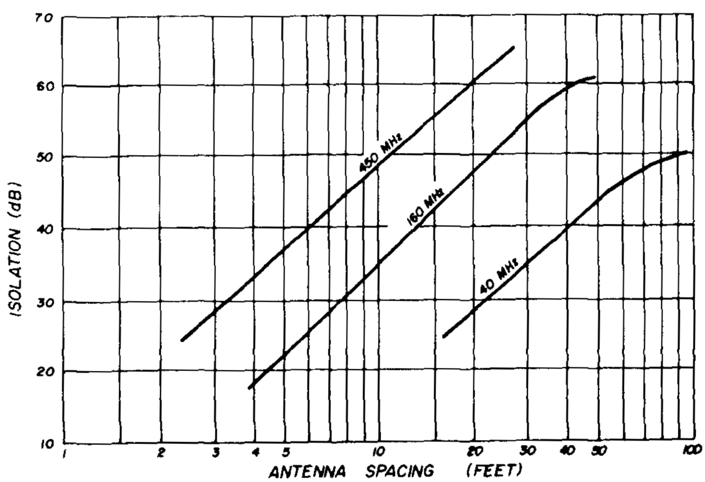


fig. 4. Attenuation provided by vertical separation of dipole antennas.

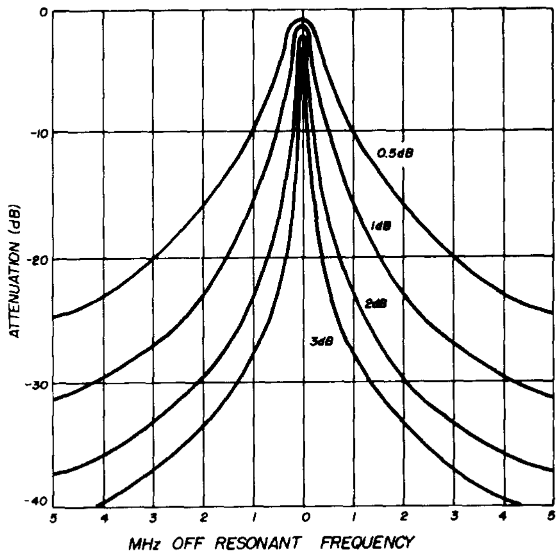


fig. 5. Selectivity curve for Decibel Products DB-4001 single cavity.

determines cavity insertion loss and selectivity. The more selective the cavity, the higher the insertion loss.

When a bandpass cavity is installed in the output of a transmitter it will pass the carrier and sidebands and attenuate nearly all other frequencies. The amount of attenuation depends on the frequency spacing between the undesired frequency

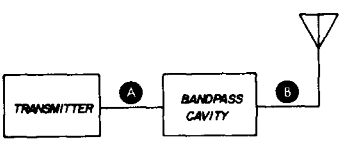


fig. 6. Using a bandpass cavity with a transmitter. Cable length A should be an odd multiple of a quarter wavelength.

and the carrier frequency. A typical bandpass cavity frequency vs attenuation curve is shown in **fig. 5**, and a typical application is shown in **fig. 6.**

The cavity presents an impedance of approximately 50 ohms at resonance but the off-resonance impedance of the cavity loop is very low. This makes coaxial cable length (**A** in **fig. 6**) very important. If the electrical length between the cavity loop and the transmitter output circuit is any multiple of a half wavelength, the cavity, if not tuned to resonance, will present a short circuit to the transmitter.

To remedy this, cable length should be an odd multiple of a quarter-wavelength. The transmitter will then see a high impedance when the cavity is off resonance, and danger of transmitter damage is much smaller. Cable length **B** in **fig. 6** is not critical.

bandpass cavities in receivers

Fig. 7 shows a cavity installed between the antenna and receiver. Coaxial cable length is not critical. The frontend selectivity of the receiver is improved by rejection of off-frequency signals that would otherwise desensitize the receiver or cause intermodulation interference. If greater selectivity is required, two or more cavities can be connected in series.

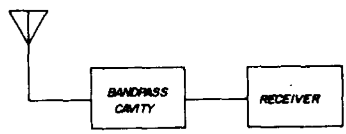


fig. 7. Using a bandpass cavity with a receiver.

checking for interference

1. Switch on the transmitter while receiving a weak signal and watch the limiter current. If it decreases, the receiver is being desensitized. Try additional attenuation in the receiver by adding a cavity.

2. With no signal input, switch on the transmitter. If limiter current increases, transmitter noise is being received. Try additional attenuation in transmitter by adding a cavity.

other items to consider

The coax cables between transmit and receive antennas should never be run together physically. The shielding of RG-8/U, for example, is only about 80%

efficient, and some coupling will result. Also, the transmitter and receiver should be physically separated in the mounting bay. Both units should be well grounded and may require shielding if a problem exists locally and not by the antennas.

Another good method of reducing receiver desensitization was described by W5KPZ.[1] He places a crystal across the antenna coil of the receiver. The crystal is an overtone type that is resonant at the frequency of the interfering signal (**fig. 8**).

duplexers

A *duplexer is used to permit operation* of a transmitter and receiver on one antenna. It uses a number of resonant cavities to provide sufficient isolation between units. At close frequency spacings duplexer adjustment is very critical to obtain sufficient isolation. Duplexers for close spacing (0.5 to 1 MHz) commercially cost anywhere from $500 to $1000.

rf interference

Rf interference is occurring more frequently since the frequency spectrum is becoming more and more crowded. Many mountain-top sites have many repeaters located near each other and using the same power levels. As a result many interference problems exist.

Rf interference can be defined as, "rf power which interferes with the reception of the desired signal thus causing reduced intelligibility." Receiver selectivity is of the utmost importance since an off-frequency signal can enter the front end of a receiver even though it is rejected later by i-f selectivity. A number of problems can occur, including desensitization, intermodulation and receiver spurious response. Most commercial manufacturers use high-Q rf filters to obtain better rf selectivity.

intermodulation

Intermodulation products (IM) are generated when two or more frequencies are mixed. They can occur in the transmitter, usually in the power amplifier stage, or in the receiver, usually at the first converter. IM products can be reduced by using bandpass or band-reject cavity filters that are tuned to the interfering signal.

table 1. Calculating intermodulation products.

Order	Formulas for Calculating Possible Intermodulation Products
2nd	A ± B
3rd	A ± 2B, 2A ± B
4th	A ± 3B, 2A ± 2B, 3A ± B
5th	A ± 4B, 2A ± 3B, 3A ± 2B, 4A ± B

Table 1 shows the new frequencies which can be produced by intermodulation. The third- and fifth-order products are the ones most likely to cause trouble. And, when a number of transmitters are located in the same general location, the IM problem becomes very difficult and complex.

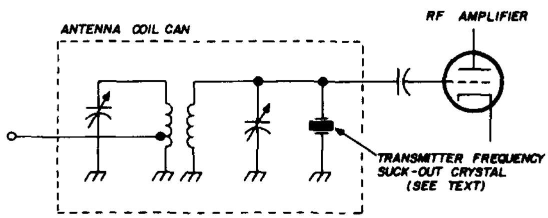


fig. 8. Installation of a suck-out crystal to reduce receiver interference. Crystal is same frequency as that of the interfering signal.

spurious responses

Spurious receiver responses fall into three general categories, i-f response, local-oscillator spurious response and *image response.*

1. I-f response results when interference at the i-f frequency enters the receiver.

2. Local oscillator spurious response occurs when an off-frequency signal enters the receiver and mixes with a harmonic of the local oscillator to produce an i-f frequency.

3. Image response; the image is twice the i-f frequency plus or minus the desired signal (depending on whether the local oscillator is above or below the incoming signal).

spurious radiation

Transmitters can cause interference to nearby receivers even if it is within the FCC or DOT requirements of 60 or 70 dB down. Interference can come from several sources, including the spurious of a transmitter crystal oscillator, second and third harmonics of the operating frequency, or from the 150-MHz energy in the tripler stage of a 450-MHz transmitter.

intermodulation tests

transmitters If a receiver is interfered with when two transmitters are on the air, place a pad between one of the transmitters and the antenna. If the interference level decreases by twice the dB value of the pad, the undesirable frequency mix is taking place in the transmitter with the pad. This is because the signal from the second transmitter is attenuated on entering the first transmitter, and the intermodulation products are attenuated on the way out. If the intermodulation is taking place in the transmitter without the pad, the interfering signal will be reduced only by the dB value of the attenuator.

receivers If intermodulation is suspected in a receiver, install an attenuation pad in the receiver antenna circuit. For each dB of attenuation in the pad, 3rd order products will be reduced by 3 dB, and fifth-order products by 5 dB. If the interfering signal is generated outside the receiver it will be reduced by the value of the pad.

references

1. D. Baxter, W5KPZ, and J. Douglas, W5OBV, "Two-Meter Repeater," *73,* September, 1966, p. 58.
2. R. C. Trott, "Considerations in the Use of Cavities and Duplexers," Decibel Products, Inc., Dallas, Texas.
3. General Electric Datafile bulletins 10002-2, 10007-2 and 10007-4.

ham radio

the cordover audio-oscillator module

Introducing a completely assembled circuit board that has many amateur applications — for less than a dollar!

J. A. Houser, WB2GQY, 23 Washington Street, Rensselaer, New York 12144

The circuit shown in fig. 1 is undoubtedly one of the best bargains available when one considers the many uses to which it can be adapted.

Known as the Cordover module,* the circuit is designed as an audio oscillator. A pnp low-power audio driver is coupled to an npn 5-watt output stage. The only other parts of the complete module are a 33k resistor and a .02 μF capacitor. As no heat sink is provided, full power can't be obtained without ruining the output transistor. An advantage (or disadvantage, depending on how you look at it) is that the module is designed to work directly into the voice coil of any speaker from 3 to 16 ohms without a matching transformer. Only 3 volts (two size D cells) are needed for efficient operation. Terminals are provided for an on/off switch or key. The circuit will switch with a bug set at its fastest speed.

Audio output is sufficient for most applications; but if greater output is desired, 6 volts may be used at considerably greater battery drain and consequent shorter battery life. I measured the current at 3 volts, and it varies between 50-60 mA over the whole audio range of oscillation. Dc input measures 0.18 watt.

*Available from Allied Radio Shack, bubble-packed with instructions, for 98¢. Listed in their 1971 catalog as no. 20-1155.

The efficiency seems to be close to 50% with just under 100 mW output available.

changing audio frequency

Because many beginning hams or experimenters may not have an audio generator to calibrate the module, and may desire to use it at a frequency other than that at which it's set, I made up **table 1** so anyone may choose the desired frequency and substitute the designated capacitor for the one supplied. The tone will be within a few Hz of that specified in the table, allowing for variation in transistors and components. Although specifications mention 1000 Hz (as supplied with the .02-μF capacitor installed), I measured 960 Hz on all modules tested, which seems close enough.

ssb testing

I use these modules for tone-testing an ssb transmitter. Two are used for a 2-tone test at full modulation. (An article is in preparation on this use of the module.) Although the observed audio waveform is closer to a square wave than a sine wave, no difficulty was encountered in evaluating ssb transmitter performance.

other uses

The module can be used as part of an off-the-air monitor;[1] as the subcarrier source for a voice scrambler;[2] and, with an integrator circuit, as a pulse timing source.

spot-frequency applications

Table 2 shows the effect of changing the value of the resistor supplied with the module. Various values of resistance were connected in parallel with the 33k unit. The data in the table was obtained with a .25 μF capacitor in the circuit, which produced the basic (nominal) frequency of 250 Hz. This experiment was made to show how the basic module frequency can be changed by a few Hz to hit a spot frequency between those afforded by various capacitor changes. Five-percent-

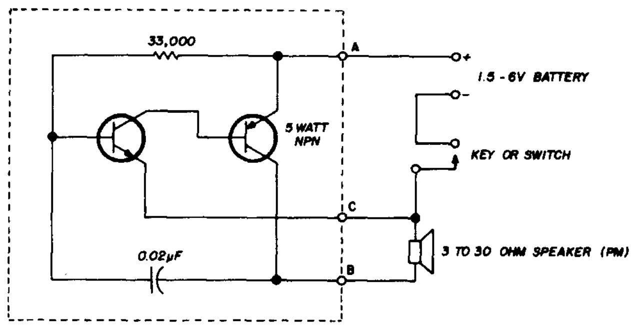


fig. 1. Schematic of the bargain audio oscillator module. Unit comes completely assembled and wired, ready for numerous amateur applications.

table 1. Module frequency as a function of capacitor value. Capacitors shown were substituted for the .02 μF unit supplied with the module. Measurements were taken with 3 Vdc at 50-60 mA.

Capacitor Value (μF)	Measured Frequency (Hz)
40 (electrolytic)	.5
10 (electrolytic)	10
.5	160-170*
.25	280*
.1	400-450*
.05	690
.02	890-960
.01	1440
.005	2800-2900 (harmonic 5700)**
.0025	4400 (harmonic 14,000)**
.001	7000***

* varied with capacitor tolerance.
** harmonic as strong as fundamental.
***out of hearing range but strong.

table 2. Module frequency change as a function of resistor value. Value shown in first column was connected in parallel with the 33k unit supplied.

Resistance (kilohms)	Observed Frequency Increase (Hz)	Measured Frequency (Hz)
1000	5	255
560	10	260
330	15	265
180	25	275
100	50	300
56	105	355
33	175	425

tolerance resistors were used, so a deviation may be found in the numbers given if you use resistors with different tolerances. The frequency can deviate from 1 Hz with a 1 megohm resistor to perhaps 5 Hz with 33k.

harmonic output

Unless the module is fully loaded with a speaker, harmonics and subharmonics can develop at the higher-frequency ranges. This condition can be detected by an increase in current from the nominal (50-60 mA) to 90-100 mA. I ran into this problem when using matching transformers as loads when the transformers were not sufficiently loaded to reflect a low (3-30 ohm) impedance to the transistor output.

fm applications

The information in the paragraphs above suggests the possibility of using these modules for tone-frequency-controlled keyers to actuate two-way frequency-shift mechanisms in certain fm transmitters. Another possibility is their use as function (tone) controls to actuate fm repeater transmitters.

In tests, the Cordover module frequencies were as stable as those obtained in touch-tone telephones. With a little juggling of components, exact zero-beats to these frequencies could be obtained.

No frequency shift was noticeable in any of the ranges when fresh batteries were used. As a matter of fact, frequencies were so stable it occurred to me that eleven of these little modules might be used to construct an inexpensive electronic organ. If more than 1 octave were desired, the modules could be followed with one or more "times two" ICs. The keyboard would probably cost more than the electronics.

Just one of these modules furnishes an excellent audio source for testing mono or stereo amplifiers, from the pickup right through the speakers; PA amplifiers ditto – from microphone or phono input to speakers. An inexpensive 6-ohm to high-impedance miniature transformer comes in handy in such applications.

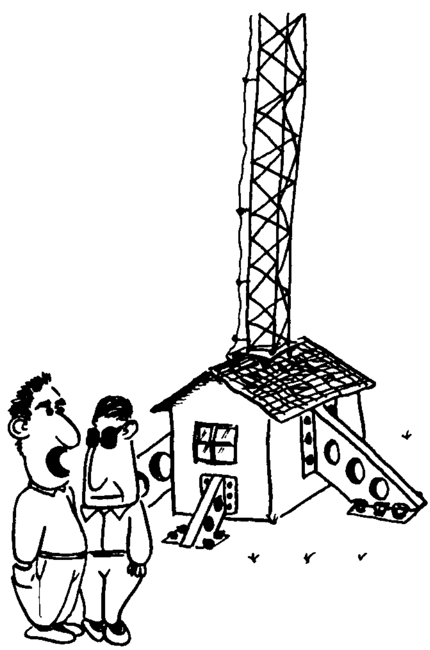
For 98¢, the Cordover audio oscillator module is hard to beat.

references

1. J. A. Houser, WB2GQY, "A CW Monitor," *73,* March, 1970, page 76.

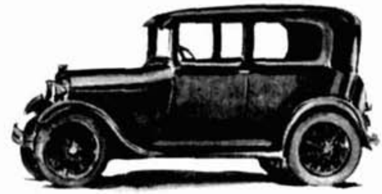
2. J. Pina, "A Subcarrier Source for a Voice Scrambler," *Popular Electronics,* March, 1970, page 42.

ham radio



Yeah — the QTH used to rotate about 20° until I put in the shack clamps!

in 1931



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rating tubes

for linear amplifier service

Peak envelope power and intermodulation distortion are important parameters when selecting tubes for linear amplifiers — here's what they mean and how they are measured

Robert I. Sutherland, W6UOV, William I. Orr, W6SAI, Eimac division of Varian

The power-handling capability of a given tube in single-sideband service depends upon the nature of the signal being transmitted and the tube's power dissipating capability. The method of establishing single-sideband service ratings should be such that relatively simple test equipment can be used to determine whether or not a tube is operating within its maximum ratings.

It is impractical to establish a rating based on voice-signal modulation because of the irregular waveforms and the varying ratios of peak-to-average signal power found in different voices. The most convenient rating method, and probably most practical, uses a single-tone audio signal to modulate the ssb transmitter. By using this test signal at its full modulation capability, the amplifier will operate under steady, maximum-signal conditions which are easily duplicated and observed.

When a single sine-wave tone modulates a single-sideband transmitter the rf output appears as a steady, unmodulated signal on an oscilloscope (see **fig. 1A**). This is because the output is a continuous signal having a frequency removed from that of the carrier by the modulating frequency, as shown in **fig. 1B.**

two-tone tests

Consequently, the operation of a linear amplifier under single-tone modulation is comparable to that of a cw transmitter under key-down conditions. As such, the performance of the power-amplifier stage at maximum signal (or peak) conditions can be determined from meter readings. However, this simple test lacks information on the linearity of the

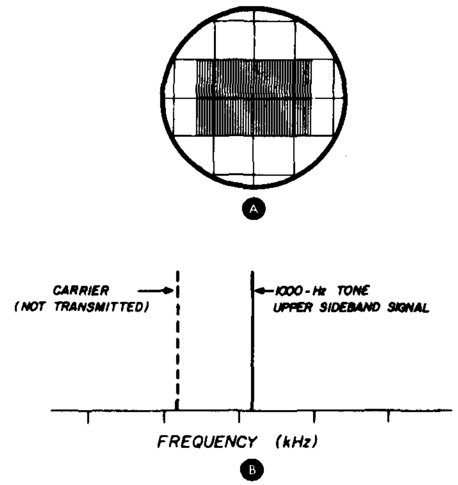
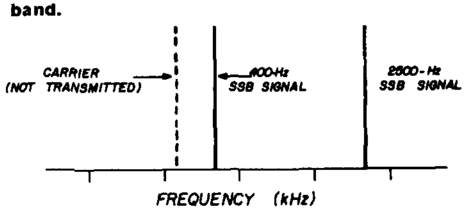


fig. 1. Rf output of ssb transmitter with single-tone modulation. Oscilloscope pattern is shown in A; spectrum is shown in B.

stage. To study linearity by observing amplifier output, some means must be provided to vary the output signal level from zero to maximum with a regular pattern that can be easily interpreted. A simple means is to use two equal-amplitude audio tones to modulate the ssb transmitter. This is termed a *two-tone* test. With this procedure the transmitter emits two steady signals separated by the frequency difference of the audio tones (**fig. 2**).

In some ssb generators, the two-tone signal is obtained by impressing a single tone at the audio input and injecting the carrier (by unbalancing the balanced modulator) to provide the second equal amplitude rf signal (**fig. 3**). The resultant beat between the two rf signals produces a scope pattern which has the appearance of a carrier 100 per cent amplitude-modulated by a series of half sine waves as shown in **fig. 4**.

fig. 2. Spectrum of ssb transmitter modulated by a two-tone test signal containing 400- and 2500-Hz tones and transmitting upper sideband.



When using the two-tone technique to measure the distortion of a linear rf amplifier it is sometimes more expedient to use two rf signal sources (separated in frequency by the desired number of cycles) and to combine them in a manner which will minimize the interaction between them. The two rf signals represent the two equivalent sideband frequencies generated by the two-audio-tone system and produce exactly the same scope pattern.

A linear amplifier is usually rated at peak envelope input or output power level. *Peak envelope power* (PEP) is the root-mean-square (rms) power generated at the peak of the modulation envelope. With two-tone or single-tone test signals the approximate relationships between single-and two-tone meter readings, peak envelope power and average power (class B or AB operation) can be determined from the formulas shown in **appendix 1.** Although the equations for average power output are different for the two tests, the PEP formulas are identical.

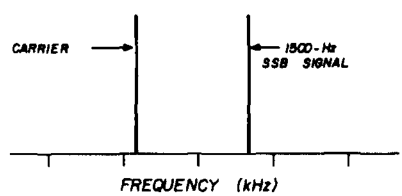


fig. 3. Spectrum of ssb transmitter modulated by 1500-Hz tone and injecting carrier to obtain second rf signal equal in amplitude to the tone.

multitone relationships

The approximate equations given in **appendix 1** are for single- and two-tone conditions, the most common test situations. However, in some multi-channel transmitter applications many more tones are used. The following method can be used to determine the peak-envelope-power to average-power ratio. (For the purposes of this explanation it is assumed that all the tones are equal.)

The following examples demonstrate two important relationships between

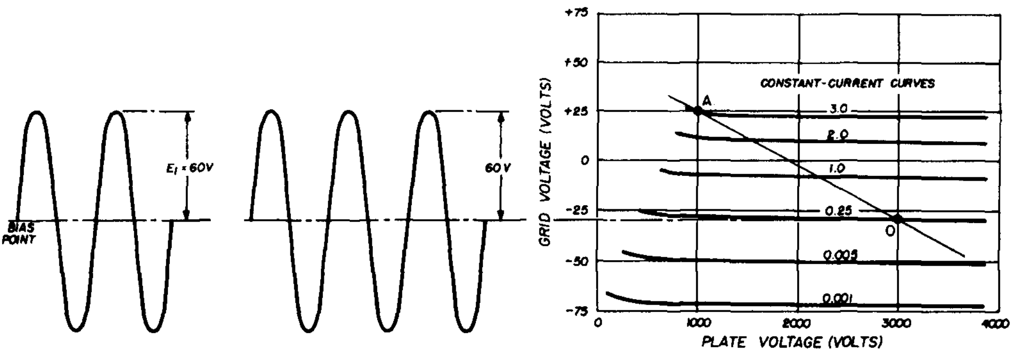


fig. 5. Single-tone condition.

single and multitone signals amplified by a linear system.

Assume the amplifier is set up for a single-tone driving signal and a Point "A" on the operating line is established (see **fig. 5**). A definite PEP output is developed under this condition. To drive this linear amplifier to the same PEP output with a multitone signal, the drive signal voltage for each tone must be 1/nth (n = number of tones) the amplitude of the single-tone signal.

By assuming a perfectly linear amplifier where the input waveshape is exactly reproduced in the output load, these grid waveshapes can be used to demonstrate the relationship of PEP to Average Power.

For the single-tone case, PEP = Average Power; for the two-tone case, PEP = twice Average Power. However, in the two-tone case the average power is one-half that of the single-tone case, so the resultant peak envelope power ratings are identical.*

The two test frequencies (f_1 and f_2) are equal in amplitude but slightly different in frequency. As a result, when they are exactly in phase the two crest voltages add directly to produce the crest of the two-tone envelope. When the two frequencies are exactly out of phase the

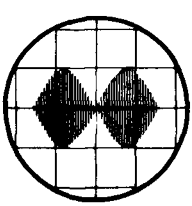


fig. 4. Scope pattern of ssb transmitter modulated by two-tone test signal.

*This is best illustrated with two practical examples.

single-tone

$$\text{Average power} = \frac{E_1(rms)^2}{R_L} = \frac{\left(\frac{60}{\sqrt{2}}\right)^2}{R_L} = \frac{1800}{R_L}\ \text{W}$$

$$\text{PEP} = \frac{E_1(rms)^2}{R_L} = \frac{\left(\frac{60}{\sqrt{2}}\right)^2}{R_L} = \frac{1800}{R_L}\ \text{W}$$

Therefore, PEP = average power

two-tone:

$$\text{Average power} = P_{1avg} + P_{2avg} = \frac{E_1(rms)^2}{R_L} + \frac{E_2(rms)^2}{R_L}$$

$$= \frac{\left(\frac{30}{\sqrt{2}}\right)^2}{R_L} + \frac{\left(\frac{30}{\sqrt{2}}\right)^2}{R_L} = \frac{450}{R_L} + \frac{450}{R_L} = \frac{900}{R_L}\ \text{W}$$

$$\text{PEP} = \frac{(E_{1rms} + E_{2rms})^2}{R_L} = \frac{\left(\frac{30}{\sqrt{2}} + \frac{30}{\sqrt{2}}\right)^2}{R_L}$$

$$= \frac{\left(\frac{60}{\sqrt{2}}\right)^2}{R_L} = \frac{1800}{R_L}\ \text{W}$$

Therefore, PEP = 2 x P_{avg}

cusp of the two-tone envelope results (see **fig. 6**).

Note that the voltage amplitude at the crest of the resultant two-tone envelope is equal to that of the single-tone envelope the single- and two-tone examples.

These results (equal amplitude tones) may be summarized by the following expressions:

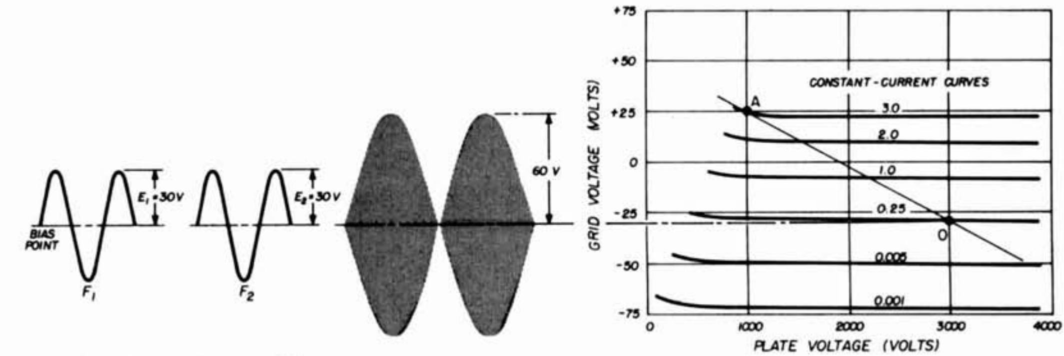


fig. 6. Two-tone condition.

and therefore the tube is driven to the same point on the operating line in each case. If the tube is driven to the same peak plate current and the same peak plate voltage swing by different excitation signals, then the peak envelope power output for both signals is the same.

$$PEP = n\ P_{avg}$$

$$PEP = n^2\ P_t$$

Where P_{avg} is the average power of the composite signal, P_t is the average power in each tone, and n is the number of tones.

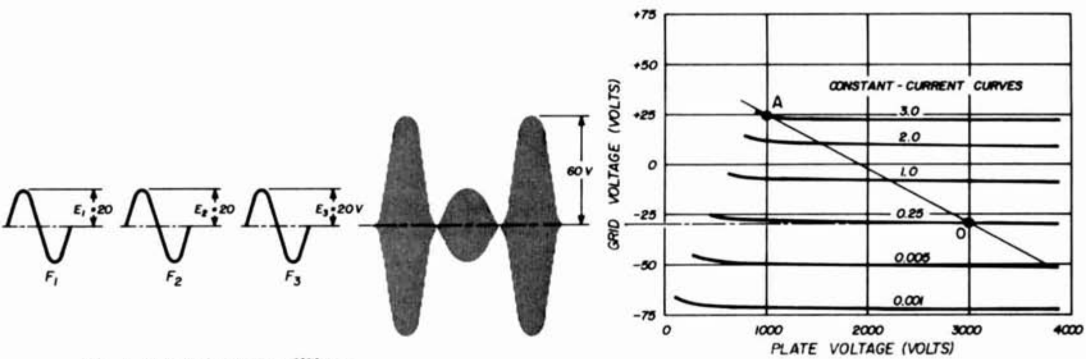


fig. 7. Three-tone condition.

The same holds true for a three-tone test signal. Note that the sum of the three individual tone-crest exciting voltages add in phase to drive the tube to the same peak current and peak plate voltage swing as that of the single-tone case (see **fig. 7**) so the PEP output is the same as

example

An fm repeater is to be designed to simultaneously rebroadcast one to eight channels. Each channel must have an average power output of 100 watts. How much peak envelope power must the linear amplifier deliver?

Each channel can be considered to be a single-tone signal. Therefore, the PEP of each channel is equal to the average power of each channel. The *maximum power output* requirement of the amplifier will be under the 8-tone condition. The average power output for the composite 8-tone signal will be 8 times the 100 watts-per channel power. Therefore, the linear amplifier must be capable of 800 watts of average power output.

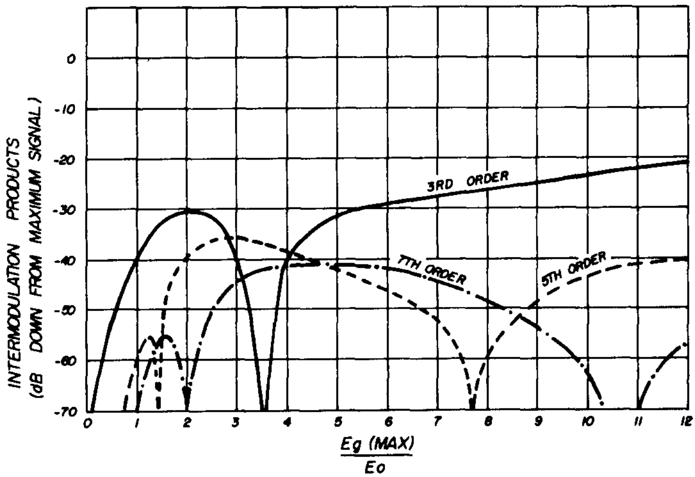


fig. 8. Graph showing intermodulation distortion products. As drive is increased, the various IMD products pass through maxima and minima. Misleading conclusions can be drawn if the equipment is tested near a cusp on the IMD curve where a particular IMD product drops to an extremely low level.

The peak envelope power will be eight times the average power of the composite signal ($PEP = nP_{avg}$) or 6400 watts. A tube must be selected to deliver this peak-envelope and average power at an intermodulation distortion level compatible with the degree of interchannel crosstalk that can be tolerated.

measurement standards

To describe adequately the performance of a tube in single-sideband linear service, it is necessary to determine many parameters. The normal electrode voltages and currents must be specified as well as the two-tone currents, the operating point, peak envelope power and the magnitude of the intermodulation-distortion products. These parameters are defined as follows:

Peak envelope power is the root-mean-square power at the crest of the envelope. This term is usually shortened to PEP.

Idling plate current determined by the operating point is called the *zero-signal*

appendix 1

Approximate relationships between meter readings, peak envelope power and average power for class B or AB operation with one- and two-tone tests.

parameter	single-tone	two-tone
dc plate current	$I_b = \frac{i_{pm}}{\pi}$	$I_b = \frac{2i_{pm}}{\pi^2}$
plate input (watts)	$P_{in} = \frac{i_{pm}E_b}{\pi}$	$P_{in} = \frac{2i_{pm}e_p}{\pi^2}$
average output (watts)	$P_o = \frac{i_{pm}e_p}{4}$	$P_o = \frac{i_{pm}e_p}{8}$
PEP (watts)	$P_o = \frac{i_{pm}e_p}{4}$	$P_o = \frac{i_{pm}e_p}{4}$
plate efficiency	$N_p = \frac{\pi e_p}{4E_b}$	$N_p = \left(\frac{\pi}{4}\right)^2 \frac{e_p}{E_b}$

definition of symbols:

i_{pm} = peak of the plate current pulse (plate current pulse is not sinusoidal)

e_p = peak value of plate swing, assumed to be sinusoidal when tank-circuit has sufficiently high Q.

E_b = dc plate supply voltage

plate current and is designed I_{bo}.

The other two plate current values of significance are the *single-tone plate current* and the *two-tone plate current*. The ratio of single- to two-tone current is 1.57:1 in a true class B amplifier (180° plate conduction angle). For other classes of linear operation and for different zero-signal plate currents, this ratio varies from 1.1 to 1.57:1.

The standard method of specifying the magnitude of the distortion products is to specify the reduction in decibels of one product from one tone of a two-equal-tone signal.

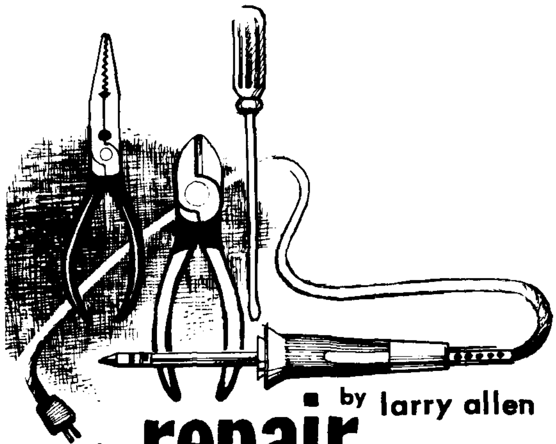
For example, assume that a particular tube under a given set of operating conditions has third-order distortion products of −35 dB and fifth-order distortion products of −50 dB. This means that the third-order product has an amplitude of 35 dB below one of the two test tones and the fifth-order product has an amplitude 50 dB below one of the two test tones. (It is also correct to add the amplitudes of the two third-order products and compare them to the *sum* of the two tones. The decibel ratio is still the same as the example.)

It is *not* correct to compare one distortion product to the sum of the two tones; that is to say, the PEP value of the signal. The resulting distortion figure would be 6 dB better than the correct example (−41 dB rather than −35 dB and −56 dB rather than −50 dB).

Normally the tube under test is adjusted to the full drive condition, and all the pertinent parameters are measured. The drive signal is then reduced. At each test point, all the parameters are measured again. The resulting data can then be plotted as a function of drive voltage.

It should be noted that maximum intermodulation distortion does not necessarily occur at maximum drive level, and it can be shown mathematically that an intermodulation characteristic like fig. 8 can be expected. In practice there is very good correlation between mathematical prediction and actual test results.

ham radio



by larry allen

the repair bench

sweep response curves for low-frequency i-f's

You've been reminding me. Some months ago I promised to show you how to display a sweep response curve for low-frequency i-f stages. This month, I keep that promise.

As you know, test equipment people have quit making sweep instruments that can be used at 60 kHz, 455 kHz, and other low intermediate frequencies. Electronically-swept rf generators of today have two drawbacks at those frequencies. First, their center frequencies seldom go below 4 MHz. Second, their sweep doesn't swing the frequency wide enough at the low end to reach that far below 4 MHz.

What's worse, not all present-day sweep generators even go down that far. Instead, they're designed exclusively for television sweep alignment. A few include a 10.7-MHz center frequency for sweeping i-f strips in commercial fm receivers.

There is a way you can generate a sweep curve centered on ham i-f frequencies. You can do it with a sweep generator that doesn't go near those low frequencies; all you need is an rf generator to use with the sweep instrument.

The secret, as you may have guessed, is heterodyning. Let's review some of the fundamentals of "beat frequencies" and be sure you understand what's happening in the method I'm about to describe.

one and one make four

If you mix two rf signals together in some kind of nonlinear stage, they beat together in a process known as heterodyning. The output of this nonlinear mixer stage is four signals. Two of them are the same as the original signals, one is the sum of their frequencies, and one is the difference.

For example, suppose you mix a 10-MHz and a 9-MHz signal in the nonlinear mixer stage. The outputs are: 1 MHz (the difference), 9 MHz, 10 MHz, and 19 MHz (the sum). Which output you use depends on your purpose. In a superhet receiver, you might pick the difference – to form an intermediate frequency. In a sideband transmitter, you might pick the sum – the 19-MHz – to raise the signal to a communications frequency.

For the purpose I'm describing in this *repair bench,* you approach this same principle from another direction. What you need to do is convert a high frequency to whatever is used in the i-f stages. To do that, you mix in a signal whose frequency is displaced from the available sweep signal by exactly the i-f.

Let me cite an example. Suppose the sweep signal is at 10 MHz, and the i-f strip you want to sweep operates at 1 MHz. You can mix a plain rf signal of 9 or 11 MHz with the sweep rf signal. Either frequency produces a difference heterodyne of 1 MHz (1000 kHz). They also produce sum heterodynes, but the i-f tuned circuits reject any but the 1-kHz frequency.

heterodyned sweep signals

If you saw my earlier *repair bench* about sweep alignment in ham gear (April, 1970 issue), you know how a sweep signal is made up. It has a center frequency, which is the frequency at which the sweep generator dial is set.

Here's what this means: A sweep signal that is 1 MHz (1000 kHz) wide swings 500 kHz above and 500 kHz below the center frequency. If the center is 10 MHz, the frequency swings from 9.5 MHz to 10.5 MHz, and does it back and forth 60 times every second.

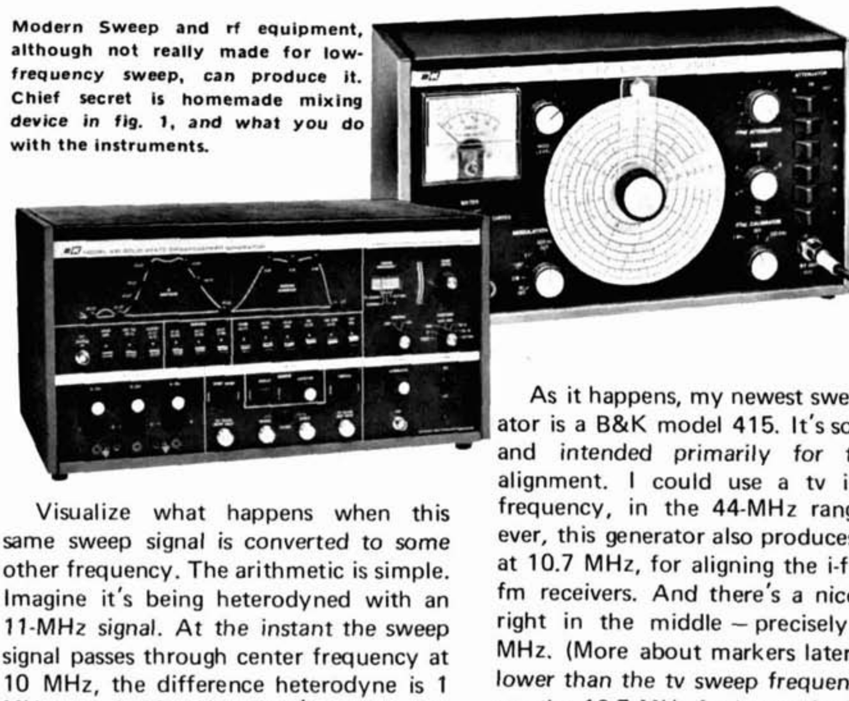
That frequency is swept upward and downward from center. How far up and down depends on the setting of the *Sweep Width* control. The sweep *rate* of most generators today is 60 times per second.

The thing about this idea is that you can make the center frequency of the "new" sweep signal whatever you want it to be merely by choosing the unmodulated rf signal you mix with the original sweep signal.

using what you have

You can use almost any sweep generator. Best results come from using the lowest sweep frequency you have available. Just be sure the sweep width is usable.

Modern Sweep and rf equipment, although not really made for low-frequency sweep, can produce it. Chief secret is homemade mixing device in fig. 1, and what you do with the instruments.



Visualize what happens when this same sweep signal is converted to some other frequency. The arithmetic is simple. Imagine it's being heterodyned with an 11-MHz signal. At the instant the sweep signal passes through center frequency at 10 MHz, the difference heterodyne is 1 MHz or 1000 kHz. That's center frequency for the "new" sweep signal. At the instant the sweep signal reaches its bottom frequency, at 9.5 MHz, the difference is 1.5 MHz or 1500 kHz. Then, when the frequency is swept up to its topmost value, at 10.5 MHz, the difference is 0.5 MHz or 500 kHz. So, by mixing a 10-MHz signal, which is swept 500 kHz each way, with a plain unmodulated 11-MHz rf signal, you generate a 1000-kHz signal swept 500 kHz up and 500 kHz down.

As it happens, my newest sweep generator is a B&K model 415. It's solid state, and intended primarily for television alignment. I could use a tv i-f sweep frequency, in the 44-MHz range. However, this generator also produces a sweep at 10.7 MHz, for aligning the i-f strips of fm receivers. And there's a nice marker right in the middle – precisely at 10.7 MHz. (More about markers later.) That's lower than the tv sweep frequencies, so I use the 10.7 MHz for heterodyning down to low sweep frequencies.

The source of unmodulated rf at my bench is a new B&K model E-200D. It's a modern version of the Old Precision Apparatus model E-200. Old-timers will remember that once-popular unit. The dial settings are reasonably accurate. But more important, the E-200D is stable once it's warmed up. That's a requirement of whatever generator you use.

The calculations for using this pair of instruments are easy. They apply to any sweep and rf generators you use. To create the low-frequency sweep I want from the fixed 10.7-MHz sweep signal, I either subtract or add the frequency of the i-f strip I'm checking.

A common i-f is 455 kHz. That's what's in the receiver I'm using for this demonstration. With a 10.7-MHz sweep signal, a 455-kHz beat can be obtained by adding 11.155 MHz or 10.245 MHz. Either one is okay, but I choose 10.245.

device that produces the heterodyning between the two signals.

Of course, you need a scope. Any ordinary servicing scope will do. Mine is a modern wideband scope, but for this purpose yours needn't be.

The model 415 sweep/marker generator uses post-injection for the marker, as most recent instruments do. The block diagram in **fig. 2** shows the equipment hookup. Here are the steps:

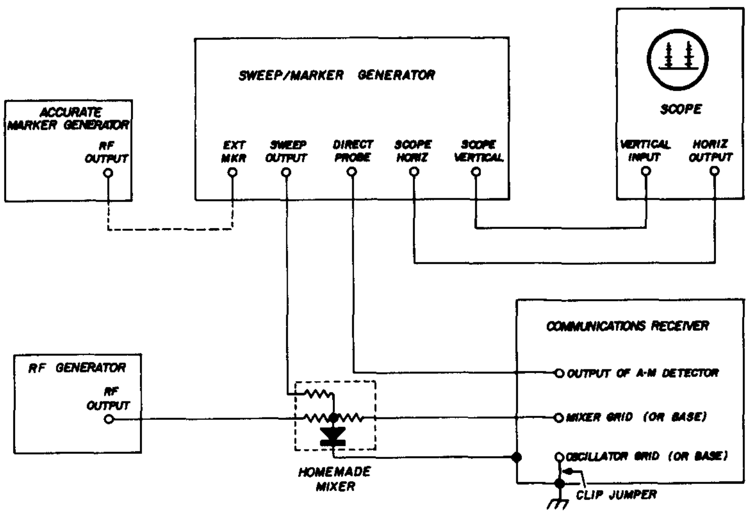


fig. 2. Equipment hookup. It is slightly different if sweep generator doesn't have the post-injection marker arrangement.

If the i-f were 60 kHz, another common one in ham receivers, an rf signal at 10.64 MHz would do the job.

You have to build a little mixer stage yourself. The simple one in **fig. 1** is adequate. The diode is the nonlinear

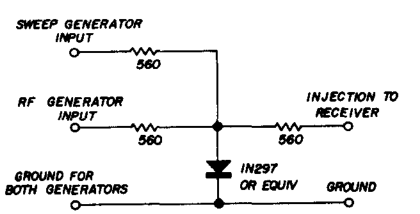
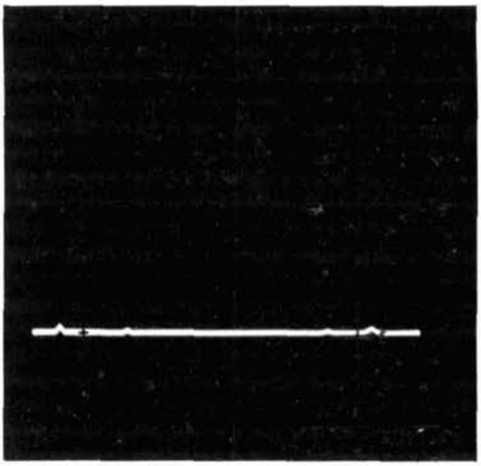


fig. 1. Four parts make up mixing device used for creating low-frequency i-f sweep signal.

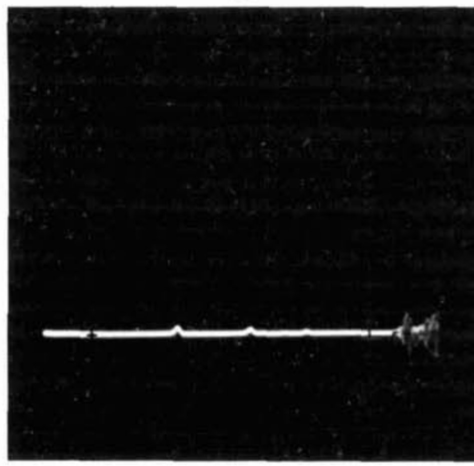
1. Let everything warm up at least 15 minutes.
2. Set scope sweep to External Input.
3. Set scope vertical-input attenuator to whatever setting gives a 1-inch deflection for about 5 volts of signal input.
4. Connect scope vertical input to Scope Vertical jack of sweep/marker generator.
5. Connect scope horizontal input to Scope Horizontal jack of sweep/marker generator.
6. Connect rf outputs of the two generators to the inputs of your homemade mixer device. Connect ground cables to receiver chassis.

7. In the receiver, clip the mixer-device diode lead to ground and the output lead to the grid (or base) of the receiver's mixer stage.
8. Clip a shorting jumper from the receiver oscillator grid (or base) to ground (or to emitter), thus disabling the receiver's oscillator.
9. Connect the direct-probe lead from the sweep/marker generator to the output of the receiver's a-m detector. **Note:** If the receiver is multiple-conversion, having more than one i-f section, make a diode detector to use at the output of each i-f strip and display the curve for only one i-f section at a time.

A



B



C

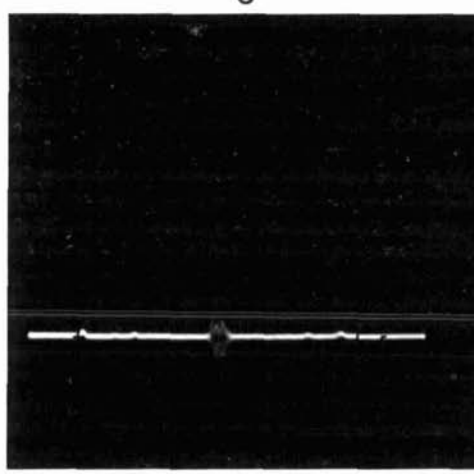


fig. 3. Traces you see when first setting up for low-frequency sweep of receiver i-f section. A shows trace without curve or marker in view. B is marker with frequency slightly high. C shows marker (and frequency) centered.

That's how the equipment hookup goes. Be sure all grounds are in place. Likewise doublecheck the connections. False curves can be the result of careless hooking-up.

getting the curve

The 10.7-MHz sweep in the model 415 has a center-frequency marker. That offers a convenient way of situating the sweep just right on the scope trace.

Here's how. Leave the rf generator output control at zero for now. Turn the sweep rf output wide open. Set the *Sweep Width* control as low as it goes; it'll still be wide enough for communications receiver i-f coils. Turn up the *Marker Amplitude* control on the generator just slightly.

Now roll the *Center Frequency* dial back and forth until the marker comes into view along the scope trace. The photo in **fig. 3A** shows the trace before you get the center frequency just right. This is sort of a fine-tuning control. **Fig. 3B** shows the marker just coming into view. Turn the *Center Frequency* control to put the marker exactly in the center of the scope trace, as in **fig. 3C.**

The object of this step is to put the marker in a position that enables you to use it as the center of the curve you will presently display. The marker is at 10.7 MHz, but it is added to the scope trace from within the sweep generator. It therefore remains as a center reference for the 455-kHz sweep signal developed when the rf signal is added.

Now set the frequency dial of the rf generator as near 10.245 MHz as you can. Turn up the output controls. If your hookup is correct and the i-f strip is reasonably normal, you'll see the curve rise somewhere along the scope trace, as in **fig. 4A.** Just how far it is from the center marker depends on how near the rf generator is to 10.245 MHz and how accurately tuned the i-f coils are.

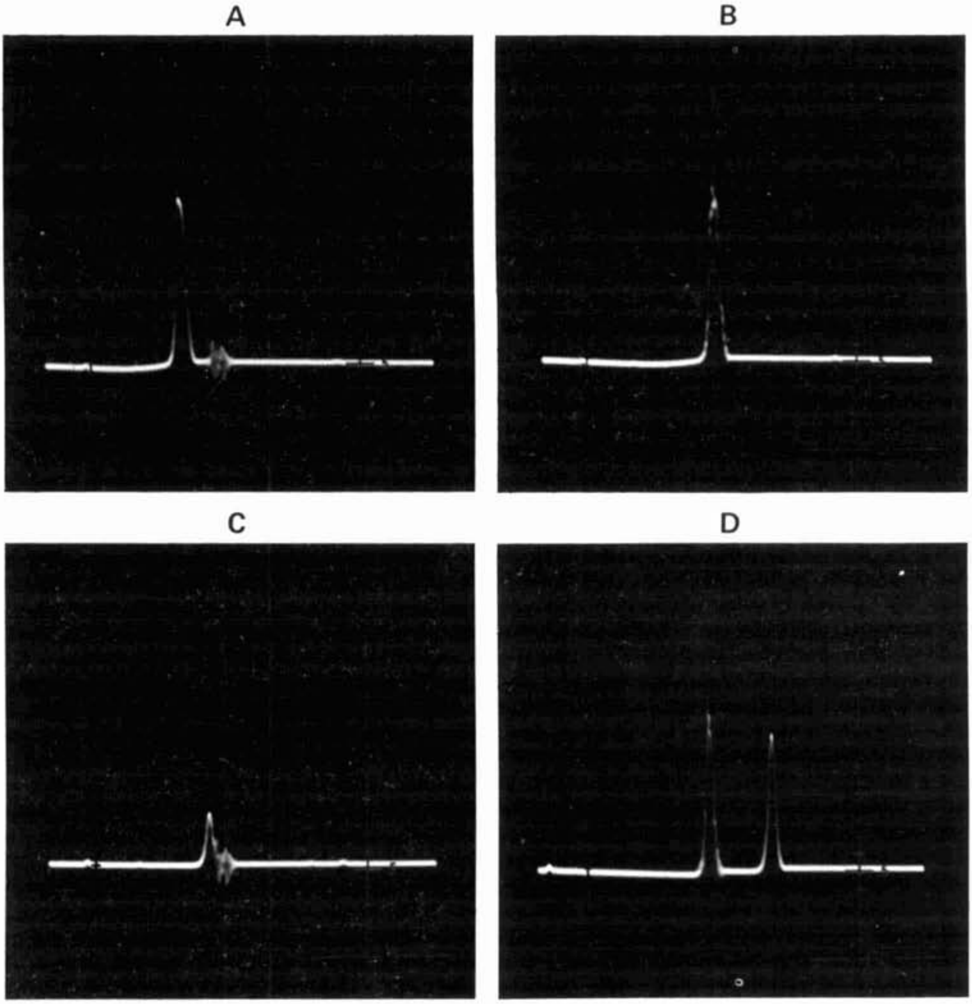


fig. 4. Curve appears when rf generator signal is added. Curve in A not exactly at i-f center marker. Curve in B moved to coincide with marker by returning i-f coils or rf generator. In C some of i-f coils detuned. Two curves in D mean the receiver oscillator hasn't been disabled.

(The ideal is a *calibrated* 10.245-MHz signal, such as from a heterodyne frequency meter that has been checked against WWV. I've used a BC-221 for this, as well as a Lampkin model MFM frequency meter. For this demonstration, I calibrated the vernier of my rf generator against a frequency meter. That way, I know the i-f stages are slightly off-frequency when I see the curve displaced from the marker as it is in **fig 4A.)**

The photo in **fig. 4B** shows the curve right on the marker. You can put it there by adjusting the dial of the rf generator. Since I knew my rf generator was precisely accurate, I readjusted the six i-f coil cores (two per i-f can) to move the curve over to the marker.

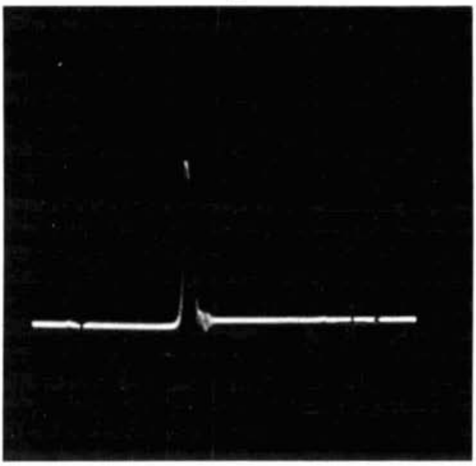
The technique is not difficult. I just turn each core a small amount in the same direction, then peak all six at the new position of the curve. The curve in **fig. 4B** results. The curve in **fig. 4A** was down-frequency from the marker. I therefore backed all six cores out about one-half turn. At first, it looked as though I was destroying the curve. (**Fig. 4C** shows how it looked when only three slugs were turned to the new setting.) But as all six were turned near the new frequency, the curve got tall again.

Be sure the receiver oscillator is cut off. I told you how, in **step 8** of the equipment hookup. Otherwise, you may get the double curve shown in **fig. 4D.** The correct curve is identified by the marker, but it's best not to have the extra curve.

You may wonder how to determine bandwidth. With another generator of high accuracy, you can put a movable marker into the sweep generator through the *External Marker* jack. Record the frequencies when the marker is at the upper skirt **(fig. 5A)** and at the lower skirt **(fig. 5B)**. Bandwidth is roughly the difference between them. The two markers in **fig. 5** are at 10.235 and 10.255 MHz. The difference is 20 kHz, the bandwidth at the bottom of the skirts. That means bandwidth at the half-points on the curve is 10-12 kHz. That's not bad for a general-purpose receiver, but a little wide for a selective communications receiver.

Another way I estimate bandwidth is with the built-in 100-kHz markers that are part of my model 415 sweep generator. **Fig. 6** shows the trace with the 100-kHz markers activated. You may have to increase *Sweep Width* slightly to get both markers on the scope trace.

A



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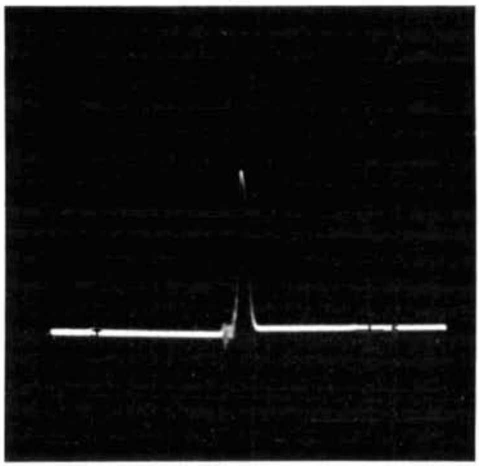

fig. 5. Movable markers show bandwidth in terms of kHz between upper skirt A, and lower skirt, B.

The 100 kHz beats with the 10.7-MHz marker and puts one at 10.6 and another 10.8 MHz. Converted in the homemade mixer, this means markers at 355 kHz and 555 kHz. Of course the main 10.7-MHz marker still makes the 455-kHz center marker. The distance between the two outside markers is 200 kHz. From that you can estimate the bandwidth of the curve being displayed.

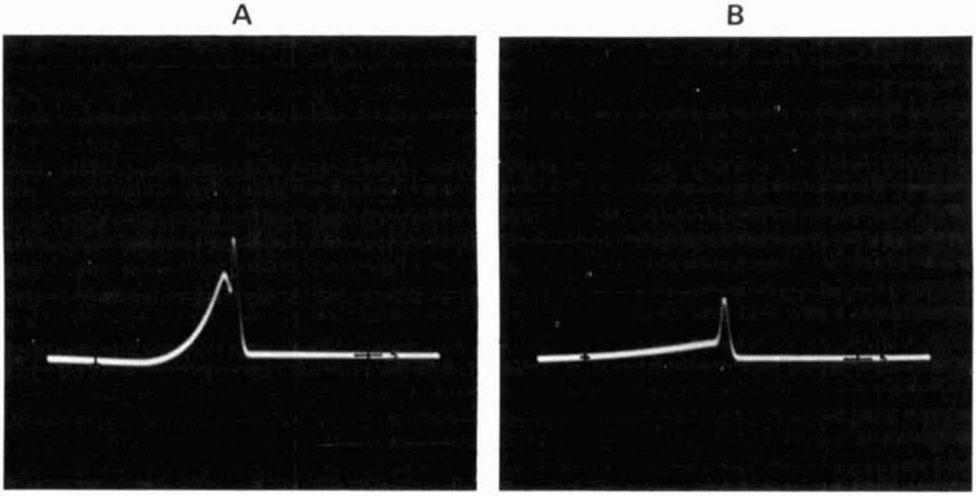

fig. 7. Selectivity switch of receiver changes response of i-f strip, as shown by the curve. Broad response, A, with crystal phasing set at one spot. Sharp crystal position, B, reduces gain but sharpens curve peaking.

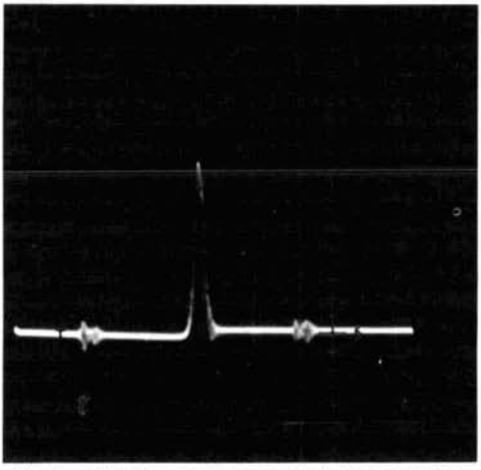

fig. 6. 100-kHz markers on each side of main center marker also can help estimate bandwidth.

other uses of sweep curve

You can see the effect of a crystal selectivity filter on the i-f response. **Fig. 7A** shows the curve with the *Selectivity* switch of the receiver set for *Crystal – Broad.* Turning the *Crystal Phasing* capacitor knob changes the curve shape somewhat.

Switching to *Crystal – Sharp* reduces the gain of the i-f strip, but sharpens the curve. You can see the result in **fig. 7B.** You can alter the *Crystal Phasing* to virtually eliminate the i-f curve.

A sweep curve generated as described here can be used for testing any rf or i-f stages. Without the gain provided by amps in the receiver, you'll need a more sensitive setting of the scope's vertical input. Or, you can build an untuned transistor amp to follow the homemade mixer. That'll give you enough signal to be useful with unamplified tuned circuits. You'll have to add a diode detector for stages that don't end with an a-m detector.

With a little practice and imagination, you can find a lot of other uses for this method of generating a low-frequency sweep signal.

ham radio

Dear Sirs:

So far, I have not often written to manufacturers; however, this time I feel obliged to let you know how pleased I am with your low power building blocks.

Several months ago I obtained . . . the TEN-TEC basic modules MR 1 (40/80m), the AC 3 (15m converter) and the AC 6 (20m transeiver module). These modules were built into a small aluminum housing . . . the result is a thoroughly pleasing piece of equipment, which gave me many hours of fun in the "field" . . .

Many QSOs have been made during the summer and fall months and always the reaction to "my input hr 2 watts" is a skeptical "unbelievable", regularly followed by the question "what antenna do you use?". Obviously the chap on the other end thinks I have some big array and is even more puzzled to hear that I only use a G.P.! Worked so far most countries of Europe, several UA9s (over 3000KM away) and a 4x4 (all during the daylight hours). Even a HBØ and a OHØ have been worked through some pile-ups! The comments on frequency stability and tone quality are always excellent . . .

To me, the most surprising thing is the sensitivity of the receiver, considering the utmost simplicity of the design; even weak DX stations can be well received . . .

Congratulations and compliments to you for a fine and inexpensive job!

Dr. Gunther Haubenberger, OE1HGW

Vienna Austria

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☐ AC6 Extend MR1 module group to 20 meter transceive operation with side-tone for all bands	7.95
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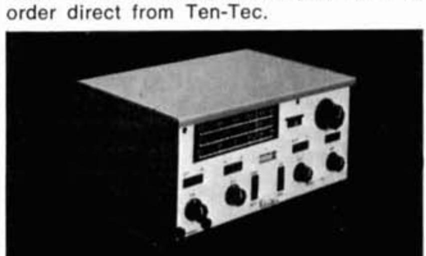
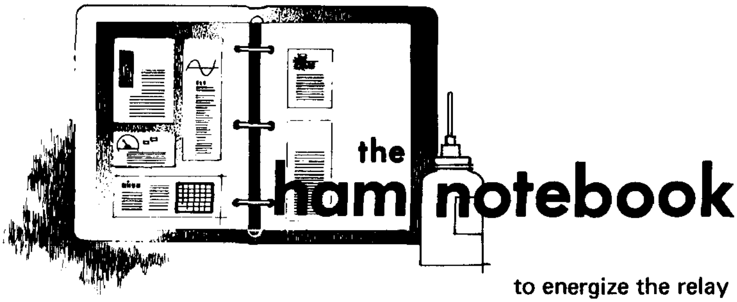


TEN-TEC PM2B Transceiver

TEN-TEC, INC.
SEVIERVILLE, TENNESSEE 37862

More Details? CHECK—OFF Page 94



safer suicide cord

Most electronics experimenters have an ac-plug-to-clip-lead adapter (better known as a "suicide cord") on their workbench. Unfortunately, too many experimenters fail to take a few simple safety precautions – precautions that can save much embarrassment or worse!

First of all, always use a fused ac plug such as the El Menco along with 5- to 10-amp fast-blow fuses. For the cord itself use about 6 feet of no. 16 heavy-duty lamp cord. For the clip-lead end, Mueller no. 60 alligator clips are a good bet, but be sure to insulate each alligator clip with a Mueller no. 62 rubber cover.

Bruce Clark, K6JYO

using undervoltage relays

Although many forms of undervoltage relays are on the market, it sometimes happens (as in my case) that a quick and dirty substitute can be found. Most standard relays exhibit a very wide difference in pickup and dropout current, typically three to one. Therefore, it's often impossible to use a single relay for a specific application.

I needed a relay that had to drop out within approximately 10% of the normal running voltage. Available relays were Allied Control type BO6-D 184VDC. These units have a 13500-ohm coil. Pickup is at approximately 10 mA, but dropout occurs at about 3 mA.

As shown in **fig. 1**, R1 is proportioned to energize the relay (RY 1) at about 20% below the operating voltage. R4 is then set to pull in RY 2 at a point a little higher – say 10% below the operating voltage. The 100k composition pot is then set to drop out RY 1 at a point 10% below the operating voltage.

This arrangement was run in a bench setup for eight hours to determine if relay heating would result in any variation of the dropout point. The maximum variation in dropout point was approximately 2% of the operating voltage.

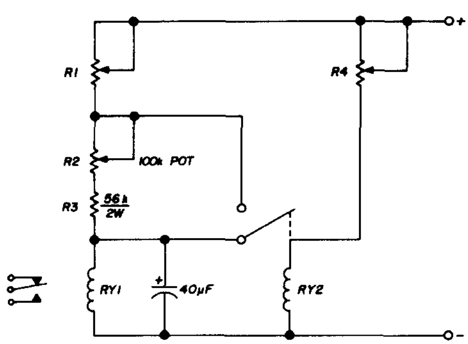


fig. 1. Method for controlling relay dropout voltage. Resistors can be proportioned to cause pull-in and dropout over fairly wide current range.

caution

Don't try to use a variation in dropping resistance as shown in **fig. 2**, or instability will result. Also, don't try to use an extra set of contacts on RY 1 to perform the function of contacts on RY 2; i. e., to switch in R2 and R3. Oscillation or instability will result.

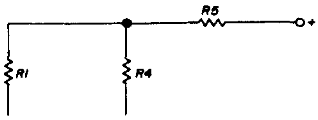


fig. 2. An example of dropping-resistor arrangement that will cause instability.

A solid-state circuit would have been preferable, except that this particular equipment was to be subjected to a radioactive environment, which precluded the use of solid-state devices.

Bill Wildenhein, W8YFB

simple resistance standard

As many amateurs know, ohmmeter readings taken with a vom can be notoriously inaccurate. However, there are times when you need an accurate resistance measurement of a higher order than that obtainable with an ordinary multimeter. Higher accuracy generally requires a Wheatstone bridge or similar laboratory-type equipment. For occasional use such expense cannot be justified.

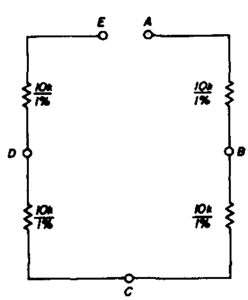


fig. 3. Simple resistance standard provides accurate checkpoints from 2500 to 40,000 ohms. Connections are shown in table 1.

The inexpensive "resistance checker" shown in the photograph and in **fig. 3** is a simple and direct solution to this problem. Four 1% resistors are wired as shown; it is apparent that there will be resistance check points at 10k, 20k, 30k and 40k ohms. If your volt-ohmmeter has not been grossly abused, you can set the meter to 10k ohms when connected across one leg of the standard — merely adjust the "zero ohms" knob so the meter coincides with the selected resistance value. Thereafter you may read resistance values with good accuracy up to 10 or 20 percent removed from the check point.

table 1. Parallel connections required for resistance values from 2500 to 40 kilohms.

desired resistance value	connect together	read ohms between
2500	A-C B-D C-E	A-B
3333	A-C B-D	A-D
5000	A-C	A-B
6667	A-D	A-C
7500	A-E	A-D
10,000	—	A-B
13,333	A-C B-D	A-E
15,000	A-C	B-D
16,667	A-D	C-E
20,000	—	A-C
25,000	A-C	B-E
30,000	—	A-D
40,000	—	A-E

In addition to the multiple 10k check points, parallel connections will result in resistor standards at 2,500, 3,333, and 5,000 ohms (see **table 1**). Other standard values may be obtained through suitable interconnection of the various resistors. The chart is provided since most of us don't want to get out the slide rule when a quick resistance check is needed. Obviously other decade values may be selected but the above setup provides resistance checkpoints at more than one dozen intervals throughout the range from 2.5k to 40k ohms.

Neil Johnson, W2OLU

cleaning printed-circuit boards

If you work with printed-circuit boards you probably have had difficulty removing solder from the holes when removing resistors, capacitors or other components. A cutting-torch cleaner — available from a welder's supply house — is a very useful aid. The cutting-torch cleaner comes with 12 different-sized steel rods which can be pushed through the solder holes. About one-quarter inch back from the smooth tip of each rod there's a machine-cut rasp surface which may be used to enlarge the holes, if necessary. The rods are usually furnished with a small metal case for easy storage.

Felix W. Mullings, W5BVF

Heath HW-17 modifications

After using the Heath HW-17 for some time, I decided that the receiver in the little rig lacked sufficient gain. The front-end seemed quiet and relatively sensitive, but overall receiver response was low. When WB2EGZ's article appeared in the August issue I built the mosfet preamplifier. It did give the receiver more gain, but didn't help much with weak-signal reception. In fact, the preamp seemed to degrade the noise figure of the HW-17's own frontend.

Since I already had the 40673 transistor and its bias and load resistors, it was decided to try to use those parts if possible. Since the frontend seemed to be quiet and sensitive I thought that the receiver needed a little more i-f gain. From a quick check of the diagram it appeared that the 40673 mosfet and associated components would fit the HW-17 like a glove. It was wired into the set between the i-f output and the second mixer. This can be done very easily without drilling any holes.

Solder is removed from the i-f output pin of the tuner where it connects to the board; a vacuum de-soldering tool is very handy here. A small piece of spaghetti is slipped over this pin to keep it from touching the foil. Gate 1 of the transistor is soldered directly to the pin, and the drain lead is soldered to the foil nearby. The transistor is mounted perpendicular to the board and the rest of the components are soldered to the transistor leads. Although the additional i-f stage is very stable, and no combination of lead placement will cause it to oscillate, use short leads.

The modification requires re-alignment of T1 (in the tuner) and L6. Adjust them for maximum signal strength as indicated on the S-meter while rocking the main tuning dial across a weak signal.

Since adding this modification, the familiar background hiss of most vhf receivers is present, and ignition and atmospheric noise can be easily heard. With the antenna disconnected, the noise is very low, indicating the frontend is quite quiet. The S-meter is much livelier because of improved agc action. Also the squelch will open with weaker signals than before.

Ed Ranson, WA5PWX

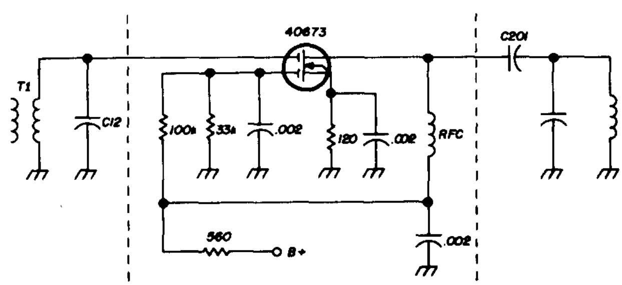


fig. 4. Added stage of i-f amplification for the HW-17. RFC is not critical.

noise limiter for heathkits

Since I live in a noisy area and own one transceiver with a noise limiter and one without, the advantages of a noise limiter are very apparent to me. With some component value changes to match the resistance of the original audio-gain control in my transceiver, a very satisfactory noise-limiter circuit evolved for the Heathkit SSB line. The components for this circuit cost less than $3.00, and the time involved is approximately one hour. The circuit is shown in **fig. 5.**

The switch on my HW-12 is mounted as low as possible and centered on the front panel. I used a miniature switch that mounts with two screws. These screws are used to support two 4-connector tie points.

If the af gain-control in your transceiver is a 500k pot, R1 and R2 will be 1 megohm and R3, 150k. If the af gain-control is a 1-megohm pot, then R1 and R2 will be a 2.2 megohm, and R3, 270k. All resistors are 1/2 watt.

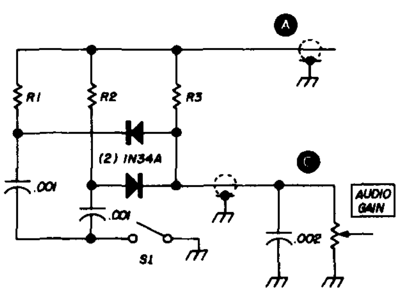


fig. 5. Simple noise limiter for Heathkit ssb transceivers. Values for R1, R2 and R3 are given in text.

Remove the shielded audio-input lead from point C of the af gain-control and connect it to the input of noise limiter at point A. Connect the output of the limiter to point C on the af gain control. You will find there is very little loss with this limiter and no noticeable distortion until the audio is too loud for comfortable listening.

Jim Welborn, W7CKH

increasing the versatility of the comdel speech processor

The Comdel speech processor can be made more versatile by the simple modification shown in the diagram. A miniature potentiometer is mounted on the rear plate of the unit and connected into the output circuit so the output level may be

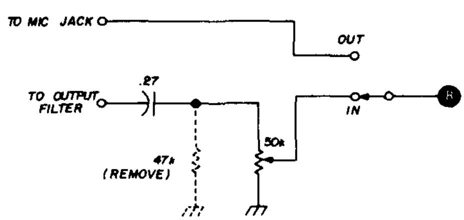


fig. 6. Gain control for Comdel CSP-11 adds versatility to the unit.

adjusted to be equal in peak amplitude to the level encountered when the unit is switched out of the circuit.*

Gain through the speech processor, without the potentiometer, is greater than unity and "in-out" checks can only be made with difficulty because of change in gain level. With the addition of the potentiometer, processor output level may quickly and easily be set to the proper amount. The output circuit potentiometer is substituted for a 47k resistor (shown in dotted lines) which is removed from the circuit board.

William I. Orr, W6SAI

*With high-level microphones, such as the D104, the peak microphone output is considerably higher than the limited 70-to 100-mV peak level available from the processor; in this case the output potentiometer should be mounted in the microphone line.

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Deluxe 2 Meter FM Transceiver

Always the quality leader, (see December and January 73 Magazine, and reviews in January QST and March CQ) the IC-2F remains the same — superb performance, deluxe features, 1 year warranty . . .

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GENERAL: Six channels (six transmit and six receive crystals) selectable from the front panel; large RF/"S" meter and easier to read controls; power requirements 12 to 15 volts DC.

The Deluxe IC-2F comes complete with high impedance microphone, three-position chrome mobile mounting bracket, crystals installed for two channels (Ch. 1, 146.34/146.94; Ch. 2, 146.94/146.94), power cables and plugs and manual. **Amateur Net $299.95**

Optional AC Power Supply with built-in Discriminator Meter, Model IC-3P. **Amateur Net $42.50**

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More Details? CHECK–OFF Page 94

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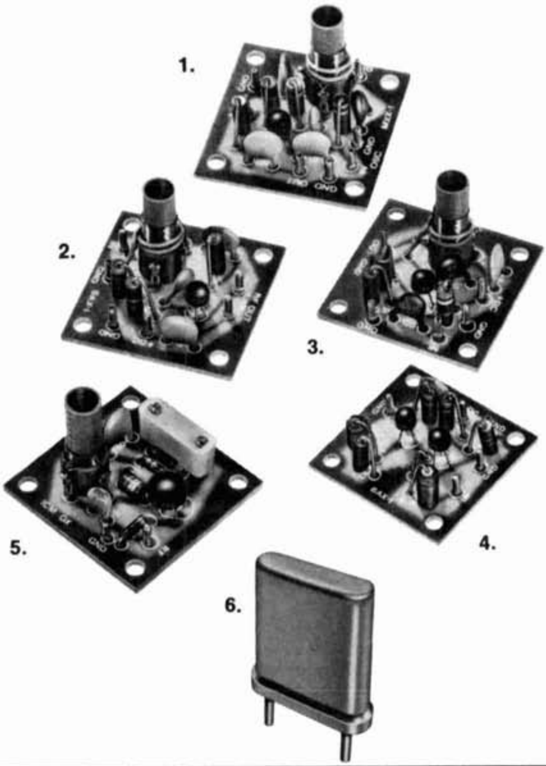

1. MXX-1 TRANSISTOR RF MIXER

A single tuned circuit intended for signal conversion in the 3 to 170 MHz range. Harmonics of the OX oscillator are used for injection in the 60 to 170 MHz range. Lo Kit 3 to 20 MHz, Hi Kit 20 to 170 MHz (Specify when ordering) **$3.50**

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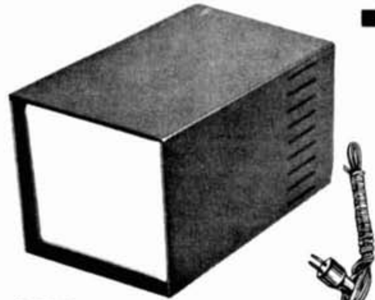
More Details? CHECK—OFF Page 94

TFME POWER SUPPLY FOR Regency HR-2



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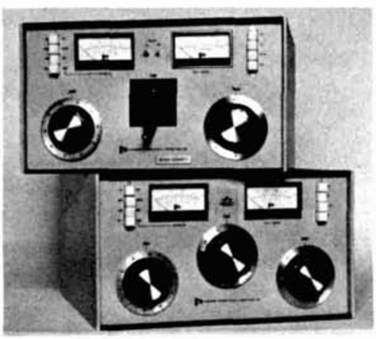


The new Delta 70 linear amplifier is externally identical to the Alpha 70 except for the plate-tuning control; it uses a vernier drive to an air-variable capacitor. Internally, the only difference between the Delta and Alpha models is the use of an air-cooled 3-1000Z in place of the Alpha 70's vapor-cooled system. The two amplifiers are almost identical electrically and handle much the same. Power ratings are identical.

While the Alpha 70 features continuous coverage from 3 to 30 MHz, the Delta is specified for the amateur bands, 10 through 80, although it too is almost continuous tuning. The Delta 70 linear amplifier is initially priced at $1195.00.

For more information on the Alpha 70 or Delta 70 linear amplifiers, write to Ehrhorn Technological Operations, Inc., Post Office Box 1297, Highway 50 East, Brooksville, Florida 33512, or use *check-off* on page 94.

mosley 75 and 80-meter conversion kit

The new Mosley RV-8C conversion kit is designed for amateurs who already own the Mosley 4-band vertical, the RV-4C, or for those who are considering the purchase of a 5-band vertical antenna system for operation on 10 through 80 meters. The 5-band antenna stands only 22-feet high and requires no guying or concrete footing.

The conversion kit includes a loading coil rated at 750 watts a-m or CW, and 2000 watts PEP ssb. Tuning is accomplished by sliding the U-shaped matching-section along the vertical element until a match is obtained at the desired operating frequency.

A plexiglass coil housing, closed at one end with a polyethylene cap, assures protection against the most severe weather conditions. Easy-to-follow instructions are included with the kit. For more information, write to Mosley Electronics, Inc., 4610 N. Lindbergh Boulevard, Bridgeton, Missouri 63044, or use *check-off* on page 94.

50-watt mobile amplifier

Varitronics has just announced a new power amplifier that should appeal to all mobile fm operators.

The Varitronics PA-50A is a completely solid-state class-C rf amplifier designed for use in mobile amateur fm applications. Because of internal rf switching, the PA-50A can be used with any two-meter transmitter with 5 to 15 watts output when used with the IC-2F transceiver (nominal 12-watts drive). Balanced-emitter semi-conductors insure complete insensitivity to high vswr – even no load conditions. This handsome and ruggedly built amplifier is styled like the Varitronics IC-2F, features a calibrated output meter and comes complete with a mobile-mounting bracket and dc power cord. $129.95 amateur net. For more information, use *check-off* on page 94, or write to Varitronics Incorporated, 2321 East University Drive, Phoenix, Arizona 20665.

two-meter fm transceiver

Regency Electronics has announced a compact mobile fm transceiver for operation in the 144-MHz band. The solid-state model HR-2 features a 10-watt power output with operation on any of six transmit and receive channels in the band. Simple operator modification, however, can enable the radio to transmit and receive on any of 12 different duplex combinations.

The receiver is a double-conversion superhetrodyne with a highly selective ceramic filter for operation on both wide- and narrow-band signals. Sensitivity is rated at 0.35 μV, 20 dB quieting and audio output at 5 watts.

The transmitter features phase modulation for exacting carrier stability. Individual trimmer capacitors enable frequency setting optimum performance in point-to-point or repeater applications. Built-in swr load mismatch circuitry protects against open or shorted antenna conditions.

The modern integrated circuitry operates on 13 Vdc with low current drain. The package comes complete with plug-in ceramic microphone, built-in speaker and mobile-mounting bracket. One pair of factory installed transmit and receive crystals on 146.94 MHz are included in the $229.00 amateur net price. An ac power supply and linear amplifier will soon be available as optional equipment.

For more information, write to Regency Electronics, Inc., 7900 Pendleton Pike, Indianapolis, Indiana 46226, or use *check-off* on page 94.

short-wave listening

A new, well-illustrated, multi-page primer on short-wave listening has been written by The Hallicrafters Company, and is being offered free to the interested reader, DXer, short-wave listener, hi-fi buff, hobbyist and amateur radio enthusiast.

Aptly titled "short-wave puts you where it's at," the multi-colored brochure takes the interested reader through the many adventures he can experience with short-wave; explains graphically and in simple terms "what is short-wave;" tells the reader what can be heard on short-wave (i. e., amateur bands, overseas marine radio, aeronautical bands, international broadcasting, military and clandestine stations, standard time signals, public safety and many others); provides a complete radio frequency spectrum in a unique and copyrighted graphic illustration; and points out what to look for when choosing a quality short-wave receiver.

Also included in the center fold of the primer is Hallicrafters' complete line of a-m and fm general-coverage short-wave receivers, special frequency monitor radios and amateur transceivers and accessories. For a free copy of the multi-page, short-wave primer, "short-wave puts you where it's at," write to The Hallicrafters Company, Dept. PR, 600 Hicks Road, Rolling Meadows, Illinois 60008, or use *check off* on page 94.

new allied catalog

Allied Electronics' new 1971 catalog of electronics parts and supplies, considered by many as the bible of the industry, is now available. The catalog lists over 70,000 separate stock items from more than 700 manufacturers. Detailed specifications, descriptions and illustrations cover a vast array of parts and components including: semiconductors, integrated circuits, tubes, relays, timers, transformers, resistors, capacitors, connectors, coils, chokes, sockets, plugs, jacks, switches, fuses, batteries, clips, lamps, wire and cable, and much more.

Other major sections of the catalog feature test instruments, recording equipment, sound equipment, intercoms and business communications gear, power supplies, electronic counters, chemicals, hardware, technical books, tools and solder equipment. Allied Electronics Catalog No. 710 sells for $2.00 (or no charge with order) and is available from Allied Electronics, 2400 W. Washington Boulevard, Chicago, Illinois 60612.

solid-state rtty demodulator

The new Space One RTTY demodulator from J&J Electronics has a number of interesting features, including heavy-duty loop supply, regulated power supply, electronic keyer stage supplying plus and minus voltages with provisions for adjusting to 1 mA when driving diodes, as well as both 850 and 170 shifts, selectable from the front panel. The solid-stage circuitry uses integrated-circuit amplifiers and high-voltage transistors for keying the loop supply.

The Space One uses standard tones of 2125 and 2975 Hz, has metered tuning (indicator lamps available as option), and provides a spare socket for the addition of a three-pole Butterworth bandpass input filter if local conditions warrant it. The basic unit is completely self contained, including loop supply and fsk driver, and is ready to connect between your receiver and printer.

Several extra features are available at optional extra cost, including receive and standby indicator lamps, auto receive without motor-control relay, and auto-start plus motor control relay. Basic unit, less options, is $124.95. For more information, write to J&J Electronics, Windham Road, Canterbury, Connecticut 06331, or use *check-off* on page 94.

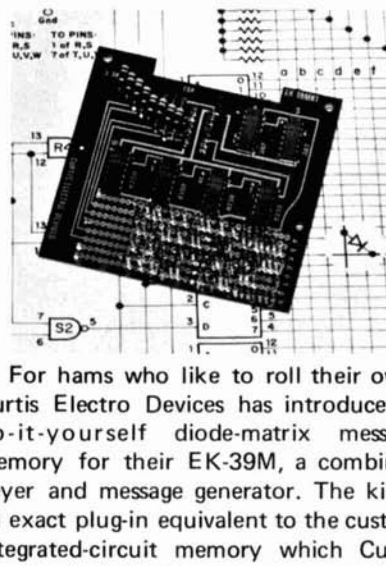
video/rf selector-control center

The new Alco CCV3 is a three-position control center that has many uses in video or rf layouts. Although it is suitable for switching *low-power* antenna systems it is designed primarily for controlling tv cameras and monitors. The unique push ON and push to RELEASE switches allow the operator to select equipment optionally at will. The unit uses standard type-UHF coaxial connectors, and no external power is required for operation. Crosstalk between adjacent channels is negligible. Price is $19.95. For more information use *checkoff* on page 94, or write to Alcoswitch Division of Alco Electronic Products, Inc., Post Office Box 1348, Lawrence, Massachusetts 01842.

two-meter fm antenna

Varitronics has recently introduced the *Redhead,* a two-meter groundplane antenna with 3.4-dB gain. This sturdily built, commercial quality antenna is adjustable for low swr over the entire two-meter band. Radials and radiator are made from heavy-guage aluminum tubing, and the loading coil is well protected by a metal shield which is painted red (hence the nickname). The model AS-2HG *Redhead* antenna is rated at 250 watts cw, a-m or fm, and 500 watts PEP ssb. $18.95 from your local dealer. For more information, write to Varitronics Incorporated, Post Office Box 20665, Phoenix, Arizona 85036, or use *check-off* on page 94.

keyer memory kit



For hams who like to roll their own, Curtis Electro Devices has introduced a do-it-yourself diode-matrix message memory for their EK-39M, a combined keyer and message generator. The kit is an exact plug-in equivalent to the custom integrated-circuit memory which Curtis supplies individually pre-programmed per user instructions. It consists of six integrated circuits, a pre-drilled circuit board and 150 diodes plus other components and hardware. Complete instructions are provided.

Assembly requires no knowledge of logic techniques or Karnaugh maps. If you can send Morse, you can program the matrix. Programming and assembly time is three or four hours. The memory kit yields three programs. A typical contest set are:

5NN03 DE W1DTY
CQ TEST CQ TEST DE W1DTY
DE W1DTY

In addition to operating convenience, the new message generator is expected to raise cw contest scores by boosting operator efficiency. The EK-39MK Diode Memory Kit is available now from dealers or direct from the manufacturer and is priced at $49.95. (The EK-39M is $179.95.) For more information write Curtis Electro Devices, Box 4090, Mountain View, California 94040, or use *check-off* on page 94.

motorola semiconductor kits

Two new construction kits with special "how to" project brochures have been introduced by Motorola HEP through its nationwide network of semiconductor distributors. The HEK-3 Radio Amateur Hobby Kit, retailing for $5.95, contains two rf/i-f linear integrated circuits and an RTL integrated circuit in addition to an HMA-36 special project brochure. Circuits in the brochure include a 6-meter preamp, 6-meter a-m modulator, 40-meter transmitter, video amplifiers and a microphone amplifier.

The HEK-4 Home Handyman Hobby Kit, retailing for $4.95, contains a silicon-controlled rectifier, a unijunction transistor, a silicon rectifier, a photo transistor and a silicon npn transistor. Special project brochure HMA-37 that comes with this kit shows 11 applications including a light dimmer, electronic timer, burglar alarm and code-practice oscillator.

The project brochures are free at HEP semiconductor distributors. HEP is Motorola's sales program for making semi-conductor devices readily available to the experimenter through a nationwide network of authorized suppliers.

mobilink

The Mobilink is a unique new product that will have wide acceptance among two-way radio users in the commercial field, CB, amateurs, and other operators who require constant monitoring of their mobile receivers. The Mobilink is helpful when out of the car or out of hearing range while on business calls, coffee breaks or lunch.

Mobilink is a low powered a-m transmitter used with a pocket receiver as an accessory for mobile communications, base stations, paging and intercom extensions. All calls and the exact content of messages will be heard up to 1/4 mile away on the small receiver. This is a great improvement over the systems that blow the car horn, or turn on the car lights. Mobilink has a greater usable distance, will not disturb others and will not discharge the car battery.

The Mobilink features easy installation – only connection needed is a pair of wires to the speaker; the internal 9-volt battery has shelf life in standard service due to the vox circuit that turns on the Mobilink transmitter only when a signal is received on the communications receiver. It can be used with all code, scramble and squelch systems without modification because it uses audio instead of an rf signal.

The Mobilink has 75 milliwatts input power, an antenna that adjusts from 5 to 18 inches, small size, weighs only 11 ounces, frequency of 27.263 MHz or any CB channel on request, crystal controlled, input impedance of 3 to 8 ohms, heavy aluminum construction, all solid-state devices and made in U. S. A. Price is $44.95 complete with crystal, battery, connecting wire and antenna.

The Mobilink receiver is a small pocket size portable transistor circuit with 18-inch collapsible antenna, rf tuned circuit, crystal controlled, speaker, earphone, agc performance, 9-volt battery and carrying case. Comes complete ready to use with crystal for $24.95 postpaid. Mobilink transmitter and receiver set is $69.90 postpaid. Units and information are available from Herbert Salch & Co., Marketing Division of Tompkins Radio Products, Woodsboro, Texas 78393, or use *check-off* on page 94.

continuous-tone encoder

Automatically activated signal-tone encoders for use with two-way radio equipment have been announced by the Ross and White Company. Keyed by closing the transmitter microphone switch, the encoder generates a short duration tone burst which modulates the transmitter, and automatically activates tone-access repeaters, tone-operated receiver squelch circuits or other signalling devices.

The two models are the TE-2, with two switch-selected output tones, and the TE-5, with five tones. Frequency range is field adjustable from 1600 to 2800 Hz. The 0.5 second output tone burst is a 6-V p-p open-circuit sine wave, with output impedance adjustable in three steps. The all solid-state circuit uses commercialgrade American-made components and silicon semi-conductors on an epoxy-fiberglass circuit board.

The encoders and their 9-V batteries are housed in 2-1/8 x 1-1/8 x 3-1/4-inch plastic cases, and are connected to the transmitter microphone circuit with a 15-inch shielded cable. Installation typically requires 20 minutes or less. An aluminum bracket is provided for mounting the encoder.

The price of the TE-2 is $29.95, and for the TE-5, $39.95. For further information, contact Ross and White Company, 50 West Dundee Road, Wheeling, Illinois 60090, or use *check-off* on page 94.

QRPP magazine

Ade Weiss, K8EEG, long time QRP enthusiast, has launched a new bimonthly, now in its second year, for the QRPP amateur radio operator. To the uninitiated, QRPP is an extension of the Q-signal QRP which is applied to amateur operation of less than five watts. The new magazine, *The Milliwatt: National Journal of QRPP,* is devoted exclusively to under-five-watt amateur radio, and has featured technical articles, construction projects, operating news, QRPP WAS standings and QRPP log selections. The first volume includes construction projects for transistor transmitters and receivers for 3.5, 7 and 14 MHz, QRPP wattmeters, dummy loads and SWR meters, articles on propagation, operating procedures and other applications of general theory to the specific requirements of very low power operation. *The Milliwatt* is published six times a year; subscriptions are $3.00 annually, $3.40 first-class mail. A reprint of the entire Volume I is available, $4.00 postpaid. Subscriptions and general queries to Wes Mattox, K6EIL/2, 115 Park Avenue, Binghamton, New York 13903. Articles and operating news to Adrian Weiss, Editor, *The Milliwatt,* Meckling, South Dakota 57044.

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The best of the Japanese, the Marker Luxury VHF FM Transceiver is built for and distributed and backed by the R. L. Drake Co.

- **Exceptional receiver**
- **Backed by R. L. Drake**
- **Complete package for . . .**

$329⁹⁵

Includes transceiver, two channels supplied, mobile mount, microphone, coax cable, Hustler antenna, and built-in AC-DC power supply.

SPECIFICATIONS

General

Frequency Coverage	144-148 MHz
Number of Channels	12 Channels, 2 supplied Channel 1 Receive 146.94 MHz Transmit 146.34 MHz Channel 2 Simplex 146.94 MHz
Modulation	Frequency Modulation
Transmitter Control	Push-to-Talk
Power Drain	AC: Receive 6 Watts Transmit 50 Watts DC: Receive 0.5 Amps Transmit 4 Amps
Power Source (Built-in)	AC: 117 Volts 50-60 Hz DC: 13.5 Volts ± 10%.
Dimensions	7⅞" W x 2¾" H x 10¼" D.
Weight	8¼ lbs.
Standard Accessories	Dynamic Microphone, Hustler Antenna, Antenna Connector Plug, AC/DC Cord, Speaker Plug.

Transmitter—transistorized with 6360 output tube

RF Output Power	Greater than 10 Watts
Frequency Deviation	Adjustable to 15 kHz maximum
Frequency Stability	±.001% or less
Spurious Radiation	Greater than —80 dB below Carrier
Output impedance	50 ohms

Receiver — completely transistorized

Receiver Circuit	Crystal-controlled Double Conversion Superheterodyne
Intermediate Frequencies	1st 10.7 MHz, 2nd 455 kHz
Input Impedance	50 to 75 Ohms
Sensitivity	0.5 μV or less for 20 dB quieting. 1 μV or less (30 dB S+N/N ratio at 10 kHz deviation with 1 kHz modulation)
Spurious Sensitivity	Greater than —60 dB.
Audio Output	0.5 Watt with 10% or less distortion.

See at your distributor, or write for details . . .

R. L. DRAKE COMPANY
540 RICHARD ST., MIAMISBURG, OHIO 45342

More Details? CHECK—OFF Page 94

More Details? CHECK—OFF Page 94

flea market

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

■ **COPY** No special layout or arrangements available. Material should be typewritten or clearly printed and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** can not check out each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue. Deadline is 15th of second preceding month.

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

LISTING SERVICE — Gear to sell? Need Rig? Sellers - $1.00. Lists information year. Buyers - Free. SASE brings details. Listing Service, Box 1111, Benton Harbor, MI 49022.

WANTED: SELF-SUPPORTING crank-up tower. At least 50′. Von Stafford, K4VUY, 8316 Denise Drive, Louisville, Ky. 40219. 502-969-5414.

ORIGINAL EZ-IN DOUBLE HOLDERS display 20 cards in plastic, 3 for $1.00, 10 for $3.00 prepaid. Guaranteed. Patented. Free sample to dealers. Tepabco, John K4NMT, Box 198R, Gallatin, Tenn. 37066.

WANTED. Will pay $15 for following set of unmutilated Ham Radio. April, June, July, Sept., Dec. 1968; Jan., April, July 1969. John Gibson, 1305 Tevlin, Berkeley, Calif. 94706. Phone TH9-1051.

HEATH HX-30 6M SSB/AM/CW xmtr $135, Gonset 6M linear model 3063 with extra output tubes $45, Motorola 6M 60W FM xtal controlled receiver and xmtr (PA8671A) strips $50. Paul Sobel, WA6HMV, 755 E. Pine, Altadena, Calif. 91001.

ASK FOR FREE LIST of used Ham gear or for prompt personal attention on any new gear. Mail your order direct to VanSickle Radio, W9KJF, Indianapolis, Indiana 46205. 40 years experience.

CODE PRACTICE TAPES - Novice - General - Extra Class - Specify - $8.00 each. W9CJJ, 1105 Schaumburg Road, Schaumburg, Illinois.

PHOTORESIST: Make professional PC boards at home with no special equipment. 10¢/board. Send 25¢ for information and instructions or $2.00 for 1 oz. of photoresist. Information included. S&H Electronics, Dept. A, P. O. Box 286, Corvallis, Ore. 97330.

MOTOROLA FM — 2 meters; U43GGT, 40 watts output, transistor supply, very clean, with cables and control head, less crystals - $145.00. 80D Transmitter strip - $15.00. Sensicon A Receiver - $20.00. Complete 80D, Dynamotor supply with cables and head - $40.00. WA1INO, P. O. Box 587, Manchester, Conn. 06040.

MECHANICAL FILTERS: 455 Khz. 2.1 Khz $18.95. 300 Hz $22.95. J. A. Fredricks, 314 South 13th Ave., Yakima, Washington 98902.

CANADIANS — Racal RA17-C12 C/W RA63SSB and RA137-B-LF components. 10KC thru 30MC. RX. Details contact G. Stewart, 26 Dominion Bay, Thompson, Man. 677-5802.

RADIO CONTROLLED GARAGE DOOR OPENER. Om's! Be kind to your XYL and your car. Now the car will be where it belongs; in the garage. Not a kit. Shipped ready for installation with easy to follow instructions. Write for free brochure and price information. You'll be pleasantly surprised. Radio Door Co., P. O. Box 282, Pomona, New York 10970.

QSLS. Second to none. Same day service. Samples 25¢. Ray, K7HLR, Box 331, Clearfield, Utah 84015.

TOROIDS! Lowest price anywhere. 40/$10.00 POSTPAID (5/$2.00). center tapped, 44 or 88mhy. 32KSR page printer, reconditioned, perfect $225. MITE UGC41KSR page printer, reconditioned, $250. Mod28 Sprocket to friction kit, $25. 28LBXD TD, $70. 28LPR reperf with gear shift, $170. Model 15KSR, $65. Matching RA87P.S. Unused, $7. Lorenz 15KSR, $75. Sync motors, $7. 14TD, $20. DPE punch, $14. HP200CD Oscillator, $95. R390/URR, $550. 11/16″ tape, 40/$10.00. 33ASR, complete, $700. Stamp for listing. Van W2DLT, 302H Passaic, Stirling, N. J. 07980.

"HOSS TRADER ED MOORY" says he will not be undersold on Cash Deals! SHOP around for your *best price and then call or write the "HOSS"* before you buy! NEW EQUIPMENT: New "Demo" Galaxy GT-550 with warranty, $389.00: New Rohn 50 Ft. *Foldover Tower prepaid,* $219.00: New Mosley Classic 33 and Demo Ham-M Rotor, $205.00: Waters 335 Coaxial Switch, $8.75: New YAESU FVdx400 VFO, $79.00: New Swan 270B Cygnet, *$405.00 freight prepaid: USED EQUIPMENT: Drake* TR-4, $449.00: R4-B, $349.00: T4XB, $365.00: Ham-M Rotor, $85.00: 2A, $125.00: SPR-4, $369.00: Swan 250 (6 meter), $225.00. Moory Electronics Co., P. O. Box 506, Dewitt, Arkansas 72042. Phone (501) 946-2820.

WANTED R390, R390A, R389, 51J4, 51S1, Racal, Nems, Clarke, Marconi receivers. SWRC, P. O. Box 10048, Kansas City, Missouri 64111.

DON'T BUY QSL CARDS from anyone until you see my free samples. Fast service. Economical prices. Little Print Shop, Box 9848, Austin, Texas 78757.

"DON AND BOB" NEW GUARANTEED BUYS. Dealer Tempo, Kenwood. Write specifications. Monarch KW SWR-Relative Power Dualmeter Bridge, now 14.95; Regency HR2 2M. FM (reg. 229.00) 195.00; Hygain TH6DXX 139.00; Hyquad 104.00; Swan 500CX 470.00; Mosley Classic 36 134.00; Ham-M 99.00; TR44 59.95; RCA 6LQ6 3.50; Motorola HEP 170 2.5A 1000PIV Epoxy diode 39¢; Amperex 8802 300Z 32.00; 6146B 4.45; Write quote Drake SPR4. Prices FOB Houston. GECC finance. Madison Electronics, 1508 McKinney, Houston, Texas 77002. (713) 224-2668.

TRANSCEIVER SR-150 and P-150C, complete with crystals for five bands and calibrator, excellent condition. Also Turner SSB mike, new. $300 plus shipping. McFolin, WA4WRU, 710 Dellwood Road, Huntsville, Alabama 35802.

WAB CONTEST. The Cannock Chase Amateur Radio Society is hosting several contests for certificate hunters looking for the Worked All Britain (WAB) award. These contests include all bands from 1.8 to 28 MHz, with both cw and phone sections. Frequencies are divided into two groups: HF 14, 21 and 28 MHz, and LF, 1.8, 3.5 and 7 MHz. HF phone contest is 14 March; HF cw contest is 28 March; LF phone contest is 4 April; LF cw contest is 11 April. For more information, write to C. J. Morris, G3ABG, 24 Walhouse St., Cannock, Staffs., England.

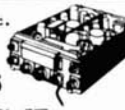
SURPLUS MILITARY RADIOS, Electronics, Radar *Parts, tons of material for the ham, free catalogue* available. Sabre Industries, 1370 Sargent Ave., Winnipeg 21, Manitoba, Canada.

TELL YOUR FRIENDS about Ham Radio Magazine.

NEW G&G CATALOG!
MILITARY ELECTRONICS

24 PAGES, crammed with Gov't Surplus Electronic Gear – the Biggest Bargain Buys in America! It will pay you to **SEND 25¢** for your copy – Refunded with your first order.

BC-645 TRANSCEIVER 15 tubes, 435 to 500 Mc. Easily adapted for 2 way voice or code on Ham, Mobile, Television Experimental, and Citizens Bands. With tubes, less power supply in factory carton, BRAND NEW..... **$16.95**



TRANSMITTER has 4 tubes: WE-316A, 2-6F6, 7F7
RECEIVER has 11 tubes: 2-955, 4-7H7, 2-7E6, 3-7F7
RECEIVER I.F.: 40 Megacycles
SIZE: 10-1/2" x 13-1/2" x 4-1/2". Shpg wt 25 lbs.

SPECIAL PACKAGE OFFER: BC-645 Transceiver, Dynamotor and all accessories, including mounting, UHF Antenna Assemblies, control box, complete set of connectors and plugs.
Brand New **$26.95**

AN/APR - 4Y FM & AM RECEIVER "FB" for Satellite Tracking! High precision lab instrument, for monitoring and measuring frequency and relative signal strength, 38 to 4000 Mc. in 5 tuning ranges. For 110 v 60 cycle AC. Built-in power supply. Original circuit diagram included. Checked out, Perfect. LIKE NEW.................. **$88.50**
All tuning units available for above.

TG-34A CODE KEYER, self-contained, automatic, reproduces code practice signals from paper tape. 5 to 12 WPM Built-in speaker. Brand new with tech manual. takeup reel and AC line cord. ... **$24.50**
Code practice tapes for above P.U.R.

WILLARD 2-VOLT STORAGE BATTERY
Rated at 20 Amp.-Hours. Model 20-2. Rechargeable. Compact nonspill construction. Lightweight polystyrene container, 3x4x5 1/2". Shipped dry, uses standard electrolyte. Shipping Weight 3 lbs. NEW, each............. **$2.79**

HEADSET
Low impedance. With large chamois ear cushions. 4-ft. cord and plug. Reg. $12.50. OUR SPECIAL PRICE.......... **$2.95**
High impedance adaptor for above .... 69¢

SCR-274-N, ARC-5 COMMAND SET HQ!

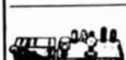
Freq. Range	Type	Exc. Used	Like New	BRAND NEW
RECEIVERS.	Complete with Tubes			
190-550 Kc.	BC-453	$16.95	$23.50	$27.50
3-6 Mc.	BC-454	$16.50	$19.50	$22.50
6-9.1 Mc.	BC-455	$14.95	$17.95	$21.50
1.5-3 Mc.	R-25	—	$19.50	$21.50
TRANSMITTERS.	Complete with Tubes			
4-5.3 Mc.	BC-457	$ 8.95	—	$11.95
5.3-7 Mc.	BC-458	$ 8.95	—	$11.95
7-9.1 Mc.	BC-459	—	—	$23.50

ARC-R11A Modern Q-5 Receiver 190 - 550 Khz $10.95
ARC-R22 540 - 1600 Khz Receiver with tuning graph $15.95
R-4/ARR-2 Receiver 234-258 Mhz, 11 tubes, NEW $8.95

SCR-625 ARMY MINE DETECTOR Complete $32.50
EE-8 SIGNAL CORPS FIELD PHONES...................... $16.95
T-30 THROAT MIKE, NEW......... 59¢ USED............. 39¢
T-17 MICROPHONE, NEW......$8.50 USED, checked out $4.95
BC-605 INTERPHONE AMPLIFIER, NEW $3.45 EXC. USED.... $1.95
TELEPHONE HANDSET, W.E. type............LIKE NEW $2.95
SCR-522 TRANSMITTER-RECEIVER, with 18 tubes. LIKE NEW $32.50

AM-300/AIC PUSHPULL AMPLIFIER
4-tube PP power amplifier with dynamotor, works on 28 VDC. Automatic gain control.
Shpg wt 15 lbs. LIKE NEW................ **$4.95**

FREQUENCY METER MODEL LM
Fine general purpose Navy unit, range 125 to 20,000 Kc. Operates on 12/24 VDC & 200V 10 Ma DC. Complete with tubes, crystal, calib. book.
Checked out, EXCELLENT USED......... **$59.50**
As above, less book $24.50 AC Power Supply.$19.50



McELROY AUTOMATIC KEYER for keying transmitter or for code practice. Photoelectric cell & sensitive relay. Variable speed motor 110V 60 cy
Complete with tubes, EXC. USED **$11.25**

BC-733 RECEIVER Receives radio signals being transmitted by US satellite on approx. 108 Mc. AM, crystal-controlled on 6 preset freqs. in 108.3 to 110.3 Mc range. Operates on 12/24 V DC & 220 VDC 80 Ma. Complete with 10 tubes. Can be converted to FM Receiver 80 to 108 Mc. Exc. Used............ **$5.95**
BC-732A Control Box for above, NEW... 1.75

T-41 / APS - 18 TRANSMITTER ANTENNA UNIT designed for 115 V 800 to 1400 cps. Tubes included are two 15E and one 15R. Complete with shock mounts and blower motor. 7x8x18", NEW.... **$7.45**

RADIO SET AN/ APR-21 TRANSMITTER & RECEIVER . Freq. modulated 152 to 174 Mc. Operated on any preset frequency within VHF range 152-174 Mc FM. Reliable voice communication over moderate distances. Includes antenna, handset H-33 and two carrying straps.
Size 12x8-1/4x5-3/4. Wt 15 lbs.
LIKE NEW, complete **$69.50**

AM-26/AIC PHASE INVERTER AMP.
4-tube pushpull power amplifier. Carbon mike input, hi-lo imp. output. Works on 24VDC. Easily converted to dandy 9-watt amplifier. Complete with tubes and dynamotor
LIKE NEW **$6.95**

DUAL AMPLIFIER has two input circuits each feeding a single 6SN7GT twin triode amplifier. Complete with 115V 60 cy. power supply using 6X5GT rectifier. NEW........... **$5.95**

IP-69A/ALA-2 INDICATOR 3" scope. Front panel controls: Vertical Pos.; horizontal pos. intensity, focus, gain, width, center freq. Pan. Operates on 115 V 380 to 1000 cps. Complete with tubes. LIKE NEW...... **$24.50**

BC-929 US GOVT SCOPE INDICATOR
Compact radar display unit uses 3BP1. A favorite with TTY fans as foundation for converter with cross-line scope presentation. Also for Hams: Modulation-monitor foundation.
Complete with all tubes. LIKE NEW.... **$16.95**

TG-5B TELEGRAPH SET for code communications or code practice. Portable, with hinged lid. Two or more units operate up to 25 miles apart. Bell call system, 1000 cycle howler, key, headpiece, canvas case, book.
Size 5-1/2x5-1/2x10". NEW........... **$8.95**

TS-100AP TEST OSCILLOSCOPE Small portable instrument used to test and calibrate range measuring circuits of radar systems. Used for viewing short video pulses on 3" screen. Power supply: 115 or 230 V 50-1200 cps.
Complete with plugs, cables............ **$59.50**

TS-126/AP RANGE CALIBRATOR TEST SCOPE Top quality 2" scope with all positioning, focus, gain and intensity controls.
Complete with tubes and cables, NEW. **$24.50**
Demilitarized, like new................. $13.75

TELEPHONE TYPE RELAY
Made by J.H. Bunnell, has adjustable sensitivity. 150 ohm coil. NEW...... **$3.45**

T-28 / APT TRANSMITTER radar jamming covering freq. 140 to 210 Mc. Osc. Amp. Plate, Grid Plate & Mixer Plate controls on front panel. Complete with tubes. 7-1/2x10x20"
Wt 40 lbs. NEW.................... **$32.50**

TERMS: 25% Deposit with order, balance C.O.D. -or- Remittance in full. Minimum order $5.00 F.O.B. NYC. Subject to prior sale and price change

G&G RADIO ELECTRONICS COMPANY
45-47 Warren St. (2nd Fl.) New York, N.Y. 10007 Ph. 212-267-4605

QSL'S — BROWNIE W3CJI — 3111B Lehigh, Allentown, Pa. 18103. Samples 10¢. Cut catalogue 25¢.

VIRGINIA STATE ARRL CONVENTION — May 22-23. War Memorial Building, Vinton, Va. Largest Flea Market in the Roanoke Division. All dealers invited. All space free. Saturday night Round & Square Dance. $1.00 per person. Registration: $1.50 ea, 4 for $5.00. Write: Roanoke Valley ARC, Van Wimmer, WA4BIX, Rt. 4, Box 446, Salem, Va. 24153

STOLEN from Red Cross emergency communications truck in Wichita, Kansas: Drake R-4B Receiver serial #11125G; Drake T-4XB transmitter serial #16428R; Gonset "Communicator II" 2M Transmitter-receiver; Gonset 2M VHF Power Amplifier. Anyone with information contact the Wichita Police Dept., 114 E. William, Wichita, Kansas 67201, phone 316-262-2611.

MICHIGAN — 24,000 square ft. for the Blossomland Amateur Radio Association 4th annual auction and Swap-Shop at Shadowland Ballroom, St. Joseph-Benton Harbor, Mich. Sunday, March 14th 9:00 a.m. to 4:00 p.m. Hot food. Prefer to do your own selling? Rent one of our swap tables. If that fails let our skilled auctioneer put your gear on the block. Direct inquiries to B.A.R.A., Box 175, St. Joseph, Michigan 49085.

TELETYPE #28 LRXB4 reperforator-transmitter "as is" $100; checked out $175. Includes two 3-speed gearshifts. Alltronics-Howard Co., Box 19, Boston, Mass. 02101. 617-742-0048.

UHF BASE STATION Antenna for sale. Comm. Products #541-509 7db omni 10db offset. With clamps, like new. Andrew Mueller, Germantown, Wisconsin 53022.

HRO-60. "B" slicer, manuals, A,B,C,D,AC coils and case, headphones, some spare tubes, excellent condition. 8 40m. xtals, 6 position xtal switch, $35, best offer. You ship. Jon Ahlquist, 205 Bender, University of Northern Iowa, Cedar Falls, Iowa 50613.

SELL: SB-101 with 400 Hz filter, SB-600 and HP23A $370; SB-500 2M transverter 28 MHz IF $169; Hallicrafters HA-6 6M transverter wth supply $150; Eico 753 transceiver and 751 supply $150; beautiful homebrew 6M linear, single 7034 $50 less HV supply. James Coulter, K8HKQ, 191 Union, Hillsdale, Michigan 49242.

GREENE — center of dipole insulator with . . . or . . . without balun . . . also the GREENE DRAGON FLY antenna . . . send for free flier . . . GREENE, Box 423, Wakefield, R. I. 02880. W1CPI.

826 TUBES wanted for cash. C. Hutnan, 308 Hickory Street, Kearny, N. J. 07032.

IMPORTANT — ROCHESTER location for W.N.Y. Hamfest and VHF Conference, May 15th, has been changed. Send for map and program. Write WNY Hamfest, Box 1388, Rochester, N. Y. 14603.

THE CHICAGO SUBURBAN RADIO ASSOCIATION will hold its annual "Hamboree" on March 21, 1971 at the Operating Engineers Hall, 9200 West Joliet Road, La Grange, (Countryside) Illinois. All Hams and the public are invited. The latest amateur radio equipment will be on display. All Hams are invited to come out and display or sell any products or items they wish free of charge. The exhibit hall has 10,368 square feet of exhibit space. Ample paved parking space will also be available at no added charge. Drawings for three grand prizes valued at $1000 plus a number of lesser value prizes will be held during the one-day Hamboree. All those who attend will be eligible for the drawings. A donation of $1.50 per person at the door. Advance tickets for only $1.00 may be purchased from: Mr. Wilson Thomas (W9KWA), 4017 Vernon Avenue, Brookfield, Illinois 60513.

AM PREPARING an article on busy and creative persons over 65. Would like to get in touch with any who are hams. L. H. Dick, R. D. 3, Box 374, Newton, N. J. 07860.

NOVICE CRYSTALS: 40-15M $1.38, 80M $1.83. Free flyer. Nat Stinnette Electronics, Umatilla, Florida 32784.

BOOKS: Don't miss our ad on pages 48 and 49 Comtec.

B A R R Y

COAXIAL DUMMY LOAD B & W Waters CDL-1K. 1500 Watt Ohm Dummy Load. DC to 150 Mhz. Brand new with built-in Fan (115 VAC) Orig. **$280.00 net. Sale $80.00**

B&W/WATERS TPC-120 W Transistor Power Supply. 120 Watt 12 V. Input 500/250/660 Volts out at 120 Watt total. Brand new. (2 lbs.) Reg. $57.80 **Sale $36.00**

WATERS MODEL 346 Nuverter. 2 & 6 M VHF converter. New. Orig. $175.00 net. **Sale $80.00**

B & W BBC-3.5 K PLATE CHOKE. 2 to 30 Mhz. 5 KV and 2 amperes. Brand new. Orig. $25.00 plus. **Sale $6.00**

COLLINS — 75A1 Receiver **$195.00**

COLLINS — 75A4 Receiver **$350.00**

COLLINS — 32V2 Xmtr **$175.00**

TMC — GPR-90 RDX w/TMC GSB-1 — (a $2000. net value) **$495.00**

HP-415B SWR METER, good @ **$89.95**

HP-5214L PRESET COUNTER, xlnt @ **$495.00**

HP-491A TWT AMPLIFIER, 2-4 GHZ @ **$125.00**

HP-492A TWT AMPLIFIER, 4-8 GHZ @ **$125.00**

HP-430CR BOLOMETER BRIDGE, good @ **$89.95**

HP-200AB AUDIO OSCILLATOR, needs work @ **$75.00**

HP-X810B SLOTTED SECTION, good @ **$39.95**

HEATH IO-18 5″ LAB SCOPE new, wired @ **$95.00**

SILICON BRIDGE RECTIFIER. Tested at 6000 volts and 1 Amp. (4 separate rectifiers mounted on Nylon card.) 2 oz. **Sale $4.95**

RAYTRACK DX 2000L. 2000 W. PEP Linear Amplifier. 10 thru 80 meters. (115 V or 230 aAC @ 50/60 Hz.) Uses pair of Eimac 3-500Z's. **$699.00** with separate 42 lb. supply.

ROTRON HIGH-POWER BLOWER. 110/220V. 50/60 Hz, 3350 RPM. 6″ Dia. wheel. 1¼ x 2⅝″. (r/e) **$17.95**

COLLINS CHOKES: 4 Hy @ 500 Ma. 2.5 KV at **9.95;** 12 Hy @ 500 Ma. 12 KV at **$19.95**

D.P. TRIPLE THROW HEAVY DUTY R.F. SWITCH. 2 KW. Ceramic insul. Sil. plated contacts. **$6.95**

4 SECTION 4 POLE MULTI-POSITION SWITCH. Ceramic insul. Silver plated contacts **$9.95**

1000 WATT INLINE WATT METER. 1000 Watts continuous, 2-30 Megahertz, Dummy Load Position, 3 scales: 0-10, 0-100, 0-1000 Watts, VSWR Function, 50 Ohm impedance. This 1000 Watt wattmeter absorbs negligible power; continuously monitors radiated power. A two-way load switch permits rapid change from dummy load to antenna, or between two antennas. NEW. **Only $39.95**

WIDE-VUE 4″ PRECISION METER, 0-1 MA, brand new @ **$4.99**

HALLICRAFTERS SX-73, SIMILAR TO SP-600 @ **$295.00**

HUNTER BANDIT 2000B, with (4) new 572B tubes @ **$275.00**

HATFIELD (ENGLISH) DELUXE BALUN MODEL B60 (52 to 75 ohm @ **$9.95**

HATFIELD (ENGLISH) DELUXE BALUN MODEL B61 (75 to 75 ohm) @ **$9.95**

RCA 1000.000 Khz CRYSTAL. **Only $3.50**

ROHN GROUND OR ROOF MODEL #25G (40 foot) **COMMUNICATIONS TOWER** finest heavy guage 1¼″ steel tubing, hot-dip, galvanized, complete with hardware. **$207.00** (Specify grnd. or roof mount.) FOB factory, Ill.

CASH PAID . . . FAST! For your unused TUBES, Semiconductors, RECEIVERS, VAC. VARIABLES, Test Equipment, ETC. Write or call Now! Barry, W2LNI. We Buy!

We ship all over the World. DX Hams only. See Barry for the new Alpha 70. (See front inside cover of this magazine.)

☐ Send 35¢ for 104 page catalog #20.

BARRY ELECTRONICS
DEPT. H-3 — PHONE A/C 212-925-7000
512 BROADWAY, NEW YORK, N. Y. 10012

DRAKE C-4

Station Console puts you in COMPLETE CONTROL

Model C-4 Amateur Net **$299.95**

Puts complete station control at operator's fingertips . . .

• **24 hour digital clock**—lighted, shows correct time to the second • **Solid state resettable timer** flashes light at identification intervals • **Station power control** with eight 120 VAC and two 240 VAC receptacles, front panel controlled heavy duty power contractor • **Equipment control switch** for changing exciters, rcvrs., etc. • **Directional RF wattmeter** with 200 or 2000 W full scale • **Built-in rotor control** for Ham-M • **Electronic phone patch** gives const. xmtr input, works PTT, meets phone co. requirements • **Remote motor-driven coax switch** selects from 5 antennas • **Dimens:** 10¾″ W x 5½″ H x 12¼″ D., **Wt.** 24 lbs.

Available at your local distributor.

R. L. DRAKE COMPANY **540 Richard Street Miamisburg, Ohio 45342**

More Details? CHECK—OFF Page 94

THE ONLY AUTHORITATIVE QRPP handbook: The Milliwatt: National Journal of QRPP. 125 pages, 10 QRPP transmitters, 2 receivers, accessories; Operating News, Log Selections, QRPP WAS/DXCC standings; articles on technical subjects for the QRPP operator. Volume I, $4.00. SASE for table of contents. Ade Weis, K8EEG/0, The Milliwatt, Meckling, SD 57044.

THE MAARC ANNOUNCES the 1971 ARRL Great Lakes Division Convention. Date: March 27, 1971. Place: Muskegon Community College, Quarterline Road, Muskegon, Michigan. Advance tickets $2.00, at the door $2.25. Large swap & shop, meetings for all MARS programs, VHF repeater program, net & traffic meetings, RTTY forum program, Ham TV program, races-CD program, midcars program, QWCA meeting, and many more. Complete luncheon facilities, parking for over one thousand cars. Easy access: Interstate 196 & US-31 to Muskegon; Junction of US-31 & Michigan 46. Complete new and comfortable facilities. Muskegon Area ARC, Box 691, Muskegon, Michigan 49443.

TRADE, SELL: Used receivers. Trade for new amateur equipment. Available HQ-180C, R-4A, HQ-200, NC-190, SX-110, 2B, HW-16, GPR-90, SX-130, Eimac 4-1000A, PL 8160/4-1000A, S-Line, Nems-Clarke 1456A, S-36. Send for current list. Steven Kullmer, Evergreen Hatchery, Dysart, Iowa 52224.

SETH THOMAS DIGITAL CLOCKS with seconds indication reg. $27.95 value only $13.95 postpaid while they last. Laboratory clear, for sale or trade: Singer Meterics Spectrum Analyzer SPA#3 200CPS-15MC R/mount $800.00 new cost $3500.00, HP520A 10 MC scaler R/mount $75.00, GR805C sig. gen. 500KC-50MC cal. output $250.00, ME74/U AC VTVM like new $50.00, TS375A/U AC-DC VTVM like new $50.00, SP 600 JX rec. 500KC-54MC retubed recal. our lab. $275.00, manuals are included all units. Want HP608D,E,F, or 390A series rec. Wawasee Electronics Co., P. O. Box 36, Syracuse, Indiana 46567.

ELECTRONICS YOUR BAG? Looking for an electronics course . . . that you can pay for by the subject AND take ONLY the subjects you NEED? . . . that you can change into ANY PHASE of electronics after completion of basics WITH NO PENALTY? For full information, write: EDCO ENTERPRISES INC., P. O. Box 432, Sparks, Nev. 89431.

TOROIDS 44 and 88 mhy. Unpotted, 5 for $1.50 ppd. W. Weinschenker, Box 353, Irwin, Pa. 15642.

WORLD QSL BUREAU — See ad page 90.

PLEASE, need type H coil for old HRO receiver. Also want J & G, Cash or trade. W2IMB, P. O. Box 721, Westfield, N. J. 07090.

WANTED: JOHNSON VIKING NAVIGATOR transmitter. WA9WGT, tel: 715-623-3107.

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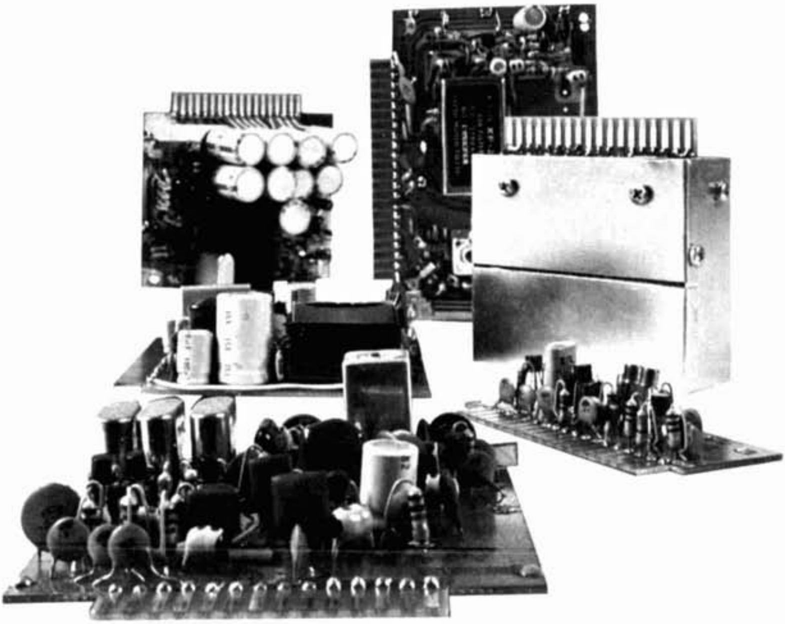

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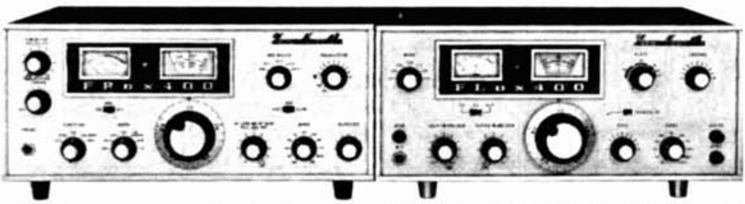

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