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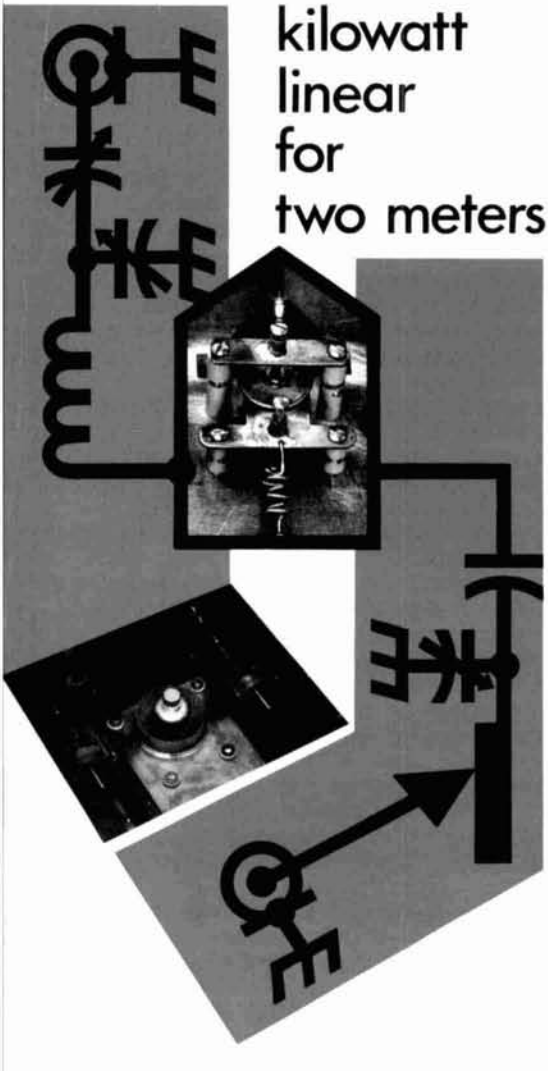

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Monte Carmelo (MG) Brazil

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march 1969

volume 2, number 3

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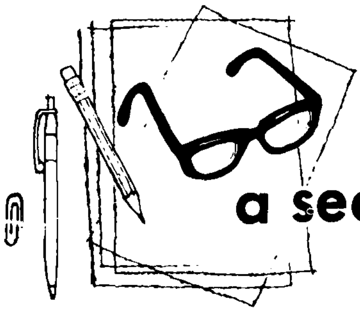

a second look by jim fisk

How many times in the last twelve months have you heard somebody comment to the effect that the days of creative basement and backyard engineering were over? With lasers, Gunn oscillators, fancy semiconductors and all the other esoteric paraphernalia that is announced every day by the scientific community, I would tend to agree. But occasionally there is a glimmer of hope—within the last two weeks I have heard of two cases where amateurs have made important contributions to the rest of the electronics world.

The first item concerns a Canadian, Syd Horne, VE3EGO, and an engineer friend, Doug Watson. Syd became interested in slow-scan television several years ago and was at the North American end of the first trans-Atlantic slow-scan television link. After experimenting with equipment originally designed by WAØNLQ, Syd recognized some of its limitations. Slow-scan requires eight seconds per frame, so any adjustments the operator makes in focus, brightness or contrast are difficult because it takes eight seconds to see the results; also, slow-scan vidicons are expensive. Doug Watson, after some prodding from Syd, came up with a solid-state camera and monitor which uses a fast-scan vidicon with sampling techniques to provide a slow-scan output. With this system, any adjustments are immediately visible and pictures are brighter and of higher quality.

The other development I heard of recently involves a new family of antennas that have performance characteristics that are pretty extraordinary—simple construction, switchable vertical or horizontal polarization, wideband and apparently, equal-to-rotary-beam performance. These antennas are the invention of George Bonadio, W2WLR, and are the result of backyard engineering work going back to 1953. At that time he was using a Windom antenna and wanted to broadband it. He took two Windoms, put them back to back, flared out the ends for broadbandedness, and found they presented a very broad reactance curve.

Experiments with different feeds, antenna tuners and element arrangements resulted in a family of four antennas with performance characteristics that apparently cannot be explained with the normal rules. A patent has been issued for the first antenna—the square-diagonal—and patents are pending on two and applied for on the last.

Some details of these exciting new antennas will be featured in next month's issue of **ham radio** along with the new sampling sstv camera and monitor from Canada. Although the slow-scan equipment was not completely amateur developed, since most of the design work was done in an industrial R & D lab, much of the ground work and certainly the concept stemmed from amateur slow-scan work. On the other hand, the family of Bonadio antennas was completely amateur conceived and amateur developed.

Jim Fisk, W1DTY
Editor

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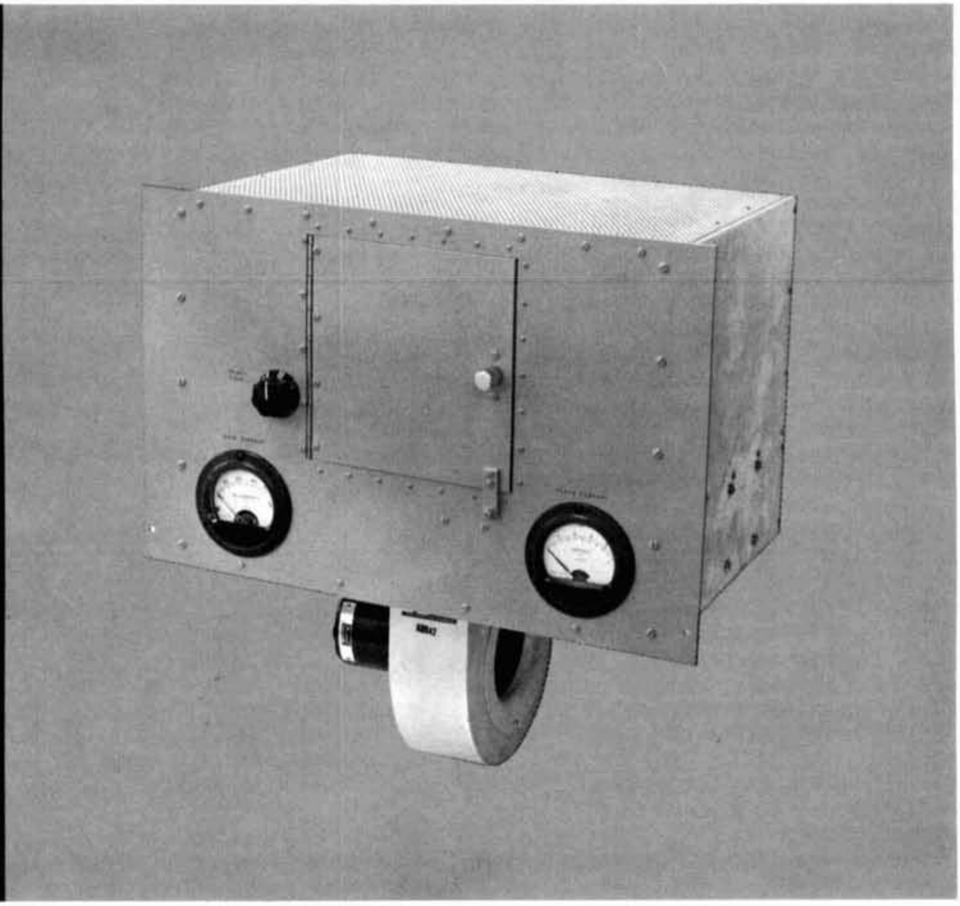


design data for a two-kilowatt vhf linear

The input matching network and plate circuit are unique in this strip-line amplifier– self neutralization is also featured

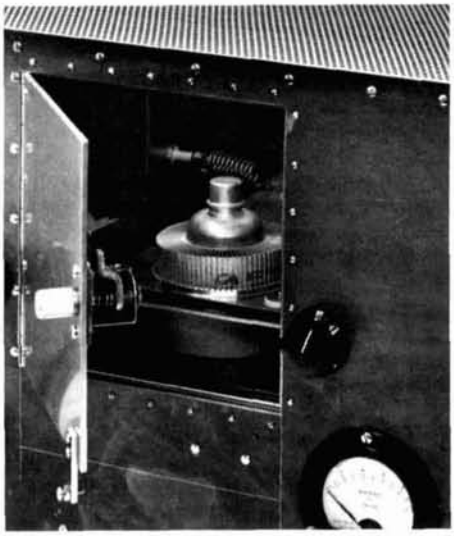
Robert I. Sutherland, W6UOV, Power Grid Development Lab, Eimac Division of Varian, San Carlos, California 94070

This article describes the design of a 150-MHz, 2000-watt PEP input, grounded-grid linear amplifier. I built this amplifier to conduct life tests and determine the performance characteristics of the new Eimac 3CX1000A7 high-mu ceramic triode at 150 MHz. Many of the design techniques and performance figures at 150 MHz will be of interest to the serious vhf and uhf experimenter. By changing the cathode matching network and the plate line length, this amplifier would be excellent for the 144-148 MHz band.

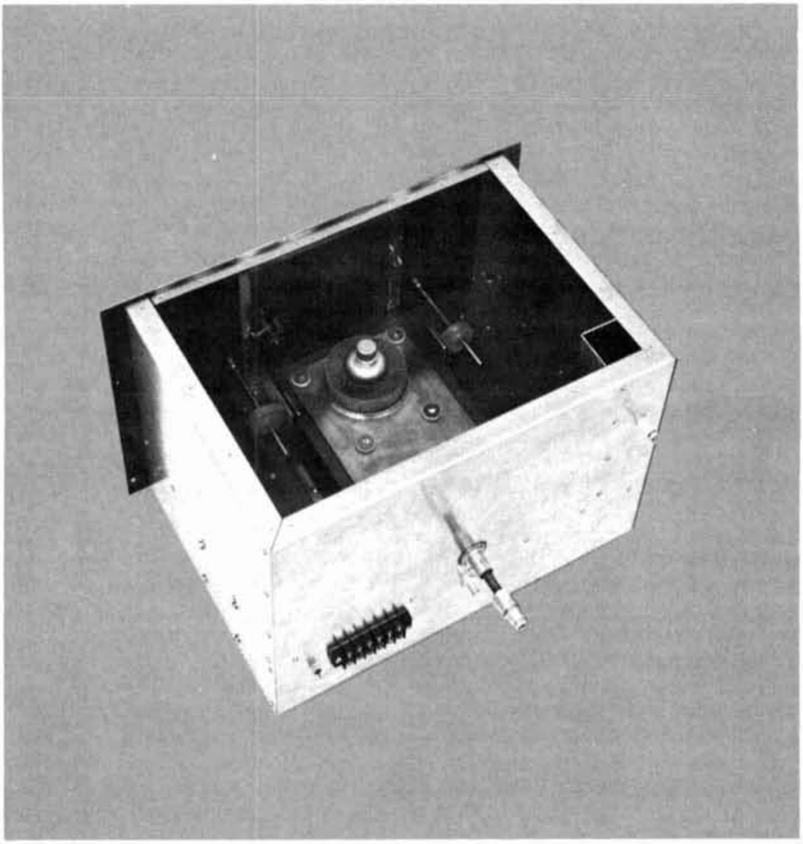
Several propagation modes, in which the maximum legal input power can be justified, are possible in the two-meter band. Meteor scatter, moonbounce, forward scatter and tropospheric bending are but a few.

Running the full, legal one-kilowatt aver-

Amplifier with the access door open; the 3CX1000A7 can be seen mounted in the plate line.



age power input to the final amplifier in the cw and ssb mode has been fairly easy in the region between 2 and 30 MHz with the large selection of power tubes and circuits available. At these frequencies, many small tubes can be paralleled to develop also use four such tubes to develop an average plate input power of 1 kW for ssb radiotelephone service, with reasonably low intermodulation distortion. A single 4CX1000K can be used to give 1 kW average input power, under voice conditions,



Top view of the amplifier with the shield removed. The variable tuning capacitor on the left was changed in the final model to a fixed capacitor. The output coupler coax may be seen protruding from the back panel.

power-handling capability. At 144 MHz, however, tubes that will handle 1-kW average power with good efficiency, stability and reliability are few, and large arrays of television sweep tubes are impractical.

choice of tubes

Many successful amateur designs have been built for 144-MHz, 1-kW continuous duty (single-tone) using the 4X150A, 4CX250A and 4CX300A tetrodes. Generally, two tubes are used in push-pull. You can in a 144-MHz amplifier[1] with good efficency, stability and low drive.

Many popular high-frequency amplifiers, using zero-bias glass triodes such as the 3-400Z, 3-500Z, and 3-1000Z, are now being used in grounded grid. The 3-400Z and 3-1000Z have been used successfully in 150-MHz grounded-grid amplifiers, but neutralization is difficult.[2] The 3CX1000A7, a zero-bias, ceramic, high-mu triode is now available, which simplifies these problems. It is well-suited for vhf.

The 3CX1000A7 is electrically similar to the 3-1000Z. The amplifier described in the following paragraphs uses this metal-ceramic tube in a circuit for 150 MHz, and it has all the advantages of zero bias and grounded grid. Bias and screen-voltage supplies aren't required. Stage gain is high, and neutralization is simple and effective.

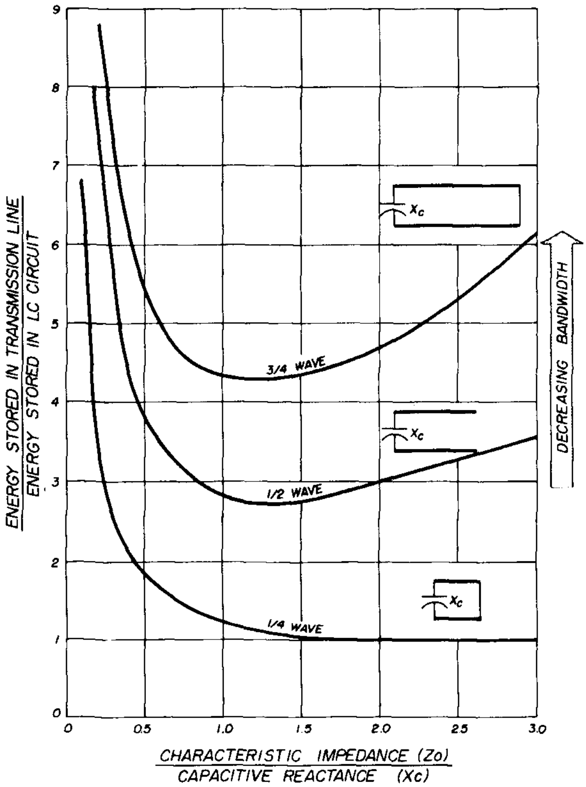


fig. 1. Frequency dependence of tuned transmission-line segments as compared to an LC circuit. Zo is the characteristic impedance of the line and Xc is the capacitive reactance acting on the sending end of the line.

the plate circuit

The choice of the plate circuit is important in the design of a vhf amplifier. I used a strip-line amplifier because it requires less machining.[3] A brake, shear and drill are all that are required. These tools are found in any well-equipped metal shop. You could do the job yourself with a hacksaw, file, drill and some perseverance.

The plate tank has a characteristic impedance, Z_0, of 60 ohms. The higher the impedance of this part of the circuit, the less will be the Q in the line; consequently, you will have a greater bandwidth. A wide bandwith isn't necessary to pass the modulation frequencies, but it is desirable if you want to eliminate a trimming device. A large amount of heat must be dissipated by the plate circuit, and if the circuit Q is low, the tank circuit will not detune as rapidly as it would with a high-Q circuit.

There's a practical limit as to how high you can make the plate strip-line impedance. Tube output capacity, plus strays, will limit the impedance and length of plate line:

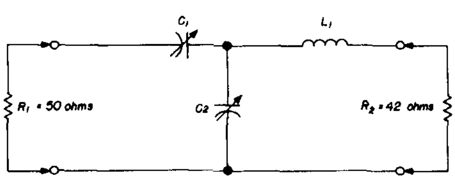
$$X_c = Z_0 \tan L$$

where:

X_c = tube output reactance.
Z_0 = characteristic impedance of plate line.
L = line length in electrical degrees.

For a quarter-wave line, $Z_0/X_c = 2$ is adequate (**fig. 1**).

The plate strip-line is also useful for making a sandwich-type blocking capac-



$R_1 > R_2$

$$X_{L1} = Q_L R_2$$

$$X_{C1} = R_1 \sqrt{\frac{R_2(Q_L^2+1)}{R_1} - 1}$$

$$X_{C2} = \frac{R_2(Q_L^2+1)}{Q_L} \cdot \frac{1}{1-(X_{C1}/Q_L R_1)}$$

Q_L = LOADED Q OF NETWORK

fig. 2. The schematic and equations used to calculate the input matching network. For this amplifier, R1 = 50 ohms, R2 = 42 ohms and assigned loaded Q is 2.

itor. In this strip-line assembly, a 10-mil-thick piece of **Isomica** was used for the dielectric. Mylar or teflon could be substituted with good results.

Output coupling is by a sliding contact on the inside surface of the plate line. As the sliding contact moves toward the anode, the area of the pickup loop increases, thereby increasing the coupling.

the input circuit

The input, or cathode tuned circuit, is a T network designed to match a 50-ohm coaxial line to the 42-ohm cathode driving impedance of the 3CX1000A7 (**fig. 2**).

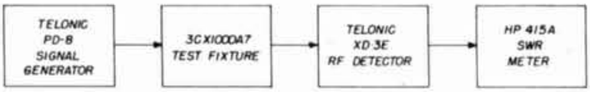
The EIMAC SK-870 socket mounts directly on the chassis with the control grid contacts in contact with the chassis; that is, the control grid is at dc ground. The grid current is metered in the cathode return lead. The SK-870 socket is modified, as described later, to accomplish neutralization.

The driving impedance of the 3CX1000A7, in grounded-grid operation, is 42 ohms in parallel with about 20 pF of input capacitance. In order to simplify the design of the input circuit, it is assumed that the input to the 3CX1000A7 is resistive only. By making the matching network components variable, it's possible to resonate the input network, including the 20 pF of tube capacitance, while accomplishing the desired match.

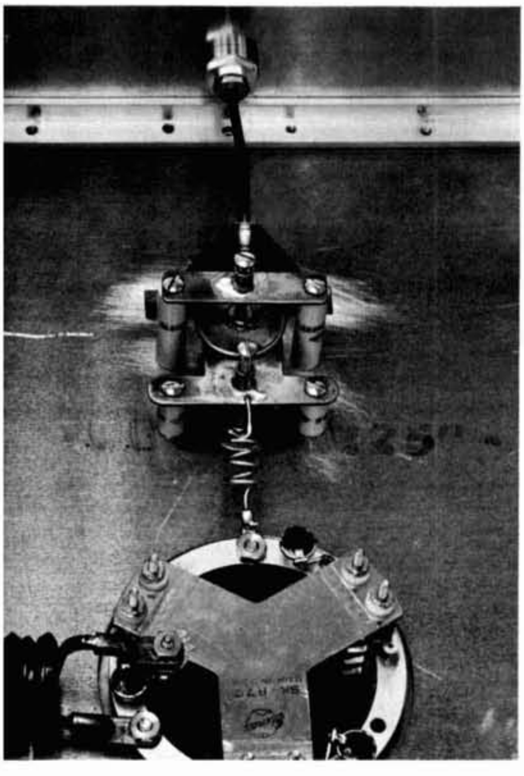
Fig. 2 shows the matching network and the design equations used. Under full plate-current load, the input match is adjusted to a 1:1 vswr, because only under full-load conditions will the tube input resistance be at the design value of 42 ohms. It's possible, however, to adjust the input network without the amplifier operating. Measure the resistance of a good-grade 42-ohm carbon resistor on an impedance bridge, then place the resistor between grid and cathode. The filament and all other voltages on the 3CX1000A7 must be off for this adjustment. A small amount of drive is applied through a standing-wave bridge. The input network is then adjusted for a 1:1 vswr at the operating frequency.

The "cold" adjustment won't be exactly correct, but the technique does allow the network to be tested and closely adjusted before application of power. The final adjustment is done with all voltages applied to the amplifier and tube with the 42-ohm carbon resistor removed.

fig. 3. Block diagram of the test set-up to determine the self-neutralizing frequency of the 3CX1000A7 triode and SK870 socket.



The input matching network in relation to the tube socket at the input coax line. The coil between the socket and the variable capacitor assembly is L1. The coil in the lower left-hand corner is the bifilar filament choke.

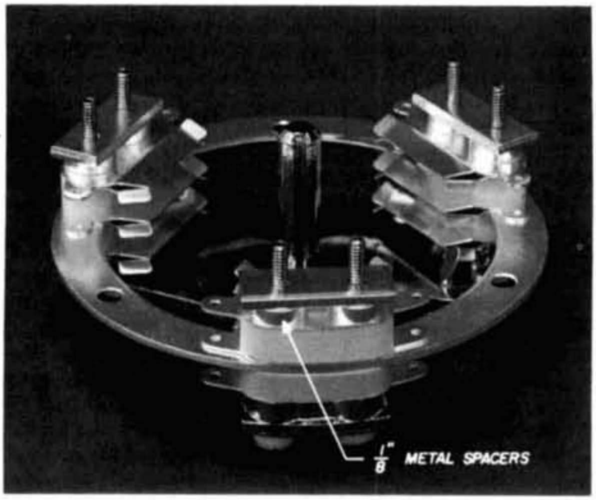


self-neutralizing frequency

The 3CX1000A7 and SK-870 were tested in a special test fixture that treats the tube and socket as a four-terminal network. The anode was driven by a high power signal generator. The feedthrough signal was then detected on the cathode (see **fig. 3**). The control grid was grounded during this test. A curve was then plotted showing the relative magnitude of the feedthrough signal as a function of the signal-generator frequency.

The radio-frequency signal amplitude on the anode must be kept the same at all frequencies. A frequency will be found at which there is a minimum feedthrough signal; this point is called the **self-neutralizing frequency** of the tube and socket (**fig. 4**). The frequency thus obtained may be used as a guide in the design of a neutralizing circuit for the amplifier.

The Eimac SK870 socket. The six 1/8-inch metal spacers must be removed to neutralize the amplifier.



The graph of **fig. 4** indicates a self-neutralizing frequency of 105 MHz; this is lower than the operating frequency (150 MHz). The amplifier was unstable at 150 MHz before neutralization was applied. To raise the self-neutralizing frequency closer to 150 MHz, it was decided to lower the control-grid lead inductance. The SK-870 socket was modified by removing the six grounding spacers (see photo). These are metal spacers approximately 1/8-inch thick on each of the six SK-870 mounting screws. This modification allows the socket to be mounted 1/8-inch closer to the chassis.

The self-neutralization curve was again run with the same fixture and this modified

fig. 4. Relative input-to-output circuit isolation as a function of frequency before the socket modification. The self-neutralizing frequency is just below 105 MHz.

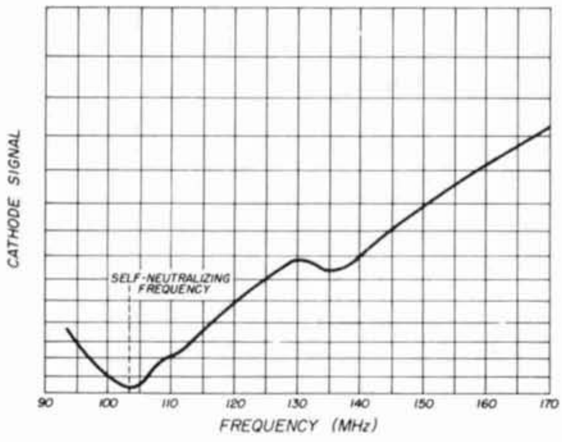


fig. 5. Relative input-to-output circuit isolation as a function of frequency after the socket modification. The self-neutralization frequency has moved up to 136 MHz.

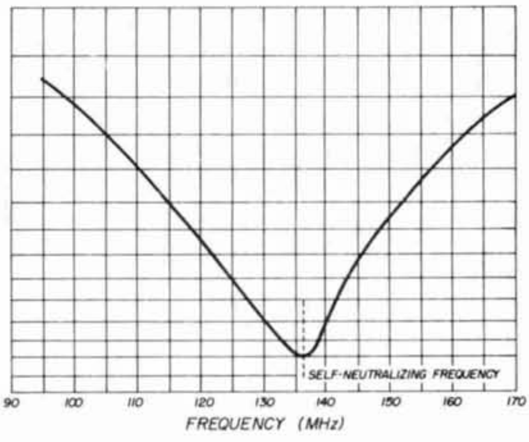
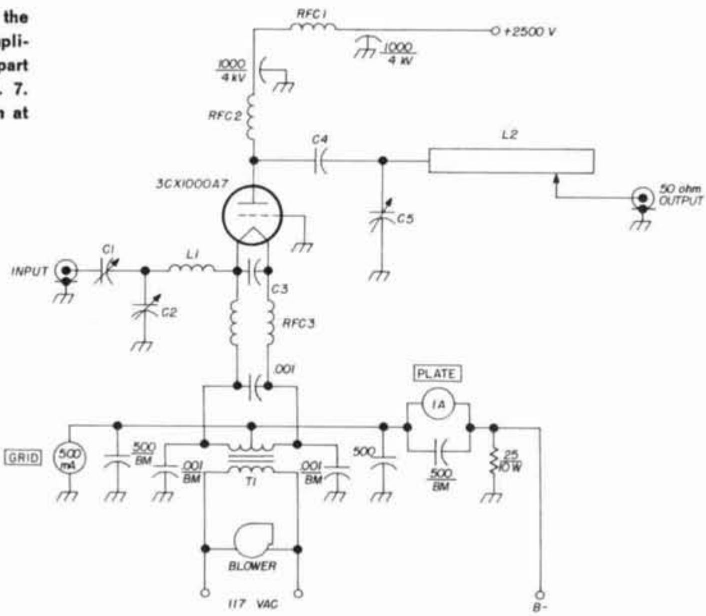


fig. 6. Schematic of the grounded-grid 150-MHz amplifier. C4, C5 and L2 are part of the plate line; see fig. 7. The blower delivers 37 cfm at 0.4 inch of water.



C1	11.9 pF (see matching network photo)
C2	1.06 pF (see matching network photo)
C3	1500 pF. Three 500-pF, 500-V stud-mounted button micas, spaced uniformly around the filament ring
L1	0.089 μH. 3 turns no. 14 wire, 1/16" diameter, 5/8" long
RFC1, 2	10 turns no. 16 tinned, 0.650" OD, 1-1/2" long
RFC3	bifilar coil no. 10 wire, each coil 5 turns, 3/4" ID, 1-5/8" long
T1	5 V, 33 ampere filament transformer

socket. **Fig. 5** shows the results: the self-neutralization frequency has now been moved to 136 MHz. The socket was again mounted in the amplifier, which was then retested for stability. The amplifier was stable, and the power output peak coincided with the plate current dip. Either arrangement of the socket grid return leads raised the self-neutralization frequency sufficiently to achieve stability or the neutralization point is sufficiently broad to include 150 MHz. It wasn't necessary to improve the neutralization further. Undoubtedly this simple socket modification is necessary to achieve optimum stability in the two-meter band.

amplifier assembly

The schematic of the amplifier is shown in **fig. 6**. Note that the circuit is much the same as that of an hf amplifier. Only the

Closeup of the output load coupler. The teflon block, with the fingerstock mounted on top, forms an adjustable loop as it slides back and forth to adjust the loading.

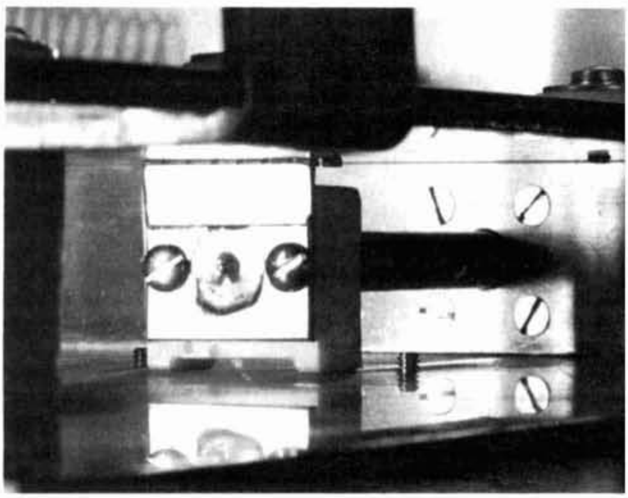


plate tank circuit and the input matching network can be considered unique. The metering of the grid and plate currents is in the negative return leads. The grid is metered in this manner to allow a very low impedance radio-frequency connection between the control grid and the chassis.

As noted previously, this grid circuit is part of the amplifier neutralization scheme, and the use of a grid by-passing arrangement could have complicated the amplifier neutralization. The plate current is metered in the negative return lead in the interest of safety. It is always dangerous to have a plate current meter mounted on the front panel if the meter is operating at a high potential with respect to ground.

A 25-ohm, 10-watt safety resistor **must** be connected between the negative terminal of the plate power supply and ground. If either grid or plate meter should become open circuited, and the plate side of the power supply shorts to ground, the negative side of the plate supply could assume a potential equal to the supply voltage. The 25-ohm resistor will prevent the negative terminal voltage from soaring and will load the power supply sufficiently to cause the fuses, or overloads, to function.

Fig. 7 is a pictorial of the plate line and the dimensions that were used in the 150-MHz amplifier.

operating results

The amplifier has been operating at 150-MHz many hours under the following conditions:

Plate voltage	2500 volts
Plate current	800 milliamperes
Plate input power	2000 watts
Grid voltage	0 volts
Grid current	240 milliamperes
Output power	1175 watts
Drive power	50 watts
Filament voltage	5 volts
Filament current	33 amperes

Note the output power and the required drive power; the power gain is 23.5 times or 13.7 dB.

No intermodulation distortion tests were made at 150 MHz although tests have been run at 2 MHz to determine the tube characteristics. Under the same operating conditions given for 150 MHz, the third-order intermodulation products were no less than 32 dB down, and the fifth-order products were better than 38 dB down from one tone of a two-equal-tone test signal.

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3. William I. Orr, W6SAI, and John T. Chambers, W6NLZ, "Strip-line Kilowatt for 432 MHz," *ham radio*, September, 1968.

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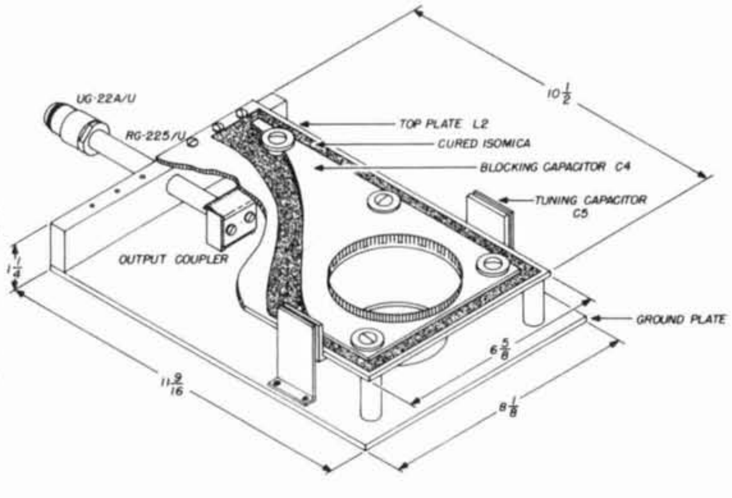
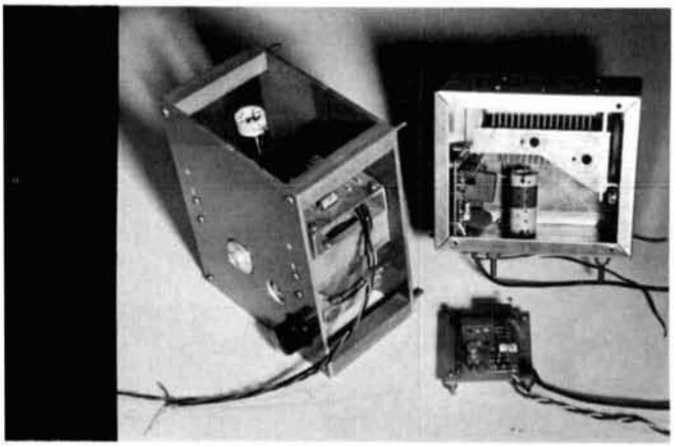


fig. 7. Cutaway view of the 3CX1000A7 plate line. The isomica is the dielectric for tthe plate-blocking capacitor C4. The two support pillars and six insulating shoulder washers are made of teflon as is the sliding output coupler block. The finger contact strip for the anode of the 3CX1000A7 is Instrument Specialties Company no. 97-133. A more detailed drawing of the plate line is available from the author.



simple high-stability variable frequency oscillator

Some experimental and practical construction notes on a stable solid-state Seiler oscillator

Bill Wildenhein, W8YFB, RD 2, Blanche Avenue, Elyria, Ohio 44038

How would you homebrewers like a vfo with less drift than most factory-built ssb gear, very fast warmup, linear dial calibration, a capacity for using a wide variety of silicon or germanium transistors (pnp or npn) without any circuit changes, unusually flat output vs frequency, low cost, compactness and the capacity to be built with simple hand tools? So did I. After building and testing four different vfo circuits, I chose the circuit in **fig. 1** as the most reproducible vfo circuit with good operating characteristics.

circuit

The oscillator circuit I finally selected was W3JHR's (now W3JM) synthetic rock.[1] My first try with this circuit showed that Captain Lee's performance claims were very modest, and some of the circuit advantages weren't even mentioned. My next effort used the same circuit but was ruggedly built in a box of precision-machined hard aluminum with 1/8-inch end plates; this served as a "mechanical standard." This model (oscillator number 1) used two RCA 2N247 germanium transistors.

A second model (oscillator number 2) was built with *plastic-encapsulated silicon transistors* (dc beta about 50) in a 3x4x5-inch aluminum utility box; the layout and circuit board are shown in **figs. 2** and **3.** However, in my unit, the circuit board was not etched; component leads were used for all interconnections. When this much more simple construction was compared to the "mechanical standard," it was obvious that it was completely adequate for single-sideband. If it were included in a complete ssb package, of course, much of the total stability would depend upon the rigidity of its mounting on the main chassis.

The drift characteristics of oscillators number 1 and 2 are plotted in **fig. 4.** Note how closely the drift curves of the two units paralleled one another when the ambient temperature was deliberately forced up 10 degrees. This is a good indication of what will happen if you mount the completed vfo next to a well-stoked 6146! Temperature compensation is definitely in order for chassis position with wild temperature ranges.

The drift runs plotted in **fig. 5** were made with the oscillators covered by small cardboard boxes. Since the first hour of these runs was spent checking out the instrumentation, no warmup drift is shown. With such minimal protection against the temperature effects in my basement—during a particularly cold spell in January—I felt the performance was nothing short of remarkable.

The drift runs plotted in **fig. 6** were made *with oscillator number 2 protected by a 1/2-inch thick styrofoam box.* Warmup drift in curve A was quite reasonable, although a slight improvement was obtained (plotted in curve B) by replacing the metal tuning shaft with a bakelite shaft to minimize heat transfer into the styrofoam package.

The next vfo I built—oscillator number 3—was a try at further miniaturization; I also wanted to check the circuit at higher frequencies. The vfo was built into a small 4x4x2-inch aluminum utility box as shown in **fig. 7.** The feedback capacitors C3 and C4 used in oscillators number 1 and 2 at 3.5 MHz were much too large at 9 MHz; unless I used a transistor with extremely high gain, the circuit wouldn't oscillate. The values I finally used are shown in **fig. 1.**

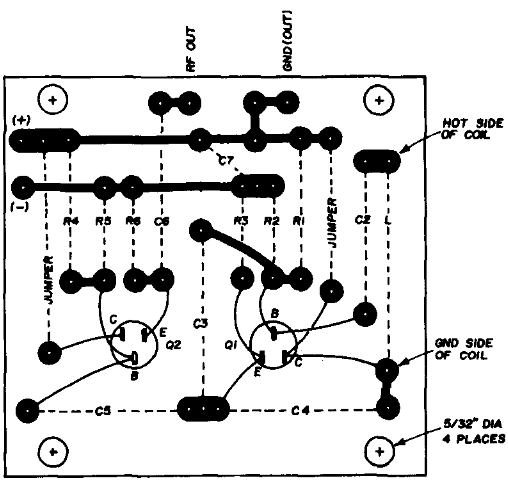
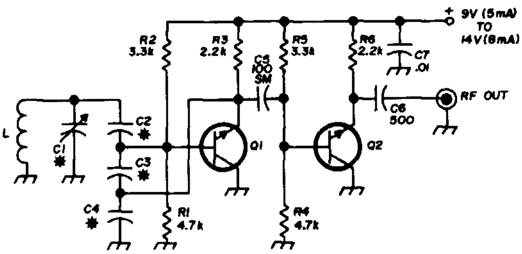


fig. 2. Full-size printed-circuit layout for the vfo shown in fig. 1.

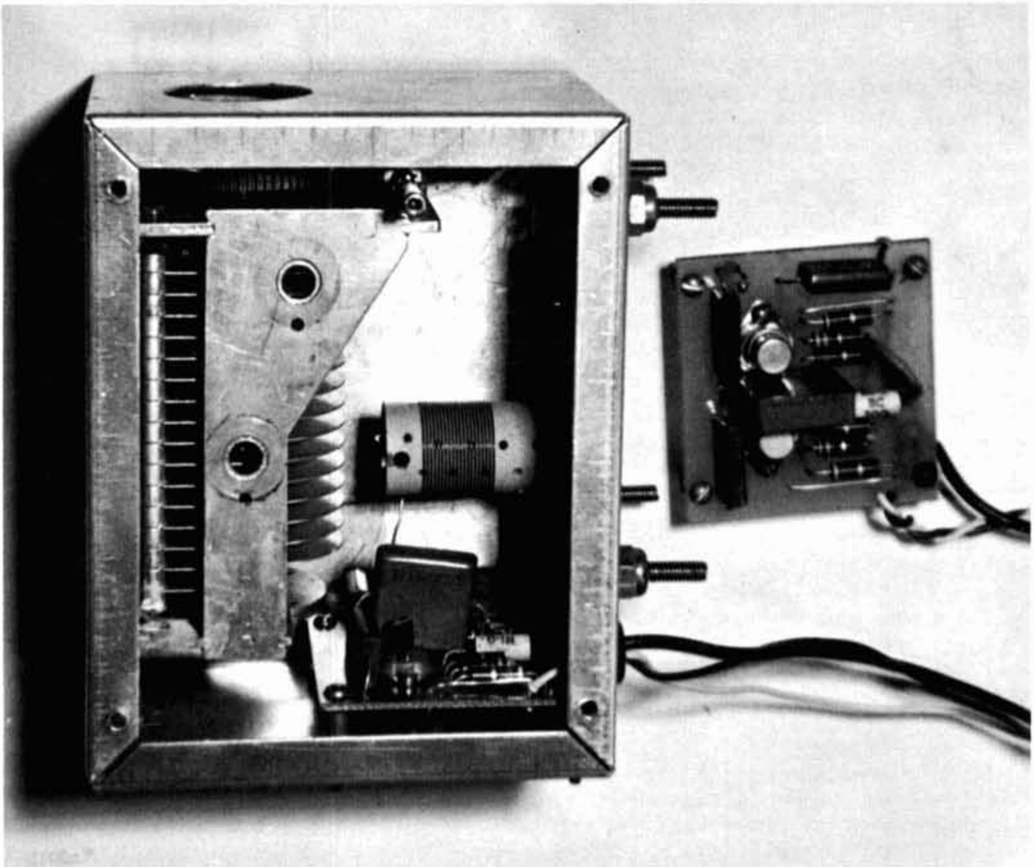


*	VFO 1, 2, 4	VFO 3
C1	150 (ARC-5)	SEE TEXT
C2	100 SM	50 SM
C3	3000 SM	1000 SM
C4	1000 SM	300 SM

fig. 1. This vfo circuit was the most stable of several tried; it was originally developed by W3JHR.

The first variable capacitor I used in oscillator number 3 was a popular low-priced double-bearing 15-pF unit. It was a bit stiff to rotate, and vfo drift was terrible: jumps of 1 kHz in 5 minutes were common each time the dial was reset to a different frequency. This capacitor was replaced by a single-bearing 15-pF Millen 22915 variable. A single-bearing variable is usually not mechanically stable where any vibration is present, but for bench tests it is adequate.

The new Millen capacitor operated very smoothly and required very little torque. The drift run plotted by curve A in **fig. 8** showed promise. The capacitor was then "exercised" by chucking the shaft in an electric drill and running it in a bit while feeding oil to the bearing. Several days later a couple of frequency runs showed that the rotation sticoscillator number 3 will make a useful vfo for vhf work. Another possibility for vhf work would be to put a larger capacitor across the feedback capacitor C4. If a 100-pF variable were placed in parallel with the 250-pF mica capacitor used for C4, the vfo will tune from approximately 8333 to 8500 kHz. This should make a very stable vfo for the low end of 6 meters. The change in feedback should not materially affect over-all stability, although the output voltage may vary somewhat from



tion had been largely eliminated: plot B in **fig. 8** is typical. Further improvements in mechanical stability could probably be obtained by replacing the utility box covers with covers made from 1/8-inch aluminum sheet.

If you have a very smooth capacitor that will fit into a small utility box, the layout of one end of the band to the other.

Since oscillator number 2 seemed to represent an optimum type for general purpose construction, an identical model was built to check reproducibility. An ARC5 tuning capacitor was used but the oscillator was set up for oscillation at 9 MHz. The oscillator transistor was a plastic encapsulated silicon device with dc beta between 400 and 500. As you can see from the drift characteristic plotted in curve B of **fig. 9**, it leaves something to be desired.

This same vfo was then shifted to 2 MHz. At 2 MHz oscillation was easily obtained with a pair of unmarked surplus silicon transistors. The frequency change was an experiment to see if such misfit semiconductors would have any significant effect on the drift characteristic. As you can see from curve A in **fig. 9**, the unit was quite stable.

The only adverse effect I could find with this circuit was the frequency shift per volt change in power supply voltage. With the misfit transistors, drift was 500 Hz per volt; all the other oscillators exhibited a shift of 100 to 125 Hz per volt. In one case, with oscillator number 1 at 2.5 MHz, the drift was 45 Hz per volt; at 4 MHz, this same oscillator showed 125 Hz per volt drift. This is not at

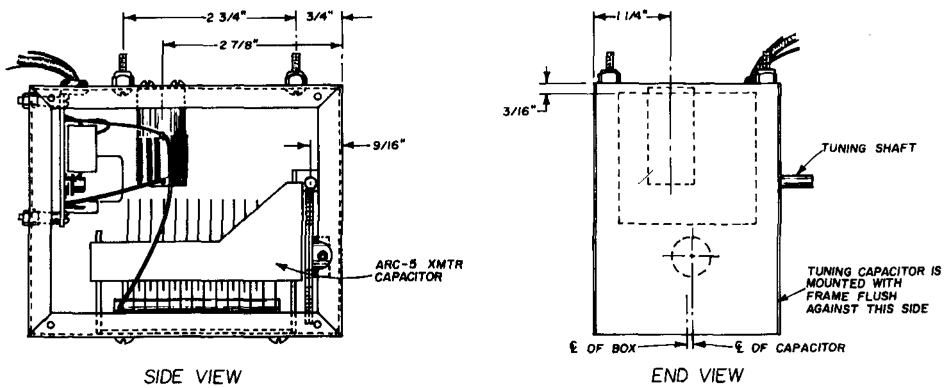


fig. 3. Mechanical construction of vfo number 2.

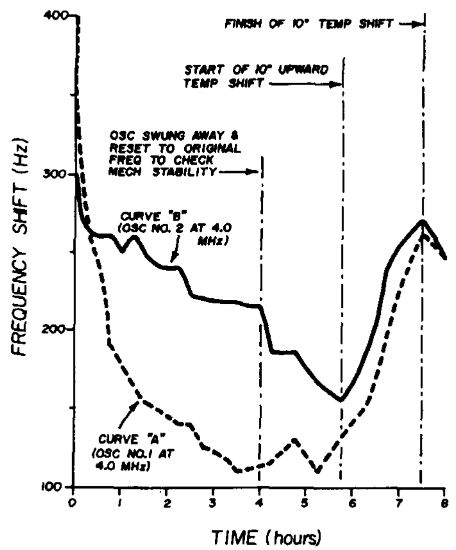


fig. 4. Drift characteristics of oscillators 1 and 2.

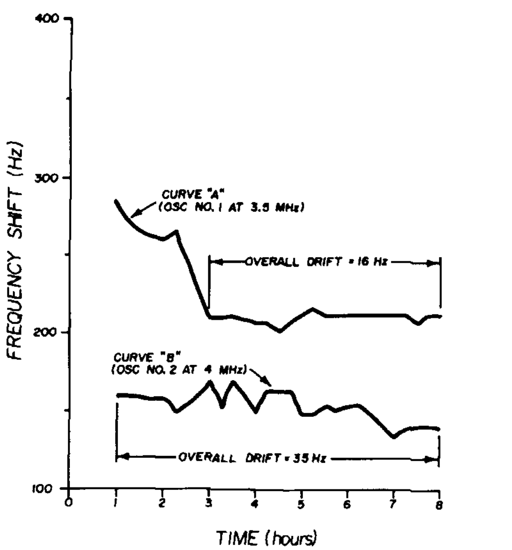


fig. 5. Drift characteristics with the vfo in a fairly constant temperature environment.

all severe and can be cured with a simple voltage regulation circuit.

If your application calls for a vfo output other than 3.5 or 9 MHz, it may be necessary to change the values of the coupling and feedback capacitors for optimum results. As a starter, the reactance of C2 should be about 600 ohms, C3 about 20 ohms and C4 about 60 ohms at the frequency of operation.

Since the output of the vfo itself is quite low—on the order of 0.5 to 1.5 volts peak to peak—it will be necessary to add a buffer amplifier for most applications. The output impedance of the oscillator stage is fairly high, so a high input impedance buffer stage using an fet or Darlington-connected transistor is required to minimize loading.

circuit advantages

Perhaps one of the most *interesting* advantages of this vfo circuit is the remarkably flat output voltage vs frequency characteristic.

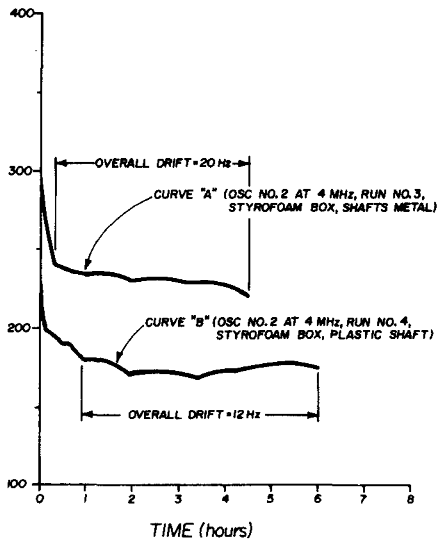


fig. 6. Drift characteristics when the vfo was protected with a ½-inch styrofoam box.

All of the oscillators were checked with a Tektronix scope, and output variations were 1 dB or less over all of the bands checked. This is obviously an advantage if the vfo is fed directly into a mixer stage. The mixer can be set up for optimum characteristics with assurance that they will not change with the vfo setting.

Another plus factor for this circuit is the clean waveform. Unless the feedback ratio—determined by C3 and C4—is too far off, or the reactance of the group of capacitors is too high (vfo on too low a frequency), waveform is excellent. This is an invaluable aid when designing a high performance mixer circuit.

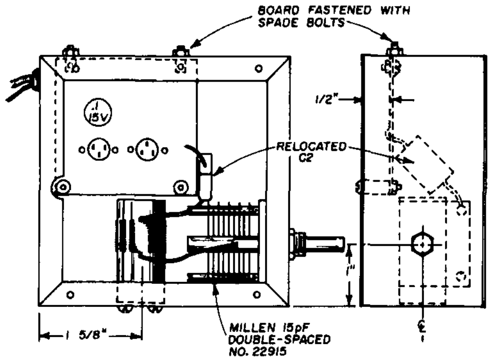


fig. 7. Mechanical construction of vfo number 3.

tank circuit components

I can't stress too highly that the real heart of these vfo's is the tuning capacitor and coil. It's probable that a good deal of the excessive drift on oscillator number 3 could be traced to one of these components. The variable capacitors used in oscillators 1 and 2 were originally installed in ARC5 transmitters. This capacitor is probably the best all-around choice for these vfo's; it is well built with high grade parts, and the gear drive ratio is adequate for the job. This is important because a *drum dial* can be attached to the end of the gear drive; this will save the cost of a separate dial and drive assembly. Another advantage of the ARC5 capacitor is dial calibration—it is essentially linear.

If you use a different type of capacitor, watch for erratic frequency jumps each time the capacitor is reset. To assess the merits of a particular capacitor in this respect, set the dial on a particular frequency from a clockwise direction. Make another run the next day, but approach the same frequency from the counter-clockwise direction. After about four frequency-setting runs you'll see the difference. This drift is mechanical and will usually be opposite to the direction you turned the capacitor.

The coil must be a rigid, quality unit. In one model I had good results with a high grade phenolic form, so this material isn't completely hopeless. I also tried commercial airwound coils; I found the best way of mounting these was to cement a block of polystyrene to one of the supporting ribs with Q-dope. Tests seem to indicate that if the leads from the coil to the circuit board are not preformed to fit with a minimum of stress, the built-in stress becomes a source of drift later on.

The oscillators used for the frequency drift runs presented here all used ceramic coil forms. The average homebrewer will have the best results with grooved forms if they're available. If they're not, try to get some phenolic tubing and have a machinist friend lightly groove several pieces at various pitches to give you some experimental forms.

In one vfo I built, I found a mysterious and sudden frequency shift. This was eventually traced to the manner in which the coil was terminated. The coil form had a hole near the end, and the coil wire was pulled through the hole several times to secure it. When the wire was pulled through the hole, the insulation was damaged and resulted in a partial tiny turn that occasionally shorted out. From there on, I used small bolts and nuts to form a stud to solder the wire to.

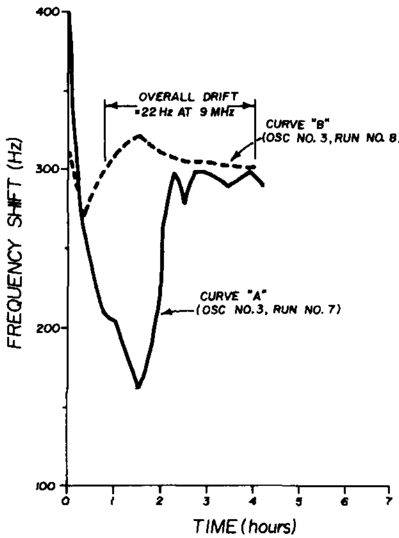


fig. 8. Drift characteristics of oscillator number 3.

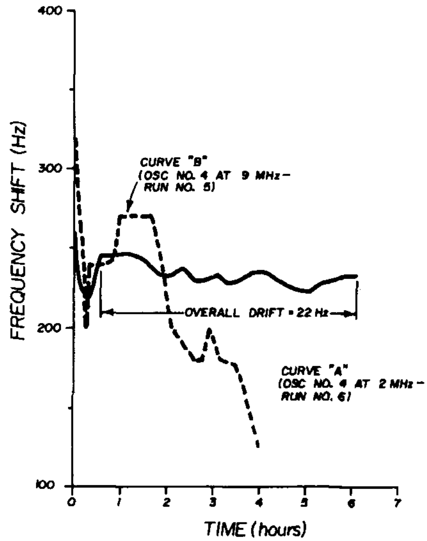


fig. 9. Drift characteristics of oscillator number 2 when it was shifted up to 9 MHz and down to 2 MHz.

Table 1 lists the approximate inductance required for any output frequency range be-

table 1. Tank circuit inductance for different frequency ranges.

vfo range (MHz)	inductance (μH)
1.7 - 2.15	34
2.0 - 2.5	25
2.5 - 3.1	16
3.3 - 4.2	9.5
4.0 - 5.0	6.3
5.0 - 6.2	4.0
6.0 - 7.5	2.8

tween 1.7 and 7.5 MHz with the ARC5 variable capacitor. No exact coil winding information is presented here because each individual builder will probably use a coil form available in his junk box. In the vfo's that I built, no effort was made to select form factor (coil length-to-diameter ratio), wire size or spacing for maximum Q. Several coils that I used departed a great deal from optimum, but results were uniformly good.

measurements

To make any kind of reasonable frequency measurements, you'll need a good crystal standard powered by a well regulated supply and capable of being zeroed in on WWV. A 100-kHz standard is generally poorer than a 1-MHz standard, but either will suffice if you use care. I use a BC-221 frequency meter with a regulated power supply in the "crystal only" mode. Owners of the LM version can shift the heterodyne oscillator out of the ballpark and depend on the crystal by itself. With a four-hour warmup, either model makes a good standard.

Many BC-221 owners are not aware that some models have a crystal frequency adjusting capacitor located underneath the nameplate on the front panel. When making a drift run, I secure the nameplate with masking tape to permit quick access for zeroing to WWV; it's best to replace the nameplate each time to minimize thermal shifts.

To measure vfo drift, the beat note between the 1-MHz standard and the vfo is compared to the audio frequency output of a Hewlett-Packard 200C audio generator. The HP-200C is very accurate and stable with a four-hour warmup period. Nevertheless, I compare the output to the 60-Hz line frequency for maximum accuracy. You can use any old oscilloscope for the Lissajous patterns.

A homebrew solid-state phase-shift audio generator could be built to cover 200 to 1000 Hz for this work. If calibrated at 60-Hz intervals, with the 30-Hz points estimated, it should be suitable for most purposes.

If you use a homebrew audio generator, it will be necessary to minimize error due to its drift. One way is to make all your frequency measurements at a multiple of the vfo frequency. For example, if a 3-MHz vfo and crystal standard are compared at 3 MHz and the vfo drifts 10 Hz, you must be able to rely on your audio interpolation oscillator to within 10 Hz. On the other hand, if you feed the output of the crystal standard and vfo into a receiver tuned to 30 MHz, you can measure the tenth harmonic.

Any drift will also be multiplied by ten, so a 10 Hz drift at 3 MHz becomes a 100 Hz drift at 30 MHz and is easily read on your audio oscillator comparison setup. Be careful: the crystal standard frequency is also multiplied! If it was set within 1 Hz of WWV at 5 MHz, 30 MHz is six times higher, so your crystal-standard error is 6 Hz.

Any oscillator will shift frequency with changes in supply voltage. If your vfo shifts 200 Hz with a 1 volt change in supply voltage, you must be able to measure voltage changes as small as 0.05 volt to be sure that frequency shift doesn't exceed 10 Hz.

One simple way of measuring small voltage changes is illustrated in **fig. 10.** In this circuit a zero-center microammeter compares the voltage difference between the power supply and a reference battery. As long as no difference in voltage exists between the power supply and the reference source, no current flows through the microammeter. With this setup, you can set the power supply voltage within about 0.01 volt.

Since the battery operates under no load, it is a stable reference if it's in good condition. The power supply must be pretty well regulated or you will spend all your time following its variations trying to keep the meter zeroed.

If you want to set your power supply to other voltages with the same precision, the reference must be changed. A string of fresh flashlight batteries connected in series provides a simple means of setting up a variety of test voltages. Although a precision temperature-compensated zener in a constant-current power supply would do the same job—particularly if the zener is held in a constant temperature environment—don't substitute a **simple** zener reference in place of the batteries.

measurement errors

Make a few drift runs on your crystal and audio standard to find out what the errors are. Similarly, make a few runs on the vfo power supply to find out how far it actually drifts. In a complex setup like this, a number of uncertainties exist, including vfo supply voltage, crystal standard error, interpolation error in reading the audio generator, audio generator drift and frequency multiplication error. In the work described here, every effort was made to maintain cumulative measuring error within 10 Hz.

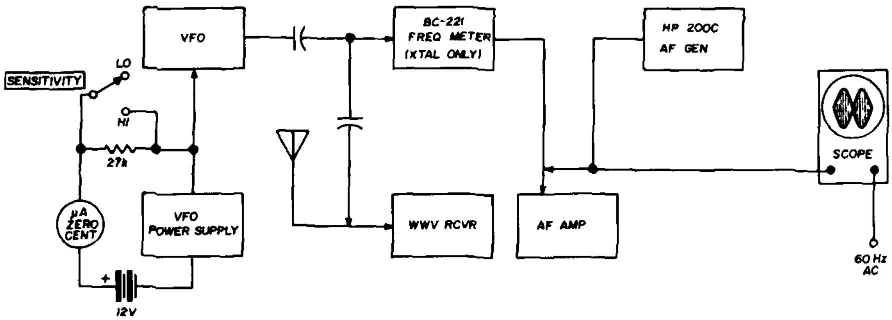


fig. 10. Test setup for measuring vfo drift.

The last source of error is usually neglected in vfo descriptions—environment. My basement is relatively cold and drafty with a fair amount of temperature variation. A number of runs were repeated when data was suspected due to temperature variations. My "standard" in this case is a photographer's darkroom thermometer. With the exception of drift run number 1, the drift curves are those which had the least ambient temperature variation during the run. Furthermore, no drift run was started less than 24 hours after any previous run, or after I did any soldering on the circuit.

summary

It may be possible that with further experimentation, the stability of this circuit could be improved. However, with the instrumentation I am using, it would be difficult to evaluate any improvement accurately. Because of the rapid warmup, I suspect that much of the warmup drift is caused by C2. Replacing this capacitor with a fixed air padder might help—albeit slightly. A larger, high-Q coil might also help.

Although I used carbon composition resistors in all the vfo models that I built, precision film resistors chosen for temperature coefficient may make some slight improvements in operating-point stability. However, these improvements would all be small, and I suspect the cost of the unit would increase considerably before there would be any substantial improvement in drift characteristics.

In conclusion I would like to thank Captain Lee, W3JM (ex-W3JHR), for this remarkable circuit; few solid-state circuits are as bug-free and tolerant of component values as this one. The transistors I have used in the course of my experiments have run the gamut—germanium and silicon, pnp and npn, pullouts, unmarked surplus, high and low beta, hf and vhf types have all been used interchangeably with no changes except polarity of the power supply. All produced remarkably similar—and good—results.

references

1. P. H. Lee, W3JHR, "A Stable Transistorized VFO," CQ, September, 1963, p. 25.
2. J. R. Fisk, W1DTY, "Stable Transistor VFO's," *ham radio*, June, 1968, p. 14.
3. E. O. Seiler, W8PK, "A Low-C Electron-Coupled Oscillator," *QST*, November, 1941, p. 26.

ham radio

a plug-in integrated-circuit frequency calibrator

You can use your existing receiver calibration crystal and tube heater supply for this IC marker generator

E. H. Conklin, K6KA, Box 1, LaCanada, California 91011

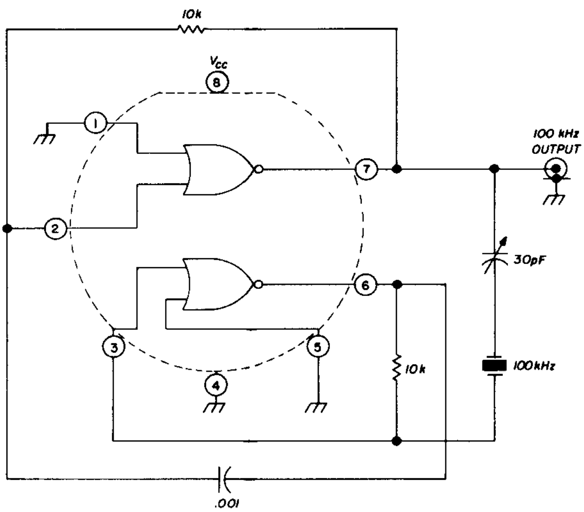
The new sub-bands reserved for amateurs who have taken advantage of the incentive licensing laws are now a fact of life. Operating in these bands is a real privilege for those who have improved their operating skills and technical knowledge.

If you don't have your advanced or extra-class ticket yet, you're probably going to need something better than the frequency calibrators built into most amateur receivers. Instead of having to worry about only two frequencies (at the old band edges), you must now be able to determine accurately the edges of the new sub-bands. Even if you're in the top 5000 who are privileged to operate down in the "basement," the little solid-state plug-in calibrator described in this article is just the answer to "where am I?"

Those who may have missed the insert in **ham radio** showing the new frequency allocations can get a copy by writing to the editor. You might like to thumbtack this handy operating aid near your receiver or transceiver as a reminder.

Presented here is a simple plug-in frequency calibrator using the crystal in your existing calibrator. No extra power is needed. You need only the power used by your present calibrator tube heater. Most calibrators put out markers at 100-kHz intervals. If you have a dial with 1-kHz accuracy, such as the Collins S-Line or Heath SB-300, an output of 10 or 5 kHz is useful. You can build this calibrator for about one

fig. 1. 100-kHz crystal oscillator circuit using a Fairchild μL914 dual-gate integrated circuit. Grounded pins 1 and 5 lead to unused inputs.



dollar above the cost of the integrated circuits. Frequency division will be limited only by the number (within reason) of JK flip-flops you're willing to include.

analysis

Switchable heater current appears at the cathode pin of the socket in equipment such as the Swan 500, Heath SB-300, and Collins 75S-3. In the Swan 500, you'll need a larger filter resistor for the plug-in calibrator because of the 12-volt heater supply. If you're using a Heath SB-300 or Collins 75S-3, you must place a jumper across the respective cathode resistors (R17 in the SB-300 and R45 in the 75S-3) to make use of the switch in that line. This power can be rectified and filtered. With low-current drain IC's such as the Fairchild 9093 JK flip-flop, a half-wave rectifier is sufficient; with more drain, a bridge circuit is advisable. Blocking capacitors will be needed in the rf ground-return and output leads to isolate the new power supply negative and the former tube's plate supply.

the circuit

A simple crystal oscillator using two IC gates as the transistors in a multivibrator circuit requires only two 10k resistors and one 0.001 μF capacitor. It will operate from 100 kHz to 1 MHz with no change. The dual-gate Fairchild μL914 performed well in the oscillator circuit[1,2] of **fig. 1**, as did the Motorola MC-724P quad gate. The latter is shown in **fig. 2**. The unused gate inputs are grounded to cut off unnecessary collector current. However, they can be used for isolation amplifiers, R-S flip-flops and other circuits. The cost is around $1.08.

Oscillator output is capable of driving a JK flip-flop as a frequency divider without any intervening circuit. A single flip-flop will divide by two; a dual in-line plastic Motorola MC-790P provides division by four at a cost of only $2.00. Two of these can provide decade division with an output every 10 kHz from a 100-kHz calibrator crystal.

Many other types that draw less current are available, but this is of little advantage except in power supply filtering requirements.* The 5-volt Motorola MC-838P decade divider will produce 50-kHz and 10-kHz harmonics while drawing less current than the 3.6-volt MC-790P. It can be "blocked" into putting out 25 kHz increments instead of decades if desired.[3]

* WØKPZ has pointed out (**QST**, February, 1968, p. 55) that the Motorola MC-778P has less than one-quarter the current requirement of the MC-790P. The MC-778P is in the milliwatt MRTL series, costs only 35c more, is a type-D flip-flop, has lower but adequate output and doesn't require as rapid an input-pulse fall time as the MC-790P to make it toggle. Unless the power supply is filtered adequately, the MC-790P may count power-supply ripple, causing a rough note or incorrect frequency division. **Editor**

construction

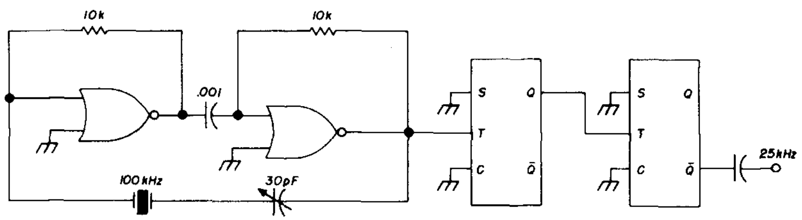
I used Vector board with alternate 0.1-inch hole spacing. I drilled a few additional holes to accept the fourteen pins of the dual in-line IC's. Two other types of Vector board that accept the IC's without any drilling are now available. A piece about 2½ x 3½ inches fits nicely into the S-line receiver. It is slotted in one corner to bridge across the stub of the Vector 7-pin tube-base plug. The leads are wired to seven convenient pins, not only to provide connections, but also to attach the plug securely to the board.

With a half-wave rectifier, using a 50-volt "glass amp" diode and two small Japanese 100-μF, 10-volt capacitors from Poly Paks, a filtering and dropping resistor of 82 ohms is required for two IC's using a 6.3-volt supply. This will vary with IC types and the voltage source, so a larger resistor should be tried first to be safe.

The crystal wasn't furnished with a trimming network of zero and negative temperature coefficient capacitors. This circuit is possible here and is advisable. A JFD VC28G piston trimmer was used, providing multiturn adjustment. A larger trimmer could have been used.

The 0.001-μF capacitor (0.1 also worked) and ½-watt, 10k resistors complete the mounting. I used Belden 8430 phono pickup-arm cable, separated into single strands, for wiring the IC's.

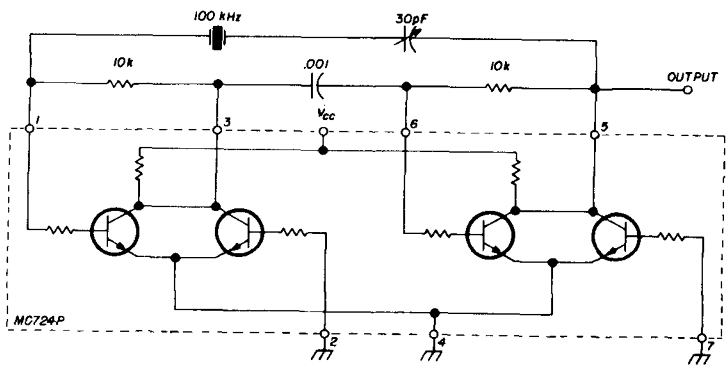
fig. 3. System using two gates and two JK flip-flops to provide 25-kHz markers with a 100-kHz input.



testing

Oscillation can be detected with a vacuum-tube voltmeter, even without an rf probe. Dc will be on the various leads, averaging about half the supply voltage. Care must be taken that there are no short circuits between IC leads, that all connections are conducting, and that all are in their correct places. Most crystals will os-

fig. 2. 100-kHz crystal oscillator circuit using a Motorla MC724P quad gate IC.



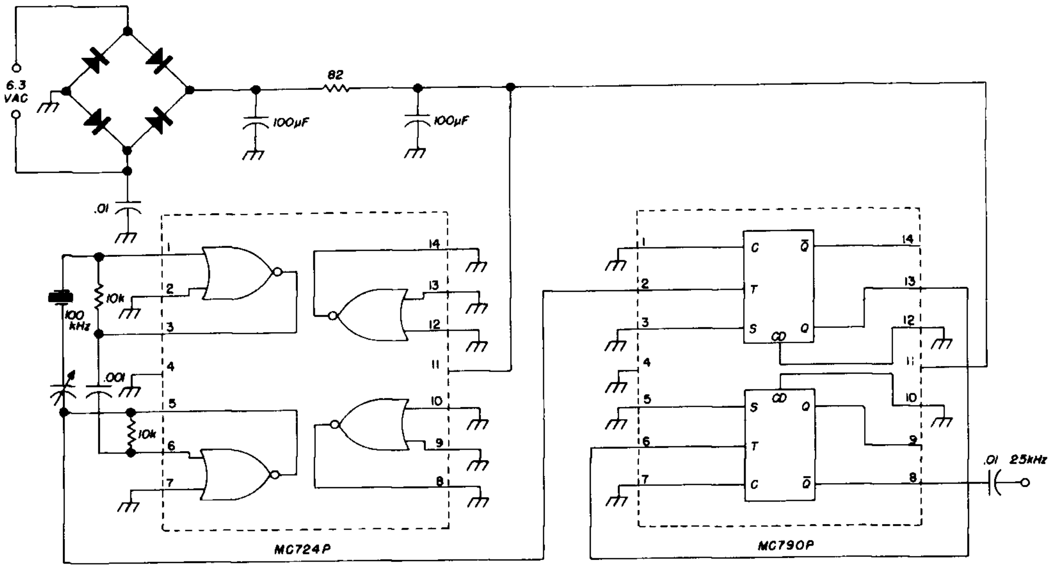


fig. 4. Complete circuit of a simple frequency calibrator that may be plugged into an existing calibrator socket in your receiver. Power supply is derived from the 6.3 Vac filament supply.

cillate in the circuit, but a few take off at a harmonic. A capacitor between 50 and 200 pF across resistor R2, which is in series with the 0.001 μF capacitor, is said to correct this.[1]

Both VK3TE and I found the 100-kHz points from an MC-790P divider to be weaker than intervening points. No correction is offered as yet for this, except to use the Fairchild 9093.

operation

When the power switch is turned to "calibrate," the ground return to the 6.3 volts is applied to the new calibrator board, which replaces the calibrator oscillator tube. The output passes through the original small antenna-coupling capacitor or "gimmick" to the receiving antenna. The new pips appear on the dial at the appointed places. With 10-kHz output, these are adequate to calibrate the intervening nine 1-kHz points by interpolation. If another flip-flop is added to produce 5-kHz harmonics, all incentive band edges are marked if the crystal is set properly—and recently—on WWV. After November 1969, 25-kHz output alone will mark all incentive band edges because the 14,235-kHz limit will not be in effect.

references

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2. "Build an IC Crystal Calibrator," *Radio-Electronics*, February, 1968, p. 32.
3. E. H. Conklin, "Calibrators and Counters," *ham radio*, November, 1968.

ham radio

"A slug-tuned coil and a silver-mica capacitor please . . . and would yuh tune them for 50.42 MHz?"

the real meaning of noise figure

Jim Kennedy, K6MIO, 5465 East Hampton, Fresno, California 93727

The availability of excellent solid-state devices makes it possible for just about any serious vhf or uhf experimenter to build a receiver with a noise figure that was unheard of only a few years ago. Today's transistors, even in the 400- and 1200-MHz region, are competing with uncooled parametric amplifiers.

Although necessary, a low noise figure in the receiver front end doesn't necessarily guarantee optimum performance of a receiving system. The receiver is only one element of the total receiving system. The performance of the antenna and transmission line can have, in the presence of a low noise receiver, just as important an influence on over-all receiving performance as the receiver itself. The receiver noise figure is a measure of the receiver's performance only. The true measure of the system's ability to detect a signal entering the antenna is the system noise figure (assuming constant pre- and postdetection bandwidths).

There was a time when, due to a poor receiver, the system noise figure was often nearly the same as that of the receiver. As noise figures moved lower, the practice of using the noise figure as a measure of performance became cumbersome. The use of noise temperature is now more meaningful and convenient. Of course, noise figure and noise temperature are related, since they both purport to measure the same thing. In reality, however, the noise temperature is the more basic unit and is actually easier to deal with, both in understanding concepts and making practical calculations.

I've used some mathematics to explain relationships and fundamental concepts. The math is quite straightforward, but it's easy to get sidetracked when there are several terms with nearly the same definitions. The list of symbols and definitions in **table 1** should help you to find your way through the mathematical expressions.

thermal noise

To establish a common basis for the discussion, it seems appropriate to begin with the meaning of the terms noise temperature and noise figure. Noise figures are actually defined in terms of noise temperature; consequently noise temperature needs to be explained first, but not without providing some background.

Any substance that is warm (and by "warm" I mean above absolute zero) contains some electrons that are free to move about in that substance. The amount of energy contained by these electrons increases as the temperature increases, and an increase in energy means an increase in the average speeds of the free electrons. However, moving electrons constitute an electric current. Since we can, in general, assign a resistance to a particular piece of that substance, there should be a voltage developed across the substance due to these thermal electron currents since $V = IR$.

The direction and speed of any given electron is random and fluctuates wildly as the electron moves through the substance and collides with the relatively immobile atoms (ions) that make up the bulk of the substance. The final effect is that, in most substances, there is no net current in any direction on a long-term average, but rather a series of random positive and negative pulses. In other words, the voltages developed by these currents constitute thermal agitation noise.

Since the currents increase with temperature, the noise power likewise increases with temperature. Further, as the pulses are random, they are spread out over a very broad range of frequencies. It develops that, if we look at the power contained in a given passband, the value of that power is independent of the actual center frequency of the passband. Specifically, Nyquist's formula states:

$$p = kTB$$

where *k* is *Boltzmann's constant*, T is the absolute temperature (degrees Kelvin), and B is the bandwidth (Hz). Note that the power is directly proportional to temperature, and at 0^0 K there is no noise.

table 1. Symbols used in the discussion and mathematical *description of noise*.

B	bandwidth
F	noise figure
f	noise factor
G	*stage gain*
I	thermal current
L	transmission line loss factor
P	thermal noise power
R	resistance
T	absolute temperature (°K)
T_A	antenna noise temperature
T_L	total transmission line noise temperature
T_{L}	transmission line noise temperature
T_P	transmission line physical temperature
T_R	receiver basic noise temperature
T_r	receiver noise temperature modified by TL
T_S	system noise temperature
V	voltage (product of IR)

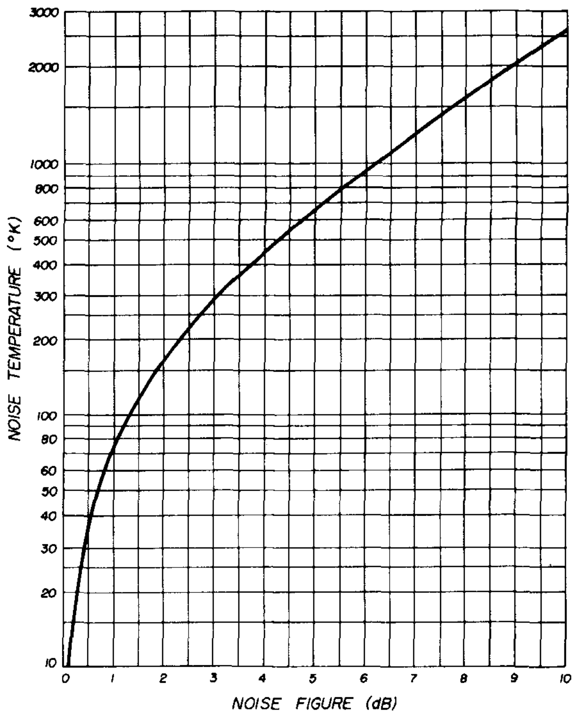


fig. 1. Noise temperature vs noise figure.

These facts about thermal agitation enter into the discussion of system performance from two aspects. One is that this mechanism can be a source of unwanted noise and the other, which will now be considered, is that this effect can be used to provide a convenient standard noise source for measuring receiver or system performance. It is in this latter connection that the concept of noise temperature has evolved.

noise temperature

Suppose you have a receiver front end that needs to be evaluated. Further, suppose that its input impedance is 50 ohms. One way to measure performance would be, in principle at least, to terminate the receiver's input with a warm 50-ohm load, attempt to detect the load's thermal agitation noise, and compare it with the noise generated by the front end itself.

To be even more specific, suppose we

could reduce the resistor's temperature to absolute zero and note the noise level on a perfectly linear S meter. This noise level would be due entirely to the receiver, because there is no thermal noise in the resistor at absolute zero. Now suppose we increase the resistor's temperature until the S meter shows a 3-dB increase. That is, until the resistor thermal agitation noise is equal to that generated by the receiver. We've obviously measured the noise generated in the receiver, but what is it?

We could determine the power in watts from Nyquist's formula, if we knew the exact bandwidth of the receiver, since we already know the resistor's temperature. But a number that depends on the receiver's bandwidth would be somewhat cumbersome for comparing two different receivers. On the other hand, a very convenient and accessible number would be the resistor temperature. For example, if heating the resistor to 400° K would produce the same as that generated by the receiver, we could say that the receiver noise temperature was 400° K. This number is independent of the receiver bandwidth, and we can use it to compare receivers of different bandwidths.

It should be noted parenthetically that this number is meaningful, because the resistor noise and the receiver front-end noise are both random and relatively broadband. In reality the noise the receiver generates may or may not be caused by thermal effects, but we can always compare the amount of noise per unit bandwidth with that which would be produced by a resistor of some certain temperature.

One example of the convenience of using noise temperature as a performance measure is that it is directly proportional to noise power. Hence if, for instance, you were to halve the noise temperature of a system, you would double the signal-to-noise ratio of any signal present. The same can't be said for noise figure.

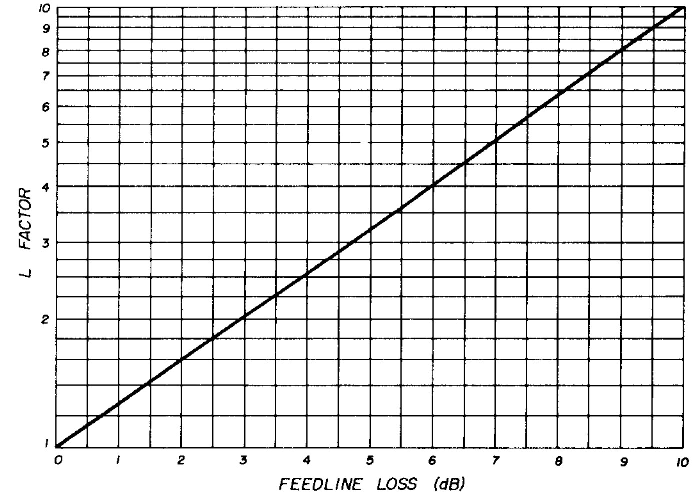


fig. 2. Curve of factor L vs feedline loss.

noise figure

Before we can define noise figure we must take one intermediate step. Suppose we define a noise factor

$$f = \frac{T}{290} + 1$$

where T is the noise temperature, and the 290 represents the value of room temperature in Kelvin units. The noise factor is a number that varies from 1 to infinity as T varies from zero to infinity.

Now we can define the noise figure as the noise factor expressed in decibels; that is

$$F = 10 \log_{10} f$$

Note that when T = 290° K, room temperature, *f = 2, and the noise figure,* F = 3 dB. In other words, both f and F are ways of comparing T and 290° K. Note also that the noise figure is in a sense two generations removed from our original unit, noise temperature. A little scratch paper calculation will show that

$$T = (f-1)\,290$$

Unlike T, the percentage change in f necessary *to produce a given improvement in* signal-to-noise ratio depends on the original value of f. This effect is particularly noticeable when f is small, which is precisely the region we wish to consider. Consequently, such calculations, while not too difficult, are not instantaneous. Hence the significance of f and F is more obscure than that of T.

The foregoing has, I hope, established the relationship between T and F and provided some initial insight into the reasons for dispensing with noise figure in favor of noise temperature in what follows.

receiving systems

Earlier it was suggested that the over-all performance of a receiving system depends not only on the receiver but also on the transmission line and antenna. Each of these elements makes a contribution to the system noise temperature, and this contribution is directly additive (another convenience of noise temperature over noise figure). It should be emphasized that the intent is to find a system noise temperature. In this context, when considering the antenna, we are only interested in the antenna's noise performance and not its gain.

A great deal has been written about the sources of noise in various rf amplifiers. It's therefore unnecessary to spend much time on this aspect of the subject, except to note that, in vacuum tubes and transistors, the actual source of most of the inherent noise is usually nonthermal in origin. However, in parametric amplifiers, the primary noise source is thermal, and cooling the paramp will actually improve its noise temperature. Usually the noise temperature of a paramp is quite a bit lower than its physical temperature due to the slightly strange way that thermal noise develops across a negative resistance. But it is related to physical temperature, and hence cooling helps. On the other hand, cooling transistors and tubes will turn them off.

Of course, the noise temperature of any good receiver is determined principally by that of the first preamp and almost entirely by the combined effect of the first two preamps. This can be seen from the general formula for receiver noise temperature.

$$T_R = T_1 + \frac{T_2}{G_1} + \left[\frac{T_3}{G_1 G_2} + \frac{T_4}{G_1 G_2 G_3} + \ldots\right]$$

The subscripts refer to amplifier stage number, and G is the stage gain expressed as a power ratio rather than in decibels. Since all the stage noise figures are usually within the same order of magnitude, the growing gain product in the denominators makes any contribution to the noise temperature beyond the second stage very small, and the series can be truncated after the second term.

transmission lines

The transmission line's contribution comes from two effects produced by a common source: line losses.

The first of these two effects is the more obvious. When a signal travels down a lossy line, the signal is attenuated. This reduces the signal-to-noise ratio, which is equivalent to directly increasing the noise temperature of the receiver. This increase can be expressed by introducing a loss factor, L, which varies from one to infinity and is the ratio of power in to power out for the transmission line. The combined effect of receiver noise temperature and this aspect of the line loss is

$$T_r = LT_R$$

where T_R is the basic noise temperature of the receiver.

The second effect arises from our familiar physical temperature considerations. The fact that losses exist implies that there is a true resistive impedance associated with the line. (Note this is distinct from the characteristic impedance, which is something else entirely.) Since the line is warm, it actually generates noise due to thermal agitation. Hence, the noise temperature is related to the loss factor, L, and the physical temperature of the line, T_p. Specifically,

$$T_L = (L-1)\,T_p$$

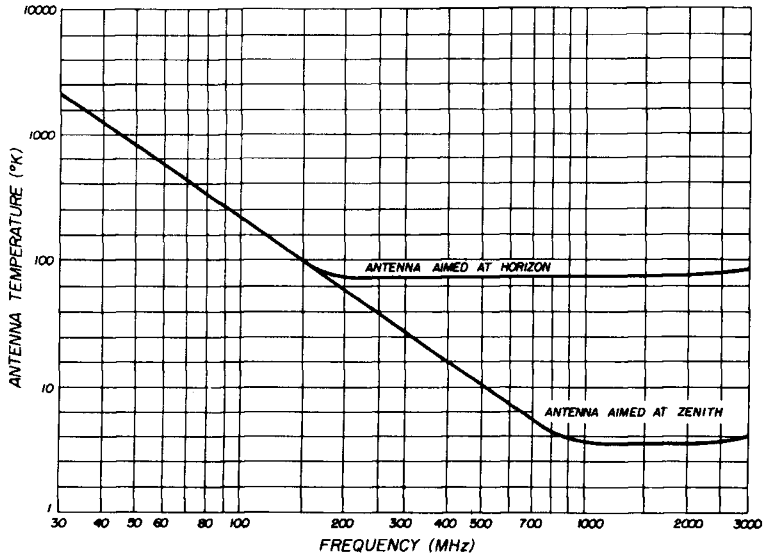
Note that when line losses are low, but receiver noise temperatures are on the order of room temperature, the predominant transmission line contribution to system noise is the first effect. However, when receiver noise is very low the second, or thermal, effect predominates. Though very few amateurs will encounter such problems, this is commonly the situation with maser amplifiers, and in such cases cooling the transmission line, while often impractical, would improve performance.

The first transmission line formula combines the line effect with the receiver noise temperature, but it's often more convenient to combine the two line effects and state the receiver contribution separately. Defining T_L as the total transmission line noise temperature we can write

$$T_L = (T_p + T_R)\,(L-1)$$

This is, again, only the transmission line contribution, although it does involve receiver temperature as a parameter.

fig. 3. Minimum expected antenna temperature as a function of frequency.*



* J. D. Kraus, H. C. Ko, "Celestial Radio Radiation," Ohio State University Radio Observatory Report 7, May, 1967; Dicke et al, "Cosmic Black-Body Radiation, *Astrophysical Journal*, volume 142, 1965, pp. 414-419.

antennas

Of all the contributions to system noise, antenna temperature is probably the most misunderstood and also the hardest to pin down. First of all, assuming the antenna to be constructed of good conducting materials, the antenna noise temperature has practically nothing to do with the physical temperature of the antenna. The antenna noise temperature is, rather, a measure of the noise the antenna is actually receiving (as compared to a warm resistor on the end of the transmission line instead of the antenna). The amount of noise an antenna picks up is often, but not always, related to the temperature of the objects the antenna "sees" at uhf, but at vhf the opposite is generally true.

If we consider the uhf case, an antenna on an earthbound circuit sees a large amount of warm earth, and the antenna temperature will be in the neighborhood of 100° to 300° K. This is because the free electrons moving in the warm earth radiate electromagnetic energy in proportion to their temperature.

There is little that can be done to improve the situation of an earthbound circuit, but an antenna that looks at the sky, such as a moonbounce antenna, would have a much lower noise temperature since the sky is much "colder" than the earth.

The effect of the earth is still present, however, since any sidelobe that sees the earth will pick up thermal noise. This effect can be quite serious, and sidelobes are of major concern in many deep-space communications and radio astronomy systems. Careful attention to antenna design with respect to sidelobes can result in antenna temperatures significantly under 50° K, while poor design can result in much higher values (approaching 300° K as a limit). This effect is indicated in **fig. 3.**

system noise temperature

The final measure of the amount of noise power per unit bandwidth that an incoming signal must compete with is given by the system noise temperature. This is just the sum of the receiver, transmission line and antenna noise temperatures,

$$T_S = T_A + T_L + T_R$$

$$T_S = T_A + (T_p + T_R)\,(L\text{-}1) + T_R$$

examples

Having presented this array of formulas, it might be useful to demonstrate them with a few typical examples.

You occasionally hear a heated discussion on the air about whether or not a super low-noise front end is really any better than a mediocre front end on six meters. The crux of such a discussion should center on the influence of sky- and man-made antenna noise on the system noise temperature. Let's join the fray and consider the question.

Antenna temperatures at six meters are quite high. A typical value for T_A would be 3,000° K. The next aspect to consider would be the feedline. In the case of an 80-foot tower, which might have a 90-foot run of RG8/U, the feedline loss, from published data, is about one decibel. From **fig. 2** we see that L is equal to 1.26. Then

$$T_L = (290 + T_R)\,(0.26)$$

Now, to find the system noise temperature all we need do is to try a couple of values for T_R. Suppose a receiver with a good front end has a 1-dB noise figure and a mediocre one, 4 dB. Referring to **fig. 3,** then, using the system temperature formula, the good receiver provides

$$T_S = 3000 + [(290 + 76)\,(0.26)] + 76$$

$$T_S = 3171°\ K$$

On the other hand, the mediocre one provides

$$T_S = 3000 + [(290 + 438)\,(0.26)] + 438$$

$$T_S = 3627°\ K$$

It was obvious from the beginning that the good front end was superior to the mediocre one, but in terms of the over-all system performance, there is less than a 0.6-dB signal-to-noise ratio advantage. The argument will, of course, rage on; but at least now it must be over the relative advantage of a 0.6-dB signal-to-noise ratio improvement.

Let's now shift our attention to a pair of 432-MHz examples. First we'll consider an example paralleling the one above. On 432 MHz, we might find an antenna temperature of 300° K. In this example we'll again assume the feedline loss at one decibel. Now consider the difference between a 2-dB paramp or transistor front end and a 6-dB 416B amplifier. In the former case

$$T_S = 300 + [(290 + 168)\ (0.26)] + 168$$

$$T_S = 587° \text{ K}$$

In the latter case,

$$T_S = 300 + [(290 + 870)\ (0.26)] + 870$$

$$T_S = 1472° \text{ K}$$

Hence the better preamp would make a 4-dB improvement in system noise. The fact that 4 dB is also the difference in the preamps noise figures is purely coincidental. To illustrate that this is so, let's take another quick example of the same sort. Consider a radio telescope with a T_A of 20° K and a feedline loss of 0.1 dB. Now if we use a maser with $T_R = 3°$ K, then,

$$T_S = 31.8° \text{ K}$$

The same system but with a 3-dB front end has

$$T_S = 327.5° \text{ K}$$

Here a 3-dB receiver noise figure improvement has led to more than 10 dB of system improvement.

In the second 432 MHz example, we'll examine the influence of the feedline. Assume $T_A = 300°$ K and $T_R = 168°$ K (2 dB). We've previously shown that when the line loss is one decibel

$$T_S = 587° \text{ K}$$

But suppose we increase the line loss to 4 dB. Then L = 2.55, $T_L = 710°$ K and

$$T_S = 1178° \text{ K}$$

The system degradation is, in this case, 3.1 dB, **not** 3.0 dB. Further, notice that the feedline noise contribution here approaches twice that from all other sources combined.

summary

Of course the foregoing examples are just that: examples. But I hope they have illustrated some of the important aspects of the problem of receiving system performance.

Perhaps it would be well to underscore in a qualitative way some of these points. For a given receiver passband and antenna gain they might be stated as follows.

1. Receiver performance is ultimately limited by the signal-to-noise ratio present at the receiver end of the transmission line. (This was obviously the case in the six-meter example.)

2. Assuming the antenna noise temperature is minimized or can't be controlled, the transmission line is a significant factor in establishing this signal-to-noise ratio.

3. Once the signal-to-noise ratio at the receiver input has been maximized, then the noise temperature of the receiver itself can be minimized to produce the least degradation in the input signal-to-noise ratio. The extent to which this is practical depends largely on actual improvement secured, as contrasted by the six-meter example and the maser example.

Finally, it should be clarified that this entire discussion has hinged on noise performance. Obviously, increasing antenna gain will also improve performance. Unless the antenna is looking at a noise source of limited size, such as the sun or a bad power-line transformer, the antenna noise temperature is, in general, independent of the gain. Therefore we could add as a fourth point: put up the biggest, grandest, best antenna you can.

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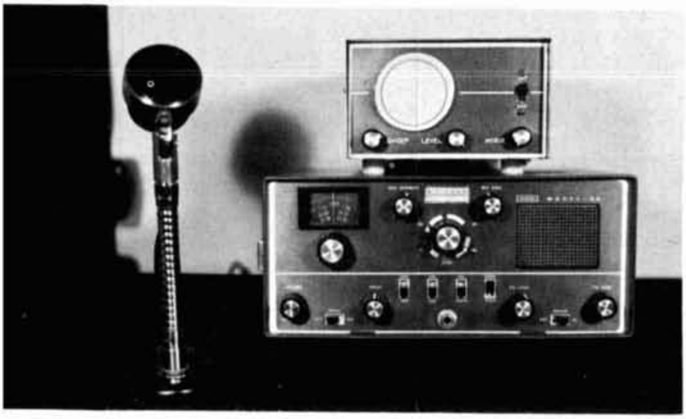


a miniature monitorscope

It is pretty hard to beat an oscilloscope like this for less than thirty dollars– it features a surplus CRT

Lee Richey, WA3FIY, R.D. 1, Franklin, Pennsylvania 16323

There is little question of the desirability of a monitor oscilloscope in today's ham shack. The problem with many of us is the availability of the funds necessary to purchase one. The oscilloscope presented here will display both envelope and trapezoidal waveforms when used with a transmitter of 10 watts or more. It uses a very linear internal sweep circuit with variable sweep rates from 30 Hz to 300 Hz, or it can be switched for external horizontal input signals with a full-scale sensitivity of about 0.5 volt rms. The scope also includes a blanking circuit that blanks the trace when no rf is present. If you have a well-stocked junk box, you can construct this scope for just a few dollars. If not, you can still build it for under $30*.

the circuit

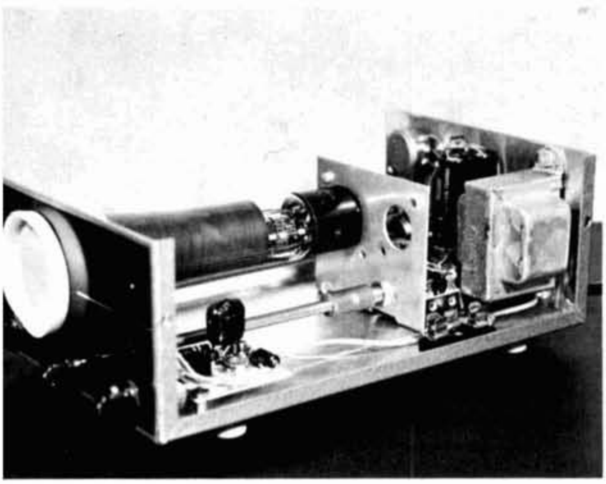
The monitorscope is built around a 902A cathode ray tube available from many surplus dealers. The 902A is ideal for this application for several reasons. First, it is available for less than $3 in many areas of the country. Second, it has an accelerating voltage of 400-600 volts, easily obtained with low-cost components. Third, the deflection sensitivity is approximately 100 volts per inch, allowing the use of transistorized deflection amplifiers. Fourth, the tube is small—2 inches in diameter, 7 inches long—and uses an octal socket.

The power supply is a voltage tripler using silicon diodes and a low-voltage power transformer. It produces 175 volts dc for the horizontal deflection amplifier and associated circuits and 525 volts dc accelerating voltage.

The horizontal amplifier consists of a source follower junction FET input stage for high impedance input and a voltage amplifier using a low-cost, high-voltage silicon transistor. The input impedance of the FET stage is 500k ohms, and the voltage gain of the amplifier is approximately 100. The undistorted output is over 150 volts peak-to-peak and gives more than adequate sweep width. Maximum sweep width is about 1½ inches with the horizontal amplifier supply voltage of 175 volts.

For normal waveform monitoring this is sufficient, but if desired, it may be increased to full scale by using a voltage doubler power supply producing approximately 550 and 275 volts dc. A higher-voltage horizontal output transistor, such as the RCA 40264, would also be necessary.

Internal layout of the monitorscope. The horizontal sweep circuit board is in the foreground. The power transformer is mounted on the rear wall.



The internal sawtooth generator is basically a unijunction transistor relaxation oscillator. The sawtooth voltage across the timing capacitor is linearized by a constant-current source (transistor Q1 on the schematic) charging the capacitor. From the equation:

$$E = \frac{TI}{C}$$

Where: E = voltage across the capacitor
I = charging current
C = capacitance
T = time

It can be seen that if the charging current and the capacitance are held constant, the voltage across the capacitor is directly related to time. This approach works very nicely in practice, as well as in theory, and yields a very linear sawtooth voltage.

The current, while held constant for any given sweep frequency, is made adjustable to set the sweep frequency. The supply voltage for the sawtooth generator is regulated at 11 volts by reverse biasing the emitter-base junction of a Fairchild 2N5135 silicon transistor. This "diode" costs $.25 compared with over $1.00 for a typical zener of the same rating.

At this point it might be worth mentioning that many of the low-cost, general-purpose silicon transistors can be used as zener diodes by reverse biasing their emitter-base junction. To tabulate a few:

2N5135	– 11 volts
MPS3704	– 9 volts
MPS706	– 8 volts
2N5138	– 7 volts
2N5134	– 6 volts

The zener voltages listed were measured on twenty or thirty devices and represent an **average.**

* The semiconductor package is available from the author for $6.00 plus tax and shipping. The total package is also available, including Minibox, CRT, transformer, semiconductors, passive components, line cord, and all hardware, switches, and knobs. Price: $28.75 plus tax and shipping.

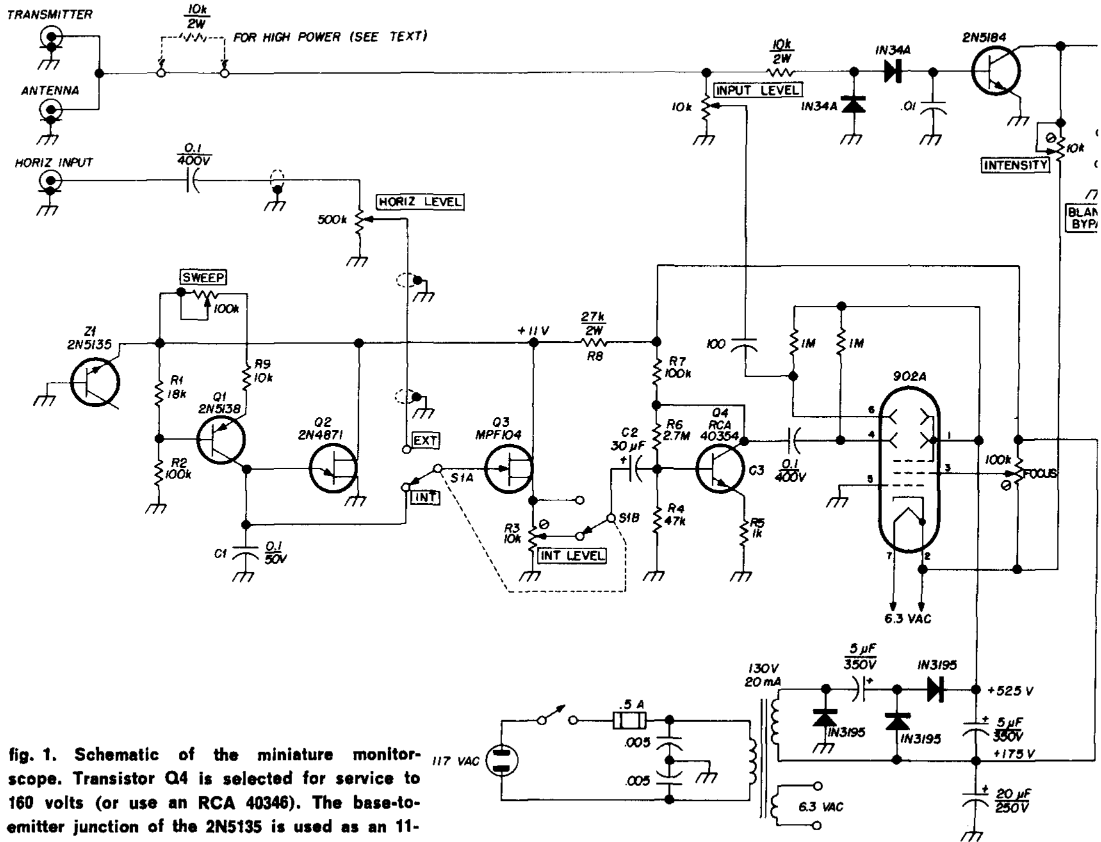


fig. 1. Schematic of the miniature monitorscope. Transistor Q4 is selected for service to 160 volts (or use an RCA 40346). The base-to-emitter junction of the 2N5135 is used as an 11-volt zener diode.

The blanker circuit is composed of a transistor switch, Q5, connected in series with the intensity control and the cathode of the CRT. A diode rectifier circuit supplies base current to the switching transistor when rf is present at the input terminals, allowing cathode current to flow and making the trace appear. However, with no rf present, the transistor is cut off, and the trace is blanked. This feature prevents "burning" the CRT and adds to its useful life. For special applications the blanking circuit can be bypassed by closing switch S2.

The vertical plates of the CRT are capacitively coupled to the input jack through the level-control potentiometer. This type of connection requires no tuned circuits and simplifies operation of the scope. This input circuit works well with coax feedline, but balanced feedlines will require either a tuned circuit transformer or a pick-up loop placed near the transmitter tank circuit or the antenna tuner. In any case, the scope requires about 50 volts peak to peak for usable deflection.

construction

The monitorscope is mounted in a 10 x 6 x 3½-inch Minibox. A combination of circuit board and point-to-point wiring was used. While the layout and wiring are not critical there are several precautions that should be taken. Since no CRT shield was used, in the interest of low cost, any magnetic fields present in the circuit should be as far away from the CRT as possible. The primary source of such fields, the power transformer, is located behind and as far to the side of the CRT as the chassis will allow. The leads carrying ac power to the front panel switch were shielded as a further precaution.

Mounting the CRT posed the biggest problem. After several unsuccessful attempts, I finally decided to use a soft foam plastic drinking cup, now almost universally available. First, cut a 2-3/16-inch-diameter hole in the front panel of the enclosure. At this point I would recommend using a pair of tin snips or a nibbling tool and then finishing with a file. Fly cutters and hole saws do a nice job, but they can be quite dangerous when the work piece is not adequately held down.

When the hole is finished, cut the bottom out of the plastic cup, insert the CRT base first through the bottom of the cup, and then insert this assembly through the front panel and pull it up snugly. The base of the CRT is supported by its octal socket mounted on an L-shaped bracket. **Do not** permanently mount the CRT socket until the scope has been tested and the tube rotated to make the trace horizontal; pin 1 of the CRT should be positioned near the top for preliminary alignment.

The excess foam cup extending through the front panel can be trimmed with a razor blade or sharp knife, leaving enough material to act as a bezel. A piece of plastic tape should be wrapped around the cup where it contacts the front panel.

Because they are seldom adjusted once set, the focus and intensity controls are mounted on the rear of the enclosure. Also, the blanker bypass switch S2 is mounted on the rear of the enclosure, because it is only used for special applications.

The leads carrying rf are kept as short as possible to the extent that the input-level potentiometer is mounted on the bracket that holds the CRT socket. A shaft extension is used to bring the control to the front panel. The blanking circuit is wired on a terminal strip and is mounted directly behind the level control.

Power supply components are wired to a terminal strip, which is mounted to the rear wall of the enclosure. The horizontal amplifier and sawtooth generator are built on a 2 x 2-inch piece of G-10 epoxy glass Vector board with holes spaced on 1/10-inch centers. The components are mounted on one side of the board with their leads extending through to the other side. The leads are bent over and soldered to the leads of the other components to which they attach. Short pieces of bare wire are used for supply leads and grounds. This is a very quick and easy way to build "printed" circuits without the fuss and mess of screens, resistors, etchants, drills, etc. Standard precautions should be taken with the semi-conductor devices.

When complete, the circuit board is mounted on ¼-inch spacers using number-4 hardware in the area behind the horizontal-level control and beside the CRT. Lead dress to the board is not critical, but shielded wire is recommended for the FET input circuit.

testing, adjustment and use

After completing the construction and double checking your work, apply power to the scope and check the three supply voltages (11 volts dc, 175 volts dc, 525 volts dc). If they are within reason, close S2 and advance the intensity control until the trace becomes visible. At that point, adjust the focus control for the sharpest possible line or dot. Switch to internal sweep, and advance the internal level control to the point where the trace no longer lengthens or where the trace is approximately 1½

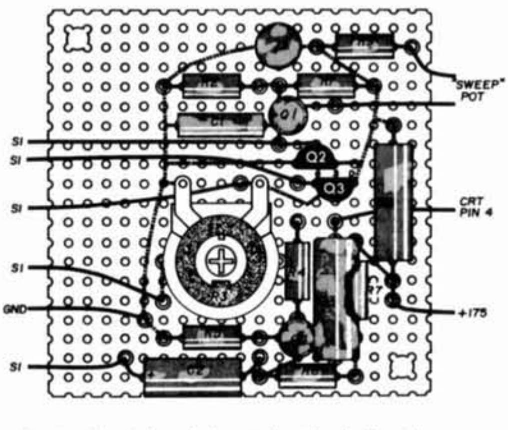


fig. 2. Circuit-board layout for the horizontal amplifier.

inches long. For best performance the 2.7-megohm bias resistor for the 40354 (Q4) should be adjusted so that the collector voltage is one-half the supply voltage (87 volts in my case). Rotate the CRT slightly to bring the trace horizontal. You may want to mark the mounting bracket and permanently mount the CRT socket at this point.

The monitorscope is now ready for use. Connect a piece of coax between the scope and the transmitter and connect the antenna to the scope. For envelope patterns use the internal sawtooth sweep, adjust the input-level control for on-scale displays, and adjust the sweep control for low sweep frequency. Open S2, and the trace will only appear when transmitting.

For trapezoidal or "bow-tie" patterns, connect the horizontal input to a point in your transmitter that has 0.5 to 2 volts of audio, and switch the scope to external horizontal input. With maximum audio applied to the transmitter, adjust the horizontal level to slightly less than with the internal sweep. Trapezoidal patterns are quite useful for monitoring the modulation percentage of a-m transmitters. "Bow-tie" patterns are obtained from double sideband, suppressed-carrier transmitters and are useful for checking amplifier linearity.

Single sideband transmitters, however, will require the use of the envelope pattern. Checking the performance of an ssb transmitter generally requires the use of a two-tone audio generator, which could be built into the monitorscope if desired. For waveform analysis and other information, consult the **Radio Amateurs Handbook**, the **Radio Handbook,** or **Radio Communications Handbook.**

When this scope is used with transmitters of 400 watts **output** or more, insert a 10k ohm 2-watt composition resistor between the input jack and the level control (the point marked X in the schematic). Also, for use with high-power rigs, SO-239 or similar types of rf connectors should be used in place of the phono jacks. There are actually several ways to connect rf to the monitorscope. **Fig. 1** shows the method just described, which is the way it's used at my station.

Some transmitters, such as the Heath HX-10, have a monitor jack provided for connecting an oscilloscope or other devices. Usually a small-value variable capacitor is connected to the transmitter rf output jack.

As mentioned before, the CRT is unshielded, so use care in the placement of this scope when in use. If it's located too close to power transformers or rf fields, distortion of the trace will occur. If it's impractical or impossible to keep the scope out of such fields, I would recommend using a CRT shield such as Millen 80802-A*.

One final note in regard to centering the trace. As you will notice, no centering controls have been used on this scope, as the 902A is fixed centered. While the trace is not perfectly centered, it is good enough for all but the most particular individuals. These controls were left off for simplicity and lower cost, but if you desire to move the trace around a bit, **fig. 3** shows a few modifications that can be made. The resistor marked with an asterisk should be chosen to develop about 400 volts accelerating potential (pin 1) at the CRT with the focus and intensity controls adjusted for use. Start with about 470k ohms and adjust accordingly.

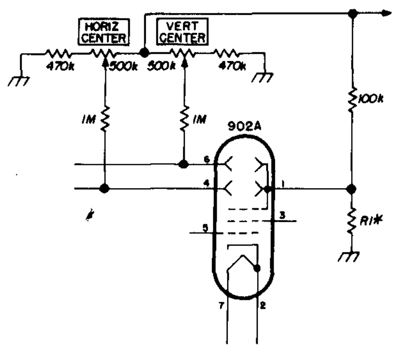


fig. 3. Circuit modification for trace centering. Resistor R1 is adjusted for approximately 400 volts on pin 1 of the 902A; start with 470k ohms.

* Available from Millen distributors for $7.30.

ham radio

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seven-tenths-wavelength ground plane for two meters

Ted Capsanes, W3WZA, 6747 Riverdale Road, Riverdale, Maryland 20840

The subject of gain antennas will often produce a varied response when taken under discussion by amateurs. This is especially true in vhf mobile applications where the system uses a grounded vertical as the radiating element.

The purpose of this article is to point out some of the basic characteristics of the ground plane, and to show how these properties were used to adapt an existing antenna to 147 MHz.

characteristics

Commercial mobile antennas designed for the frequency spectrum of 140-170 MHz have certain structural characteristics that distinguish them from their lower-band counterparts. At these higher frequencies, the heavy-duty spring mount base is not practical. Gain antennas within this range are generally limited to half-wave or five-eighths-wave radiating elements that are base loaded to extend the electrical length to three-quarter wavelength. The matching network is sealed within a thin cylinder that forms the mounting base for the entire antenna.

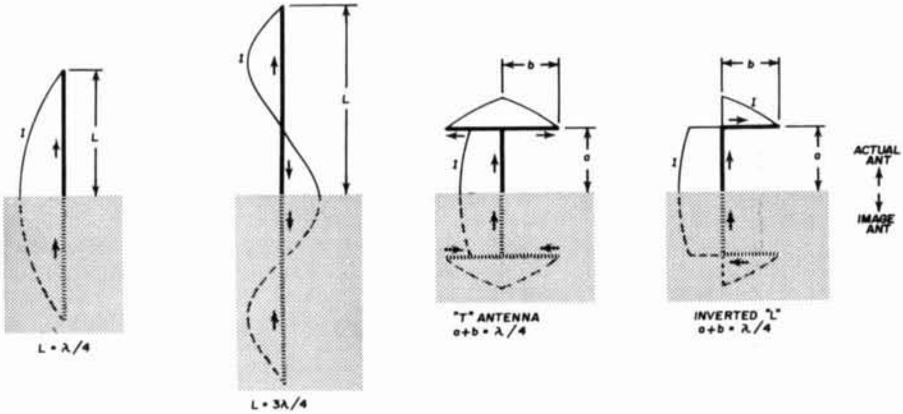
The electrical properties of a grounded vertical are shown in **fig. 1** and **2.** The common quarter wave is widely accepted because the feed point is not reactive and presents an impedance of suitable value. The lobe pattern of a half-wave antenna provides some gain, but the element end presents a current null that can't be matched directly to common transmission lines. A three-quarter-wavelength radiator is an ideal match for 50-ohm transmission line, but low-angle lobes are secondary. With more energy being directed toward the higher angles, direct-wave field strength, at zero elevation angle, is less than that of the quarter-wave antenna.

Most vhf amateurs recognize the five-eighths-wavelength antenna as the ultimate in a single-element radiator, but many don't know the true gain of the device. This is sometimes brought about by misleading literature that uses the dipole or isotrope as the reference source. The top curve of **fig. 2** is convenient for determining true zero elevation angle gain under ideal conditions (perfectly conducting ground).

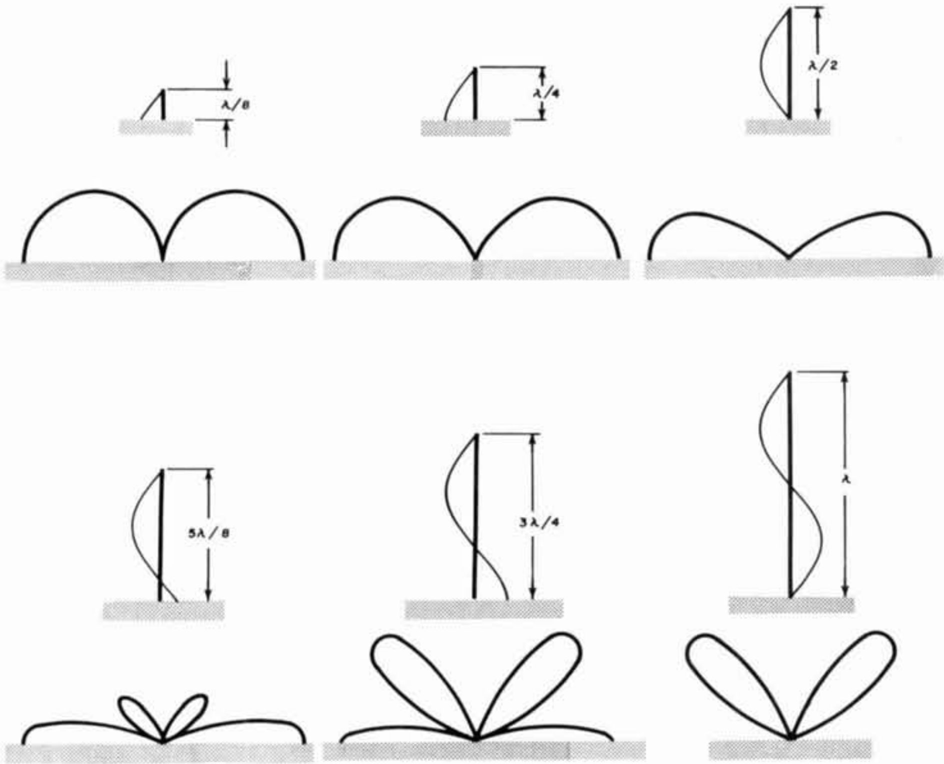
construction

These facts presented an interesting challenge. I wanted to evaluate some Motorola equipment in the fm portion of the two-meter band. However, the only permanent antenna system on the car was a quarter-wave six-meter whip, using a 232-Series Master Mobile tapered spring base. I couldn't see any way to utilize this system as a gain antenna in any conventional manner.

The only practical place to locate a matching network was at the coax terminal point inside the trunk of the car. As stated before, the purpose of the loading network is to extend the electrical length of the system to three-quarter wavelength. This means that the junction point of the



(a) CURRENT DISTRIBUTION



(b) VERTICAL PLANE RADIATION PATTERNS

fig. 1. Characteristics of grounded vertical antennas.

loading coil and the radiating element will exhibit a high impedance with a half-wave radiator, and the impedance will decrease as the radiator length is extended.

Seven-tenths wavelength appeared to be a good compromise. The zero elevation angle gain was better than that of a quarter-wave whip, and the impedance at the junction point approached minimum. The over-all length of the antenna (including base) is 52-1/2 inches for 147 MHz. The

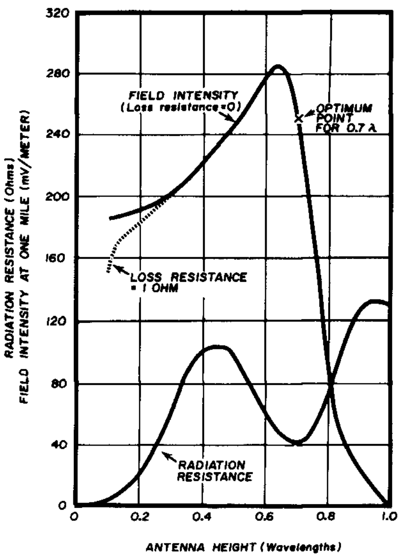


fig. 2. Radiation resistance and field intensity as functions of antenna height.

gain slope in this area is very steep (**fig. 2**), and a difference of one or two inches will alter the characteristics considerably.

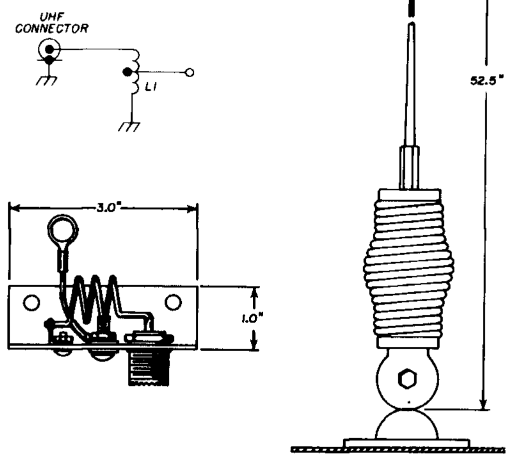
Fig. 3 shows the electrical and mechanical characteristics of the matching network. The device is built on a three-inch length of aluminum angle, with holes spaced to accommodate two of the mounting screws of the existing base. The coil is wound around a ½-inch form using number-14 bus wire. A teflon feedthrough, with a 6-32 screw, serves as the junction point for the coil tap and the antenna base coupling wire. This wire should be cut so the terminal lug center-to-center dimension is 1-3/4 inches. Typical solder lugs provide sturdy mechanical support of the coil at the tap point and ground end.

Electrically, L_1 supplies the requirement of two coils. The 1¼ turn between the uhf connector and the antenna is the series loading inductance. The remaining portion provides the shunt impedance required to cancel approximately 72.5 ohms of capacitive reactance.

Part of the capacitive component of this reactance is due to the mechanical structure of the Master mount and its relationship to the automobile body, when properly installed. This small amount of X_c can be overlooked at the lower frequencies but must be compensated for at vhf. Some additional strays are introduced with the installation of the matching network.

For a period of time, the development of the antenna overshadowed the original task of equipment evaluation. Practical

fig. 3. Mechanical and electrical details of the antenna. L1 is 4 turns no. 14 bus wire, 3/4" long, 1/2" diameter, tapped 2-3/4 turns from ground end (total inductance = 0.16 μH).



problems had to be discovered and corrected by trial and error. A seven-tenths-wavelength antenna is not conventional, but it does have useful applications. The purpose in pursuing the project was to prove that it could be done.

references

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J. D. Kraus, "Antennas," McGraw-Hill, New York, 1950, pp. 315, 316.

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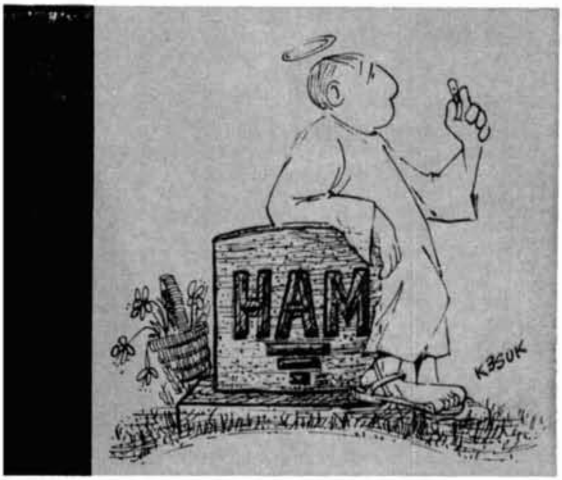


"Just 15 lousy little milliamps"

safety in the ham shack

Safety in the ham shack should be second nature to amateurs, but often it's not– with catastrophic results

Jack Darr and Alan James

Most of us don't think of it very often—in fact, not often enough—but safety precautions in the ham shack are doggone important. One careless move, and your call letters may be up for grabs (to someone who has more respect for the right way to do things). If people visit your shack, an unexpected slip, stumble, or fall might be more than just annoying or painful; it might slide someone into the hospital or undertaker's, and you into a law-suit.

Actually, there's nothing hard about safety precautions. Most are just good old common sense. Wire has insulation, power supplies have covers, transmitter cabinets have interlocks, chassis have ground posts—all for a purpose: to keep the careless or untrained out of danger. Many of the simple safety devices on commercial equipment can be added to homebrew gear with very little trouble. A few cheap signs and a little thoughtful housekeeping around your shack will probably take care of most hazards.

the protection racket

There are three classes of people you've got to think of: **You,** who spends more time in there than anyone; **your family,** especially the ubiquitous kid brother (or kid sister) who may sneak in while you're not around, and **casual visitors,** like girls (you remember, those high-pitched voices you sometimes hear on the air), or neighbors, or just family friends; all may be the inquisitive type who just can't resist touching "all those cute little things" on the bench.

Certain standard precautions will keep the last two groups out of most trouble. Just keep all of the hot stuff safely boxed up in tight, well grounded metal cases. The only thing that could bite 'em then would be an open transmission line. Big, red-lettered signs labeling open voltages are a warning to anyone who can read, but—judging from the number of people who have gotten needless rf burns in one shack we know of—not everyone does. Complete insulated shielding is the surest protector.

Keeping all three classes of ham-shack inhabitants safe is your responsibility. Make a "safety inspection" of your own shack. Look for hazards you hadn't thought of, and clean 'em up. If you don't find at least a couple of things that need fixing, it'll be unusual.

no horseplay

Talking about visitors brings up a serious point: don't horse around with electricity! We all know the type of guy who hands other people charged electrolytic capacitors, or touches them with hot wires and that kind of stuff, just to see them jump. Guys who do this are idiots. It's not only painful, but can have sobering consequences. If you give someone a playful jolt and he turns out to have a weak heart, you may find yourself trying to beat an involuntary manslaughter rap!

"And there's the class II idiot"

And, there's the Class II Idiot. This is the guy who comes up behind you when you're working on a piece of gear with high voltages exposed and yells "Boo!" or jabs you in the ribs. Only once did either of us ever tell anyone to leave the shack and never come back, and that was one of these numbskulls. Fortunately, the jolt he caused was merely painful, but it wasn't funny. Working on anything with exposed high voltages, you're naturally tensed up and ready to jump anyhow. If you aren't, you should be.

It's no place for you to show off, either. You'd best keep a healthy respect for the voltages and rf fields that abound. Don't try to prove you're a big smart operator who knows just how to play around live transmitters without getting killed. You only get one chance to be wrong.

During World War II, we knew a young smart-alec ham in the Signal Corps who knew "all about transmitters." He worked around high-power transmitters and wore a finger ring. We told him to take it off, but he wouldn't. One day he reached into a 1-kW transmitter to "make an adjustment" with the soup still boiling. You know what happened when that ring got into the high-intensity rf field: the tank coil made an efficient rf heater. He came out a heck of a lot faster than he went in. He suddenly wanted that ring off. After the big blister had healed up, he did get it off and never put it back on.

the shock treatment

The danger of electric shock is the ham shack's worst hazard. Exactly what can cause shock is not as well understood as it should be. You gotta know what to watch out for if you plan to keep your beam from being lowered to half-mast.

This doesn't mean only novices, who might not know the different hazards. It also applies to the OM who's been lucky. He may have worked around the stuff so long without a jolt that he has gotten contemptuous. **Don't!**

How much "electricity" does it take to put you off the air permanently? Not your rig, but **you!** 2,000 volts? 5,000 volts? 110 volts?

Pick up a #47 pilot lamp. It draws 150 mA at full brilliance. Only **one-tenth** of that through your heart can kill you. Just 15 lousy little milliamps! You couldn't even let the bulb light up to a dull red glow before you would become part of a "ground system" yourself (large conductive object, buried deep).

Scare you? It should. It isn't voltage necessarily that kills; it's the current the voltage can push through your body. Even the "lowly" 117 volts of ac house power can be astonishingly deadly, given an easy access to your body (through wet hands, wet feet, damp cement floor, grounded water pipe or chassis, and so on). Not all shock deaths in ham shacks come from transmitter high voltage.

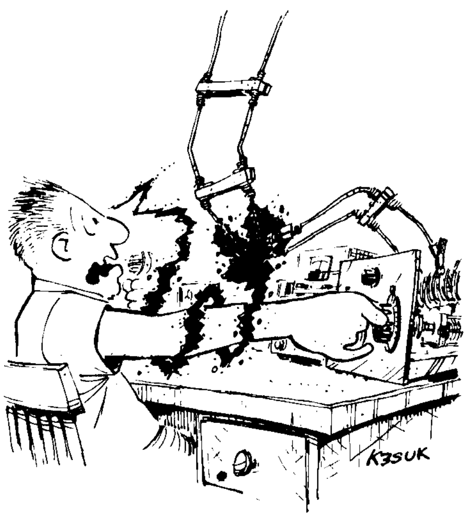
There's one thing a lot of hams forget. The ac line coming into your shack has two wires. The *black* one is hot, and the *white* one is grounded right outside the house, at the first utility pole, and at all the other poles—well grounded. The black wire, therefore, is always hot, with reference to **any** grounded object, and that includes **you.** You can light a 1,000-watt lamp from **one wire** (the hot one) merely by furnishing a ground for the other contact of the lamp.

In 220-volt systems, the black and white wires are both hot, and a **green** wire is the ground (called neutral or common). In three-wire "safety" cords on a lot of newer tools, appliances, and the like, the black wire is hot, the white wire ground, and the third (green) wire goes to the round pin of the AC plug—for a separate ground, usually to the metal case of the unit. However, don't put blind trust in color-coding! Even electricians make mistakes sometimes, and you might find wire-colors reversed.

So, if you happen to be grounded, and touch a hot side of the ac line with one hand (even with the other one in your pocket, as the old saw goes), **bang!** Standing on a dry wooden floor, you might get away with it. On a cement floor, on bare ground, or with any part of you touching a grounded object, look out.

The basement shack is dangerous because it usually has a cement floor. Even vinyl tiles or linoleum seldom help. Moisture works up between the tiles.

There are two things that will help. One: put down a thick rubber runner or mat on the floor near your gear. Use one-piece stuff, without cracks. Don't trust wood; it absorbs moisture. Two: wear shoes with rubber or plastic insulating soles. Caution: if the soles are of the sponge or foam type, and you've been walking through water, look out—you've lost your protection!



High-energy rf voltages have the disconcerting ability to reach out and burn.

A wooden-legged stool or chair is best for working or sitting. If you have a metal stool, put plastic cups on the ends of the legs.

If you're working on ac-powered gear, the first thing to do is pull the line plug, and lay it on the bench where you can see it. Also, be sure you pulled the **right** plug. Many's the ham who has gotten the whop knocked out of him by pulling the wrong plug and then grabbing a wire in the wrong place!

hard-hitting dc

Hams seem to pay attention to the dangers of high-voltage dc in their rigs. Rightly so. It can be a dangerous source of electrical energy. Voltages range upward from 300 volts in receivers, up to 1,500-2,000 volts in transmitters. In well designed power supplies, shunting resistors across each electrolytic capacitor bleed off the voltage stored in the capacitors when power is turned off. They bleed it off **if** the resistors are good. You have no way of knowing, unless you check with a voltmeter. Don't put much faith in bleeders. A "shorting switch" may be provided to short high voltage to ground when the cabinet is opened.

If these devices work, okay. But the handiest gadget you can have for working around lethal electrical energy is a suspicious mind! Before you poke your little pink, *uninsulated finger in there, check for* residual voltages!

long-reaching rf bite

High-energy rf voltages have the disconcerting ability to reach out and burn you without your even contacting the circuits carrying them. Consequently, the inside of live transmitters, and the feed lines from them to the antenna, are places to keep your distance from. Coaxial cable is safest for the feed line, but it isn't feasible at some frequencies and with some kinds of transmitters.

If you have a high-power rig with an open-wire antenna lead, you can put this line too high for anyone to reach. Or you can put a plastic cover over any exposed antenna wires, switches, etc. The antenna line itself can be ordinary automotive ignition wire. The insulation on this handles up to 25,000 volts, which will safely contain even a California kilowatt. It's even available with "pretty" bright-red plastic insulation, to dress up the shack.

Under no circumstances use a metal screwdriver to make adjustments in high-power rf circuits. This is a real shock-hazard. Besides, metal screwdrivers detune rf circuits. Use insulated tuning tools or shaft extensions.

protection from ufo's

That pretty well takes care of you, if you use your head. Now, how about the rest of the world, especially Kid Brothers and such? KB's are good at sneaking in and turning the whole thing on to show visiting

Kid brothers are good at sneaking in and turning the whole thing on to show visiting buddies.

buddies. In fact, even a non-ham Pop isn't immune to that kind of temptation: "Look at this thing my kid built! How about that? Lemme show you how it works!"

There's one way to make sure the Unlicensed Foolish Operator (UFO) can't get into trouble. Wire the rig to a separate ac power supply, and put a master switch on it. When this is turned off no power reaches the rig at all.

This is easy to do, with heavy Romex wire and "surface" fittings. Use an enclosed switchbox with fuses inside and a lever-operated double-pole switch to open both sides of the line. These switches have provisions for a small padlock to be slipped over the lever. The thing will be safe unless Kid Brother finds the key. So, keep it with you. If there is a spare, give it to Mom for safe-keeping; she won't let KB or Pop have it!

safety and showmanship

Back when most ham gear was homebrew (there weren't any kit companies), there was a lot of exposed wiring. Haywire "lashups" were common—wires going everywhere. Nowadays, a little ingenuity can make the shack look as smooth as a broadcast station. This is not only much better looking, but a whole lot safer for everyone concerned. It keeps the hot circuits and wiring covered up.

How? It's easy. Just put all the gadgets into boxes or behind panels. You can buy metal boxes in any size you can imagine. Power supplies, antenna couplers, preamps, modulators, or anything else, can be built into these boxes. If you have some unit that can't stand the added capacitance of a metal box—say, an antenna coupler—use a non-conductive box: masonite, bakelite, acrylic, polystyrene.

With nice professional-looking, neatly lettered panels on the front, your boxes can dress up the whole place! You can find knobs in any color or size that looks nice. Lettering has always been the hardest part. Now, you can buy lettering decals in black or white, in almost any size. They're simple to put on, and give the whole thing a neat touch. Also, you'll be surprised how much easier (and safer) the equipment is to use when all controls are labeled!

If you have a chassis so goodlooking you hate to cover it up, use a clear plastic panel. Quarter-inch stock can be bought in almost any size sheet you need. (Try aircraft supply houses; plane windows are plastic. Or look around the boneyard at the airport; wrecked planes always have "lots of good parts.") Use black lettering on the clear plastic panel. For a final touch, turn the pilot light so it illuminates the chassis when it's turned on!

With the stuff enclosed in boxes and panels, the shack looks a lot better. You also keep it safer, and the worst trouble a visitor is likely to experience is a bawling-out from you for fiddling with all those pretty knobs!

safe and sane construction

Commercial and kit gear is pretty well safety-ized; homebrew gear is something else, but it shouldn't be. When you build a new transmitter or receiver, if there are any voltages present higher than about 25 volts dc, take precautions. There are a few simple steps that make any rig safer to use and work around.

For one, be sure the ac power coming to the switch and power transformer of the rig is well protected. Mount a strong three-terminal strip just inside the chassis, and solder the ac cord solidly to the lugs, along with the leads for the power transformer primary and the switch.

In transmitters, there are several controls to adjust for proper tuneup or loading. The shafts of some of these must be "hot"—for example, the small trimmer capacitor across the final tank in the antenna circuit. When you mount such controls, situate them so you can use insulated extension shafts. Then you can make tuneup adjustments from outside, in perfect safety. You can get plastic tubing 16–18 inches long that'll fit over a 1/4-inch shaft. All you have to do is slip the open end over the shaft and fix it there with a dab of epoxy-resin cement. Leave about an inch of the tubing sticking out, if the control works easily, and you won't even need a knob.

A new piece of gear usually starts out in breadboard style, even in fancy electronics labs. Temporary wiring, if done sloppily, can be dangerous. To keep it safe, use well insulated wires, and make sure all power connections are tight (so they can't work loose and touch things they shouldn't).

There's one good way to connect two wires together temporarily. Take a 6-inch piece of spaghetti large enough to slip over the insulation. Slide the spaghetti over one wire. Strip about 1/4-inch of insulation from the end of each wire, and solder a smooth lap joint. When the solder sets, slip the spaghetti over it so the joint is right in the middle. When you're ready to put the thing into permanent form, slide the spaghetti back, and a tap with the hot soldering iron will open the joint. You can even put the spaghetti "back in stock" unharmed. No waste at all!

The lap joint is also useful for temporary connections in the apparatus itself. Tack the wire end to the terminal lug solidly. Don't make a hook in the wire; let the solder do the holding. The joint will be safe and solid, but easily disconnected when you get the final design done.

Exposed multiple-screw terminal strips on the back of a piece of gear might not seem particularly dangerous since they'll be well out of the way—or, will they? Try dropping a pencil or something down behind and then reaching for it. (Voice-Of-Experience stuff again!) All those terminal strips can be covered up, either with plastic covers bolted in place or with a wide piece of cloth-backed adhesive tape. The tape is a good temporary precaution during construction, as well.

When you make interconnections between units, make them safe. The best way is to make them plug in. A good source of cheap plugs and sockets is a junked TV chassis; octal tube sockets and old tube bases can give you enough plug/socket combinations to last a long time. One hint: when you hook these up, be sure the voltage **source** is connected to the **female** plug! This way, the contacts are out of reach. Never have voltage on a male plug, with its exposed pins; this is courting trouble.

Safety in the ham shack is really simple and easy if you go at it in the right way. All it takes is a little common sense, some insulation and decent housekeeping. Keep the hot stuff well covered up, so the ignorant or uninitiated can't get their fingers into it. Keep the floors cleared so no one trips and breaks something (of yours or theirs). Practice looking for possible hazards, and then take precautions to make them harmless.

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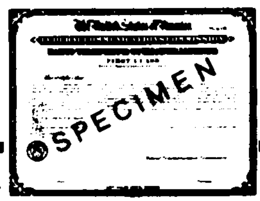

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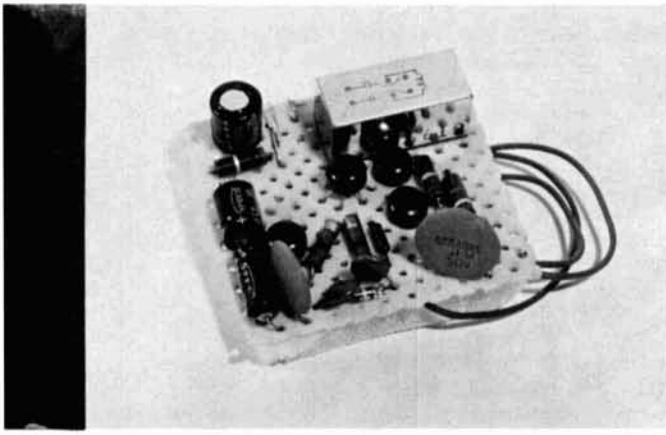

versatile ic vox

The many faceted μL914 IC in a simple but effective microphone control circuit

John J. Schultz, W2EEY, 40 Rossie Street, Mystic, Connecticut 06355

Using an inexpensive integrated circuit for stage functions, this vox unit can be added to any transmitter. Operation is particularly stable and adjustment simple. If an antitrip stage is not needed, the circuit requires only two IC's and one transistor.

An effective vox circuit should have

1. Good sensitivity.
2. Positive relay switching.
3. Good antitrip action.
4. Independence of the controls for over-all sensitivity, antitrip sensitivity, and time delay.

The unit described may not be the last word in vox performance, but considering its relatively simple circuit, it performs much better than many elaborate tube or transistor units. The switching action is positive, and it has none of the transient problems associated with many other circuits, particularly those using tubes. Its construction and power supply requirements are straightforward. It can be easily incorporated into an existing transmitter or built as an outboard unit for mobile or portable service.

The heart of the unit is several Fairchild μL914 integrated circuits. This versatile IC costs less than a dollar from major supply houses and is fast becoming one of the most popular units for amateur use. In fact, you might say that it is the 6V6 of integrated circuits. Part of this popularity derives from its basically simple internal circuit, **fig. 1.** The circuit is certainly simple compared to many other IC's, but this very simplicity allows it to be used, by varying its external connections, for a wide variety of uses ranging from switching to amplifying circuits. Packaging four transistors inside the unit allows compact and economical circuit construction.

The vox circuit illustrates the wide variety of uses for the μL914. Even if you don't build the vox, the circuits may inspire ideas for other applications.

the circuit

The complete vox circuit is shown in **fig. 2.** Three basic stages are used, each containing one μL914—an input amplifier, inhibit gate, and delay generator.

The audio input circuit is conventional. If you compare the terminal connections of the μL914 in **fig. 2** with the actual μL914 internal circuit of **fig. 1,** you will see the amplifier consists of two tandem grounded-emitter stages. The capacitors at pins 1, 5 and 6 are not adequate for good speech reproduction (they should be 20 to 25 μF), but this is not important for this particular application.

The audio input can be taken from the first audio (microphone) amplifier stage in the transmitter, if sufficient level cannot be obtained directly at the microphone connection. Alternatively, if this is inconvenient, another μL914 amplifier stage can be added to the vox, with the sensitivity potentiometer connected between the two stages.

The second μL914 stage is an inhibit gate or switch for antitrip action. It prevents microphone pickup from the station loudspeaker from activating the vox circuit. The antitrip reduces the vox's sensitivity to speaker signals by reducing the over-all vox gain. The second μL914 performs this function in a unique manner.

If the terminal connections for the μL914 are followed, it will be seen that one transistor is an ordinary grounded-emitter amplifier. Another transistor is a shunting element, with its collector and emitter across those of the first transistor. A positive control voltage applied to the base of the second transistor decreases its collector-emitter resistance and shunts the output.

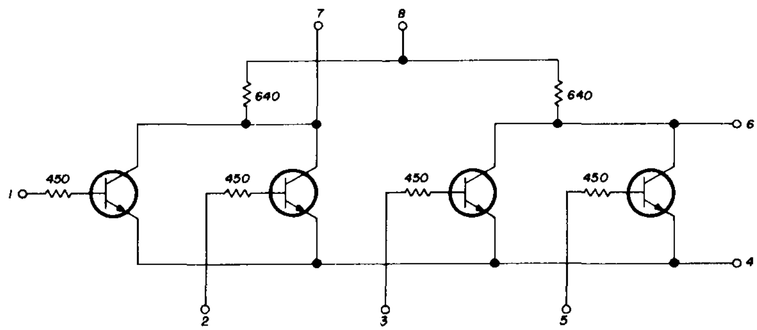

fig. 1. Internal circuit of the μL914 integrated circuit.

The control voltage is developed by simply rectifying part of the speaker voltage. As shown, a transformer (miniature transistor type) matches the speaker impedance. If an audio connection can be made at a high-impedance point, the transformer will not be necessary, and connection can be made directly to the antitrip level potentiometer through a 1-μF capacitor.

The entire vox unit can be considerably simplified if the antitrip feature is not required. In home stations where the microphone gain is run fairly high and loudspeaker operation is used, antitrip is required. In situations where the microphone gain is run low

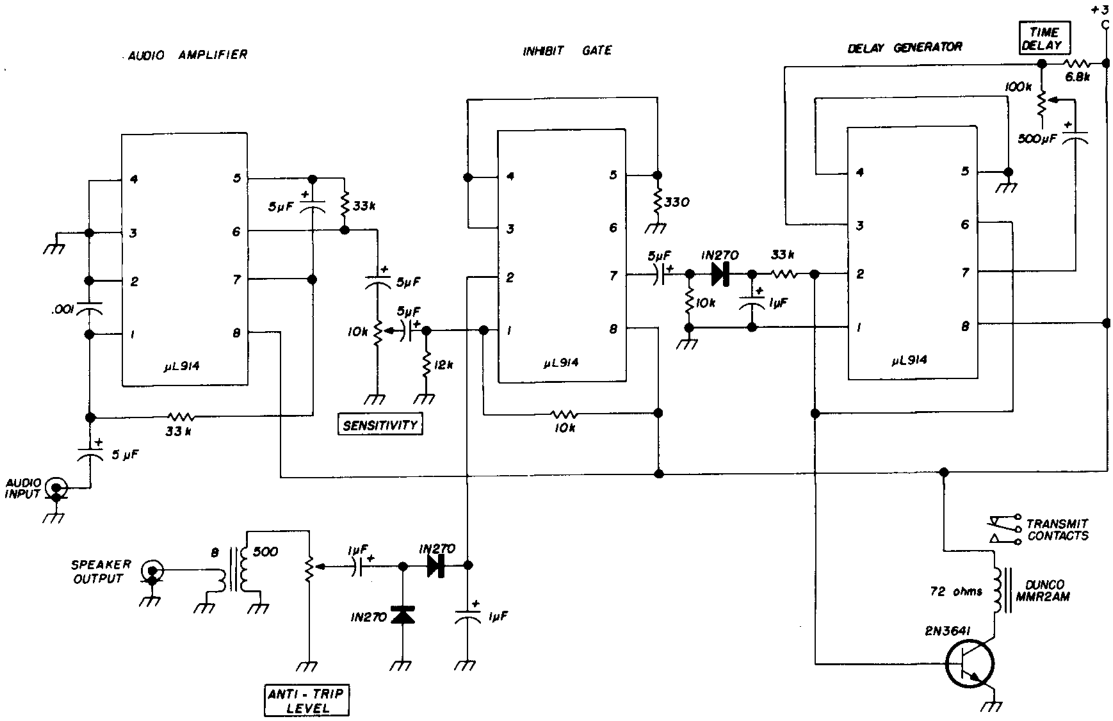

fig. 2. Schematic of the IC vox; each integrated circuit is a µL914. The relay is a Dunco MMR2AM.

and the microphone held closely to the lips, antitrip is often unnecessary, even with loudspeaker operation. If antitrip is not needed, the second µL914 can be eliminated, and the arm of the 10k sensitivity potentiometer connected to the left side of the 5-µF capacitor that is connected to terminal 7 of the second µL914.

The third µL914 is connected as a form of monostable vibrator. A positive input pulse produces a positive output pulse. The rectifier circuit between pin 7 of the second µL914 and pin 2 of the third µL914 provides the positive input pulse. The output pulse remains positive for a period after the input pulse has decayed; this is determined by the time constant provided by the 100k potentiometer and 500-µF capacitor. A maximum delay of about 3 seconds is possible, although this can be increased as desired by increasing the capacitor value.

The output pulse from the delay generator controls the 2N3641 switch, which in turn activates the relay coil. The relay contacts are connected across the transmitter push-to-talk circuit contacts. The relay can be almost any low-coil-resistance type that works on 3 to 6 volts.

construction

Actual construction depends upon how the vox unit will be used. If used as an outboard unit, it should be placed in a shielded enclosure. In general there is nothing critical about the wiring.

The photo shows how the components can be easily assembled on a piece of Vector board. The potentiometers can be either mounted on a separate control panel, or miniature PC types can be mounted directly on the Vector board if frequent readjustments are not made. In fact, for a stable situation with specific equipment, they can be replaced with fixed resistors. A suggested parts layout is shown in the photo, but any similar arrangement can be used. The µL914 terminal numbering in **fig. 1** should be carefully noted. The index mark denotes terminal 8, and not terminal 1.

Other types of integrated circuit "dual 2-input NAND/NOR gates" may be usable in place of the μL914, but the specifications for their internal values should be carefully checked to see that they generally correspond to the μL914.

The vox may be battery powered from D cells or operated through a voltage divider circuit from a low-level dc source in the transmitter. If battery operated in a mobile station, a zener voltage regulator is desirable to prevent voltage fluctuations from changing the time delay.

summary

Adjustment is quite simple. If the antitrip stage is not used, the sensitivity control is set for the microphone level at which you want the transmitter to be turned on. The time delay is adjusted for the desired pause period between words until the vox disables the transmitter. If the antitrip feature is used, the procedure described above should be followed with the speaker volume turned down. The speaker volume is then turned up and the antitrip level adjusted so the speaker output does not activate the vox. Control interaction is nil.

A further interesting use to which the vox unit can be put is to add cw operation to a ssb-only transceiver. A keyed audio tone is fed to the transmitter audio input and the vox unit. The vox then acts as a cw break-in circuit with an adjustable time delay. One important precaution that must be observed, however, is that the tone be of a single frequency and as pure as possible. The output of any tone oscillator used should be checked on an oscilloscope. Through suitable amplifier circuits, the keyed tone can also serve as a sidetone for monitoring the keying.

A final word of caution concerning handling the μL914 is in order. Although it will withstand considerable environmental extremes, the μL914 can be easily ruined by excessive terminal heat or incorrect supply voltages. The same precautions applicable to all transistor circuits should be observed.

ham radio

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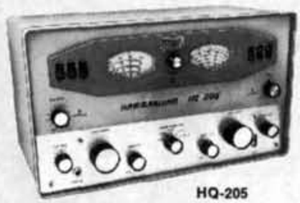

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propagation predictions for march

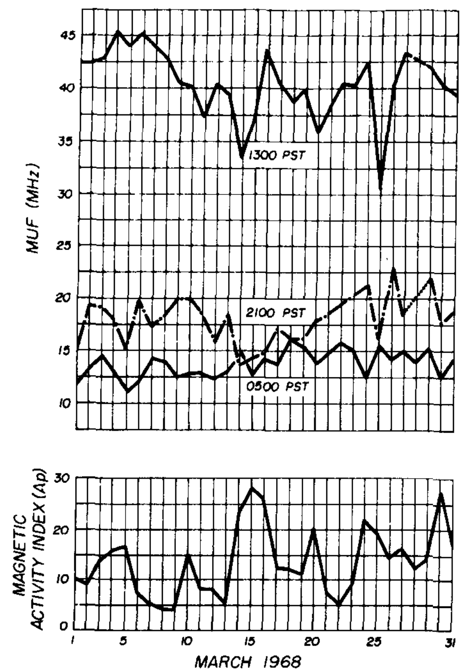
Victor R. Frank, WB6KAP, 12450 Skyline Boulevard, Woodside, California, 94062

Let the reader beware; I am in the process of modifying the computer program used to derive the maximum range charts for this column. The first step (incorporated in the February column) was the conversion of distances from kilometers to statute miles (previously done after the chart was drawn). The only change you will notice is that the minimum range is now 1000 miles instead of 1000 km (625 miles). The problem: new "refined" formulas may cause a greater change in predictions between months than is actually present. Next month 160 meters will leave the charts.

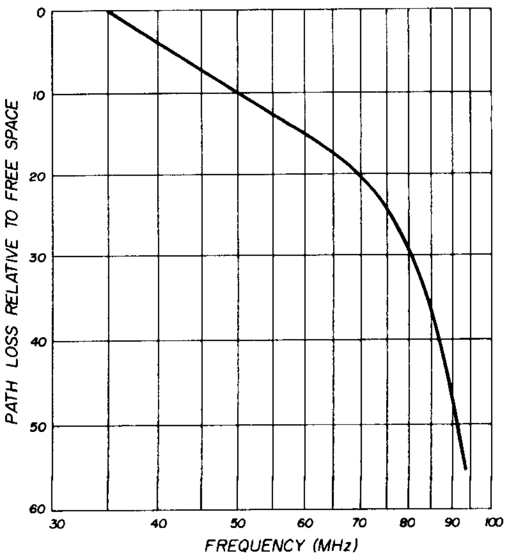
Predictions of sporadic-E activity may deservedly cause you to entertain some reserved skepticism. Looking back on December 1968, not only were there no two-meter sporadic-E openings reported (in the Northern Hemisphere), but six meters didn't fare well by sporadic-E either. However, ZK1AA in the Cook Islands moved his beacon to 50.100 MHz, and I have reports of it being heard in Southern California on December 5, 7, 9, 10, 21, 22 and 29, generally between 1400 and 1530 or between 1830 and 1930 pst.

maximum usable frequencies

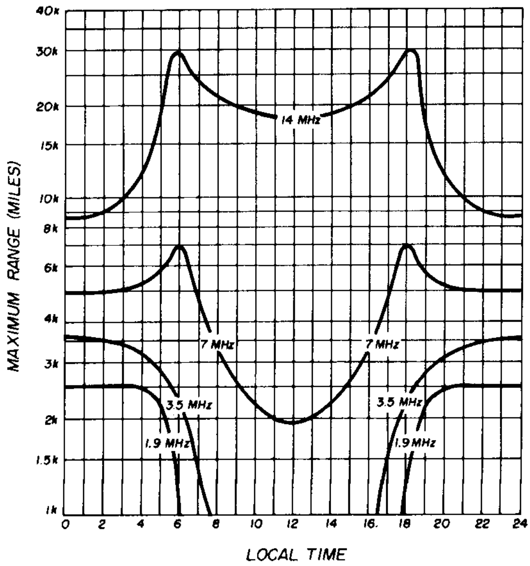
It is expected that solar activity will continue its very slow descent from its peak in 1968. The small change of smoothed sunspot numbers from last March (103 for March 1968, 98 for March 1969) may only be noticed by 50 MHz operators, and an increase in the number of ionospheric disturbances **could** result in even more openings. The most likely 50-MHz openings during March and April



1. Maximum usable frequencies (F2 layer) scaled from vertical incidence ionograms taken at Point Arguello, California between March 1 and March 31, 1968 compared with magnetic activity.



2. Variation of path loss with frequency for transequatorial propagation between Oahu, Hawaii and Raratonga, Cook Islands, during March 1968.



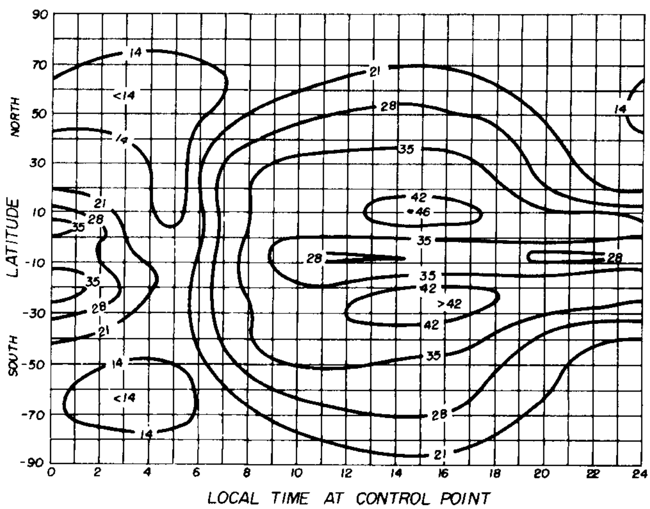
4. Maximum range due to absorption and noise vs local time from 38° N. Latitude to the north.

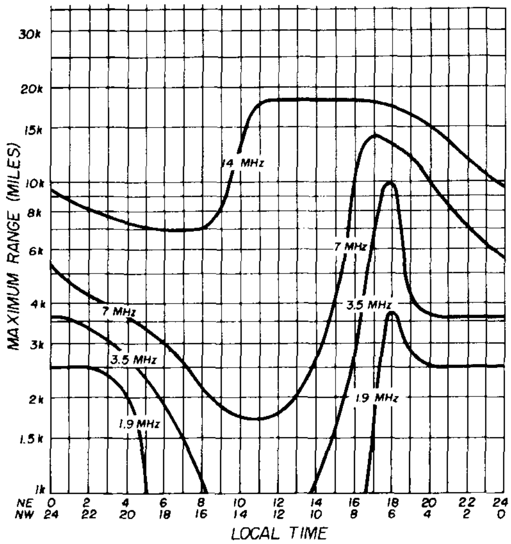
will be by transequatorial forward scatter (for Southern United States) and by aurora (for Northern United States) during the evening hours.

Maximum usable frequencies during March 1969 will probably be within a few percent of those of March 1968. I have scaled vertical-incidence ionograms taken at Point Arguello, California (35.5° N. latitude) during March 1968 to determine the muf for the maximum one-hop distance for a path with the control point at that latitude. The muf's at 0500, 1300 and 2100 local time (pst) are indicated for each day of the month in **fig. 1.** The median muf's predicted by ITS for a 4000 km path were 14.8, 36 and 20.5 MHz, respectively.

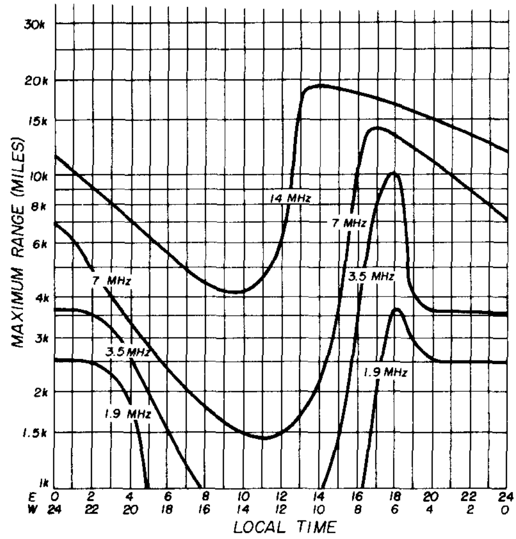
It appears that ITS overestimated night-time muf's and underestimated daytime muf's. The predawn minimum of F2-layer critical frequencies occurs near 0500. The

3. Time chart of predicted median muf for March 1969 based on 90° W. Longitude.

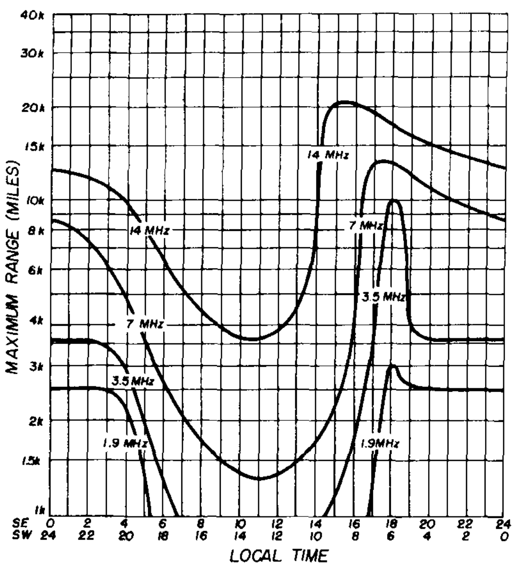




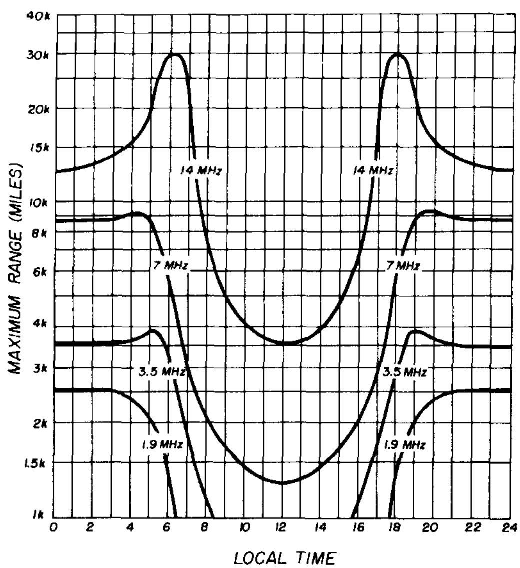
5. Maximum range due to absorption and noise vs local time from 38° N. Latitude to the northeast (top time scale) and the northwest (bottom time scale).



6. Maximum range due to absorption and noise vs local time from 38° N. Latitude to the east (top time scale) and to the west (bottom time scale).



7. Maximum range due to absorption and noise vs local time from 38° N. Latitude to the southeast (top time scale) and the southwest (bottom time scale).



8. Maximum range due to absorption and noise vs local time from 38° N. Latitude to south.

how to use these propagation charts

1. To find the maximum usable frequency for F2-layer propagation for distances of 2500 miles or more in any direction, read the frequency at your control point from the muf time chart. Your control point is 1200 miles away from your station in the direction of the propagation; this is about an 18-degree difference in latitude for a north-south path, or 1½ hours difference in time for an east-west path. The muf time chart may be treated as an muf contour map in the longitude interval between 45° W. and 135° W. As such, each hour is the equivalent of 15° of longitude. A map drawn to the same scale could be overlayed and positioned to the right or left to show the variation of the muf contour map with time.

2. Over any particular path involving more than one hop, the path is the lower of yours *and the other station's control-point muf.* Curved lines may be drawn on the overlay representing the great circle path, as found from a globe or "Ionospheric Radio Propagation," printed by the U. S. Government Printing Office.

3. To find the maximum propagation distance as limited by ionospheric absorption and atmospheric noise, refer to the maximum range charts for the directions you wish to work. Note that the time scales are reversed for westward propagation. These curves are based on unity signal-to-noise ratio in a 6-kHz band*width with 100 watts output power and antenna* gains (over an isotrope) of 6 dB for 20 meters, 0 dB for 40 meters, and —6 dB for 80 meters at each station.

The muf time chart was derived from "Ionospheric Predictions" for a longitude of 90° W. These predictions are published monthly by the Institute for Telecommunications Sciences (ITS), Boulder, Colorado and available through the U. S. Government Printing Office. The maximum distance curves were derived from consideration of atmospheric noise levels (from CCIR report 322) and calculated path losses at fixed distances in each direction from 38° N. latitude. Some minor differences in maximum range would be noted due to change in absorption for stations located between 26° N. and 50° N. latitude. Somewhat greater ranges *would be expected over paths further from the* subsolar point (more northerly latitudes).

The predictions given in this column are for median conditions. On any particular day, muf's may be as much as 10% higher or lower than the median. Absorption and noise levels, particularly on the lower amateur bands may be as much as 10 dB different from the median. Residential noise levels (from electrical lines, appliances and vehicular traffic) may, and frequently will, be tens of decibels stronger than atmospheric noise.

highest muf's occur near 1300 or somewhat thereafter. Prime operating time (for those who work days) is near 2100, which also happens to be in the middle of the transequatorial scatter period (not evident on soundings this far north). Note a decrease in daytime muf's as the month progresses, and an increase in nighttime muf's. The lower curve is of the magnetic activity index Ap.

effect of magnetic storms

Magnetic storms occured between March 3, 0700 and March 6, 0100; March 9, 2300 and March 11, 1200; March 14, 0200 and March 17, 2000; March 23, 0700 and March 27, 1100; March 29, 0200 and March 31, 0000; and March 31, 0300 to April 1, 2300 (gmt). The most obvious effect of the magnetic disturbances was to lower the 1300 and 2100 muf's. The predawn muf's were affected to a much smaller degree. One effect noted on the nighttime ionograms during the storms at the middle and end of the month was spread-F, a time-delay spread echo from ionospheric irregularities, i.e., the ionosphere no longer behaved like a smooth reflecting surface.

transequatorial propagation

Transequatorial scatter propagation involves oblique reflection from F-region irregularities near the magnetic equator. Transequatorial propagation (TE) may occur at frequencies at least twice as high as the muf for regular ionospheric refraction. The signal is often spread in time delay and undergoes Doppler shifts that correspond to reflection from equatorial F-region irregularities drifting east-west as fast as 330 mph. **Fig. 2** shows the variation of minimum path loss with frequency for TE propagation between Oahu, Hawaii, and Raratonga, Cook Islands, during March 1968. Peak signal levels occured between 2100 and 2200 local time. For reference, well-equipped amateur radio stations could probably communicate with a path loss of 50 to 60 dB in excess of free-space loss at this distance.

In view of the preceding, and infrequent propagation at 108 MHz, it appears that 144-MHz TE is somewhat beyond the range of amateur radio capabilities. However, the same has been said of 220-MHz meteor scatter and 432-MHz aurora.

seasonal changes

As the vernal equinox (March 21) approaches, the effect of geomagnetic control on the F2 layer becomes more evident in the muf time chart, **fig. 3.** At 90° W. longitude, the muf contours are centered on the geomagnetic equator, about 9° to the south of the geographic equator. Seasonal changes from earlier months are:

1. *Higher noise levels; 80- and 160-meter* noise levels at midnight are expected to be up an average of 8 dB during Spring.

2. Lower daytime F2-layer muf's in north temperate latitudes, especially during morning hours, possibly higher F2-layer muf's during midafternoon in tropical latitudes.

3. Higher nighttime F2-layer muf's with fifteen meters being open as late as 2200 local time and twenty meters staying open all night during the latter part of the month for southerly paths.

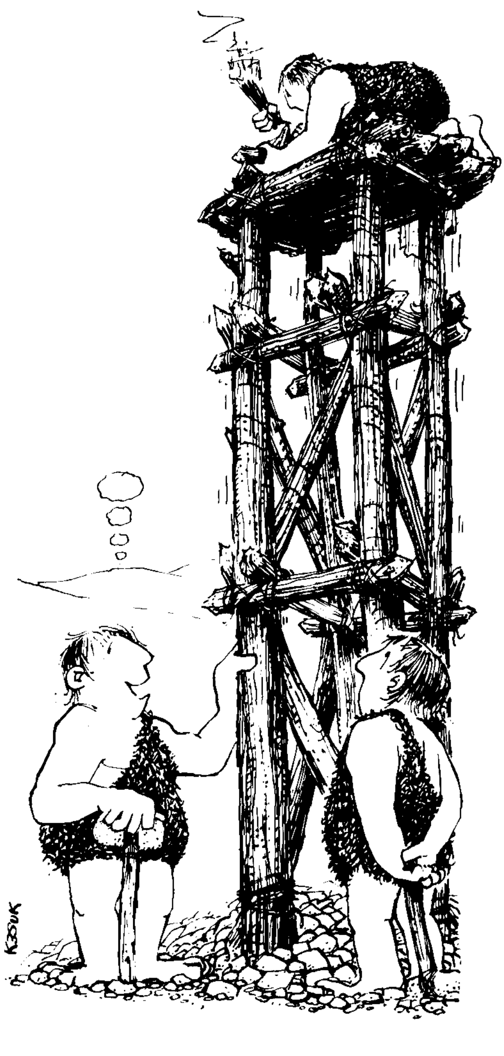
4. Higher absorption during daytime in the Northern Hemisphere.

5. Polar paths will be increasingly difficult on 21 and 28 MHz as the muf contours move southward.

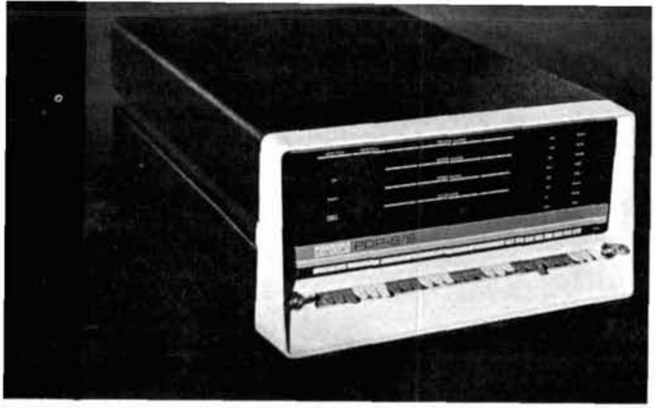
Optimum conditions are expected for contacts between Northern and Southern Hemispheres.

ham radio

a look at those days before spark... bs



. . . so I sez to him look . . . you want your signal to get out, you gotta get it up in the air . . .



Desk top computer that *could be easily adapted* to amateur use*.

computers and ham radio

This is probably as far-sighted as you can get, but it's a challenge to the imagination

Louis E. Frenzel, W5TOM, 4822 Woodmont, Houston, Texas 77045

Have you noticed the publication explosion that's taken place recently in electronics? Next time you're at your favorite parts supply house take a look at the book rack. The number of books and periodicals devoted to solid-state technology is staggering. You really have to dig way back into the dust bin to find an article on the application of a 6AK5 in a vhf preamp, for example. Indeed, it seems rather pointless to fool with **any** vacuum tube unless it's required for developing large amounts of rf power. We may as well face the facts: the vacuum tube is going the way of such quaint items as the razor strop and the silver fifty-cent piece.

It's hard to find any electronic circuit that hasn't been adapted to solid-state devices. For example, a recent issue of one popular amateur electronics magazine had a total of nine articles involving the use of solid-state devices but only one that used vacuum tubes. So it's a healthy sign: amateurs certainly aren't dragging their feet.

One area of technological advancement in electronics that hasn't made much of an appearance in the amateur field is the computer. During the past ten years the computer has developed into a powerful tool for business, industry, education, and the government. All our lives are affected by the computer. If anyone doubts this, all he has to do is try to get a gasoline credit card cancelled. One fellow spent about five bucks in stamps and telegrams trying to do this, and he finally gave up. Business

*The Digital Equipment Corporation's PDP-8/S computer sells for under $10,000. The basic system includes 4096 words of 12-bit memory and is capable of real-time, on-line computation.

is so automated these days it's somewhat frightening. However, I have no doubt that the future will bring forth a computer that will not only read handwriting, but will sass you right back in your own language. In fact, right now it's possible to talk to computers in a rather crude way—but more of this later.

The big question is, what effect, if any, *will the computer have on amateur radio?* I'd like to theorize a little and consider some of the implications of the computer. Computers are already being used in amateur radio. For example, some ham organizations and equipment manufacturers use them to take the drudgery out of bookkeeping, and there are many other applications. This is pretty indirect, but valid.

There's been a lot of mystery surrounding the computer, mostly in the minds of the lay public. You hear all sorts of remarks such as "thinking machine," or "electronic brain," etc. Well, first of all I'd like to set the record straight. The digital computer is **not** a thinking machine, nor is it any kind of brain. As a matter of fact, the computer is a charter member of the idiot squad. It's stupid. It can only do what it's told. Furthermore, if it's not told correctly, all kinds of problems can develop. For example, the IBM 7090 general-purpose computer costs something like $500 an hour to operate, depending on the amount of peripheral equipment. If the machine isn't programmed properly it's possible to run up a pretty fair-sized tab. However, these machines have time-limit instructions in their soft-ware to circumvent loops or system-oriented problems.

Stated simply, a digital computer is nothing more than a sophisticated calculator with a memory, input/output (I/O) and peripheral equipment. The I/O consists of some means of communicating with the computer (input) and a means of obtaining computation results (output). Input could be punched cards, magnetic tape, or even a graph, depending on the machine. Output can consist of printed listings, cards, tape, or graphs.

You must learn a new language to communicate with the computer. Because these machines use on/off circuits, ordinary numbers as we use them have to be translated into the binary system. There are many books on binary arithmetic, so I won't go into an explanation.

However, it's pretty clear that, if the machine can be in either an "on" or "off" state, it can't very well handle numbers whose base is ten. Furthermore, the digital computer does nothing more than the four basic operations of arithmetic: add, multiply, divide, and subtract. And this is where the programmer comes into the picture. It's his job to translate complex mathematics into combinations of these basic operations.

computer development

The computer industry is young, and in the past ten years fantastic changes have taken place. Computers have undergone the same technological changes we have seen in ham gear. Early computers used relays, then tubes. Most recent machines are fully transistorized, and the newer units use integrated circuits. The use of integrated circuits has drastically reduced computer costs. You can now buy a complete computer for under $10,000. The $5,000 mark has just been made, and no doubt the future will eventually see a $1,000 machine. Already several small educational computers are selling for several thousand dollars. When we start talking in the lower price ranges, the feasibility of a computer in the ham shack doesn't sound too fantastic.

Just how could the computer be used? Since computers work exclusively with codes and pulses, their greatest application appears to be in the area of CW and RTTY. I'll list a few of the possibilities, keeping in mind that the computer is a versatile device with an extensive memory and can be programmed to do almost anything.

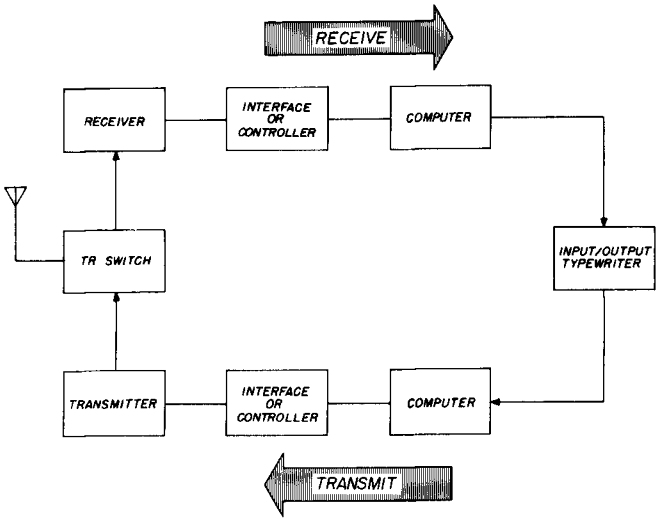
cw keyer

The computer could be used as an automatic CW keyer. The I/O typewriter would be used, as in teletype operation, to send the letters and numbers. The computer program would recognize the code generated by the I/O typewriter and would, in turn, generate the appropriate dots and dashes to drive or key the transmitter. The program could be written to include a speed-selection feature wherein the desired output speed would be selected before sending by typing in the desired speed. The control program would recognize the speed and set up circuits to generate code at the selected speed. Naturally, this feature would be limited according to the operator's typing speed.

goodbye code practice

With the help of some special external circuits, the computer could also be used to receive conventional CW signals, interpret them and type them out on the I/O typewriter. The external circuits are needed to compensate for the wide variations in speed, spacing, and dot-dash length ratio. This is really a beautiful application since it would ensure a perfect, typed copy for every radio contact with no operator CW skill required.

fig. 1. Block diagram of a computer controlled amateur station.



The use of the computer merely as an automatic keyer doesn't really tax its capabilities at all. The computer's extensive memory would permit storage of complete words and sentences that could be called for by the operator from the keyboard. It would make the ultimate CQ wheel. In fact, entire conversations could be canned, including CQ and the initial response with name, signal report and location. All information would be stored as part of a master control program before the contact. Then the operator could call for this information when needed by simply typing in the proper message on the I/O typewriter. How about that? Almost takes the joy out of living.

rtty

Because of the wide versatility of the computer's logic circuits, it could also generate standard RTTY signals without additional hardware. Only a special program would be needed. Of course, the fsk or afsk modulator would be external. Having a computer in the ham shack would mean a total CW-RTTY capability in one package. And with the proper control program, the computer could perform CW-to-RTTY and RTTY-to-CW conversions so that the two modes could cross-communicate.

automated log-keeper

The computer is a willing worker and is quite adept at such routine jobs as bookkeeping or record keeping. With proper programming, it could perform the job of an automatic log keeper. During a computer contact, the operator would enter pertinent data such as dates, times, power, frequency and other required log information via the I/O typewriter. During the contact, this data would be stored along with that accumulated during the contact such as name, location, signal report, etc. All data would be stored during the day's operation. At the end of the day, the operator would simply call for a log printout, and the I/O typewriter would type out all log data in a predetermined format under the direction of the control program. The log printout could be filed, as required by law.

qsl monitor

If the computer's memory system was extensive enough, it could store information from the callbook, and upon completion of a contact it would automatically type out a QSL. Oh—too much.

contests

The automatic capability and record-storing feature of the computer would really be a boon to contest operators. In fact, the computer could conceivably carry out the whole contest alone if programmed properly. It would send and answer CQ's and exchange contest information. It could keep track of the station's call, contact number, and section worked and do cross-checking and log keeping. When it was all over, the operator would call for a log dump on the I/O typewriter. Out would come a neatly typed, complete log of all contest activity. Fantastic? But entirely feasible. Contest scores by computer should be sky-high.

Carrying this a bit further, when you're in your car on the way home from work the night of the contest, you could push a button on the dash and get the whole shebang into operation precisely at the moment of contest start. Then you could go into the house, take a leisurely shower, sort out your mail (who needs mail with computers around?), have dinner, read the latest issue of **ham radio** (which by this time would be a printout) and wander out to the shack to see what's going on.*

as a mechanized operator

The computer can also be used to control and monitor the operation of other equipment in the shack such as the receiver and transmitter. In fact, if proper circuits in these units were made available, the entire station could be set up from the computer. The transmission mode (CW, RTTY) and frequency of transmitter and receiver could be set up by just typing in the desired information.

Computer output pulses would control circuits in the receiver and transmitter to set the mode and frequency desired. Another example would be where the computer would recognize the location of your man during the contact, compute the distance to the station and its local time, then type out this information for you. The bearing angle would also be calculated under computer control.

the qsl bureau

The problem of exchanging QSL's could be simplified and improved if put under a computer system. One large central QSL bureau could be established with a computer to keep track of incoming and outgoing cards. Instead of the usual colorful printed QSL's, confirmations could be a punch card. While not as individualistic and colorful, the confirmation would be just as valid and easier for a computer to handle. Much of the usual paperwork headache associated with QSL bureaus could be delegated to the computer.

I've only mentioned a few items here for consideration. I think they illustrate the point well. But by no means do they represent the entire capability of a computer for ham applications.

Many of you will read this article with some skepticism, and I don't blame you. It does all sound a little farfetched. The amazing thing about it, though, is that it's

* You'd better have on a padded suit, because the rascal could very well reach out and backhand you for not kissing it goodbye before leaving for work that morning. **Editor**

all entirely possible today with existing technology. All it takes is money and initiative.

A small computer could be purchased outright for about $10,000 to $15,000. It could then be interfaced with the other units as shown in **fig. 2.** The nature of the interface electronics would depend on what you want to do with the computer. Then comes the tough part—writing the control program. Because of the versatility, you could program almost anything. For about $15,000 and a little time, study and effort, you could own a complete computer-controlled station, TODAY! Who will be the first?

One nice feature about a computer-controlled station is that when you're not hamming you can use the computer for other applications. Bear in mind the computer is a general-purpose unit that can be programmed to do almost anything. You could use it to maintain a budget, keep your bank account up-to-date, keep track of charge accounts and figure your income tax. You could use it to estimate your chances with a given horse race or a stock on the securities market, and your wife could use it for keeping track of addresses, telephone numbers and Bridge scores. The applications are unlimited. Perhaps now we could justify the cost.

Within the next several years, computers will decrease in cost, and knowledge of their use will be more widespread. The computer will probably be just like the telephone. Each home will have one, and everyone will know how to use it.

the last word

One of the most significant recent developments in the computer field is timesharing. This is a process where one large computer is used to serve many individuals concurrently. Since large, powerful computers are still very expensive, they can't generally be afforded by small businesses and individuals. But occasionally, the services of the larger computer are needed. Timesharing makes it possible. Each user in a timesharing system has a small, inexpensive I/O terminal, much like the typewriter unit shown in **fig. 2,** at his home or place of business. The computer is located at some central and convenient point, and the user communicates with the computer via the telephone lines with his I/O terminal.

Timesharing places the computing power of a large computer in the hands of a number of users. Since the computer is shared, the cost is divided among them, making the price of computing very low. In fact, it's so low that in the near future all of us will probably have a timesharing I/O unit in our homes. As timesharing equipment and programming techniques are improved, their cost will no doubt become lower.

It doesn't seem as though ham radio and timesharing go together though, does it? However, there are possibilities. Why not ham-station control by timesharing? The cost would probably be cheaper than buying a complete computer. Our control program would be stored in the main computer, and because of the vast power of this larger computer it could be a very extensive and sophisticated program permitting features too complex for a smaller computer.

Perhaps we could set up a system where we could communicate with the central computer by radio rather than by the telephone lines. Timesharing by radio would be faster and cheaper, since there would be no charge for the telephone lines. Such a timesharing system could be set up for hams. Then we could all use it for ham-station control or any other application. A computer system like this, coupled with a satellite system, would put a fantastic communications capability in our hands.

It is not a question of technical feasibility, but rather of whether we should do it at all. Is it just too fantastic? We could do it right now. But maybe you don't want a computer to operate your station even if you could afford it. Then again, the prestige and convenience may be just what you are looking for. Besides, you will still operate the station yourself by controlling the computer. Or would you?

ham radio

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repairing high-voltage transformers

Alf Wilson, W6NIF, 3928 Alameda Drive, San Diego, California 92103

The plate voltage transformer is pretty much taken for granted by most hams. It represents a pretty large initial investment and is expected to perform dependably with no servicing other than general cleaning and removal of accumulated dust. A transformer rated to provide power for a kilowatt rig can cost anywhere from about $40.00 to over $100.00, depending on how much horse trading you're willing to do. It is therefore not unreasonable to expect trouble-free operation of the device, providing the usual overload circuits are incorporated in its installation.

Despite good installation practice it's possible for power transformers to fail, sometimes for no apparent reason. Regardless of whether the transformer is a secondhand pole pig obtained from the power company, or a brand-new one from a well-known manufacturer, there is no absolute guarantee that something can't happen to cause a failure (Murphy's third law).

I have had two sad experiences with large power transformers. Both are commercially made units bought from reputable firms. The first failed as a result of rectifier tube flashback, and the second just plain short circuited in the secondary. Both problems occurred despite overload protection circuits. Each transformer was enclosed in a steel case, and each was wound with the secondary over the primary. One was even impregnated with tar. The tar is supposed to protect the windings from moisture penetration. (It doesn't.) The unit that failed because of rectifier flashback was easiest to repair. The other was a more involved problem and entailed complete disassembly to locate and repair the trouble; the secondary had to be completely rewound on this unit.

Both transformers appeared to be hopeless cases as far as being repairable. However, I like to operate the rig and really couldn't stand the expense of replacing a $75.00 piece of equipment. I figured I had nothing to lose anyway, so I decided to see if the transformers were worth repairing. The following paragraphs describe how these transformers, which would otherwise have ended up as expensive junk, were doctored and restored to service.

causes of transformer failure

Most power transformers fail because of high voltage insulation breakdown. It is rare for a transformer to develop an open or short circuit in the primary winding. If problems do occur in the primary (e.g., a short between turns, open circuit, short to the case), then you are faced with removing anywhere from 3000 to 4000 turns of secondary wire, usually about number-22 AWG, just to expose the primary. This, of course, is assuming the primary is wound under the secondary as is the case with many large power transformers. The primary, once you get to it, is easier to repair than the secondary since the primary consists of 300 to 400 turns of fairly large wire (about number-16 AWG).

preliminary checks

It is not necessary to remove the case for an initial check, because all you want to do at this point is try to get a clue as to where the trouble is and how serious it might be. Not much can be done with a bad transformer while still in the power supply, so the first thing to do is set it on the workbench and make some resistance measurements. First test for a short between primary and case, then between secondary and case. Next measure the resistance across the secondary and between each end of the secondary and center tap. The secondary resistance should be around 300 ohms between each end and the center tap if there is no short between turns. If the meter shows a resistance **differential** of more than 30 or 40 ohms between each end of the secondary and the center tap, then you know the problem is somewhere in the secondary.

The next step is to remove the case. Remove the bolts and save the lockwashers and nuts. You'll find upon reassembly that you must pull down the nuts on the case bolts quite tightly to minimize core hum. The lockwashers are necessary on these monsters!

The primary and secondary leads should now be exposed. These are just long enough to reach the terminals without much slack to spare, so you'll have to use reasonable care while working with them.

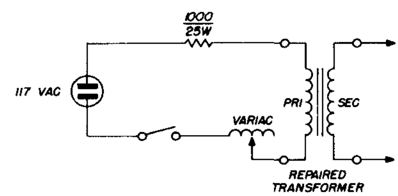


fig. 1. Circuit for "smoke testing" the repaired transformer. The 1000-ohm resistor is for current limiting in case one of the windings is still shorted.

They will stand some flexing, but it is possible to break one off where it disappears into the winding. Power transformers are pretty rugged otherwise and will withstand ordinary handling during disassembly and assembly.

Unsolder the leads from the lugs on the insulators, then dig out any tar. (Comes out in chunks—no problem.) Inspect the winding area for charred spots. These will be pretty obvious if the short was caused by rectifier flashback. If the failure was caused by some other problem then the trouble will be harder to locate, and you will have to disassemble the core.

flashback failure

My transformer caught fire when one of the rectifier tubes flashed back. For some reason I'll never know, the overload circuit just flat failed to protect the transformer. There was a charred spot where one of the secondary leads was brought up out of the transformer innards. Chances are pretty good that, with a rectifier flashback failure, the short-circuited area will be near the coil surface, and probably in the first secondary winding layer. In this type of failure, extreme heat caused by the high current surge destroys part of the insulation, allowing one or more secondary wires to touch.

Carefully peel away the insulation and clean off the carbonized material with an old toothbrush dipped in alcohol. Don't attempt to replace any of the original insulaation, even if it appears to be okay. Apply at least six coats of red glyptal varnish all around the exposed wire, and work it well into the surrounding layers of insulation. It is essential that every bit of carbonized material be completely removed before applying the glyptal. Allow five full hours for each coat to dry.

Next, wrap a layer of Scotch number-33 electrical tape (rated at 10,000 volts per layer) over the exposed wires, then apply two more coats of glyptal over the tape and surrounding area. It's a good idea to slather glyptal all over the outside of the windings, again observing adequate drying time between coats. You just can't put too much glyptal on these things.

After another ohmmeter check, as described previously, the unit can be reassembled. It's really not necessary to pour melted tar around the windings. As a matter of fact, my transformer had only an inch layer of tar at the top and bottom of the case where the end bells join, so I didn't bother to replace the tar. This transformer has been working perfectly for the past five years. (By this time maybe you're getting the message that I don't have much faith in tar-impregnated power transformers. I have a strong suspicion that this stuff does more harm than good.)

The repaired transformer should now be given a "smoke test" before reinstalling it in the power supply. The simple circuit shown in **fig. 1** is used for this check. You can substitute several 115-volt light bulbs for the Variac, but they should be arranged so they can be progressively shorted to increase the primary voltage. Close the switch and slowly turn up the Variac. It should hardly be necessary to emphasize that you're dealing with upwards of 3000 volts of instant death, so use utmost care during this test. If you've done a good job of cleaning and insulating, your transformer can now be reinstalled in the power supply, and you're back in business.

digging deeper

Why should an expensive, well-made power transformer mysteriously develop a short circuit? Commercially built transformers are conservatively designed, and engineers specify high voltage insulation with large safety factors. Nevertheless, a transformer can be working fine one day, and suddenly a failure can occur in the insulation, causing a short circuit. Apparently moisture somehow penetrates into the secondary and causes a high resistance path to build up. Finally, one day the insulation just breaks down.

When you inspect the external winding area after one of these "mysterious" failures, chances are you won't see anything as obvious as in the flashback case. But don't give up—all you have to do is remove the core, then unwind the secondary to expose the short circuit. This task isn't really as formidable as it might appear. First, let's take a look at how the core is put together.

core arrangement

The core consists of E I sections of silicon steel about 0.01-inch thick. The E sections are placed over each other back-to-back, interleaved with I sections at each outer edge (**fig. 2**). You will find that the laminations have been driven quite tightly into the coil. A little strong-arm effort here will work one of the end laminations loose, then the others will come out easily. You will also find upon reassembly that it will probably be impossible to drive all the laminations back into the coil. My rewound transformer has about ten E I sections missing, but the transformer doesn't seem to know the difference.

the solenoid

As the coil is unwound, you'll have to look carefully for evidence of insulation breakdown. It's a good idea to go over each layer with a magnifying glass, because the area of failure will probably contain extremely small holes in the insulation. Be sure to count the number of turns taken from each layer and keep track of them. While unwinding my coil, I made a rough sketch of each layer, indicating the winding area and number of turns per layer. It is not worthwhile to rewind with the old wire, because no matter how careful you are, it's virtually impossible to avoid nicking the wire. Even one tiny nick will wash out all your hard work.

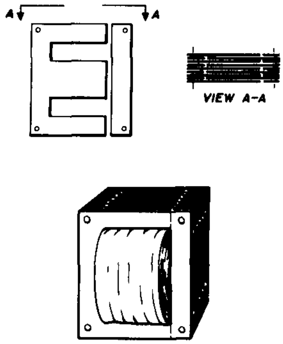


fig. 2. Core buildup and assembled transformer.

the electrostatic shield

If you have to remove the entire secondary winding, you'll probably find a layer of paper-thin copper between secondary and primary. This is a shield to prevent electrostatic coupling between the two windings. Its purpose is to keep higher order line frequency harmonics out of the d-c plate supply. This shield isn't really necessary for ham power supplies and just causes added insulation problems. If you decide to keep the electrostatic shield, make certain it is reinstalled exactly as it was originally. My recommendation is to throw the thing away.

secondary wire

If your transformer is more than ten years old it is probably wound with enamelled Formvar. I searched all over trying to find a source of this wire, but found it's practically nonexistent these days. I rewound my transformer secondary with HPTX-200, made by Essex Wire Corporation. This material has a high temperature insulation of some type of polymer. It costs about $2.00 per pound for number-22 AWG; it weighs about the same as Formvar, so you can determine how much you'll need after you remove the old wire.

When you've located the short circuit, splice on the new wire, wrap the splice with Scotch number-33 electrical tape and give the entire area the red glyptal treatment. You are now ready to rewind.

rewinding the secondary

I built a jig out of a piece of mop handle to hold the solenoid for the rewind job. The solenoid, which has a paper tube core, was force fitted to one end of the jig and held with a couple of wooden wedges. I turned down the other end of the jig to fit into the chuck of a large portable drill motor. I mounted the motor on the bench with the solenoid protruding about eight inches over the edge of the bench. The spool of new wire was mounted onto a U-bracket fastened to a wooden cleat. This assembly was placed on the floor beneath the solenoid.

The gears in the drill motor provide just enough drag so that the solenoid can be turned by hand during the rewind process. Maybe it's possible to apply power to the motor and rewind the coil, but I found that to control the windings you have to rotate the solenoid by hand. This takes about an hour per layer for us old folks. As you rewind, put on the same number of turns per layer that were removed—no more, no less. Don't attempt to hop up the transformer by changing the primary-to-secondary turns ratio. You are only asking for more problems, and an additional 500 volts or so on the secondary won't make that much difference to your signal anyway. (Remember, you have to **double** your transmitter power just to gain a 3-dB increase in signal strength.)

Wrap each rewound layer with Scotch number-33 electrical tape and apply two coats of red glyptal varnish on each layer. You are now ready to reassemble the core laminations.

reassembly

If you have rewound the coil as tightly as possible, you should have no trouble reinserting the core. It may be necessary to squeeze the solenoid slightly to accommodate the laminations. With one layer of tape around each layer of wire, plus the glyptal, the solenoid buildup should be very close to the original. It may be necessary to tap the last few laminations home with a mallet. Don't worry about slight bends in the laminations. When you pull the bolts down in the case, the laminations will flatten out. Now give the transformer the ohmmeter check, then the smoke test as described earlier.

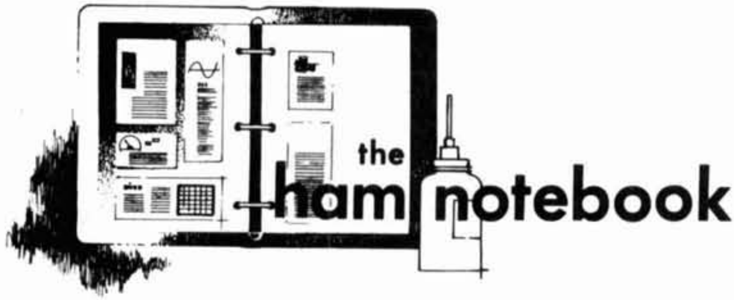
baking

An added refinement, though not necessary, is to give the repaired transformer a baked varnish treatment. For $7.50 I had this done at a local electrical shop that specializes in rewinding motors and generators. (Incidentally, while there I asked them for a quote on how much they would charge to repair my transformer. Would you believe $65.00, **not** including material?) For the baking treatment, the uncased transformer is immersed in a vacuum tank, and insulating varnish is forced into the windings. The unit is then baked for several hours. I was a little concerned as to how the baking would affect the temperature resistance of the Scotch electrical tape, but apparently it does no harm. This baking treatment is probably an improvement over tar impregnation.

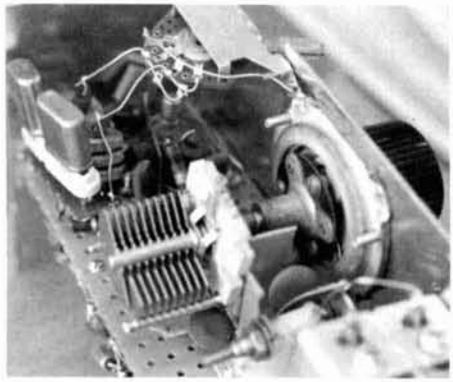
concluding thoughts

You now have spent about $25.00 for material, are back on the air, and have had the privilege of being introduced to the all-but-forgotten art (at least in ham circles) of transformer winding. Hey, you old timers—kind of tugs at the heart strings, eh?

ham radio



dc crystal switching



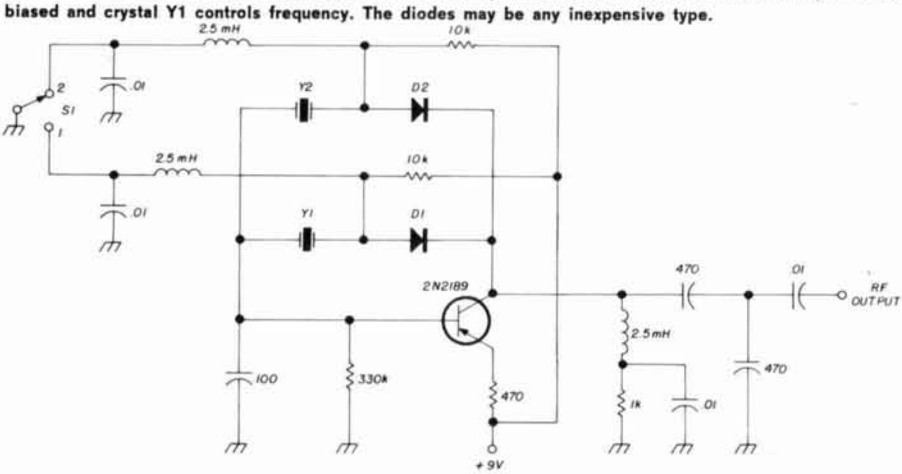
This short article was prompted by an article by W7OE in the May issue of **ham radio**.* It's often desirable to use a single oscillator and switch crystals as a source of multiple-frequency check points. Usually a number of crystals are simply mounted around the periphery of a multiple switch. The major difficulty you run into with this approach is from the mechanical configuration that results. First, some of the rf leads are undesirably long. Second, the physical requirement for the switch shaft to stick through the front panel limits the over-all oscillator configuration.

A diode switching approach allows flexibility that simplifies the layout, uses a single oscillator and handles multiple crystals. The circuit in **fig. 1** shows the principle applied to the same type of oscillator used by W7OE. The beauty of this approach results from the fact that switching is accomplished with low-voltage dc.

The oscillator can be located anywhere and the dc switching wires carried to a switch located at a convenient place. Since there is no rf on these wires, their length is unimportant. The photograph shows an oscillator using two crystals for sideband selection installed in an ssb receiver. In this type of

H. S. Pyle, W7OE, "Mini-Spotter Frequency Checker," *ham radio*, May, 1968, p. 48.

fig. 1. Diode switched crystal oscillator. With switch in position 2, diode D2 is reverse biased; D1 is forward biased and crystal Y1 controls frequency. The diodes may be any inexpensive type.



application, an additional advantage is gained from the fact that the wire only carries dc so it doesn't radiate any undesired rf into adjacent receiver circuitry. This approach could also be used for selection of crystals in ssb exciter transmitter circuitry.

R. J. Schlesinger, K6LZM

sbe linear amplifier tips

When the original owner of my new second-hand SBE SB1-LA linear boasted that he had keyed the unit at full power for over two minutes off resonance without any damage, I was skeptical; when I looked inside, I wasn't surprised at what I saw—a full kilowatt input can raise havoc in two minutes. The envelopes of the six 6JE6 tubes were discolored and bubbled, and subsequent tests indicated that only two of the tubes had any useful life left.

My first task in getting the linear back on the air was a set of new tubes. Three weeks and $22 later, I had them; however, they weren't balanced—with power applied two or three of them would glow cherry red while the rest loafed along acting as parallel capacitors. Results: overheated tubes, poor efficiency and blown line fuses. A new set of factory-balanced tubes, a look at the schematic and a few simple modifications solved the problems.

The linear was originally built with the cathodes grounded and common bias fed to all six control grids. The circuit was simple enough, but there was nothing to cut off a tube if its idling current went over the normal 50 mA. My initial modification was to install a 51-ohm, 2-watt, 5 percent resistor in each of the six cathode leads with as short leads as possible—each resistor bypassed with a .02-μF ceramic capacitor. Resetting the bias adjustment brought the idling current back up to the normal 300 mA.

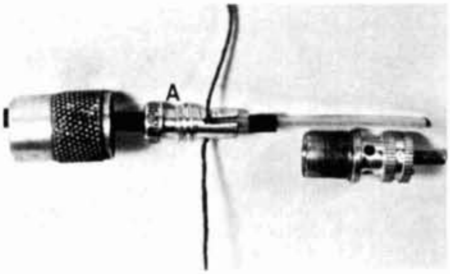
Since completing this simple modification, I have accumulated over 1000 operating hours on this set of tubes. They are not at all discolored, and recent tests indicated high emission and no internal shorts.

R. L. Wentworth, WA6DCW

coaxial cable connectors

Whenever I put a coaxial fitting on a piece of RG-48/U, I always seem to end up with a short circuit. At least one of the shield strands breaks, leaving a small piece to float around inside the connector until it shorts the whole thing out. A simple solution that works well on the high-frequency bands is shown in the photo.

All you have to do is saw two L-shaped slots in the reducing adapter (A in photo). Saw a slot down the center of the adapter almost to the threaded section with a hack saw; then saw or file a short notch at right angles to the main slot—do the same thing on both sides of the adapter. Tin the notches on each side with a hot soldering iron.



Prepare the coaxial cable by pushing it through the adapter; strip off the outer jacket, unravel the shield and twist it into two leads opposite from each other. Slip the two pieces of twisted shield down the slots and solder them into the notch. If you've done a good tinning job, this shouldn't take too much heat. Now cut off the excess pieces of braid. With a little care and minimum solder, you should have no trouble screwing the adapter into the rest of the plug.

Save a small section of the outer jacket—about a quarter inch long. This can be pushed into the reducing adapter and fills up the space around the dielectric, providing final electrical isolation. The inner dielectric is stripped off 1/16 inch in front of the adapter. When soldering the inner connector to the plug, be sure to slant it downward to keep any solder blobs from running down inside and shorting everything out.

Ted Woolner, WA1ABP

miniature receiver antenna tuner

Most modern, high quality receivers have an input impedance of 50 ohms and are designed for use with matched, transmitting-type antennas. Unfortunately, these receivers must sometimes be used with random-length wires. This often leads to inadequate performance, especially poor sensitivity and degraded image rejection.

A simple antenna tuner can be used to correct this situation. A miniature tuner which will match a short high-impedance antenna to a receiver is shown in **fig. 2.** The version shown, which was suggested by a tuner built by K4BXO, has proved useful for matching 10-to-25-foot antennas between 10 and 30 MHz. Changing the type and size of core, number of turns, and tap positions will modify the impedance matching and tuning range.

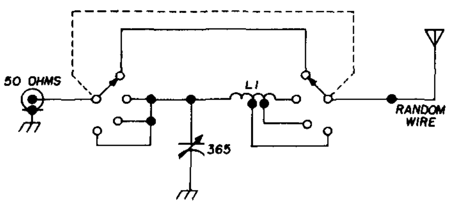


fig. 2. Receiver antenna tuner for random length antennas. For the range 10 to 30 MHz, the coil is 35 turns no. 26 on 5/8" diameter toroid, tapped at 10 and 20 turns.

The tuner can be built in a very small minibox, since few parts are required and those that are needed can be miniature ones. A toroid similar to the one I used is available from Amidon. A plastic-dialectric variable capacitor from Lafayette is excellent for C1; its capacitance is not critical. I used a miniature Alco rotary switch.

The tuner is very easy to use. Simply tune the capacitor through its range for each switch position. There should be a significant improvement in signal strength and image rejection as this is done. If no improvement is noted, the antenna length or number of active turns on the core can be changed.

Paul Franson, WA7KRE

using dipole antennas on non-harmonic frequencies

There are cases where it's desirable to use a dipole at frequencies on two bands which are not harmonically related. A good example is the phone man who wants to use a single antenna centered on 3.9 and 7.25 MHz. Since these frequencies are not harmonically related, the operator resorts to a compromise arrangement that leaves something to be desired on both frequencies.

Here's a system I use to obtain resonant operation with an off-center-fed Windom antenna. I cut the antenna as a full-wave dipole at 7.25 MHz as a starter; natural half-wave resonance is around 3.625 MHz. The resonant point is moved **up** to 3.9 MHz by the simple expedient of putting a fixed capacitor of the right value in the center. This is simple and can be used on **non-center-fed** dipoles operating on 10 and 15 meters or 15 and 20.

To compute what size capacitor you need in the center, consider the antenna as an isolated single-wire transmission line operating above a ground plane. Although the characteristic impedance of this line can be computed from the formula

$$Z_o = 138 \log \frac{4h}{d}$$

where h is the height above ground and d is the diameter of the wire, an assumed value of 600 ohms is close enough for our purpose.

The difference between a quarter wavelength at 3.625 MHz and 3.9 MHz is 4.6 feet; at 3.9 MHz, this represents 6.55 electrical degrees. The reactance of 6.55 degrees of 600-ohm line measured against a voltage node is 600 tan 6.55° or 69 ohms. Therefore, a 69-ohm capacitive reactance in series with each quarter wave will do the job; this is the same as 138 ohms in the center of the dipole. At 3.9 MHz, this is 290 pF; either 270 or 300 pF are close enough. A 1000-volt mica capacitor will be more than adequate for a full kilowatt.

To lower the frequency, the same approach may be used, but an inductance must be used as the reactive element.

Henry Keen, W2CTK

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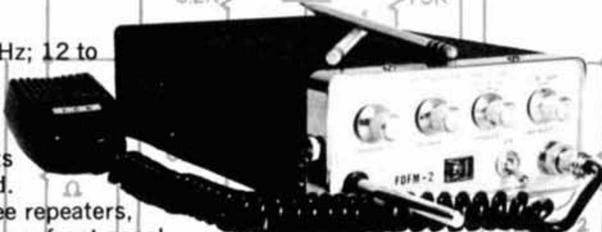

GENERAL
Frequency range — 144 to 147 MHz; 12 to 14.5 VDC operation; solid-state devices — 32 silicon transistors, 10 diodes; microphone, battery pack, whip antenna, and three sets of crystals of your choice included. Tough modular construction. Three repeaters, transmit and receive, selectable from front panel.

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new products

for the ham builder

Here's a bookful of circuits that can fit into the rig or accessory you're planning to build. Most of the circuits are simple ones, mainly for the Novice and Technician, but they'll suit almost anyone's operating ambition.

There are couplers, mike amps, modulators, monitors, filters, preamps, converters, receivers, transmitters, linears, a lot of accessories and some test instruments. Many tube circuits are included for hams who haven't made the move to solid-state yet, but there are plenty of transistor circuits for those who have. The projects are comparatively inexpensive to build, and parts are easy to find for them.

The author, Bert Simon, W2UUN, has put 104 separate projects into this book. He tells you only briefly how to put each one together. There is not much instruction to help with layout or mechanical arrangement; the author has assumed the builder already knows the rudiments of putting together ham gear, dressing wiring, and so on. The circuits, however, are explained where necessary, and tuning-up data is included.

This isn't a beginner's book, but the simpler Novice circuits don't require much experience. **Ham Radio Projects for Novice and Technician;** paperback $3.95; hardcover $6.95; G/L TAB Books, Blue Ridge Summit, Pennsylvania 17214.

mobile manual for radio amateurs

In case you, as I, have and use all of the ARRL publications, you may not have noticed that a new edition (the fourth) of the **ARRL Mobile Manual** is out. The cover looks the same—though they've changed the photo—but the inside is completely different. Much has happened since 1962, when the last edition appeared, and the manual reflects it. Now the book is full of modern semiconductor equipment (and vacuum tubes where they are still needed) for all sorts of uses: receivers, transmitters and audio equipment, transceivers, ssb equipment, power supplies and test equipment. Complete sections cover noise suppression and the all-important antenna. Perhaps most interesting are the chapters devoted to portable gear, which has really come into its own lately. In addition, the text has been rewritten and reset, making an easy-to-read book you'll likely refer to often. Best of all, the price remains the same old $2.50. Anyone want an old mobile manual?

ic fundamentals and projects

There are few things in modern electronics that rival the integrated circuit's influence in circuit design and application. This new book, written by Rufus Turner, covers the technical development of the IC, its general features, types and applications. In addition to an informative discussion on how the IC is built, there are many inexpensive construction projects described, including a dc voltmeter, af-rf signal tracer, crystal-controlled frequency standard, high-gain preamplifier, and quarter-watt audio power amplifier. 75c postpaid in the U.S.A. from Allied Radio Corporation, 100 N. Western Avenue, Chicago, Illinois 60680.

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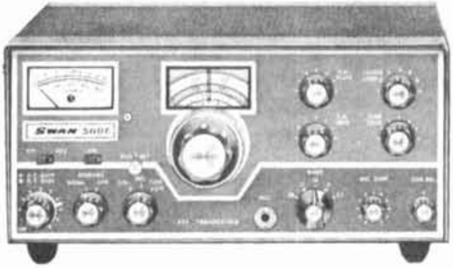

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the radio amateur's vhf manual

I've owned three copies of Ed Tilton's **VHF Manual** since it came out in 1965, and have worn out two of them. When it appeared, almost every ham interested in vhf was grateful, and many who weren't became so. Now Ed, W1HDQ, **QST's** vhf editor and one of the two or three best-known ham vhf experts, has revised the manual to make it even better. The original edition appeared just when semiconductors killed receiving vacuum tubes for hams, so that version didn't have too much on transistors. The new edition more than makes up for this lack. It contains a great amount of new material as well as the invaluable information that's made the **VHF Manual** a necessity among vhf'ers. The new edition costs only $2.50, and you couldn't make a better buy. Available the American Radio Relay League, 225 Main Street, Newington, Connecticut 06111.

want to fix your own tv?

There's now an easy way to learn how. A brand-new low-cost TV servicing/repair course, designed for the layman, is off the press at International Correspondence Schools; it's written by **ham radio's** roving editor, Forest H. Belt.

It begins with the simplest things, like how to make adjustments and recognize tube troubles, and takes you all the way through circuit servicing. In the simplest terms you can imagine, it explains transistors and color TV as if they were no more complicated than a one-tube code oscillator.

You're already familiar with editor Belt's easy-reading articles in **ham radio;** the new six-book course is written in what he tells us is his **Easy-Read** format. All of the books are profusely illustrated, and the two that go into color-TV servicing use full-color pictures.

The whole course is written so plainly that anyone who can read can learn to repair a TV set. For a ham, who already knows electronic basics, the course is duck

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THE FT DX 400 TRANSCEIVER

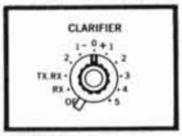
Conservatively rated at 500 watts PEP on all bands 80 through 10 the FT dx 400 combines high power with the hottest receiving section of any transceiver available today. In a few short months the Yaesu FT dx 400 has become the pace setter in the amateur field.

FEATURES: Built-in power supply • Built-in VOX • Built-in dual calibrators (25 and 100 KHz) • Built-in Clarifier (off-set tuning) • All crystals furnished 80 through the complete 10 meter band • Provision for 4 crystal-controlled channels within the amateur bands • Provision for 3 additional receive bands • Break-in CW with sidetone • Automatic dual acting noise limiter • and a sharp 2.3 KHz Crystal lattice filter with an optimum SSB shape factor of 1.66 to 1.

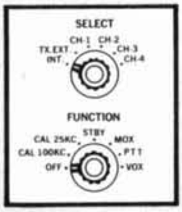
Design features include double conversion system for both transmit and receive functions resulting in, drift free operation, high sensitivity and image rejection • Switch selected metering • The FT dx 400 utilizes 18 tubes and 42 silicon semi-conductors in hybrid circuits designed to optimize the natural advantages of both tubes and transistors • Planetary gear tuning dial cover 500 KHz in 1 KHz increments • Glass-epoxy circuit boards • Final amplifier uses the popular 6KD6 tubes.

This imported desk top transceiver is beautifully styled with non-specular chrome front panel, back lighted dials, and heavy steel cabinet finished in functional blue-gray. The low cost, matching SP-400 Speaker is all that is needed to complete that professional station look.

SPECIFICATIONS: **Maximum input:** 500 W PEP SSB, 440 W CW, 125 W AM. **Sensitivity:** 0.5 uv, S/N 20 db. **Selectivity:** 2.3 KHz (6 db down), 3.7 KHz (55 db down). **Carrier suppression:** more than 40 db down. **Sideband suppression:** more than 50 db down at 1 KHz. **Frequency range:** 3.5 to 4, 7 to 7.5, 14 to 14.5, 21 to 21.5, 28 to 30 (megahertz). **Frequency stability:** Less than 100 Hz drift in any 30 minute period after warm up.

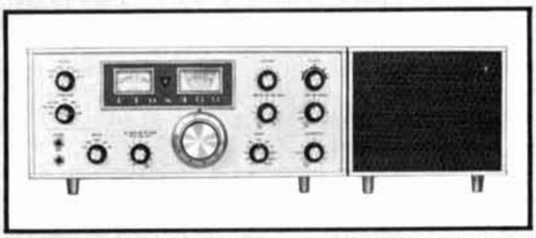


CLARIFIER CONTROL — Does the work of an external VFO — allows operator to vary receive frequency 10KHZ from transmit frequency, or may be used as an extra VFO combining transmit and receive functions.



SELECT CONTROL — Offers option of internal or outboard VFO and crystal positions for convenient preset channel operation.

FUNCTION CONTROL—Selects crystal calibration marker frequency and desired transmit mode of operation.



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soup. The section on servicing logic—called 1-2-3-4 troubleshooting—lays out a technique that could be applied to ham gear or any kind of electronics. International Correspondence Schools, Scranton, Pennsylvania 18515.

silicon power transistors

Motorola has announced a new line of 4-ampere power transistors that combine high current, top efficiency and power-handling capability with economy prices. These new devices can be used in npn/pnp pairs to gain all the advantages of direct-coupled complementary symmetry circuitry.

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handbook of semiconductor circuits

If you're looking for ready-made transistor circuits, this new handbook contains 124 examples of standard transistor circuits, complete with operational data for amplifiers, oscillators, logic and switching circuits and power supplies. All in all, a comprehensive source of well-designed examples of contemporary circuits. Since a design philosophy section is included with each group of circuits, this volume won't go out of date as new transistor types are introduced. Each circuit description includes any unique design or operational data along with a schematic diagram; very helpful if you're working on transistor projects in your shop—must reading for laboratory and engineering technicians involved in transistor design work. $7.95 from TAB Books, Blue Ridge Summit, Pennsylvania 17214.

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TEST EQUIPMENT WANTED: Any equipment made by Hewlett-Packard, Tektronix, General Radio, Stoddart, Measurements, Boonton. Also military types with URM-( ), USM-( ), TS-( ), SG-( ) and similar nomenclatures. Waveguide and coaxial components also needed. Please send accurate description of what you have to sell and its condition to Tucker Electronics Company, Box 1050, Garland, TX 75040.

KEY KLICKERS OF STIRLING will hold their first annual HAM AUCTION on Friday, April 11, 1969 at Central School Gym. Central Avenue, Stirling, N. J. at 8:00 p.m. A 300 plus seating arrangement is planned so come early and bring items for sale. For further information and/or directions contact Van W2DLT after 10:00 p.m. at 201-647-3325.

DAYTON Hamvention April 26, 1969: Sponsored by Dayton Amateur Radio Association for the 18th year. Technical sessions, exhibits and hidden transmitter hunt. An interesting ladies program for XYL. For information watch ads or write Dayton Hamvention; Dept. H, Box 44, Dayton, Ohio 45401.

POLICE-FIRE RADIO STATION DIRECTORIES show callsigns, frequencies; nationwide. Used by AREC, CD, RACES, Vamps, VHF buffs. Stamp brings catalogs. Communications, Box 56-HR, Commack, N. Y.

TO ALL DXERS: Starting January 6, 1969, the Arkansas DX Association will sponsor a DX information net on 3860 KHZ every Monday night at 0030 GMT. This net will be open to all amateurs *interested in DX no matter what call area you are* in. Members of the Arkansas DX Association will act as net control stations. These stations will be WA5EFL, K5QHS, W5HTY, W5HJA, K5HYB, WA5QYR, WA5OFT, or W5THY.

LOOK FOR VK2BPO and VK2BRJ operating from Norfolk Island (VK9) for two weeks starting February 12: Cocos-Keeling (VK9) starting March 2 or 3. Frequencies will be 7005, 12025, 21025 and 28025. QSL with SASE to Bob James, W4WS/VK2BRJ, P. O. Box 635, Dunedin, Florida 33528.

GONSET GSB-6 SIDEWINDER, brand new, sealed factory carton, $285; ac supply, $60; dc supply, $50; 500-watt 913A linear, $245; all new equipment. WB2LZD. 607-785-5862.

FLORIDA QSO PARTY. FLORIDA SKIP is happy to announce the Fifth annual Florida QSO Party to be held March 29 and 30th, 1969. All amateurs are invited to participate. Contest Periods: 1500-2000, 0000-0500, 1400-2400 all times GMT. Suggested Frequencies: CW 1815, 3560, 7060, 14060, 21060, 28060 kHz. Phone 1815, 3860, 7360, 14260, 21360, 28860 kHz. For complete details contact Florida Skip, Inc., P. O. Box 501, Miami Springs, Florida 33166.

CELLAR FULL fax, RTTY, other surplus gear. List free. G. White, 5716 N. King's Highway, Alexandria, Va. 22303.

The **BLOSSOMLAND AMATEUR RADIO ASSOCIATION** will hold its annual AUCTION on Sunday, March 16, 1969 at the Downtowner Restaurant, 69 Wall Street, Benton Harbor, Mich. The auction will start at 10:00 a.m.

Anyone, including hams, CBer's, hobbyist, RC modelers, etc., is invited to bring anything electronic they have to sell or have auctioned off. Come to join in the fun, and possibly pick up some good bargains in the process. Call-in 146.94 and 52.525 MHz for FM and 3.930 MHz for SSB.

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THE TENTH ANNUAL NEW YORK STATE Southern Tier Hamfest sponsored by the IBM Amateur Radio Club, QCWA, AREC and affiliated clubs will be held on April 19, 1969 at St. John's Memorial Center in Johnson City, N. Y., starting at 1 p.m. Adult tickets $4.50 and Students tickets $2.50. Advance sale only. Closing date on ticket sales is April 16th. Afternoon activities include speeches, displays and contests. Surprise events throughout the day. Banquet/Dinner promptly at 7:00 p.m. Tickets and full particulars may be obtained from ticket chairman, Joe Kuntz, WA2ZTY, 1020 Forrest Road, Endwell, N. Y. Zip code 13760. Don't miss this one.

MANUALS — TS-173/UR, TS-186-D/UP, TS-323/UR, BC-638A, TDA-2, $5.00 each. Sam Consalvo, W3IHD, 4905 Roanne Drive, Washington, D. C. 20021.

FOR SALE: KWM2, Waters Rejection Tuning, 516F2, $750. KWM2-A #15,965 (very late), 516F2 (new), $925. 312B5, $275. 75S3-C (latest series), $600. KWM2 Noise Blanker, $75. KWM2 Mobile Mount, $75. 32S2, 516F2, $450. 75S1 #11,472, 0.5, 2.1 kcs, $275. 75A3, $250. Ranger I, LPF, $75. Gonset G-28, $125. Heath Q-Multiplier, $5. Match-Box #250-23, $35. #250-30-3, $115. Telrex 10M-309-B, $35. Telrex 20M3E26, $165. Eldico SSB-100-F, $225. SSB-1000-F Linear, $225. P & H LA-500-M "SPITFIRE" linear, new, $75. 75A-4 #3126, 2.1 kcs, 7360/6U8A Mixers, $350. 75A-4 #3481, 0.5, 3.1 kcs, $385. Eico 320 Signal Generator, $15. SW-500-C, VOX, $390. GSB-201, $225. James W. Craig, Jr., W1FBG, 29 Sherburne Ave., Portsmouth, N. H. 03801.

FANTASTIC — 1969 New England ARRL Convention May 24 & 25, Swampscott, Massachusetts. Save money! Early bird registration $10.50 including Saturday dinner, dance and night club entertainment. Be a winner! Every major manufacturer will exhibit plus top speakers from science & industry. Tickets: W1KCO, John McCormick, Berkeley Street, Taunton, Massachusetts.

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CQ WAS. Reno novices will enable those needing Nevada for WAS to contact us. Frequencies 3710, 3735, 7160, 7175, 7190, 21120, 21150. Call CQ — WAS 0800 GMT March 22 to 0800 GMT March 24.

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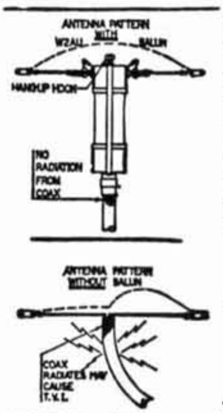

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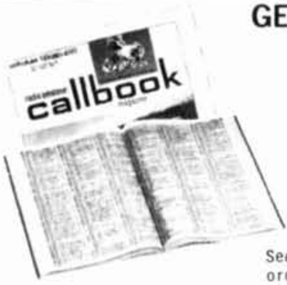

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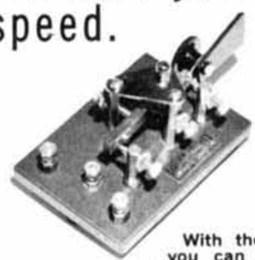

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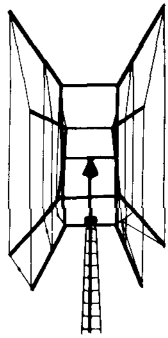

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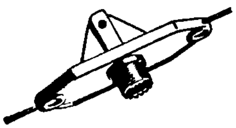

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SP-600-JX in creampuff condition .54-54 mc	325.00

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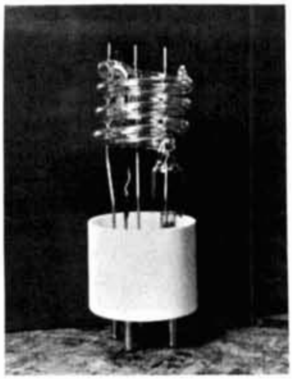
CLEAN SWEEP month. The following items, all bargains offered as special "clean 'em out" prices. Some are one or few of a kind, some we just want to make room.



50,000,000 LUMEN FLASHTUBE

Brand new Sylvania flashtube and that's correct, 50,000,000 lumen output. This will make a "fantastic" psychedelic lighting effect. Spec sheet with each. $10.00

TAPE PUNCH-READER-TYPER

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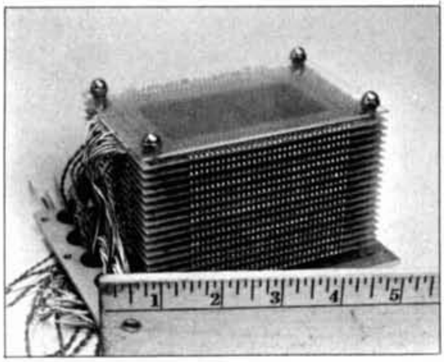

MEMORY CORE PLANES

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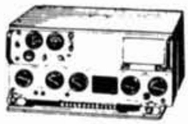
AN/ART-13 100-WATT XMTR
11 CHANNELS
2 to 18.1 Mc

$10

Poor condition good for parts



Collins Autotune Transmitter, extremely stable and suited for side band. Written up in QST Oct. issue 1953.

PDR-27 GEIGER COUNTER, m/roentgen scale. No batteries, unchecked. As is $15.00

ARC-5 TRANSMITTER, exlnt condition. 3 models as listed. Any one at $9.50 each. 4-5.3 * * 5.3-7 * * 7-9

ARC-5 RECEIVER, Q-5'r, one only, brand new with motor and rack $25.00

BC-639 RECEIVER 100-156mc, good condition, with power supply & cables .. $75.00

BC-221-T Freq. Meter. Excellent, w/calib. book $75.00

LM-13 Freq. Meter, excellent, w/calib. book $65.00

POWER SUPPLY Regatron, programmable model 231, unchecked. 300 volt, 100 ma. $15.00

4CX1000A tube, brand new $50.00

RCA 5819 PHOTOMULTIPLIER, New $10.00

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DX-ARRAY

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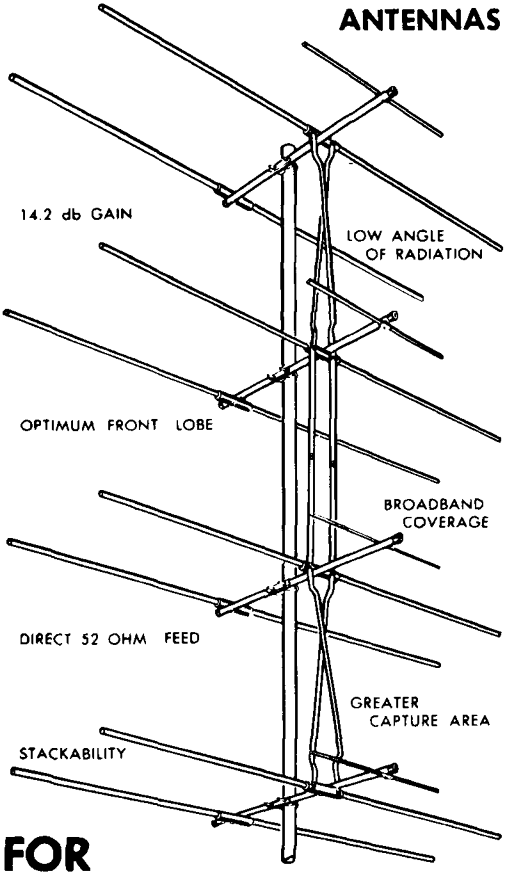

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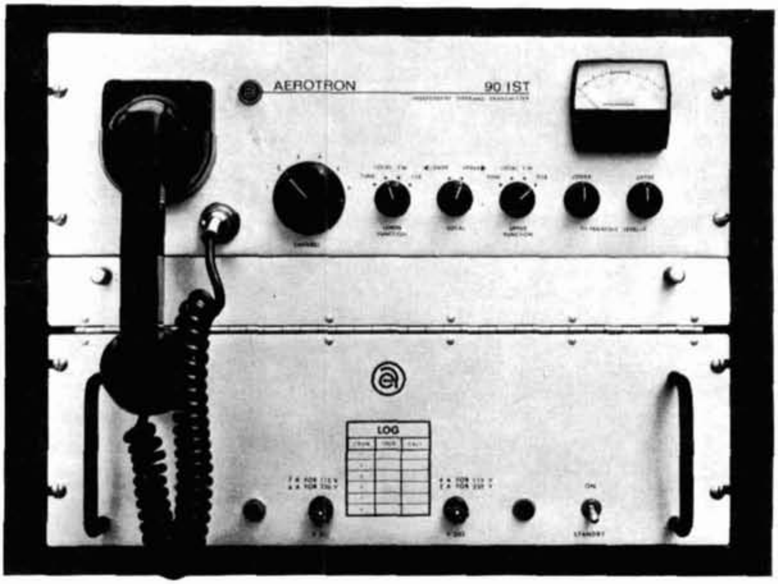

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