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# ham radio

magazine

JUNE 1969

## SOLID-STATE single-band SSB transceiver

PAGE 8

*this month*

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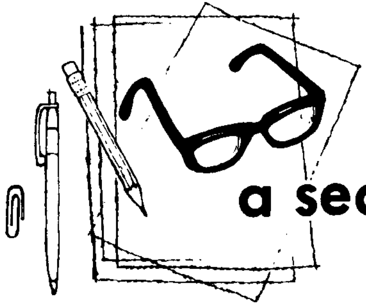

# a second look

by jim fisk

**It seems that more and more** stations are getting ready for serious moonbounce work. And by the end of the summer the number will probably double. Stations capable of eme work were pretty scarce three or four years ago—only the most serious and perservering workers ever made the grade. But techniques have been improved, and probably more important, equipment is available so just about anyone can hear his own two-meter echos from the moon.

In the days right after World War II, when the first radio signals were bounced off the moon by Army experimenters at Fort Monmouth, New Jersey, it wasn't nearly so simple: 8 kW input on 111 MHz, a tremendous billboard antenna with 64 phased dipoles and an incredibly complex receiver with a 50-Hz passband. Even then the moon echos were weak, and success unpredictable. (To improve reliability, the Army eventually increased transmitter power to 100 kW.)

With this kind of a background, the prospects of amateur communications via the moon were pretty remote, but W3KGP and W4AO launched Project Moonbeam in the late 1940's with a goal of bouncing two-meter signals off the lunar surface. All indications were that a successful effort would require the full amateur power limit, antenna gain of at least 20 dB and receiver performance that was practically unattainable. But in July, 1950, came something like an echo, faint and indefinite, but it sounded like the real thing and it was captured on a wire recorder. Test after test followed, with failure after failure, but finally, 2½ years later, and many equipment changes in between, they managed to record a whole series of echos off the moon.

After this initial amateur success, progress was slow. Many amateurs tried, but few succeeded. There was a flurry of activity as amateurs built bigger and bigger two-meter arrays and high powered amplifiers—but successes were limited and there were no two-way eme communications.

Until practical parametric amplifiers became available, moonbounce activity was confined to two meters. Even with a low-noise front end, moonbounce attempts on 432 MHz were impractical because of the power limitation, so the next logical step was 1296 MHz. After a lot of sweat and tears, W1BU came on the air in early 1960 with a 1296-MHz station that could bounce signals off the moon with some degree of reliability. W1FZJ extended the challenge to vhf enthusiasts; Hank Brown, W6HB, picked it up, and shortly thereafter the first two-way amateur contact via the moon's surface was history.

Since then progress has been slow but steady. Nearly all the vhf bands up to 1296 MHz have some sort of moonbounce activity, but at the moment two meters is the most popular. Nor is activity confined to the United States; successful moonbounce stations are located in Australia, Finland, France, Greece, New Zealand and Sweden.

Moonbounce is still a very sophisticated method of vhf communications, but on two meters at least, it is within the grasp of any serious worker. Moonbouncers K6MYC and W6DNG live on city-sized lots, so space limitations are apparently no problem. KØMQS uses all commercial equipment except for the antenna, so equipment is not a problem. The only other major problem is perservance—but nevertheless, more and more stations will be showing up on the low end of two with their antennas pointed toward the moon. And in the not to distant future, working all 50 states on two meters may even be a reality.

**Jim Fisk, W1DTY**
**Editor**

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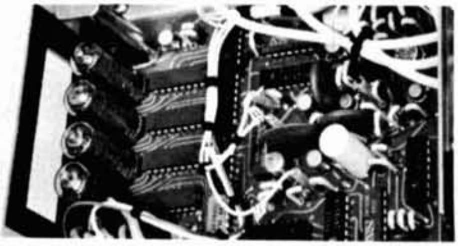

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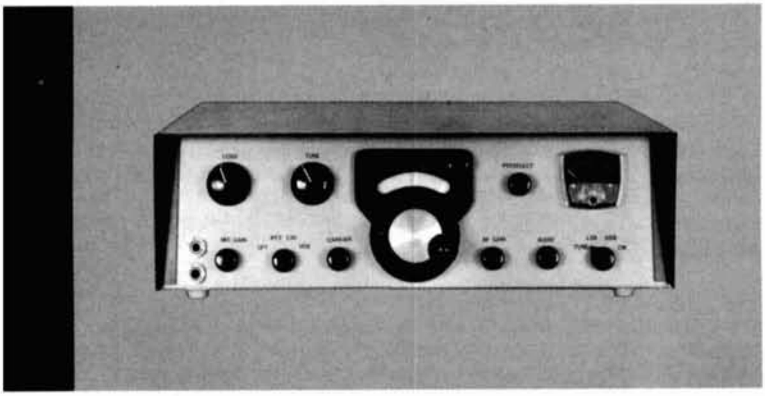


# homebrew single-band ssb transceiver

Complete construction details for the HR ssb transceiver– an easy-to-build modern design for 75 meters incorporating integrated circuits, transistors and a vacuum-tube final

Jim Fisk, W1DTY, Box 25, Rindge, New Hampshire 03461

**Although solid-state has been** with us for a long time, there have been very few reproducible solid-state transceiver designs in the amateur literature. Most of the homebrew ssb transceivers that you hear on the bands—although they are few and far between—are tube types. In fact, the only station I have worked using a homebrew solid-state ssb transceiver was UF6ACR in the U.S.S.R.

Evidently solid-state is new enough that few amateurs are willing to tackle a project as large as a transceiver. The big hangup, of course, is the sideband generator; amateurs are willing to build microphone preamps, electronic keyers and rf power amplifiers, but when it comes to balanced modulators and crystal filters, they stop.

When Spectrum International* started advertising miniature solid-state sideband exciters several months ago, I was really intrigued. A quick note brought more detailed literature. The ssb exciter, made in West Germany by DJ3CI, includes a three-stage microphone preamp, crystal-controlled oscillators, balanced ring modulator and a 9-MHz crystal filter. All the hard work is done—here is a miniature solid-state source of 9-MHz ssb with 55 dB carrier suppression and 45 dB suppression of the unwanted sideband. In addition to the selectable sideband capabilities of the module, it has provisions for a-m, fm and CW.

I was particularly interested in the KVG crystal filter used in the transceiver module. This 8-pole crystal filter is very popular in Europe. Its excellent passband characteristic has a shape factor of 1.66:1 from 6 to 60 dB down; minimum stop-band rejection is greater than 80 dB.

duced to a balanced mixer stage along with the output from the vfo crystal-oscillator circuits. For operation on the 3.5 and 14 MHz bands, no crystal oscillator or mixer stage is required; the output from the 5.0 to 5.5 MHz vfo is injected directly into the balanced mixer.

The output of the balanced mixer is amplified by several broadband amplifier stages. The transistors in these stages are run in class B for minimum distortion and maximum efficiency. Gain is lower in this configuration, but linearity is good, and no external tuning is required. If you are willing to put up with an external control for peaking up these driver stages, you could probably delete one of the broadband amplifiers. These transistors are inexpensive, though, and for my money the operating convenience of minimum tuning is worth the additional stage.

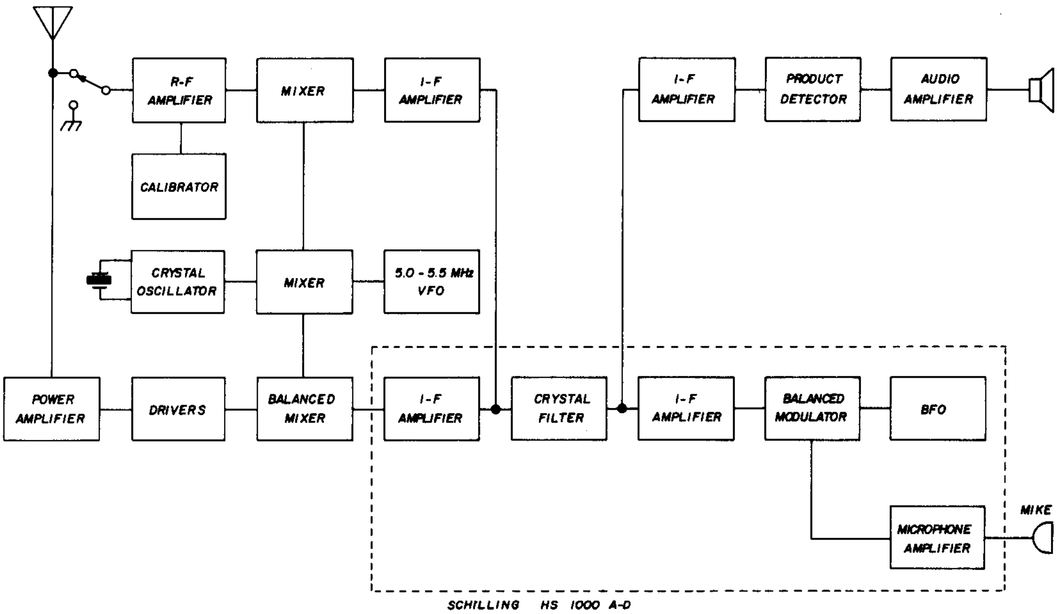



**fig. 1. Block diagram of the single-band transceiver.**

## design

To keep things as simple as possible, the initial design was for a single-band unit. This is in keeping with most mobile and portable operation and minimizes the mechanical problems of bandswitching. Also, with the single-band approach, the same basic design philosophy can be applied to the vhf bands with very few changes.

A block diagram of the complete transceiver is shown in **fig. 1.** The imported ssb exciter module is enclosed in a dotted box. The 9-MHz output of the module is intro-

* Spectrum International, Box 87, Toppsfield, Massachusetts 01983

The vfo uses the basic fet Seiler oscillator described previously[1] followed by a class-A buffer stage and emitter follower. For operation on 80 or 20, this is all that is necessary.

The final power amplifier provides about

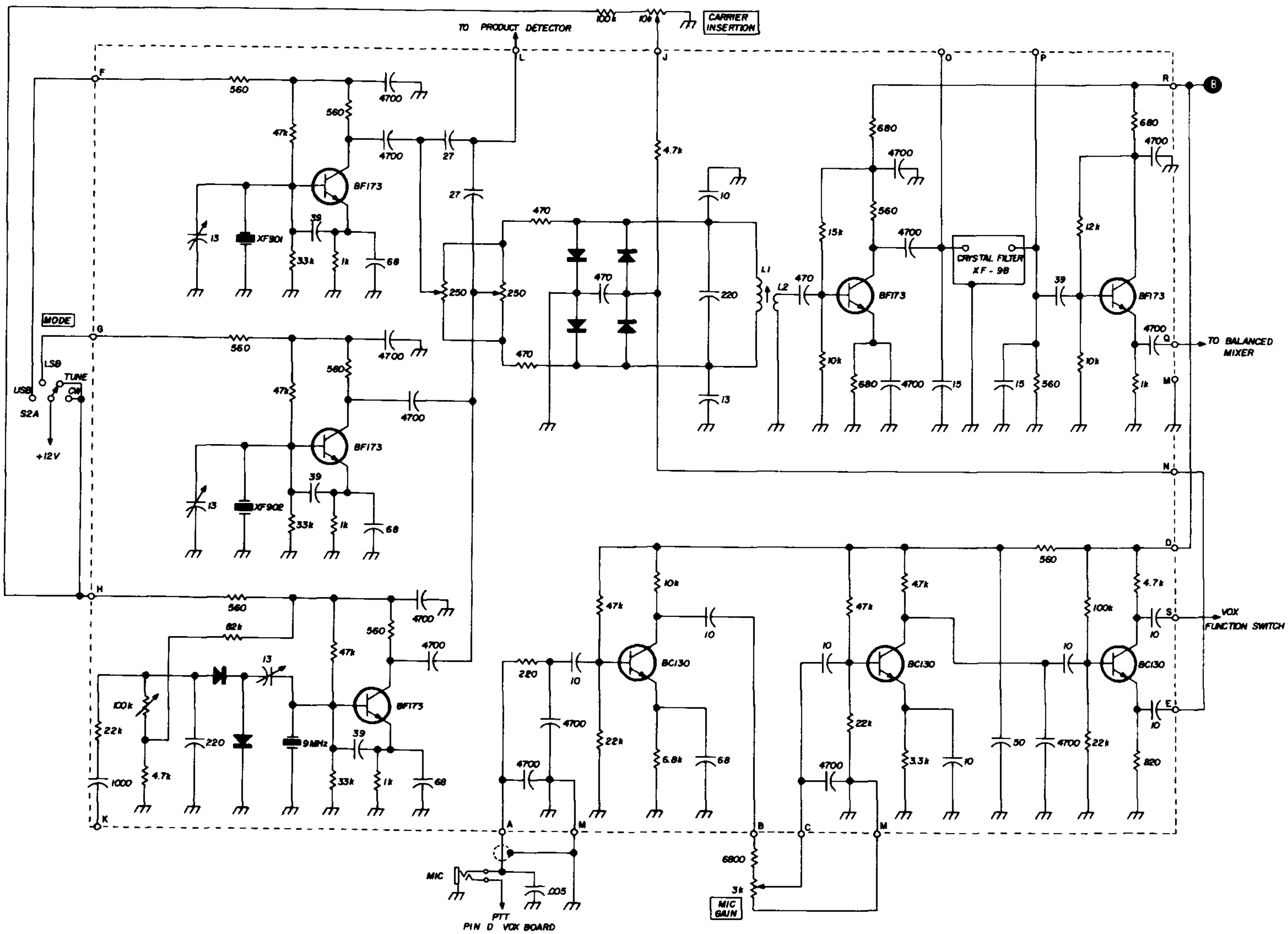
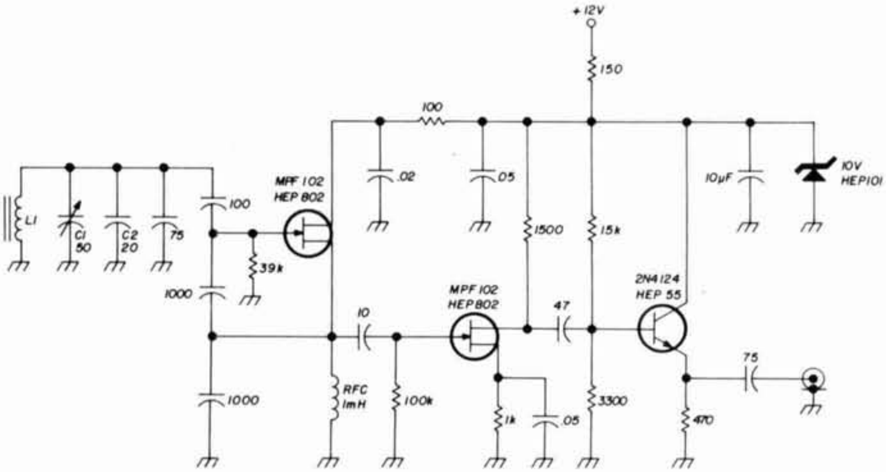



fig. 2. Schematic diagram of the Schilling HS 1000D 9-MHz transceiver module. Components outside the dotted line must be added by the builder.

50 watts PEP output. There are several transistors on the market designed for ssb service that will provide this much output, but I felt that for the present, a vacuum tube was much more feasible. The physical layout of the transceiver is such that when the cost of high-power rf transistors drops within reason, the vacuum-tube power-amplifier assembly can be replaced with an all solid-state unit.

The receiver lineup is pretty conventional —mosfet rf stage followed by a mixer into the 9-MHz crystal filter. Output from the filter is amplified in an integrated-circuit i-f amplifier and fed to a product detector and the audio stages; agc voltage is derived from the audio section and provides excellent dynamic range.




**C1** 50-pF variable (Millen 21050MK)*

**C2** 20-pF variable, printed-circuit type (Jackson Bros. 5440/PC/20)

**L1** 29 turns no. 24 enamelled on a toroid form (Amidon Associates T-50-2)

**fig. 3. The Seiler vfo circuit tunes from 5.0 to 5.5 MHz. The 75-pF capacitor consists of a 33-pF, N750 temperature-compensating capacitor in parallel with a 42-pF silver mica.**

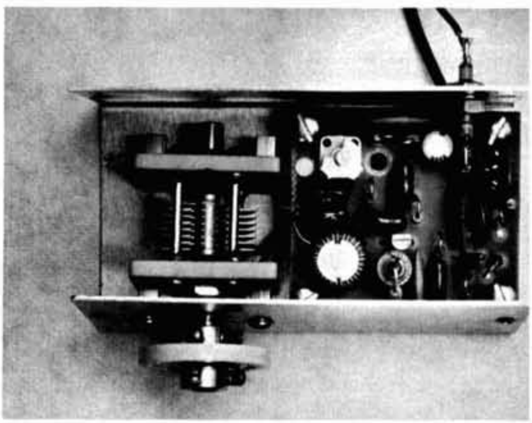
* Millen parts are available from James Millen Manufacturing Company, Inc., 150 Exchange Street, Malden, Massachusetts 02148. Millen 21050MK double-bearing capacitor is priced at $2.91; the 39016 flexible coupling is $.75.

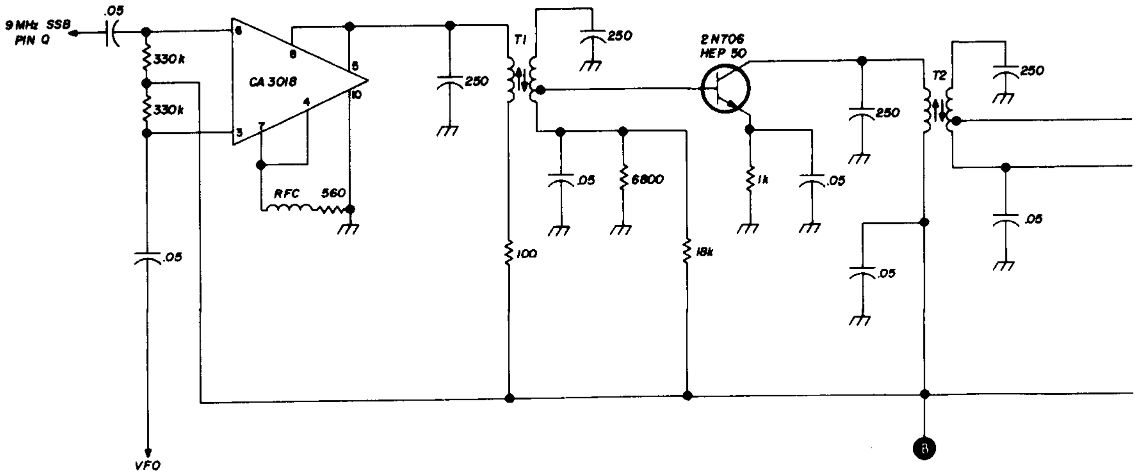
Jackson Brothers components are available from Arrow Electronics, Inc., 97 Chambers Street, New York, New York 10007; 5440/PC/20 capacitor is $2.50.

## transmitter section

After you receive the exciter module, you'll probably be pretty anxious to get it hooked up and working. I know I was. You can put it on the air in a matter of minutes if you have a 12-volt power supply and a handful of

**Complete vfo and buffer circuits are built on a small board mounted in a 2x2x4-inch minibox. Millen tuning capacitor and flexible coupling are on the left.**






| | |
|---|---|
| C3 | 20-pF (part of Miller 1460, see fig. 5) |
| C4 | 100-pF variable (Hammarlund HF-100) |
| C5 | 150-pF, 500 Vdc |
| C6 | 730 pF (parallel-connected dual-section 365-pF trf receiver capacitor) |
| C7 | 1000 pF mica |
| L7 | 30 μH (65 turns no. 30, scramble wound on a 1/4" slug-tuned form, tapped at 20 turns) |
| L8 | 9.5 μH (32 turns no. 14 enamelled on a 2" toroid form—Amidon Associates T-200-2) |
| T1, T2, T3 | Primary is 33 turns no. 32 on 1/4" slug-tuned form, tuned with 250 pF; secondary is 33 turns no. 32 on a slug-tuned form spaced 1/2" from primary, 6 turns from ground, tuned with 250 pF |
| PS1 | Parasitic suppressor, 8 turns no. 20 wound on body of 100-ohm, 1-watt carbon resistor |
| K1 | spdt relay, 12 Vdc coil, mounted in power-amplifier compartment |

**fig. 4. Transmitting mixer, drivers and power amplifier.**

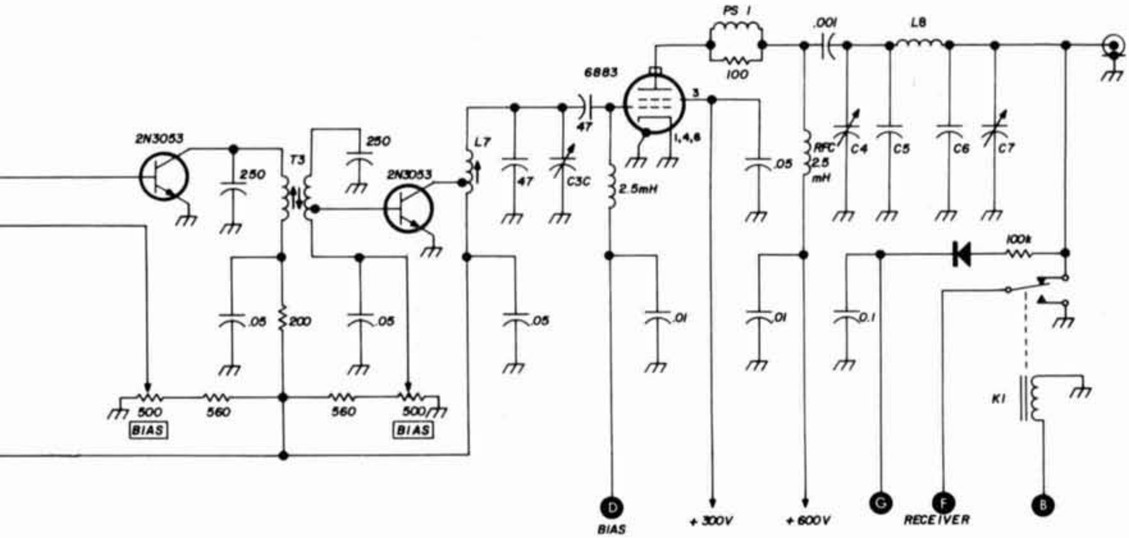
clip-leads, but it only takes a little while longer to do it right with a microphone gain control and a mode switch. If you bought the vox module, you can wire this in, too, since it only takes a few minutes to make the connections. The vox module is a good buy because it gives you built-in vox with anti-trip along with push-to-talk and a 4pdt relay to handle the transceiver switching functions.

The mode switch in **fig. 2** selects the applicable crystal oscillator for upper or lower sideband or CW. In the CW and tuneup positions, carrier insertion is adjusted by the 10 kilohm control. If you have a receiver that will tune to 9 MHz, you should be able to hear yourself on 9-MHz single sideband without even connecting an antenna to the receiver. If you don't have a general-coverage receiver, couple your grid dipper to the output—it's sufficient to pin the needle when the gdo is tuned to 9 MHz.

## vfo

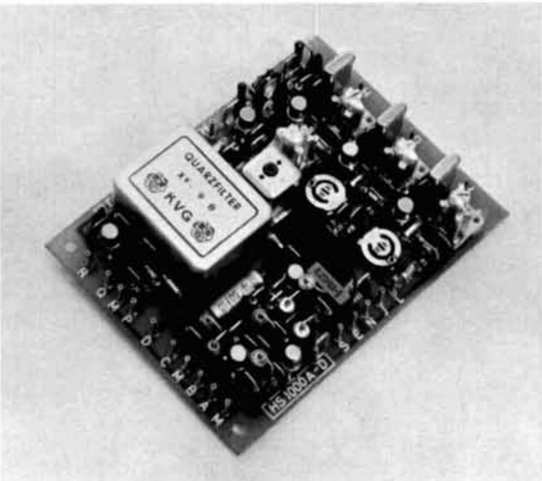
After you get the exciter module going, the next logical step is the 5.0- to 5.5-MHz variable-frequency oscillator. The vfo and buffer stages are mounted on a piece of printed circuit board and mounted in a 2x2x4-inch minibox. The heart of this very stable circuit is the Seiler oscillator; the output level varies less than 0.5 dB when the vfo is tuned through its range, and resetability is excellent.

The buffer stage uses an fet operated in class A to minimize loading on the vfo. The emitter-follower provides a low-impedance output for driving the miniature 50-ohm co-




axial cable to the balanced mixer; maximum output is 2.5 volts p-p. The 75-pF output coupling capacitor should be adjusted to give 1 volt p-p at the input to the balanced mixer.

Temperature compensation requirements are minimal because of the high stability of the variable oscillator circuitry. In this circuit, stability is primarily a function of the tuned-circuit components and is only slightly affected by the active device. A 33-pF N750 negative-temperature coefficient capacitor in the tank circuit should take care of any temperature-induced drift.




**This 9-MHz ssb generator is the heart of the transceiver.**

## transmitting mixer

The transmitting mixer uses a low-cost integrated circuit in a balanced configuration. An earlier design used a junction fet with injection to the source and gate, but spurious outputs and carrier feedthrough were a problem. When I switched to the balanced circuit shown in **fig. 4,** these problems disappeared. With a properly operating balanced mixer circuit, little 5-MHz carrier and 9-MHz ssb appear across the output so problems with intermodulation distortion from this source are eliminated. Also, carrier feedthrough is a serious problem with bipolar transistors; before the balanced mixer circuit was used, the 5-MHz vfo signal fed through to the final.

Although an integrated circuit is not absolutely necessary in this spot, the transistors should be closely matched for best operation. If you have a matched pair of npn transistors with suitable frequency response they should work as well as the CA3018. I chose the IC because it was inexpensive and its transistors are practically identical since they are made on the same chip of silicon.

The bandpass coupler on the output of the balanced mixer is designed to pass the entire amateur band for which it was designed. This is most difficult on 80 meters where 500 kHz is a big percentage of the center frequency; on the higher bands it is somewhat easier to achieve.

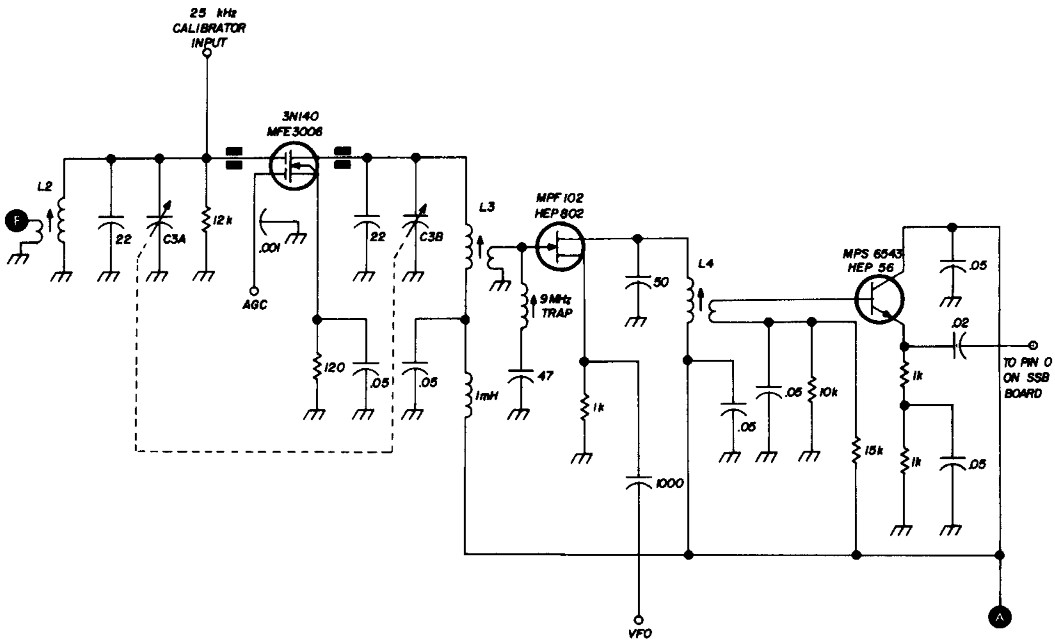
## transmitter drivers

The transistor driver stages are operated in class B for maximum linearity and efficiency. This is accomplished by slightly forward biasing each driver stage. The bias supply must be very "stiff" so that bias remains constant with varying input signal; consequently, be careful when setting up stage bias. If the forward bias is set too high, the transistors will destroy themselves by thermal runaway. However, this is no problem if you put a milliammeter in the collector supply lead when setting the no-signal collector current.

The correct amount of no-signal bias current varies slightly from one transistor type to another, but will be in the range from 2 to 10 mA. If the forward bias is set too high, it will be immediately apparent if you have a meter in the circuit—with no input signal, the collector current will creep upward, slowly at first, and then alarmingly fast, until the transistor fries itself. However, if you're aware of the problem, you shouldn't lose any transistors. Furthermore, once the bias is set up it should require no further attention. Correct no-signal collector current for the 2N3053's is approximately 5 mA.

I used 2N3053's in the driver stages because they're inexpensive and I had some on hand. They also have frequency response and voltage ratings that are appealing. Power gain of typical units starts to fall off in circuits operating above 25 MHz, but by selecting transistors you can still get enough drive to the power amplifier on ten meters. If selecting transistors isn't your cup of tea, simply add an additional driver stage!

When setting up the driver stages, never




**C3** Three-section variable, 20 pF per section, (J. W. Miller 1460, third section used in transmitter driver, see fig. 4)

**L2** 36 μH (Miller 40A335CBI) with 15 turn primary

**L3** 36 μH (Miller 40A335CBI with 18 turn secondary)

**L4** 30 turns no. 26 on a 1/4" slug-tuned form with 6 turn secondary

**Trap** 5.2 μH (Miller 40A476CBI)

**fig. 5. Receiver front end and high-frequency mixer.**

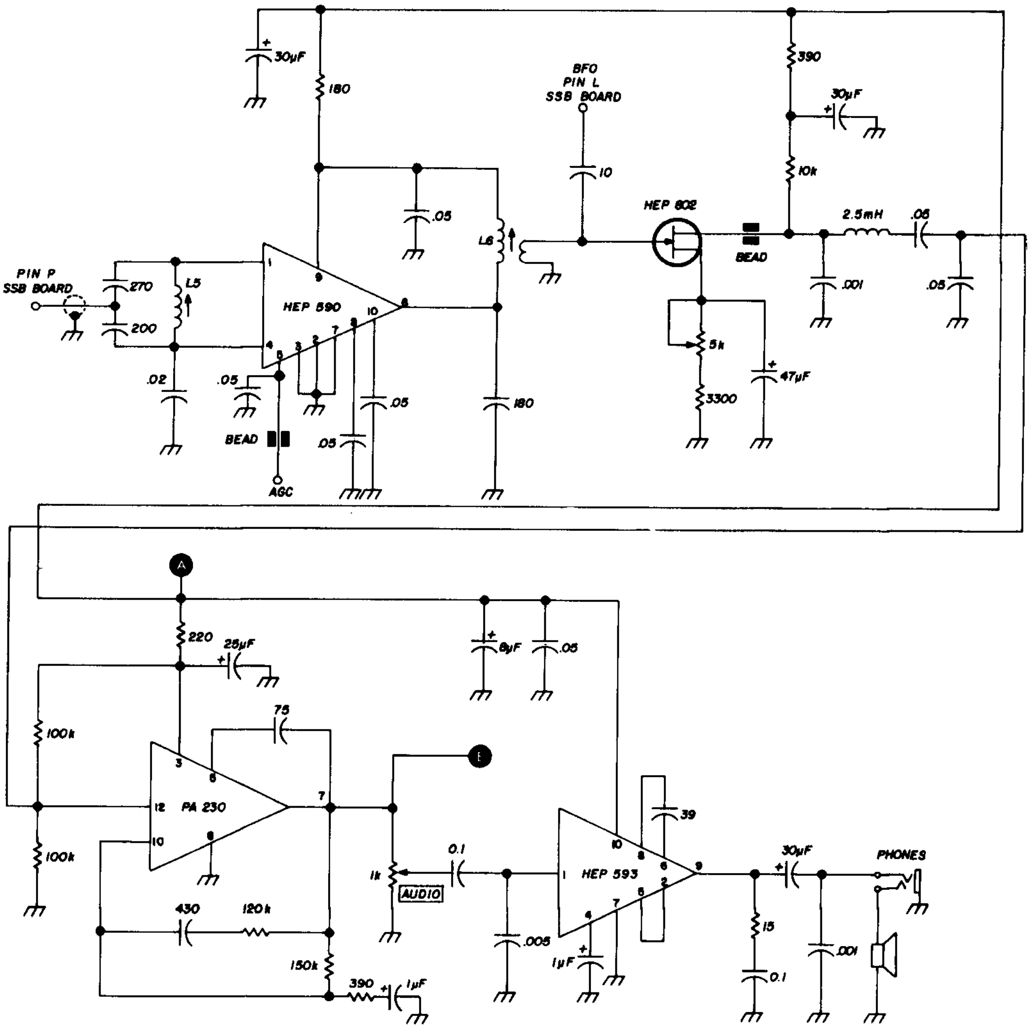



**fig. 6. I-f amplifier, product detector and audio power stages. L5 and L6 are 1.6 µH (Miller 40A156CBI), secondary winding on L6 is 4 turns.**

turn the power on unless the output tuned circuit is loaded down—either by the next transistor or a resistive load. When the stage is unloaded, the voltage across the high-Q tank circuit may be high enough to burn out the transistor. This is another advantage of the 2N3053: the high maximum-voltage rating allows some mistakes.

When the final driver stage is complete, you should be able to drive it to about 1 watt peak dc input. If you're anxious to put your low-powered creation on the air, you can haywire a T-network together to match the coaxial line to your antenna. With this arrangement on 75 meters one quiet morning, I was able to work Maine, Massachusetts and New Jersey.

## receiver section

Although I will discuss the receiver beginning with the mosfet front end, actual construction is simplified if you build the audio stages first and the rf amplifier last! If you build the audio section first, followed by the product detector, i-f amplifier, mixer and rf stage, you can test each circuit as you go along. Then, if you run into a problem, you can fix it before moving on to the next stage.

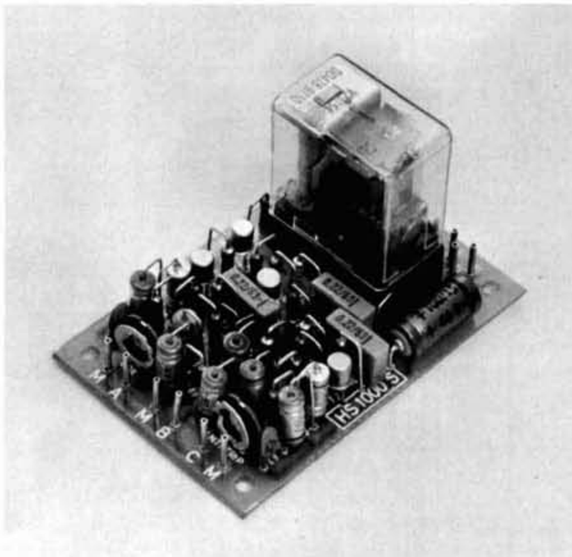
The rf amplifier uses a new dual-gate mosfet, the Motorola MFE3006. This mosfet features good high-frequency (and vhf) performance at reasonable cost. Circuit layout is very uncritical as long as you keep the output isolated from the input. The feed-back capacitance of the transistor itself is very low, so no neutralization is required—if you have problems with instability, your layout or construction is not up to par.

The high-frequency mixer stage uses a junction fet. The input signal is applied across the gate with local oscillator injection across the source resistor; the output circuit is tuned to 9 MHz. The stage following the mixer is a simple untuned RC-coupled amplifier for driving the 9-MHz crystal filter. Connection to the filter is made through a short length of miniature RG-174/U 50-ohm coax.

## i-f amplifier and product detector

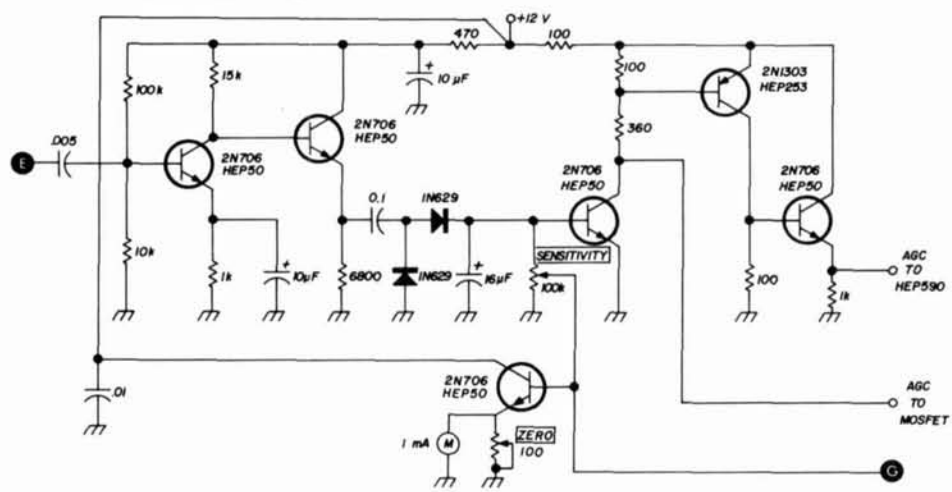
The high-gain 9-MHz i-f amplifier uses an integrated circuit—the HEP 590—a common-emitter, common-base cascode circuit designed for communications equipment. In the circuit shown in **fig. 6,** the input circuit is designed to match the 50-ohm coax line from the crystal filter to the input of the IC.[3] The 9-MHz i-f signal is coupled into the product detector through a 14-turn link.

Although the HEP 590 provides a good deal of gain in a small package, no problems were experienced with instability. Keep in mind when wiring this device into the circuit that pins 2 and 3 should be connected together and grounded; pins 8 and 10 should be by-passed to ground with good quality low-inductance disc bypasses. The gain-bandwidth




**Schilling vox/anti-trip module.**

**fig. 7. Audio-derived agc circuit for the single band transceiver. The s-meter is a Micronta 1-mA instrument available for $2.95 from Radio Shack.**



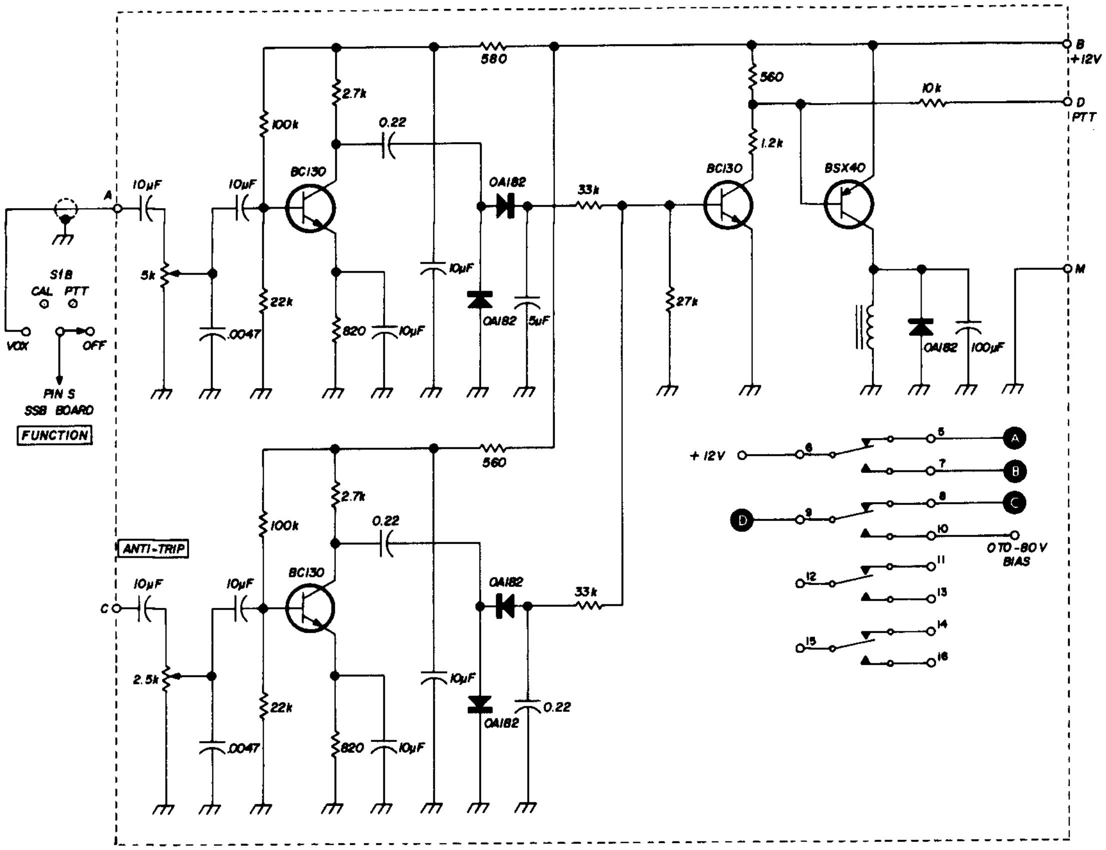


fig. 8. Vox circuitry for the single-band transceiver uses the Schilling HS1000S vox/anti-trip module.

product of the basic IC is in the neighborhood of 2 GHz, so it is imperative that you use good vhf construction practice when wiring it into a circuit.

The product detector uses a junction fet with both signal and bfo injection across the gate. The optimum bias point for the transistor is set by the pot in the source lead. With the bfo turned off, you should get practically no signal through to the audio stages. The bfo injection capacitor is adjusted for maximum gain with minimum noise contribution. If too much bfo injection is used, the product detector will be very noisy. Some fet's work better than others in this circuit; the zero-bias current range for the HEP 802 is 2 to 20 mA—devices with the lower values work best. The product detector in the transceiver shown in the photographs consumes 500 μA with no bfo injection and about 600 μA with the bfo turned on.

The receiver audio section uses two integrated circuits—a PA230 preamplifier and HEP 593 audio power stage. Output power is greater than 1 watt with a 12-volt supply. The bypass and coupling capacitors in the audio section were chosen to limit the frequency response to 300 to 3000 Hz, the range required for communications work.

When wiring the two audio IC's be very careful to use short direct leads. The individual transistors in the HEP 593 audio power IC have excellent vhf response, so circuit layout is very important. Instability in this stage can be caused by excessive lead inductance or stray capacitance; parasitic oscillations may even cause rf heating and eventual device burnout. The circuit shown in **fig. 6** includes all the necessary bypasses.

The RC bypassing network from pin 9 to ground should be placed right next to pin 9. This circuit eliminates vhf instability caused by the inductance of the speaker leads. The power supply line should be bypassed by a good quality vhf bypass capacitor directly from pin 10 to ground. In addition, leads to pins 7, 9 and 10 should be as short as possible and the input should be isolated from the output through good layout and short leads.

For maximum audio output with a 12-volt supply, the HEP 593 should be used with an 8- or 16-ohm speaker. Although the circuit will deliver usable power into a 3.2-ohm speaker, it has to work a lot harder to do it, and harmonic distortion is much higher. For best results, use a small transistor auto-radio replacement speaker; these usually have a higher voice-coil impedance.

## power supply

One of the design goals for this transceiver was a built-in power supply for both mobile and fixed station use. This is provided by the circuit shown in **fig. 10.** The transformer is a standard commercial off-the-shelf item manufactured by Thordarson. The high-voltage secondary is used with a voltage-doubling circuit that provides +600 volts for the plate and +300 volts for the screen of the 6883 power amplifier. A negative bias supply is provided by a shunt rectifier circuit off the secondary winding.

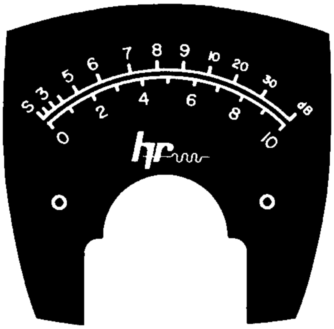
When the transceiver is operating from the 117 Vac line, the regulated power supply for the solid-state circuitry is developed from a full-wave bridge across the 12-volt winding on the transformer. When the power supply is connected to the 117-volt line, the dc-to-dc converter transistors must be disconnected from the power transformer. This is accomplished automatically by the two different power plugs shown in **fig. 10.**

Total current drain is very low in all modes. The receiver requires from 60 to 100 mA depending upon the audio level. Current drain from a 12 volt battery while transmitting depends on loading. However, when the final is loaded up to 100 mA, total input current from the 12-volt supply is 6 amperes.

## construction

All of the transceiver circuits except the power amplifier stage and power supply are built on pieces of copperclad board. Although printed circuits were not used in the transceiver shown in the photographs, they would be ideal for this purpose and would result in a somewhat more rugged unit. I doubt that reliability would be improved much since the unit shown here has been extremely dependable.

The transceiver circuitry is built on four different boards: transmitter mixer and driver stages; receiver front end, mixer and crystal-filter driver; receiver i-f, audio and agc; and vfo. The 9-MHz sideband generator and vox boards are mounted on top of the 4x7x1½-inch chassis on the right-hand side of the unit.



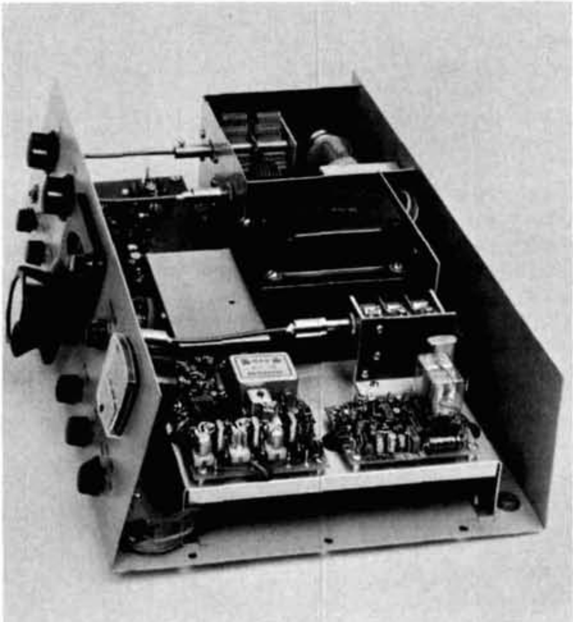

**New dial face for the s-meter.**

The receiver front end, mixer and crystal filter driver board is underneath as are the transmitter and mixer stages.

The vfo board is installed inside the 2x2x4-inch minibox. One side of this box is bent back at a 60° angle to conform with the front panel of the "Tilt-a-View" cabinet (Bud TV-2155). The sloping front panel requires that the vfo tuning capacitor be mounted on an angle so the shaft is perpendicular to the front panel; the shafts from the final-amplifier tuning capacitors use flexible couplers to provide the necessary displacement. The other controls are mounted on the front panel. The end result is a miniature, modern-looking package that can be carried around in a brief case.

Although the sloping front panel wastes some space, there is still plenty of room to spare. Although it's difficult to see in the photographs, the area under the chassis is almost completely unused. There's plenty of room for more circuitry—such as an additional vfo, a noise blanker, sidetone oscillator, speech processor or even an electronic keyer!

If you want to use a more conventional cabinet, there are any variety available. However, all of the modern-looking ones are so large you could package this transceiver and have room left over for a high-powered linear amplifier. This might not be such a bad idea for the home station, but for mobile and portable operation, the smaller size and weight of the package shown in the photos is more desirable.



**Internal layout of the transceiver. The 9-MHz ssb generator, vox board, receiver rf amplifier and transmitter drivers are mounted above and below the chassis in the foreground. Vfo box is in front of the power transformer. Heat sink for the power transistors is behind the rear panel. I-f amplifier, audio power and agc stages are built on the board in front of the power amplifier compartment. Flexible shafts are lengths of speedometer cable epoxied to short pieces of 1/4" tubing.**

The only other construction point of importance concerns the vfo tuning knob. The arrangement shown in the photo consists of two back-to-back vernier drives*—one on each side of the front panel. Each drive has a 6:1 reduction ratio. When they are connected in tandem as they are here you have a choice of either 6:1 or 36:1 reduction. The 6:1 (with the larger knob) is ideal for moving around the band; the 36:1 is perfect for tuning sideband.

The tuning dial is mounted on the reduction drive that is mounted inside the cabinet. The escutcheon was cut out from a piece of quarter-inch aluminum, filed to shape with a hand file and painted black.

## alignment

Before lining up the transceiver circuits, it's a good idea to make sure the 9-MHz excited module is properly aligned. This is a simple process with the directions furnished by Spectrum International and consists primarily of setting the carrier oscillators in proper relationship to the filter passband.

Vfo alignment is essentially a process of setting up the trimmers in the tuned circuit so the 50-pF variable will tune the oscillator over the desired range. For 80 and 10 meters, a full 500-kHz range is required to cover the band; on the other h-f bands, slightly less coverage will give you more bandspread—practical ranges are 300 kHz for 40, 350 kHz for 20 and 450 kHz for 15. If you are not interested in CW work, you may want to limit vfo coverage to the phone section of the band. For 10 meters you might even want to increase the vfo range to a full megahertz, but ssb tuning will be a little rough with this much coverage.

Regardless of the range you want, the vfo alignment procedure is basically the same. With the constants shown in **fig. 3** the basic tuning range is from about 4095 to 5505 kHz. With the 50-pF variable fully meshed, set the oscillator frequency to approximately 5500 kHz with the 20-pF trimmer; when the variable is fully open, the frequency should be approximately 5000 kHz. If you can't get

* Jackson Brothers type 4511 DAF. $1.50 each from Arrow Electronics Inc., 97 Chambers Street, New York, New York 10007.

the full 500 kHz range, replace the 75-pF shunting capacitor with the next smallest value. If the tuning range is larger than you want, increase the value of the shunt capacitor.

If you change the range within a few kHz, the inductance should require no adjustment. However, if you want to make a big reduction in vfo range, you may find it necessary to remove or add several turns to the toroid inductor. If you leave 4- or 5-inch pigtails on the inductor when winding it, you'll have plenty to work with when one stage at a time, peaking each tuned circuit as you go. Be sure to decrease signal generator output so you don't overload the receiver stages. Finally, hook the 9 MHz source to the antenna jack and adjust the 9-MHz trap for minimum signal feedthrough.

To line up the rf amplifier, tune the signal generator to the low edge of the amateur band, fully mesh the variable capacitor and tune coils L2 and L3 for maximum. Move the signal generator up to the top edge of the band, unmesh the variable and peak up the trimmers on the variable. After

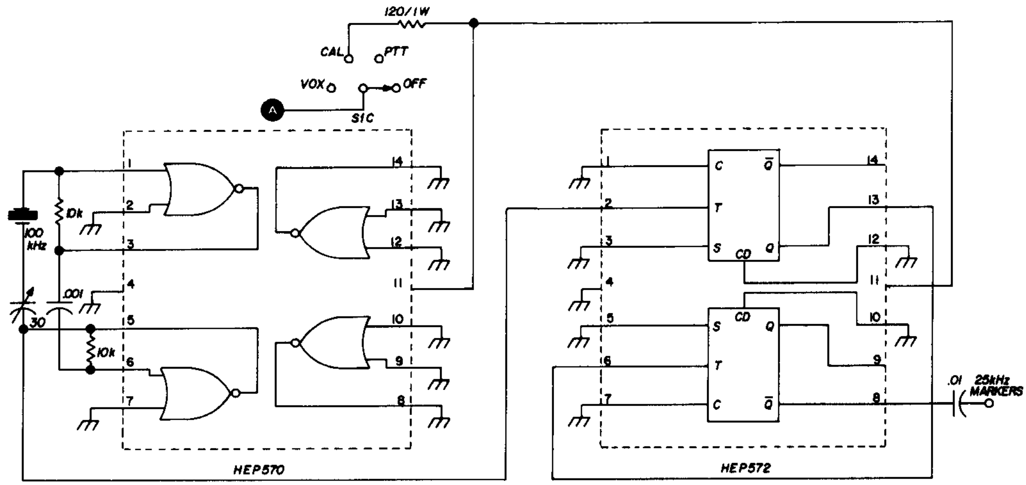



**fig. 9. Crystal calibrator is mounted on the same board as the receiving rf amplifier.**

setting up the frequency range. A little juggling of values may be required to cover the precise range you need, but it is not difficult nor time consuming. Remember that the inductor essentially determines the center of the frequency range; the shunting capacitor determines how much the frequency is changed by the air variable.

Receiver alignment is next and consists of peaking up the i-f amplifier and receiver mixer tuned circuits. If you built the unit from the audio section back, this is probably already done. If it isn't, inject a 9 MHz signal to the gate of the product detector through a 1000-pF capacitor. Tune the signal generator around until you get a beat note. Now move the 9 MHz source toward the rf amplifier, several tries it will be found that neither the lower-frequency inductor settings nor the upper-frequency capacitor settings will further improve the signal.

Before lining up the transmitter stages, remove the final power amplifier tube from its socket. A sweep generator is a big help in lining up the broadband transmitter drivers, but it isn't absolutely necessary. If you have a sweep generator, set it to sweep from 5.0 to 5.5 MHz; adjust the output to approximately 1 volt p-p and connect it to the transmitter balanced mixer (vfo injection mixer if you use one). Turn the exciter module to the CW position and insert sufficient carrier to provide a respectable trace on the scope; now align each of the

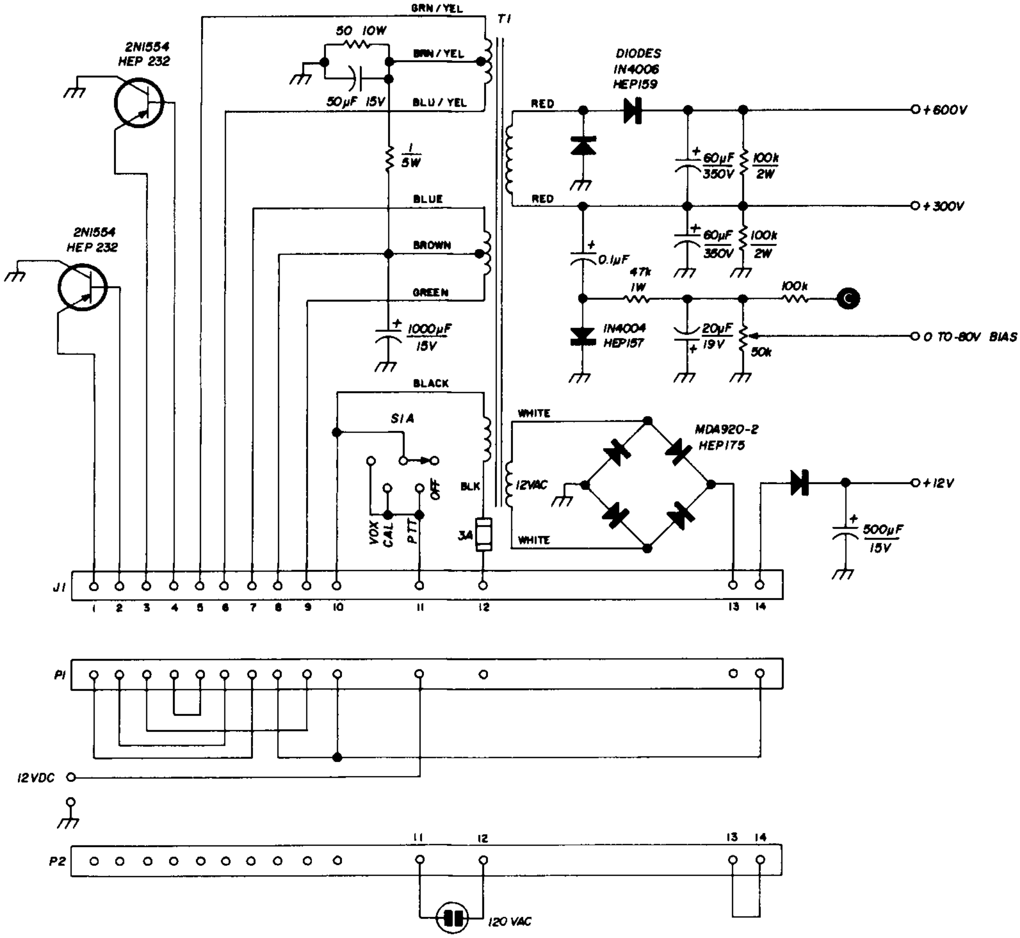



**fig. 10. Power supply for the single-band transceiver operates either 120 Vac or 12 Vdc. Transformer T1 is a Thordarson TR 294. The 2N1554 power transistors must be mounted on heat sinks.**

broadband transmitter stages for flat response over the amateur band.

If you can't beg or borrow a sweep generator, set the vfo about 10 percent in from the lower edge of the band and peak each of the stage **input** circuits; then tune the vfo in about 10 percent from the top edge of the band and peak each of the **output** circuits. After going through all the stages several times, there should be no further improvement in signal at either end of the band. As a final check, the output signal (measured at the grid pin of the power amplifier tube) should vary less than 1 dB when the vfo is tuned through its range.

When all the solid-state circuits are aligned, plug in the power amplifier. After it has warmed up, adjust the bias for 25 mA no-signal plate current. With the exciter control in the tune position, adjust carrier insertion and drive, then dip the final. If everything is in order, you should get about 50 watts input to the dummy load.

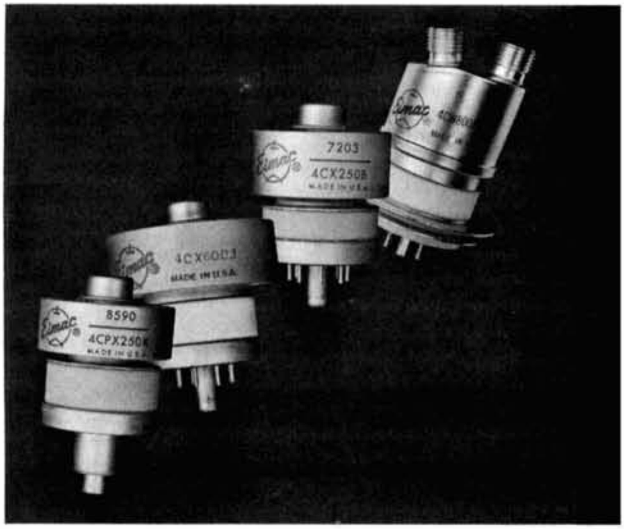
## references

1. J. R. Fisk, W1DTY, "Stable Transistor VFO's," *ham radio*, June, 1968, p. 14.

2. R. C. Hejhall, "Getting Transistors into Single-Sideband Amplifiers," Motorola Application Note AN-150, 1965.

3. J. Robertson and B. Welling, "An Integrated-Circuit RF/I-F Amplifier," Motorola Application Note AN-247, 1968.

**ham radio**




# external-anode tetrodes

This is a handy reference source, complete with quantitative data, on these popular rf generators

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**The 4X150A external-anode** tetrode was developed by Eimac back in 1947. This highly efficient, vhf-rated transmitting tube is the forerunner of a whole family of similar tubes that have evolved over the years since the war. The tube is now manufactured by a host of companies, but the original design is still going strong, and it's still the choice for a reliable rf power source with many vhf enthusiasts.

During the past few years a bewildering number of "4X-. . ." tubes have appeared. Each has characteristics slightly different from the original 4X150A. I'd like to discuss this family of tubes and identify, once and for all, the basic characteristics of each type. Amateurs interested in these tubes will then have a ready reference for future applications.

## the original 4X150A

Let's take a look at how the nomenclature describes the tube. The numeral **4** signifies four active elements: cathode, control grid, screen grid, and anode—a tetrode. The **X** indicates an external anode (forced-air cooled), **150** indicates the plate

| Eimac | EIA | Po Watts | Ep Volts | Fmax MHz | Heater V/A | Base | Figure of Merit | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | | 4X150A Family | | | |
| 4X150A (old) | — | 150 | 1250 | 500 | 6.0/2.6 | 9-pin | 86 | old style anode; weight: 5.2 ounces |
| 4X150A | 7034 | 250 | 2000 | 500 | 6.0/2.6 | 9-pin | 86 | new style anode; weight: 4 ounces |
| 4X150D | 7035 | 250 | 2000 | 500 | 26.5/0.55 | 9-pin | 86 | aircraft version of 4X150A |
| 4X150G | 8172 | 150 | 1250 | 1200 | 2.5/6.25 | coaxial | 56 | uhf and video service |
| 4X150R | 8296 | 250 | 2000 | 500 | 6.0/2.7 | 9-pin | 73 | ruggedized 4X150A/7034 |
| 4X150S | 8297 | 250 | 2000 | 500 | 26.5/0.56 | 9-pin | 73 | ruggedized 4X150D/7035 |
| | | | | | 4X250B Family | | | |
| 4X250B | — | 250 | 2000 | 500 | 6.0/2.6 | 9-pin | 85 | ceramic shell, glass-based 4X150A |
| 4X250F | — | 250 | 2000 | 500 | 26.5/0.56 | 9-pin | 85 | aircraft version of 4X250B |
| 4CX250F | 7204 | 250 | 2000 | 500 | 26.5/0.56 | 9-pin | 85 | all ceramic 4X250F |
| 4CX250B | 7203 | 250 | 2000 | 500 | 6.0/2.6 | 9-pin | 85 | all ceramic 4X250B |
| 4CX250K | 8245 | 250 | 2000 | 1200 | 6.0/2.6 | coaxial | 54 | uhf and video service |
| 4CX250M | 8246 | 250 | 2000 | 1200 | 26.5/0.56 | coaxial | 54 | aircraft version of 4CX250K |
| 4CX250R | 7580W | 250 | 2000 | 500 | 6.0/2.6 | 9-pin | 81 | ruggedized 7580 |
| 7580W | 7580 | 250 | 2000 | 500 | 6.0/2.6 | 9-pin | 82 | high-perveance 4CX250B |
| 4W300B | 8249 | 300 | 2000 | 500 | 6.0/2.6 | 9-pin | 85 | water-cooled 4X250B |

**table 1. External-anode tetrode characteristics.**

dissipation in watts, and **A** signifies the first production version.

Recent productions of the 4X150A have included a radically new brazed anode structure having a complex arrangement of cooling fins. The new design allows increased plate dissipation ratings. The designation of this version is 4X150A/7034. It is operationally equivalent to the 4CX250B at frequencies below 150 MHz.

## how to identify them

The different versions of the 4X150A are not easy to tell apart. Some transitional 150-watt tubes have the improved cooling fins but not the brazed anode structure. In general, the old- and new-style 4X150A's may be distinguished by weight. The 150- and 250-watt tubes weigh approximately 5 and 4 ounces respectively; their respective anode diameters are 15/16 and 13/16 inch. Interestingly enough, plate dissipation has been increased with reduced weight and size.

High-voltage heater versions of the 4X150A were introduced as the 4X150D and 4X150S (ruggedized). These new tubes, plus the redesigned descendants of the 4X150A, bear alternate Electronic Industries Association (EIA) nomenclature. This consists of four-digit numbers in the seven- and eight-thousand series. Thus the EIA 7034 is the 4X150A, etc.

The 4X150G (2.5-volt heater) and its offspring, 4CX250K (6-volt heater), have coaxial terminations. They are designed for internal cavity operation at frequencies into the gigahertz region.

| Eimac | EIA | Po Watts | Ep Volts | Fmax MHz | Heater V/A | Base | Figure of Merit | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | | 4X150A Family | | | |
| 4CX300A | 8167 | 300 | 2500 | 500 | 6.0/2.7 | breech-block | 52 | ceramic-metal ruggedized |
| Y-180 | — | 300 | 2500 | 500 | 6.0/2.7 | breech-block | 52 | nickel-rhodium plated 4CX300A |
| 4CX300Y | — | — | 2500 | 500 | 6.0/3.4 | breech-block | 53 | high-plate current version of 4CX300A |
| 4CX350A | 8321 | 350 | 2000 | 500 | 6.0/3.0 | 9-pin | 143 | high transconductance, high current 4CX250B |
| 4CX350F | 8322 | 350 | 2000 | 500 | 26.5/0.57 | 9-pin | 143 | aircraft version of 4CX350A |
| 4CX125F | — | 125 | 2000 | 500 | 26.5/0.57 | 9-pin | 52 | aircraft version of 4CX125C |
| | | | | | special versions | | | |
| 4CN15A | — | 15 | 2500 | 500 | 6.0/3.0 | breech-block | 52 | low-duty pulse work or heat-sink cooling |
| 4CN15L | — | 15 | 2000 | — | 2.1/7.5 | 9-pin | — | quick-heat cathode |
| 4CS100L | — | 100 | 2000 | — | 2.1/7.5 | 9-pin | 85 | quick-heat cathode, heat-sink cooling |
| 4CX125C | — | 125 | 2000 | 500 | 6.0/2.7 | breech-block | 52 | horizontally finned 4CX300A |
| 4CX125F | — | 125 | 2000 | 500 | 26.5/0.56 | breech-block | 52 | identical to 4CX125C except for filament voltage |
| 4CX250L | — | 250 | 2000 | — | 2.1/7.5 | 9-pin | — | quick-heat cathode |
| 4CPX250K | — | 250 | 5500 | 500 | 6.0/2.7 | coaxial | 85 | pulse rated 4CX250K |

## the 4X250B family

The 4X250B features ceramic insulation. It evolved from the glass-insulated 4X150A. Early versions were made with a ceramic outer cylinder and a glass base; later designs are all ceramic and are called 4CX250B. These 4X-series tubes are rated at 250 watts with a maximum plate voltage of 2000.

The latest offspring of the 4X150A is the popular, rugged 4CX300A. This Ceramic and metal tetrode operates at plate voltages up to 2500. Special-purpose versions are currently in production. Among these is the 4CX300Y, which should be of interest to ssb amateurs and others contemplating new equipment. The 4CX300Y resembles the 4CX300A in appearance, but has a heavy-duty heater (6.0 volts at 3.4 amperes). This permits unusually high values of plate current.

## external anode tetrodes in grounded grid?

Modern, high-gain external-anode tetrodes don't perform well in the conventional class-B grounded-grid arrangement for several reasons. The external-anode tube is characterized by high perveance, together with extremely small spacing between grid bars and between grid and cathode. Thus while performing excellently as grid-driven tetrodes, they are not suitable for grounded-grid operation as such.

For proper operation, the screen requires much higher voltage than the control grid. Older tetrodes having lower gain tend to have more equal balance between absolute grid and screen currents. When these electrodes of the newer, high perveance, external-anode tetrodes are tied together, the control grid tends to draw tremendous currents, and there is grave risk of destroying the grid. Peak grid current, for example, in a 4X150A operated in grounded grid can easily be **twice** the value of peak plate current.

It's permissible, however, to operate the external-anode tube as a *cathode-driven* tetrode, with the grid and screen at rf ground, but operating at the normal dc potentials. Grid dissipation under these conditions is minimal, and stage gain is greatly increased. Screen dissipation is nearly the same as in the tetrode connection. Greater stage gain can be obtained with this circuit, because the driver doesn't have to supply large screen and grid losses. Excess drive power should be absorbed in a resistive load.

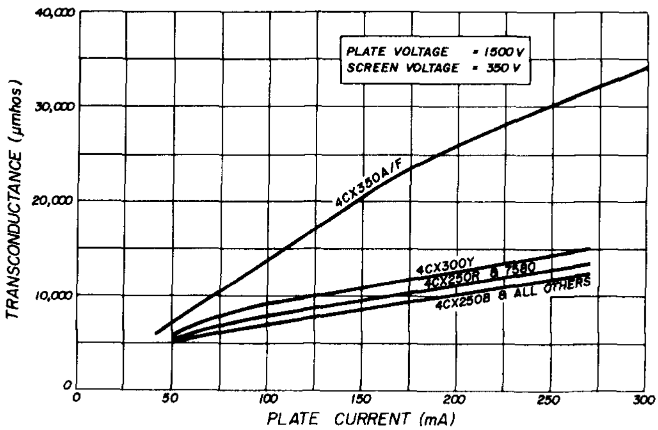



**fig. 1. Mutual transconductance vs plate current for several external-anode tetrodes. The 4CX350A and 4CX350F have about twice the transconductance as the rest of the line; the 4CX300Y has approximately 30% higher transconductance than the "standard" tubes while the 7580 and 4CX250R/7580W are approximately 20% higher.**

## the tube socket

In addition to permitting connections to the elements, the socket for external-anode tubes conducts heat away from the tube stem and, in some cases, serves as a capacitive screen bypass.

Complete Air-System socket assemblies for all noncoaxial-based external-anode tubes are available. These consist of socket and air chimney (**table 1**). The sockets are designed to permit air to be directed axially on the tube base, past the base to the envelope, and then over the anode cooler. Use of other than the Air-System socket with external-anode tubes is not recommended, because tube temperature can't be adequately controlled. A receiving-type loctal socket with 4X150A-style tubes is emphatically **not** recommended. Dangerously high stem temperatures will occur from the filament heat unless the base structure is cooled by an air blast. The solid construction of the simple receiving-type loctal socket blocks the flow of air around the tube stem.

I'd like to emphasize that heater voltage on the 6-volt external-anode tetrodes is 6.0 volts ±5 percent, **not** 6.3 volts. What this means is that the tube will operate at 6.3 volts, which is the upper limit of the specification (+5 percent), but for longest heater life, the voltage **should not** exceed 6.0 volts rms.

Anyone using these tubes, or any transmitting tube for that matter, should measure heater voltage **at the tube heater terminals.** The meter should be calibrated against a one-percent laboratory instrument, and the measurement should be made under full-load, key-down conditions.

You would do well to take a tip from broadcast and TV stations. Some of the large tubes in these installations cost around $1,000.00 to replace, and no maintenance engineer is about to face the embarrassment of having a final amplifier tube go west because of high heater voltage. At KFMB-TV, for example, the senior transmitter engineer (W6QCN) says that their big tubes have a meter in the input to the heater voltage source, which is regulated to supply the exact voltage at the tube heater terminals.

## the figure of merit

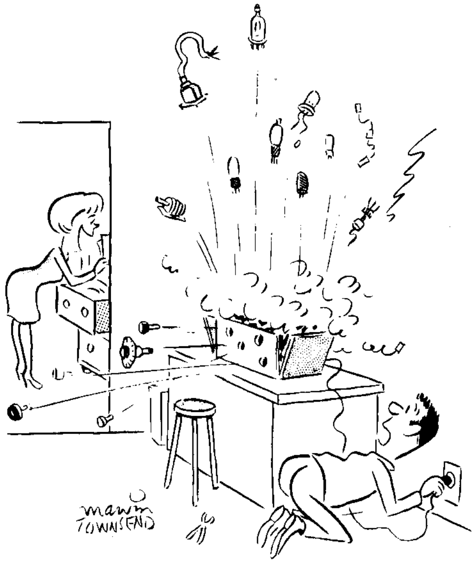
A graphical presentation of the mutual conductance for external-anode tubes as a function of plate current is given in **fig. 1.** The 4CX350A and 4CX350F have about twice the $g_m$ of other tubes in this class. The 4CX300Y has about 30 percent higher $g_m$, and the 7580 and 7580W/4CX250R are about 20 percent higher than the 4X150A. Mutual conductance (or transconductance, as it's sometimes called) is a figure of merit of a particular tube. Also known as the gain-bandwidth factor, this quantity is

$$\text{Figure of merit} = \frac{g_m}{2\pi C_t}$$

where $C_t$ is the total input and output capacitance of the tube.

The figure of merit is a relative number and should not be interpreted as an absolute value. $C_t$ is an average, taken from a number of typical tubes. Highest figure-of-merit values are reached by a combination of high $g_m$ and low interelectrode capacitances. The 4CX350A and 4CX350F, which have the highest $g_m$ and reasonably low interelectrode capacity, have the highest figure of merit. The coaxial- and breechlock-based tubes, with their higher capacitances, appear to have lower figure-of-merit values. However, the coaxial-based tubes perform more efficiently at the higher frequencies, and they are especially designed for cavity operation.

**ham radio**



**"Good news, dear! I've finally found the instructions for that kit you're trying to assemble."**

# lighthouse tubes for uhf

**Planar triodes or lighthouse tubes** are well suited for amateur use in the uhf spectrum; various surplus versions, such as the 2C40, 446B and 2C39 have been used at frequencies up to 2400 MHz. A relatively new member of the family, the 3CX100A5, is available for improved service at uhf.

The 3CX100A5 is relatively unknown to the amateur fraternity, but its older relative, the 2C39A, has been long a favorite uhf tube of the "surplus hounds." The 2C39A and its twin, the 7289, fit into the amateur picture nicely as amplifiers, doublers or triplers in the range from 1000 to 3000 MHz. They are not expensive, and various glass versions of the older 2C39/2C39A/2C39WA can often be obtained at give-away prices on the surplus market. The 3CX100A5 is an improved, modern version of this old World War II tube, dressed up in a brand-new ceramic and metal envelope.

Performance of the 3CX100A5 as a grounded-grid uhf power amplifier and multiplier is shown in **fig. 1, 2** and **3.** Because of the high power gain of the tube, grounded-grid circuitry is desirable since intercoupling between the input and output circuits is reduced to a minimum and neutralization is not required. The graphs may be used to estimate the performance of the 2C39 glass family of tubes by noting that the useful power output of this style tube will be somewhat less (depending upon the frequency)—up to 25 percent at 2.5 GHz.

A variety of 3CX100A5 tubes were run in a coaxial cavity capable of tuning from 1000 to 3000 MHz, and a series of measurements was made with a representative sample of production tubes operating as amplifiers, doublers and triplers. Drive and output power were carefully measured for each test, and appropriate filters were used to eliminate feedthrough and harmonic output. When a tube is operated as a doubler or tripler, feedthrough power is at the driving frequency and is undesired. In practice it is necessary to eliminate this power from the output circuit of any grounded-grid frequency multiplier; high-Q tuned circuits or wave filters will do the job.

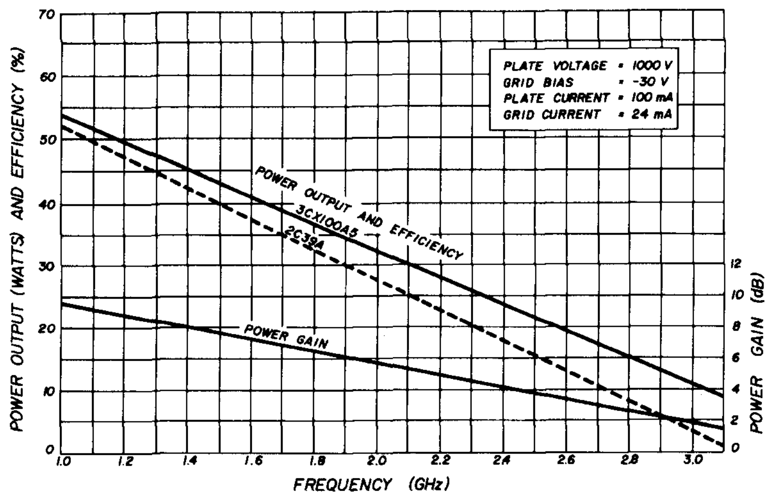
## amplifier performance

A graph of average tube performance as a grounded-grid amplifier is shown in fig. 1. Grid drive, grid bias and plate loading were adjusted to provide maximum power output while maintaining plate current at 100 mA. Plate voltage for these tests was 1000 volts, and grid bias was −30 volts.

At 1300 MHz, the 3CX100A5 is capable of about 47 watts power output at an efficiency of 47%. The power gain of the tube is 8 decibels, indicating a required drive level of about 7.5 watts as measured at the input to the cathode cavity.

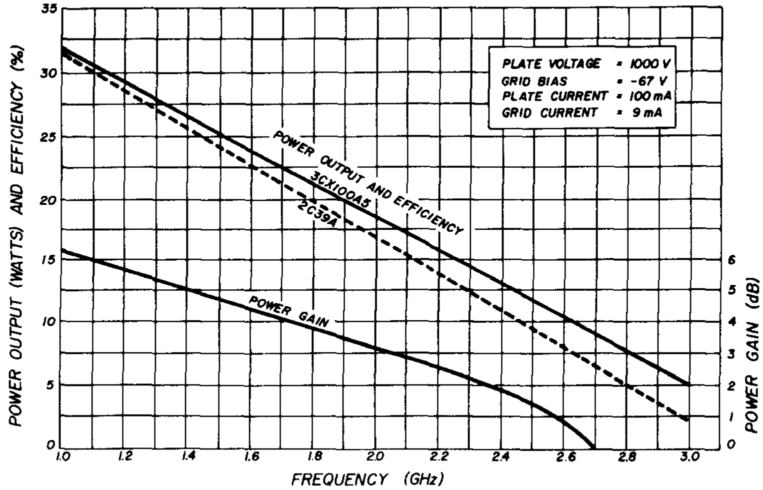
Power output gradually decreases as the frequency of operation is raised. At 2400 MHz power output (at 100 watts input) drops to 25 watts, and grid driving power increases to 10 watts. Power gain at this frequency is 2.5. A power output and efficiency curve for the 2C39A over the same frequency range is shown by the dotted line.

**fig. 1. Typical power output, gain and efficiency of 3CX100A5 and 2C39A grounded-grid amplifiers.**




## doublers and triplers

After completing the amplifier tests, the same tubes were operated as frequency doublers in gain and power output tests. Excitation was applied and the operating conditions and tank circuits adjusted for maximum power output while maintaining 100 mA plate current. Plate supply voltage was 1000 volts, so the operating config. 2. Typical power output, gain and efficiency of grounded-grid doublers.




ditions represent 100 watts input.

At 1300 MHz, with 650-MHz drive, power output was 27 watts; this is a circuit efficiency of 27 percent. Drive power of 8 watts was required, a power gain of 5.3 dB. At 2400 MHz, power output was 13 watts with 9 watts drive at 1200 MHz. Power gain as a doubler drops to unity at about 2700 MHz although the 3CX100A5 is still useful as a doubler at this frequency since 10 watts output can be obtained. This data is plotted by the solid lines in **fig. 2;** 2C39A performance as a doubler is plotted by the dotted line. The same tubes and general test techniques were used to determine the operating parameters of the 3CX100A5 as a frequency tripler. Drive power was applied at one-third the output frequency and the circuit was adjusted for maximum power output. At 1300 MHz, 17 watts of power were obtained with about 10 watts drive at 435 MHz. At 2400 MHz, power output was about 8 watts with 12 watts drive at 800 MHz. Power gain as a tripler drops to unity just above 2700 MHz but useful power output is still available, although efficiency is very poor.

fig. 3. Typical power output, gain and efficiency of grounded-grid triplers.

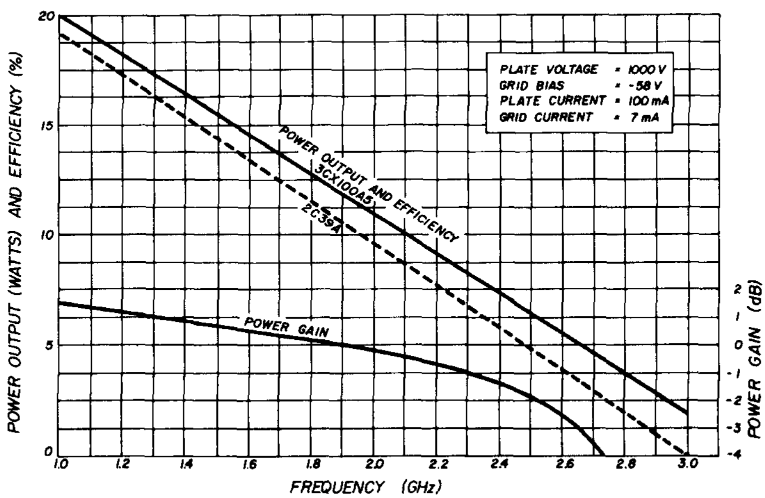


**table 1. Planar triode tubes.**

| | | |
|---|---|---|
| 2C39A | Glass or ceramic construction | Eimac, Machlett |
| 2C39WA | Glass or ceramic construction | Eimac, Machlett |
| 2C41 | Not interchange-able physically with 3CX100A5 or 7289 | Machlett |
| 3CX100A5 | All ceramic construction | Eimac, Machlett, GE |
| 3CX100F5 | Identical to 3CX100A5 except heater voltage is 26.5 volts | Eimac |
| 381 | 3CX100A5 type, rated for pulse service | Eimac, Machlett |
| 6897 | Not interchange-able electrically with 3CX100A5 or 7289 in most uhf sockets | GE |
| 7289 | Identical to 3CX100A5 | Eimac, Machlett, GE |

A socket for the 3CX100A5 is a rare bird since it is an integral part of the resonant cavity in most equipment. However, collet rings for the tube are available from the Instrument Specialties Company or Braun Tool and Instrument Company. A complete socket assembly can be purchased from Jettron Products.*

## conclusion

The planar triode tubes of the 3CX100A5 family perform well in the frequency range encompassing the 1215-MHz and 2400-MHz amateur bands. Efficiency is good, considering the frequency of operation. F. E. Terman indicates[1] that a doubler will provide about 65 percent of the power output of a straight-through amplifier, and a frequency tripler will provide about 40 percent of the power output of the amplifier. These figures agree closely with the data shown here. Two recent articles[2,3] show that these tubes can put quite a dent in the 1215-MHz band.

### references


1. F. E. Terman, "Radio Engineering," McGraw-Hill, New York, 1962.
2. P. Laakmann, WB6IOM, "Cavity Amplifier for 1296 Mc" *QST*, January, 1968, p. 17.
3. P. Laakmann, WB6IOM, "Kilowatt Amplifier for 1296 MHz," *ham radio*, August, 1968, p. 8.


* Instrument Specialties Company, Little Falls, New Jersey; plate collet, 97-70; grid collet, 97-72; cathode collet, 97-76; and filament collet, 97-80.

Braun Tool and Instrument Company, 140 5th Avenue, Hawthorne, New Jersey; plate collet, 134-53; grid collet, 134-51; cathode collet, 165.

Jettron Products, Inc., 56 Route 10, Hanover, New Jersey, can supply complete sockets.

**Bob Sutherland, W6UOV**

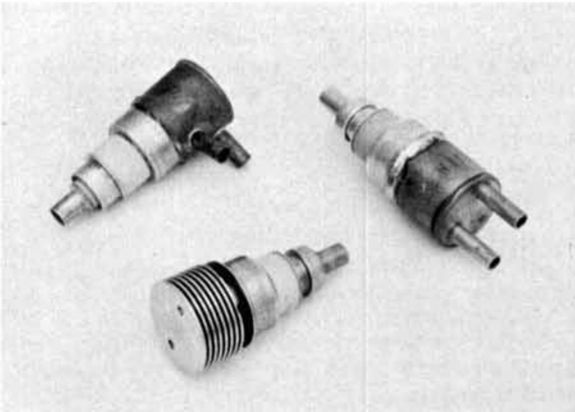
# water cooling the 2C39

**There is a gradual movement** of amateur radio to higher and higher frequencies where there is more spectrum and room for interesting experimentation. Probably the most popular tube for amateur operation on 1296 and 2300 MHz is the erstwhile 2C39 or a modern member of the same family. Originally air cooled and rated at 100 watts plates dissipation, by using water cooling these tubes can safely dissipate 150 to 200 watts without noticeably shortening tube life. If you want to build efficient high-power and **quiet** amplifiers and multipliers for these bands with 2C39-type tubes, water cooling is the answer.

## water jacket

First of all, slightly loosen the two Allen screws that hold the finned heat sink in place and pull it away from the tube body. Even with the screws loosened, pull-ing the heat sink off may be difficult because the heat sink is aluminum and the tube anode is silver-plated copper. I've found that cooling the whole works in a freezer sometimes helps; sometimes lubricating with acetone will help. Not all 2C39 manufacturers use Allen screws to hold the heat sink in place; the heat sinks screw onto the anode of some tubes, but this type can be removed as well.

**Watercooled 2C39's. Side-inlet versions are used in a UPX-4; top-inlet types are used in a WB6IOM two-tube 1296-MHz amplifier.**



The water jacket is made from a 1-inch length of 1-inch diameter (ID) copper or brass tubing. Punch out a 1-1/8-inch disc from 1/16-inch copper or brass sheet with a punch. Next, drill two 1/4-inch holes for the water inlet and outlet tubes 7/16 inch apart. These can be located in one side of the water jacket or on top, depending upon the application. Cut two 1/4-inch OD copper or brass tubes about 3/4-inch long; these tubes should have an inside diameter of 3/16 or more.

Fit the tubes into the 1/4-inch holes in the jacket so that their ends are flush with the inside surface of the jacket; silver solder the four pieces together—jacket, disc and two tubes. After cleaning the completed water jacket to a shiny finish, soft solder it to the 2C39 anode with a small torch. Be sure to keep the flame entirely on the water jacket to prevent damage to the 2C39.

## coolant system

Cooling water is run into the 2C39's with 3/16-inch inside-diameter vinyl or tygon tubing. If you use more than two tubes in the system, it's a good idea to use intake and exhaust manifolds for splitting and recombining the water. The manifolds are made from 8-inch pieces of 1-1/8-inch OD copper or brass tubing.

Quarter-inch holes—spaced 1 inch apart—are drilled along the sides of the tubing; small brass tubes, 1/4-inch OD and about 3/4-inch long are pushed into these holes. One end of the manifold tube is capped with a 1/16-inch thick brass disc and the other end is fitted with standard garden-hose fittings. Then all the pieces are silver soldered together.

Half-inch hose is used for the main lines to and from the pump. The pump is a "Little Giant" submersible pump that is designed for small backyard waterfalls; this inexpensive little pump doesn't make any noise while it's pumping. Be sure to ground the manifolds because the cooling water has full plate voltage on it when the amplifier is turned on. (Distilled water is supposed to be a good insulator, but don't bet your life on it.) A 3- to 5-gallon plastic bucket can be used to hold the pump and water for the complete system.

At K6HCP's successful moonbounce station, the 2C39's in the 300- to 600-MHz doubler, 600- to 1296- MHz double-mixer, two-tube 1296-MHz driver* and six 3CX-100A5's in the UPX-4 ring amplifier are all water cooled. After many hours of echo tests and moonbounce schedules, not a single tube has been replaced or even suspected of having low output. Best of all, for weak signal detection with a full kilowatt input, nothing but the purple glow of stressed 3CX100A5 ceramic disturbs the silence of the shack.

* Peter Laakmann, WB6IOW, "Cavity Amplifier for 1296 Mc," *QST*, January, 1968, p. 17.

**Mike Staal, K6MYC**

# a modular fm communications receiver

## Project report on a functional design using off-the-shelf modules

David M. Stahley, K8AUH, 6401 Brookside Drive, Cleveland, Ohio 44144

**Among my interests in** amateur radio is fm technology. About a year ago I outlined a project for myself to design and build a functional receiver with certain features needed to pursue my particular interests. I wasn't interested in a deluxe, high-performance commercial design, nor was I interested in a lot of embroidery. I wanted an inexpensive receiver for continuous mobile or base-station monitoring. The features of this fm receiver were to include:

1. Noise-operated squelch
2. Carrier relay
3. S-meter option
4. Minimum power consumption

I also wanted to use off-the-shelf components to minimize construction difficulties and to keep the cost within reasonable bounds.

The receiver described in this article fulfills all these requirements. It is, of course, a compromise between good engineering practice, state of the art and practical home construction. Some of its features are readily adaptable to your equipment, and for this reason I've included discussion material at each level. This isn't necessarily a construction article, but rather a report on the outcome of the project.

### rf deck front end

The front end (**fig. 1**) was obtained from Plectron. It was available in both low band (30-54 MHz) and high band (144-174 MHz) models; the costs were

$10.00 and $13.00 respectively, less crystals. The crystals will depend upon your particular requirements and location. Another approach would be to use any of the many available solid-state converters. A particularly good example are those produced by Vanguard; they will "custom tailor" a converter (rf deck in our case) for $2.00 over the cost of the basic converter. This price includes the crystal. Additionally, units with dualgate mosfets are available, which are excellent. Should you elect this route, be sure to specify the desired input (monitoring) frequency and 10.7 MHz output. It seems logical that some cost reduction might be realized if the deck is ordered less case and plugs.

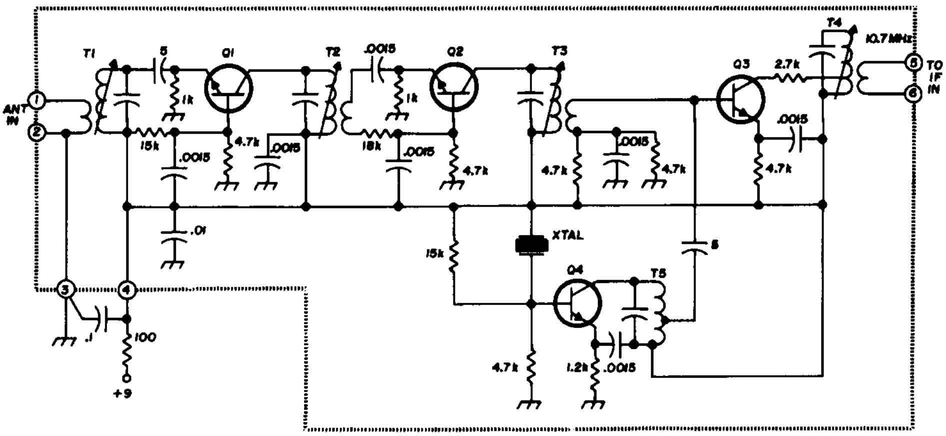



fig. 1. The Plectron low-band rf deck.

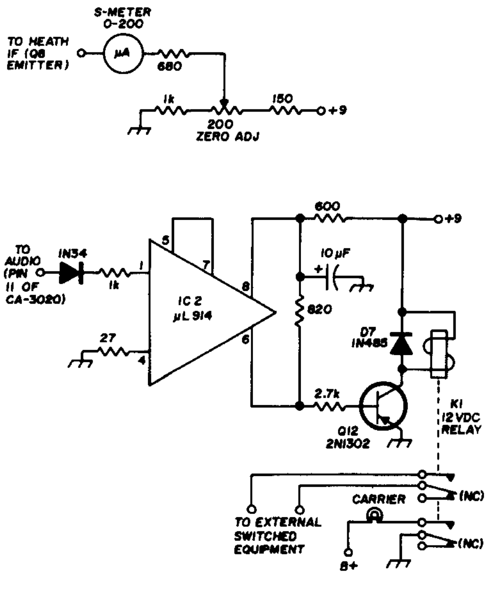
## squelch

The noise-activated squelch (**fig. 3**) is simple but effective. The squelch transistor is a high-gain type similar to the Motorola HEP 54. Because of some poor experiences with noise squelch circuits in the past, I made several tests to ensure acceptable performance. Specifically, this circuit does not squelch off in the presence of high modulating frequencies such as are found in some selective-calling and remote-signalling systems. Neither is it affected by the mark (2125 Hz) and space (2975 Hz) tones used with audio frequency shift keying (afsk) radio teletype. Finally, because of its characteristics, mixed wide- and narrow-band transmissions cause no problem.

## carrier relay

The optional carrier relay (**fig. 2**) has been used to actuate a tape recorder for

fig. 2. Optional s-meter and carrier relay circuit.



logging and recording. It's also very handy for operating a carrier indicator lamp. The usefulness of such a lamp becomes apparent if more than one receiver is operating in the same room. Any 12-Vdc relay can be used, provided it will pull in at 30-40 mA and drop out at 10-15 mA. The one used here is a Potter & Brumfield KM11D, which is a dpdt type approximately one cubic inch in volume.

rf and i-f sections.

This modification would resolve the problem but add considerably to the cost and complexity, which would move beyond the limitations noted earlier. I've shown how to add an s-meter to the unit (**fig. 2**); however, in this type of service it was found to be more window dressing than necessity. Any other compatible i-f strip could be substituted.

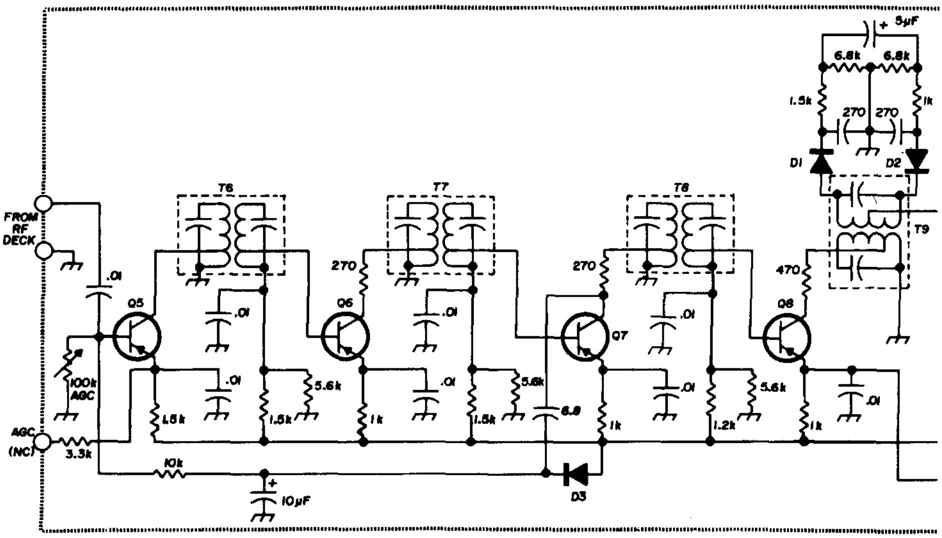



**fig. 3. The Heath 10.7-MHz i-f strip (dashed box), squelch and IC audio amplifier.**

## i-f strip

The i-f strip is shown in the dashed box of **fig. 3**. It was one I found in the Heath AJ-43D receiver.[1] It was available from Heath complete and ready to operate for about $17.00. This choice results in an i-f of 10.7 MHz. Benefits include availability, commercial development, compact construction, low cost and relative freedom from drift. Disadvantages are relative low audio recovery and susceptibility to adjacent-channel interference. The first is overcome by additional gain in the audio stages. The second, where it might be a problem, can be reduced by addition of a ceramic filter and additional amplification by using an RCA CA3028 between the

## audio power amplifier

The audio output section (**fig. 3**) uses the RCA CA3020 integrated circuit. This is a high gain, self-contained audio amplifier capable of 500 mW output, which is quite adequate for indoor use. For mobile service, a better choice would be the CA3020A, which is rated at one-watt output. This should provide sufficient power to overcome most wind and traffic noise. The audio system frequency response has been limited to 300 to 3000 Hz to facilitate communications and reduce operator fatigue due to hiss and noise. A further extension of this would be to use a Jensen type PC4V3 four-inch speaker. The response of this speaker is similarly restricted.

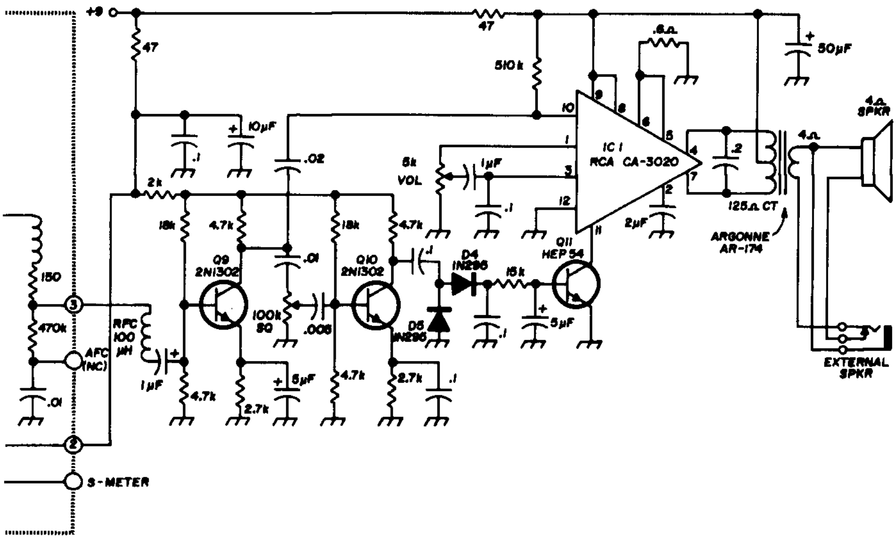
## power supplies

The power supply is completely open to choice. Four are shown in **fig. 4.** A nine-volt battery will work nicely, as will an ac supply consisting of a 6.4-Vac filament transformer and diode bridge. For mobile service a zener regulator or zener-transistor regulator would be in order to help tame the shifty voltages. Further, a small blocking diode is a cheap form of insurance against accidentally reversed battery polarities. The ultimate would be to include a rechargeable battery inside the case, with a regulated ac supply. Then you could unplug from the base ac mains, move to the car, change antennas, plug into the cigar lighter, start up and drive away—all without missing a word.

The problem of both ac and dc operation can be greatly simplified by using two power cords terminated with 4-pin Jones female plugs. This eliminates the need for changeover switching. One cord is made using pins 3 and 4 for 110 Vac. The other cord would be for mobile use, connecting pin 1 to +12 Vdc and pin 2 to vehicle ground. Don't forget the blocking diode. The battery can be kept charged while on ac power by means of a resistor and diode combination.

The next generation will probably have IC's in the rf and i-f sections. This hasn't been done as yet, because it's difficult to find commercially available i-f and detector transformers that match the available IC's. I'm interested in using ceramic i-f and discriminator units, such as are available from Murata and Clevite. However, so far everything in this whole area seems to be either wrong impedance, too wide- or too narrow-band, too expensive or generally not available.

Another nice item would be an IC suitable for an untuned crystal oscillator (10.245 MHz) and mixer unit for dual conversion. Also, a linear IC with an fet




### materials and suppliers

1. Heath Company, Benton Harbor, Michigan 49022. Order: 10.7 MHz solid-state i-f strip P/O Heath Model AJ-43 or AJ-43D Part number 100-M521
2. Plectron Corporation, Overton, Nebraska 68863. Order: high-band rf board number 3185 ($12.00 ea.) low-band rf board number 3283 ($9.00 ea.); crystals for Plectron Boards HC-25, holders non-oven type, 0.005% third-overtone, 32 pF load ($8.00 ea.)
3. Vanguard Electronics Labs, 16-23 Jamaica Avenue, Hollis, New York 11423

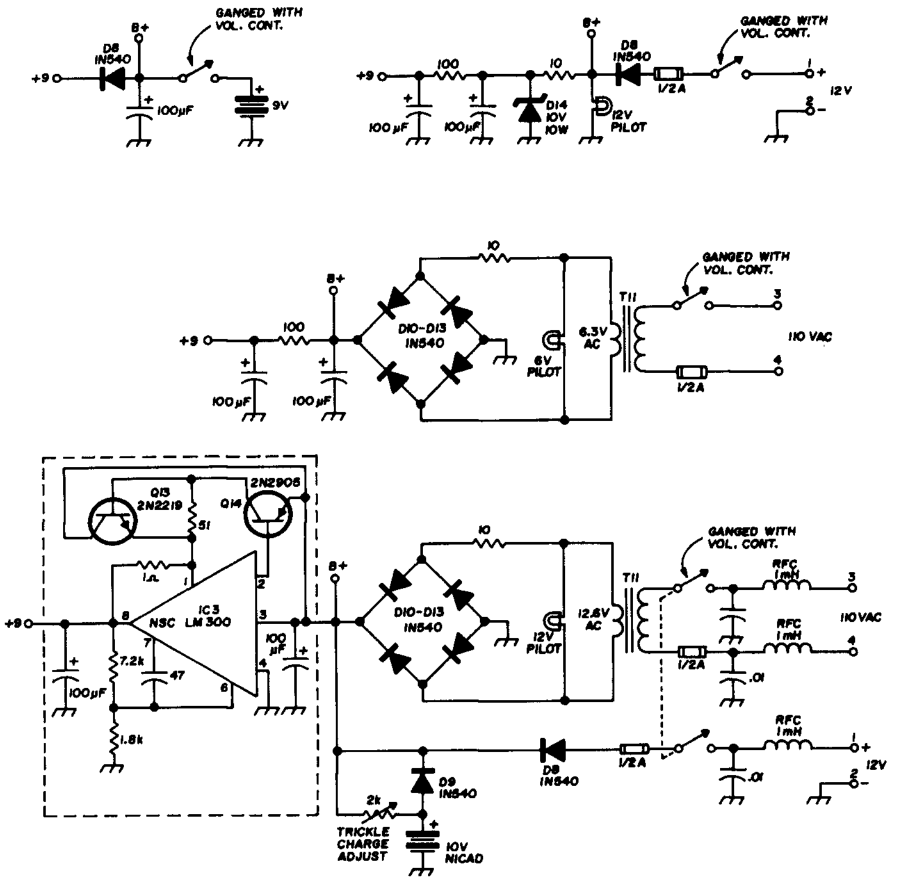



**fig. 4. Power supplies for the modular fm receiver.**

mixer section for the first converter/first i-f amplifier would be desirable. National Semiconductor has just released a complete squelch and agc unit, which would shrink the audio sections still further. Then there are LSI (Large Scale Integration) techniques, which could mean practically the whole receiver pasted on the back of the speaker; next year's receiver should be a lot smaller, a better performer and quite a bit cheaper and easier to build.

**ham radio**

# crystal control for the HW-100

**Crystal control is an** option not offered by most transceiver manufacturers. Granted, most vfo's are stable and accurate enough not to require the steadiness of a rock, but there are times when crystal control is a definite advantage. Mobile operation is enjoyed by a lot of amateurs, and here a stable, known frequency is most welcome. Many of my friends operate on a single frequency most of the time; there's someone monitoring the frequency nearly 24 hours a day, and this can be reassuring to a lone mobileer. Crystal control is also useful for net operation.

The crystal oscillator shown in **fig. 1** provides more drive than necessary and must be padded down with the 45-pF trimmer. The circuit is very inexpensive to build—less than the cost of the crystal itself. A positive supply voltage is picked off the zener diode that biases the vfo amplifier tube. With the switching circuit shown, it is possible to select: vfo-controlled transmit **and** receiver; crystal-controlled transmit and vfo receiver; or, crystal-controlled transmit **and** receive.

When ordering the crystal for this circuit, specify that it will be used with a 32-pF load. The vfo tunes from 5.5 to 5.0 MHz (low to high end of the band). Therefore, to operate crystal controlled on 3999 kHz for example, you need a crystal cut for 5001 kHz. The 12-pF trimmer is used to put the crystal exactly on frequency. If you plan to operate near a band edge, it would probably be a good idea to spend the extra money for a commercial-grade crystal.

The crystal oscillator is built up on a terminal-strip board and bolted to the back of the vfo chassis as shown in the photo. An insulating strip is placed under the board to keep it insulated from the chassis. Drill a hole beside the 6AU6 to accommodate an insulated feedthrough bushing: the 45-pF trimmer is mounted between the circuit board and the feedthrough insulator. Additional holes are drilled through the top of the vfo chassis to accommodate the wires needed to operate the crystal circuit and incremental tuning unit.

**Front panel of the modified HW-100 showing the crystal/vfo control switch.**

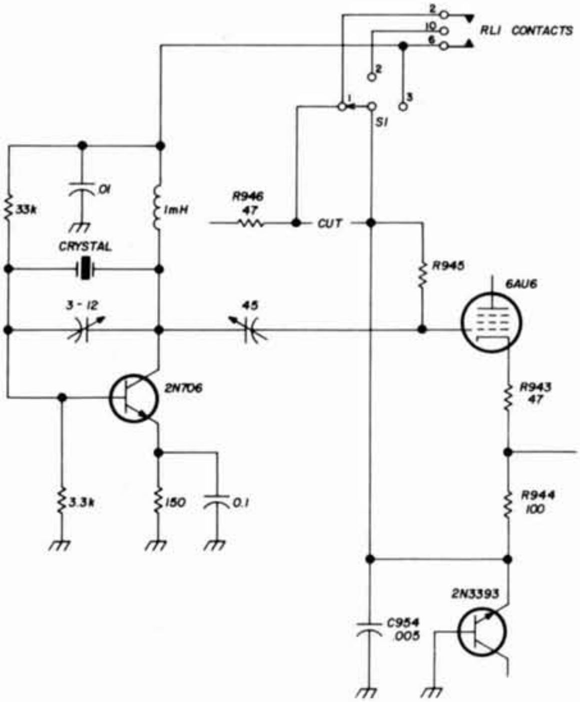
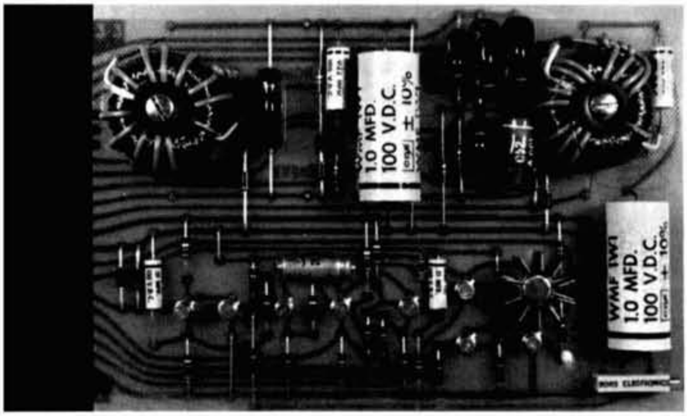



**fig. 1. Crystal control for the Heathkit HW-100. In switch position 1, the vfo controls both transmit and receive; in position 2, crystal control on transmit, vfo control on receive; position 3, crystal control on both transmit and receive.**

The 47-ohm resistor is disconnected from terminal strip FF (pictorial 7-2 in the HW-100 manual). A wire is soldered to this resistor and passed through the top of the chassis to terminal 2 of the rotary vfo/crystal switch: a wire soldered to terminal 1 of terminal strip FF is connected to the common terminal of the vfo/crystal switch: a wire coming from terminal 3 of the switch is connected to the B+ tie point of the crystal oscillator. Three more wires are connected to the switch as shown in the schematic and connected to terminals on relay RL1.

**Bill McCracken, K1GUU**




# why not try RTTY?

Circuits for sending and receiving radio teletype— plus some station-improvement ideas

E. C. Sherrill, K6JFP, 4745 49th Street, San Diego, California 92115

**While reading amateur radio** publications I've noticed a very few simple, easy-to-follow construction articles on RTTY. To help fill the void I'd like to present some circuits that have added a great deal to the operating convenience of my station. Solid-state devices are used exclusively except for power supply transformers. For those who would like to learn more about RTTY theory and design, some references are included at the end of the article.[1, 2, 3]

## basic equipment

The most expensive item in an RTTY station (excluding transmitter, receiver and antenna) is the teleprinter. As with most equipment, these machines can be obtained by judicious horse trading. I've seen some advertised for as little as thirty dollars. Rebuilt ones cost up to $150 if you want to go first class.

If you have a teleprinter, all you need to receive RTTY is a terminal unit (TU). The TU accepts tones representing code characters from the receiver, discriminates between the tones, and changes them into positive- and negative-going pulses. These are sent through limiter and flip-flop stages and finally to a keyer stage. The keyer operates a relay in the teleprinter.

To transmit you'll need a frequency-shift keyer (fsk). This is a simple capacitance-tuned LC circuit that shifts the transmitter vfo output (usually 850 Hz) to form the code characters. The remaining equipment consists of two simple power supplies. Added refinements include an oscilloscope to monitor keying waveform and an audio frequency shift keyer (afsk).

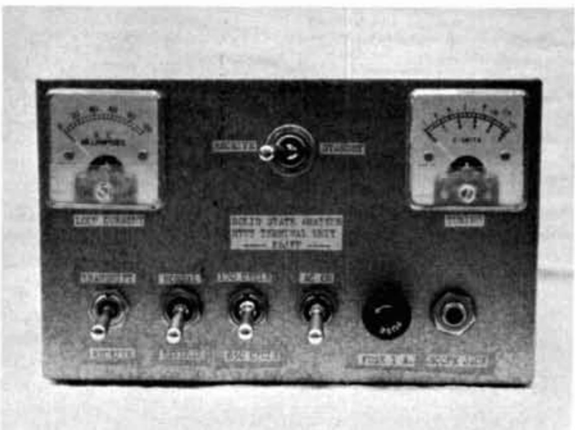
The TU printed circuit board is available at nominal cost.* It is a heavy-duty fiberglass board, and information on parts layout is included. (Mine came equipped with all edge connectors and transistor sockets.) You can get the complete unit with all components, wired and ready to play, for about sixty dollars. Either package comes with complete and extensive technical data.

The TU is the basis of the entire system **(fig. 1).** I modified the original Cashion circuit to accommodate some switching circuits for added operating convenience, and I added the power supplies and fsk board. A schematic is also included for an afsk board **(fig. 5)** for those who might be interested.

## power supplies

These are diagrammed in **fig. 2**. Jacks J3, J4 and J5 must be insulated from the TU panel. A transmit/receive switch (S5A) gives

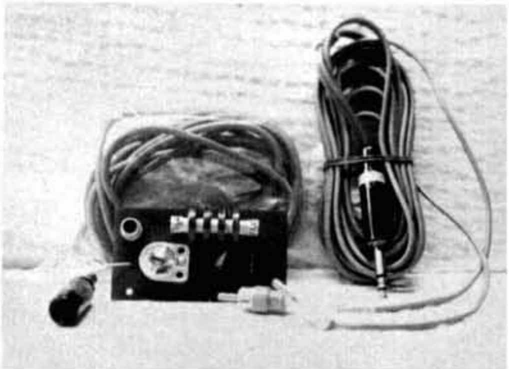
**Front panel of the solid-state TU.**



control of the transmitter from the RTTY position. (See also **fig. 3** which shows connections between TU board and transmitter.) Switch S5B, which is one-half of S5, disconnects the TU keying circuits during transmission but lets you monitor the tones with an oscilloscope. (see also **fig. 1.**)

## the TU board

Most RTTY terminal units have provisions for normal/reverse copy. Occasionally you'll find a station using reverse transmission, or you just might have tuned him in on the wrong sideband. Switch S2 **(fig. 1)** will give



**The fsk with accessory cables and a dummy plug for the TD.**

the correct copy. Also I added a narrow/wide control; this allows you to choose between 850- or 170-Hz shifts, which are most commonly used.

My TU has a three-circuit microphone jack on the front panel. This is used to monitor signals with an oscilloscope, either during transmit or receive. Signals vary in amplitude, of course, and the S-meter is handy; but a scope is much better, especially during net procedures.

In the TU panel photo the switches are, from left to right, transmit/receive switch S5; normal/reverse switch S2; narrow/wide

* Cashion Electronics, P. O. Box 7307, Phoenix, Arizona 85011. Order a "two-tone limiterless TU no. 6." Price is about $10. A phenolic board, without holes or plating is available for $5.

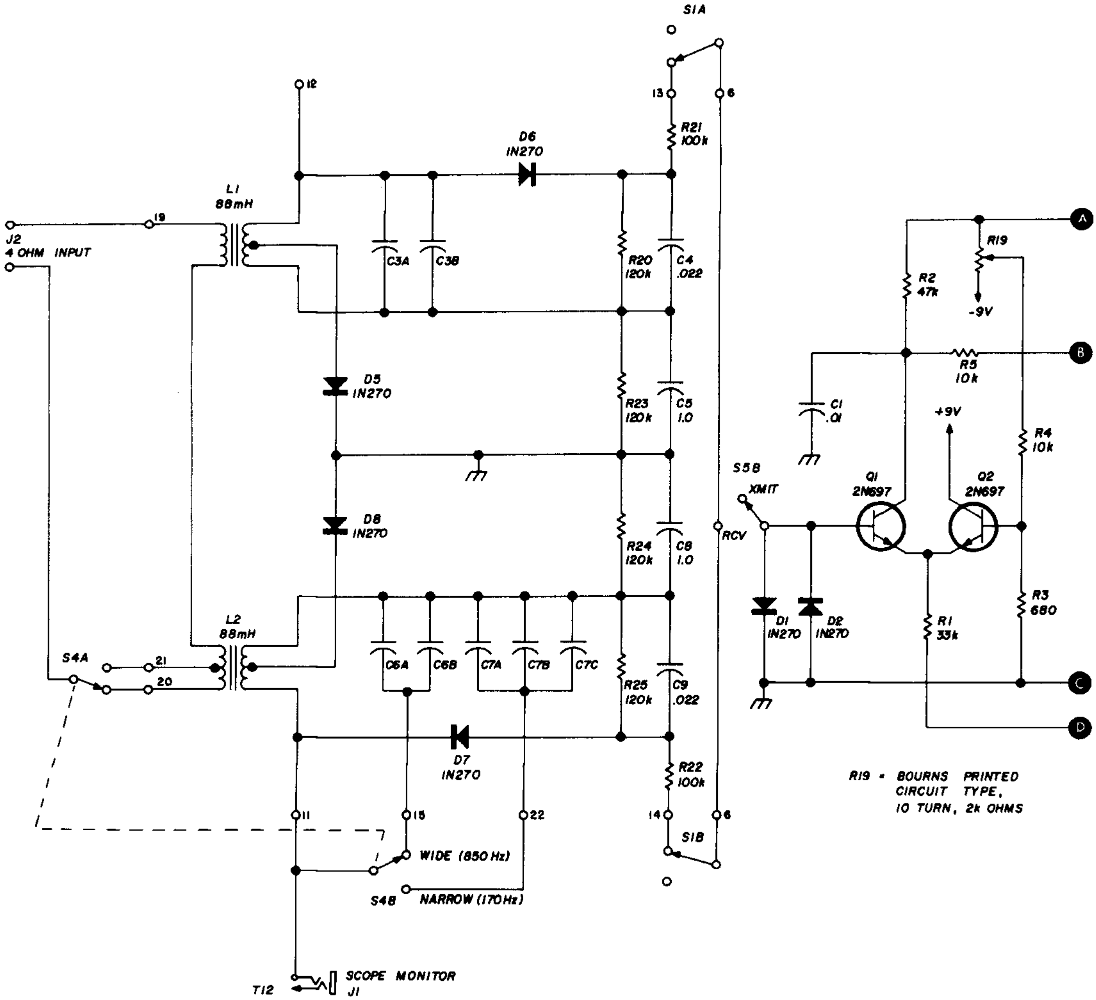



**fig. 1. Schematic of the tuning-unit board. This is the basic unit; the text explains how accessories were added.**

switch S4; and ac switch S3. Next to these are the fuse holder for F1 and oscilloscope jack J1. At the top are the 0-100 mA dc loop meter, receive/standby switch S1, and the tuning meter.

For transistors Q1-Q8 I used 2N697's, but other more inexpensive ones are now available. I used an RCA 2N3440 for Q9; again, these aren't absolutely the final word. Other types will work equally well. Be sure to use a heat sink with Q9.

## the fsk unit

This circuit is shown in **fig. 4.** Parts are mounted on a PC board measuring about two by three inches. **Fig. 3** shows how the fsk output is brought into the TU board. The fsk is connected to the vfo in the transmitter by a single loop of wire wrapped around the vfo-tube cathode.

## construction notes

The photos show the general layout of parts and the interconnecting cabling. Recognized techniques and precautions should be used when assembling these solid-state components. I shall emphasize again that transistor Q9 on the TU board **must** be installed with a heat sink.

**Table 2** gives the connections to the TU

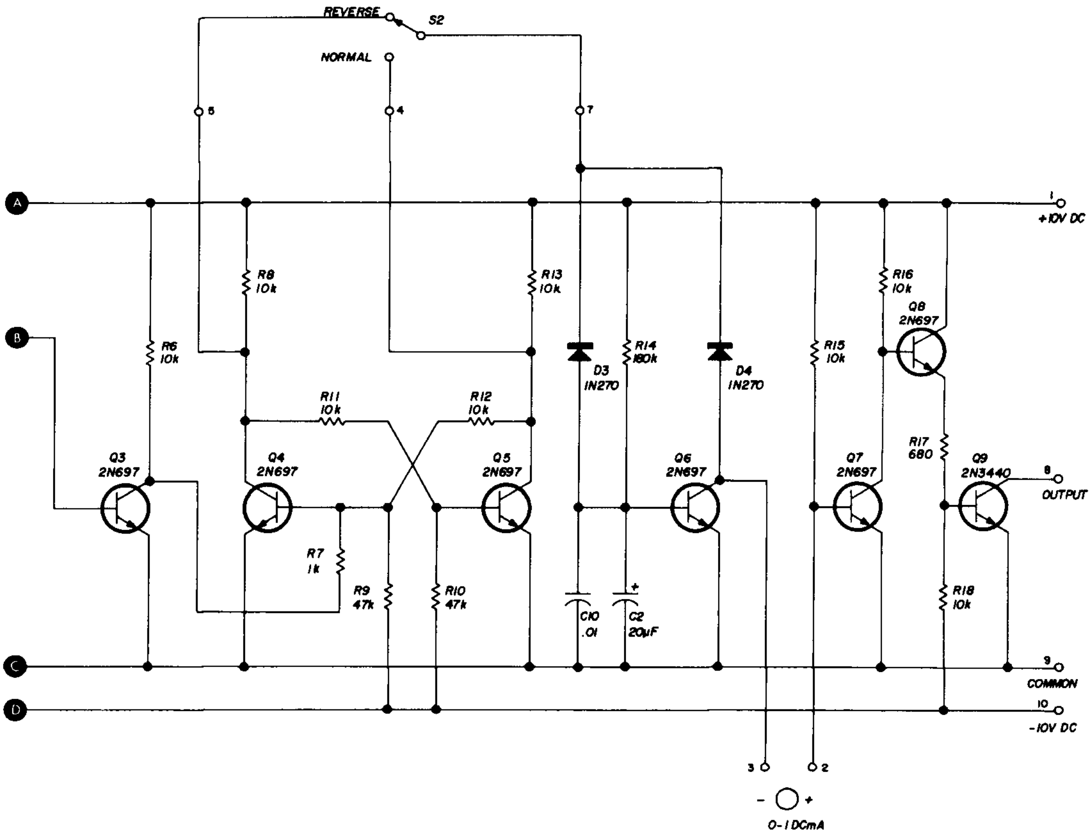



table 1. Parts list for the power supplies, fsk, switching circuits and accessories. (Note: Does not cover the TU board. See fig. 1.)

**Jacks**

J1 & J6, 3-circuit microphone jacks
J2, J3, J4, J5, J7 single-circuit phone jacks

**Switches**

S1 dpdt mark/space—standby
S2 spdt normal/reverse
S3 spst ac switch
S4 dpdt narrow/wide shift
S5 dpdt transmit-receive

**Meters**

1 ea 0-100 dc mA Lafayette Miniature
1 ea 0-1 dc mA or VU Lafayette Miniature

**Cabinet**

1 ea 5 x 7 x 9 inches Cal Chassis Company LTC 463

**Transformers**

1 ea Triad R-30 or equivalent
1 ea 120 V primary, 15- to 24-V secondary, 100 mA, Triad F-45X or equivalent

**Fuses**

F1 1A, 150 V

| tu terminals | functions |
|---|---|
| 1 | +10 Vdc from regulated power supply |
| 2 | plus terminal of 0-1 dc mA VU tuning meter |
| 3 | minus terminal of 0-1 dc mA tuning meter |
| 4,5,6 | normal-reverse switch S2 |
| 6 | To switch S5B mark space tones input to board |
| 8 | connect to RY-KBD-TD insulated jacks via loop supply |
| 9 | common ground |
| 10 | minus 20 Vdc from regulated power supply |
| 11, 15, 22 | vertical scope input, switch S4B or tuning bulb wide/narrow tuned circuit |
| 12 | horizontal scope input or tuning bulb |
| 16 | nc |
| 17 | nc |
| 18 | nc |
| 19 | from receiver output, 4-ohm input (J2) |
| 20, 21 | switch S4A. wide/narrow shift tapped coils |

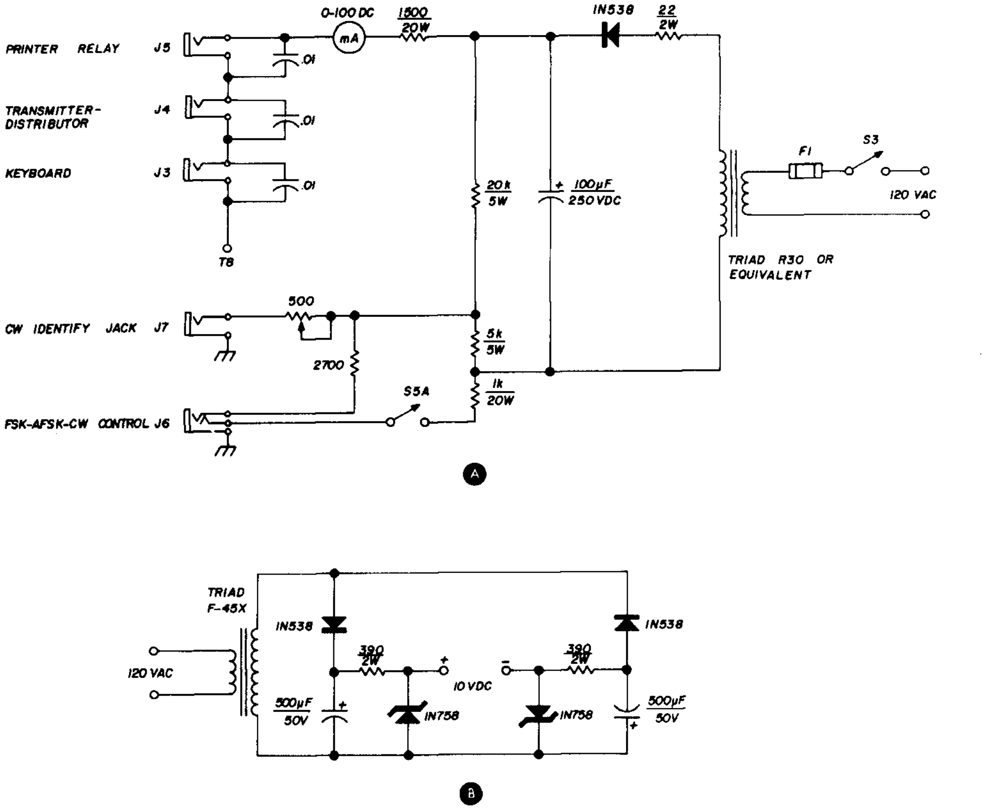
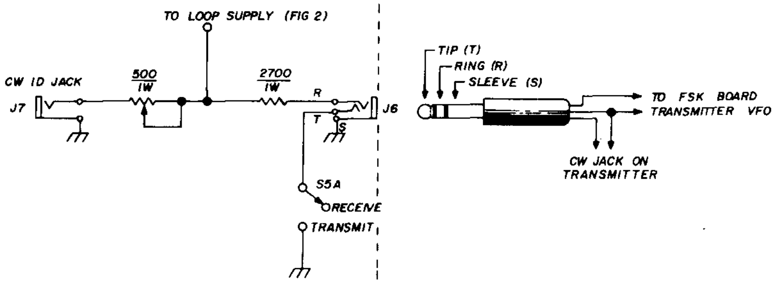



**fig. 2. The loop supply (A) ties into the TU board at terminal 8. The low-voltage supply is connected to terminals 1 and 10. See fig. 1.**

board. These jacks are shown in **fig. 1.** The power transformers and TU printed circuit board are mounted above chassis; all other parts are mounted below chassis. The front panel of my TU is secured by the switches, fuse holder and jacks. I used a Triad R-30 transformer for the 120-volt supply and a Triad F-45X for the low-voltage supply, although any equivalents will work satisfactorily.

After everything is assembled, check all connections and wiring, then you're ready to insert the plugs. Turn on the power and check the 100-mA meter. It should indicate

**fig. 3. Fsk connections between the terminal unit and transmitter.**

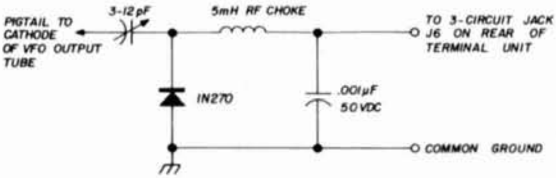


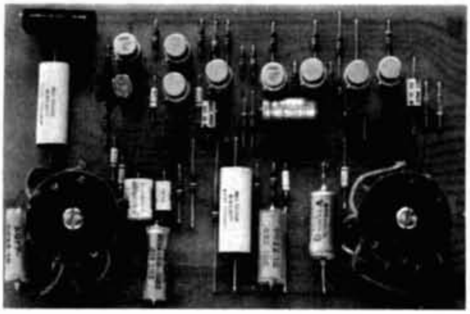
between 55 and 70 mA. If not, something is wrong, and you should recheck the circuits.

If the meter reads okay, turn on the audio, and then watch the loop meter and tuning meter. If signals are tuned in properly, the teleprinter will print out correctly. If it doesn't, check the beat frequency oscillator sideband in use, or the normal/reverse switch.

If you don't have the proper test equipment to tune the fsk unit, load the transmitter on a dummy load and vary the 12-pF capacitor. Try to match the received mark and space signals on your oscilloscope. When the tones are nearly correct, put your transmitter on the air and call a station. Your mark/space signals might not be just right, but he'll receive **something.** Then the real spirit of amateur radio will prevail!

**fig. 4. The fsk circuit; this provides 850-Hz deviation for RTTY characters.**



**The Cashion TU-6 board as assembled by the author.**

## some parting thoughts

I am quite pleased with the circuits described. If you try them and have any real problems, send your questions and a self-addressed, stamped envelope. I'll do my best to help you. The most important watchword when working with these units is: **get the polarity right the first time.**

### references

1. Byron H. Kretzman, W2JTP, "The New RTTY Handbook," 1961, Cowan Publishing Corporation, New York.
2. Durwood J. Tucker, W5VU, "RTTY from A to Z," CQ, August, 1964, through July, 1966.
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**ham radio**

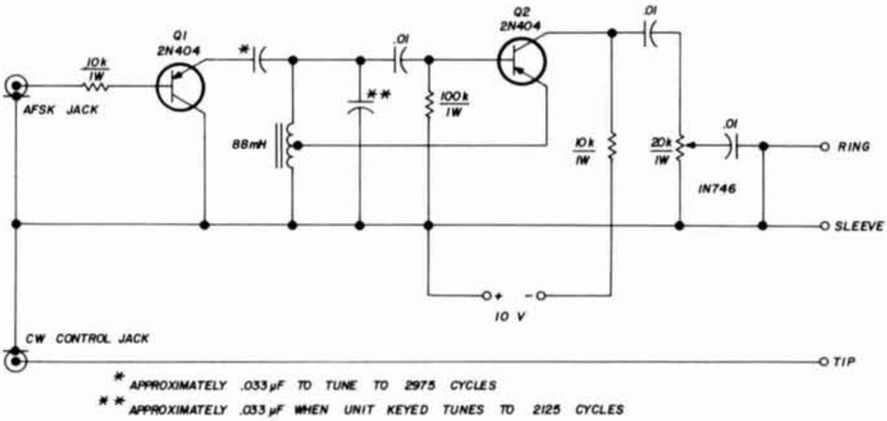



**fig. 5. The afsk unit. Directly replaces the fsk if you wish. Remove the cable from the fsk and plug into the afsk. Output plug of the afsk (PL-68) plugs into an a-m or fm transmitter.**

# grounding and wiring

Jim Ashe, W1EZT

**When you are trying** *to make a circuit that* you've built from a schematic work properly one of the problems that may plague you is the grounding bug. This has probably caused more instant insanity than any other problem facing the electronics experimenter. As with any worthwhile project, there's a right way and a wrong way to do things. I'd like to pass along the results of some of my experiences with ground connections and wiring. If you're interested in exterminating the grounding bug on your next construction project, read on. It may save you much time and trouble getting the circuit to play.

## grounding and wiring principles

*Successful grounding in any electronic* circuit depends on how dc voltage and current are controlled by wiring placement. Voltage can do strange things to your circuit. Reason: voltage is a workhorse which, if not treated with respect in circuit wiring, can be most unforgiving. Depending on the circuit, the negative pole of voltage may be grounded at a common point on the chassis. Or it may be left *floating, as in a transformerless circuit* that works directly from the ac input source.

Current, in contrast to voltage, doesn't terminate at some point on the chassis, but makes a complete pass around the circuit. Anything that interferes with the current loop (stray capacity and inductance) reduces circuit efficiency and produces an instability problem.

In the following discussion I shall explode some myths about grounding that have hung around since the early days of radio. If you consider what I have to say, you should have a better understanding of how voltage and current behave in electronic circuits. Then you can construct your equipment with these thoughts in mind and be reasonably sure that luck, at least, won't be one of the independent variables that influences hardware performance.

## about voltage

Digressing for a moment, voltage is electrical pressure between two points. It's measured by the indication on a meter connected between the two points. Commonly, one of these points will be at ground potential. One definition of ground is "a circuit point that may be earthed without upsetting the circuit." This definition was valid for circuits years ago, but for today's modern circuits it is an oversimplification.

The circuit designer has a choice as to whether a ground will be included, and if so, which part of the circuit will be at common ground potential. Usually a large piece of metal, such as a chassis, is chosen as the place where you attach one lead of your meter to measure dc voltages (**fig. 1**). The circuit is usually designed so that signals look good when viewed from this reference point.

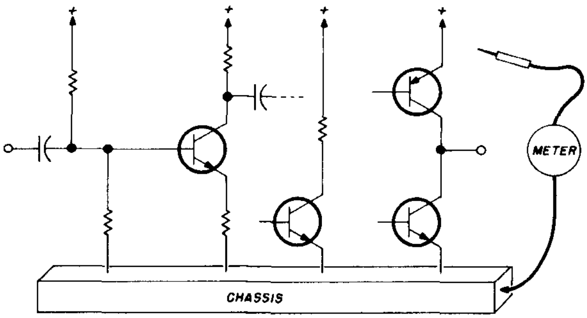
The manner in which voltages are controlled in circuits can mean the difference between success and failure when you first turn on that new piece of equipment. The schematic is an idealized road map. It does not show the many extraneous resistances, capacitances and inductances found in the hardware. If all these elements were included in the schematic it would be quite messy, indeed. Good wiring practice and lead dress will minimize these problems, which are the grounding bugs I mentioned earlier.

into the input circuit. Then you have feedback, and an unstable system.

## about circuits

Modern electronic circuits seem to be harder to work with than those of a few years ago. Active devices have more gain, which means more sensitivity to unwanted feedback. The higher gain is often accompanied by response to much higher frequencies. This means smaller unwanted coupling inductances and capacitances can return enough signal from output to input to produce instability. Have you noticed construction projects lately containing RC circuits or ferrite beads in their input circuits? These are added, as in **fig. 3**, to control high-frequency response. Older circuits didn't need these provisions.

**fig. 1. When you think of a circuit ground, you usually think of something like this. Everything in the circuit refers to the one solid piece of metal, and test meters are attached to this reference point.**




## about current

Current can be thought of as a kind of fluid, but flowing in a solid medium rather than in a pipe. If you want to measure current, you insert a measuring device into the stream, or you may insert a resistor into the stream and measure the voltage developed across it.

The water pipe analogy for current flow is misleading, at least when you're trying to understand what happens to current flow in an electronic circuit. Eventually water in a pipe runs down a drain somewhere. But current makes a complete pass around an electronic circuit, as in **fig. 2.** There's no common point where current can be disposed of, as with voltage. Current pops up again somewhere else, and when you're building a circuit you must know where.

A current gone astray can cause unwanted feedback. **Apparent** grounding of an audio amplifier, for example, can fool you. If you choose just any handy tie point, some of the output current can find its way

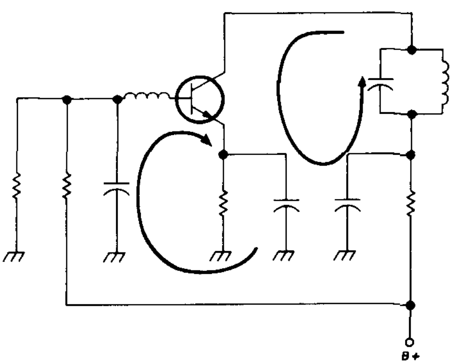



**fig. 2. Input and output currents follow loop paths in this single i-f amplifier stage. Interfering with the current loops reduces efficiency and increases hazard of unwanted feedback.**

A schematic contains two circuits: the dc supply circuit and the ac signal circuit. This fact is obscured in the schematic, because many components perform two jobs. The collector resistor in a transistor audio amplifier, for example, functions as a signal load resistor as well as a device to decrease the supply voltage to a lower value as seen at the collector. Let's trace these circuits and see what happens (**fig. 4**).

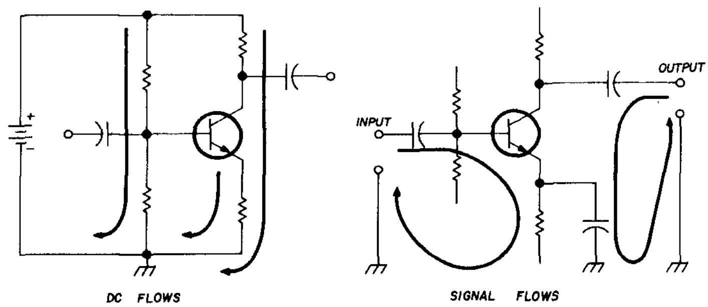
From the power supply positive terminal, the dc bias current flows along the supply line. Then it reaches a point where it can flow through the load resistor to ground. Going back, we find other routes: through the base bias network, and from base to emitter to ground. At the ground terminal these currents meet, and we trace them back to the power supply. This completes the current loop. It shows that the dc-supply circuit actually extends through the active elements in the circuit. Thus there's a lot more to the dc supply than two wires with the circuit between.

Now let's look at the signal circuit. We trace the current loop the input signal follows. The signal flows to the base, down to emitter and ground, and back to the input. The collector signal flows to the emitter, to the emitter bypass capacitor, then to ground, and finally back to the collector.

Here's an important point, sometimes easily missed: not **all** of the signal follows this route. No matter what resistance is placed in the collector circuit, some of the signal finds its way to the supply lines and to all the places to which they extend. This is why some writers emphasize decoupling.

Now for some practical examples.

**fig. 4. Signal and dc biasing paths share elements in this simple audio amplifier circuit.**



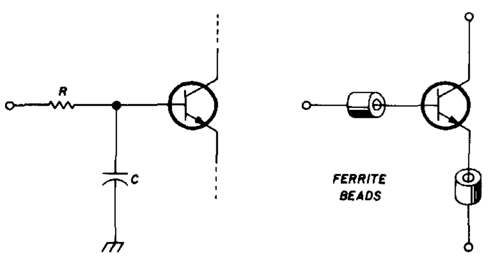




**fig. 3. Two methods for reducing high-frequency response.**

## oscillators

In **fig. 5** I've drawn a simple oscillator circuit. It can't feed currents into the rest of the system, because it has no signal ground. It could be operated from a negative supply by returning the positive terminal to supply ground, with the negative terminal above ground; this is the commonbase oscillator. There's no magic about having the base connected to a large piece of metal, so this connection is omitted. All currents have free paths to follow correct routes, and the circuit works fine.

## audio amplifiers

I once had an experience with an intercom amplifier that simply would not stabilize. It turned out to be caused by a speaker ground return to a handy tie point under the gain control. Let's see what happens when such an amplifier is wired according to the single-point ground theory.

The circuit of **fig. 6** is one you might assemble from a printed-circuit amplifier kit. Why isn't it stable?

Heavy output current is provided to the speaker. One watt into eight ohms is 125 mA. The speaker return is connected to the

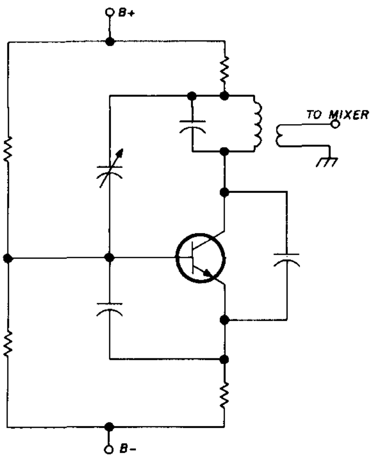



**fig. 5. Here is a conventional common-base oscillator with no ground connection for feeding a simple rf mixer.**

chassis. After passing through the speaker, the current flows all the way around to the common ground wire and finally back to the power amplifier.

Probably because of the way input connectors are constructed, and because there's no extra terminal on the PC board, the input current must follow a route through the amplifier, along part of the same wire to the chassis, and back to the input connector. This doesn't look too bad. But let's estimate the voltage produced by the output current across the input terminal.

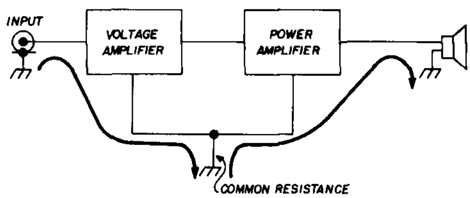
If the entire resistance of the common wire, including chassis connection, is 10 milliohms (and with a poor connection it could be more), the 125 mA audio current can generate 1.25 millivolts of unwanted current. If the phasing is correct, oscillations may result. At some frequency, the phase probably will be correct. The remedy is a small revision of the output circuit. This will allow the heavy output current to follow a **direct** route to the output stage.

## rf amplifiers

The grounding bug can be responsible for rf feedback in rf stages. I once talked to a fellow with a well-shielded but unstable kW rf power amplifier. "How can this be unstable?" he asked. I don't know how it finally came out, but I saw something that appeared to be a prime suspect.

Rf current flowed from the two 813 anodes to the pi network. From there, it flowed into the antenna coax center conductor. The key here is that equal return current came **back out** of the connector and eventually found its way down through the two holes in which the tubes are placed. Finally, the current found a way to return to the tube cathodes. If the phasing is correct, current

**fig. 6. This audio amplifier is unstable because of feedback through a resistance common to both the input and output.**




coupled into the input circuit will cause oscillation.

This problem can't be resolved by shielding, because that's not where the trouble is. Some provision must be made to carry the return rf current **directly** to the cathodes. My recommendation, before building any rf power amplifier, is to draw a picture of the current route, including the coupling system. Include any direct paths that the current could follow. If you can't see the route, the current probably can't either, and some rerouting of return leads is a must to tame the circuit. This will yield an additional benefit of improved sensitivity (in a receiving system) and better performance.

**ham radio**

# a top-loaded 80-meter vertical

This efficient antenna can be built for under twenty dollars— it's one answer to restricted space

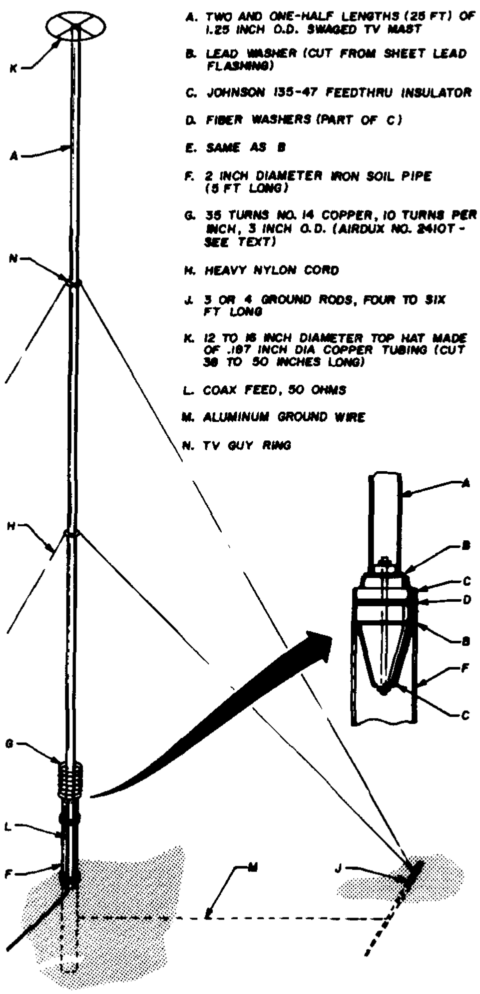
George Cousins, VE1TG, Box 18, RR 2, Lower Sackville, Nova Scotia

**The search for an efficient,** low-cost antenna for 80 meters often takes on strange forms, mostly because of the fairly considerable space necessary to get any sort of decent performance. Limited lot sizes often prevent erection of anything like a proper horizontal dipole, and even a long wire becomes a problem. However, a convenient answer to the problem may appear in the form of a vertical.

Many thousands of hams operate 80-meter mobile with small whips, using their car bodies as ground planes. Many attempts have been made to use these whips in home installations, with limited success. I believe the best answer is a happy compromise between whip and full-sized antenna.

The array described here is just such a compromise, but quite an efficient one, which should find ready appeal because of its low cost, small size and ease of installation. It's constructed of readily available materials, and can be built and installed in less than a day with no strain whatsoever. This antenna was designed and built by Wilbur (Bill) Hills, VE1KK, a well-known 80-meter man here in the Maritime Provinces. Reference to **fig. 1** will provide clear construction details.

**fig. 1. Construction of the low-cost vertical antenna for 80 meters.**




## construction

The radiating section is made from two and one-half ten-foot lengths of tv mast, approximately $1^1/_4$ inches in diameter. When purchasing the mast, pick up a couple of tv guy rings at the same time. The base support is made from a length of two-inch iron soil pipe (a five-foot length will be adequate). The pipe will be eventually buried in a hole where the antenna will be positioned, but don't dig the hole until you finish this article so you have an idea of just where to dig it.

Also remember that the soil pipe must be set truly vertical, or the antenna will have a drunken lean to one side or the other. To insulate the antenna from the mount, a Johnson number 135-47 feedthrough insulator is used. The insulator is inverted and its longest section is placed inside the pipe. The antenna is then placed on the insulator's base. To protect the porcelain from contact with the metal pipe, two washers cut from a sheet of lead flashing separate the insulator from the metal.

The heart of the antenna is the loading *coil at its base and the capacitance hat* at the top. Both are easy to construct. The coil is made from a section of commercial Air Dux number 2401T, or homemade using 35 turns of number 14 copper wire, wound ten turns per inch three inches long. Small plastic strips, similar to the commercial stock, should be cemented to the wire for support. Alternately, the coil can be wound on an insulated form.

The capacitance hat is 12 to 16 inches in diameter, using 3/16 diameter copper tubing or a close equivalent. If the outer ring is soldered to the radials, and the inner ends of the radials soldered to a metal ring clamp, the hat will be rigid and can then be clamped or even soldered to the top of the mast.

## final assembly

Because the efficiency of a vertical antenna depends greatly upon its ground system, provision will have to be made to lay out as many ground radial wires as possible. The radials can be buried in the ground a few inches, although laying them on top of the earth will be all right. With this in mind, as well as remembering that the antenna must be guyed, proceed to lay out the position of the antenna and its guy stakes.

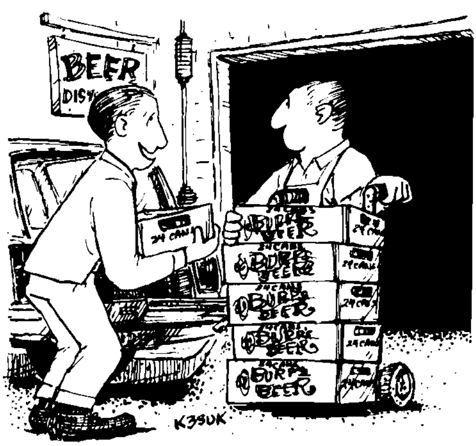
Dig the hole and set in the soil pipe. Next place the insulator, with the bottom lead washer, into the pipe. Slip the loading coil over the pipe and let it slide down onto the ground for the moment. The antenna element can now be assembled, and the guy rings installed. Because the element is very light weight, heavy nylon cord can be used for guys, and these should now be fastened to the rings. Two sets of three guys should be quite sufficient.

Before raising the mast, mark out the position of the guy stakes, and install them in a triangular pattern around the base. Ground rods a few feet long will be fine. Now the mast can be stood up, with its base near the soil pipe. When it's vertical, carefully lift it straight up and set it on top of the insulator. (Don't forget the lead washer.)

At this point I'll assume you have a friendly helper, and that he, or she, can run around and snub the guys while you hold the antenna upright. This will have to be done again later, to get the mast perfectly vertical, but at least it won't come down around your ears!

Now, slide the loading coil up the pipe and fasten its top end to the bottom of the mast. Slip a couple of small plastic strips between the coil and the pipe to hold it in place and prevent it from shorting against the metal. Connect the other end of the coil to the center conductor of the 52-ohm coaxial feedline, either RG 8/U or RG 58/U, depending upon the power you plan to run. The RG 58/U will be fine for up to a half kilowatt at least.

Bond the coax outer conductor to the junction of the ground radials, which can be made from copper or aluminum wire. Although they should be laid out radially, fanning out from the base in all directions, in practice this will probably be impossible. Follow the simple rule of "the more, the better," and lay them out in any pattern allowable. If the guy stakes are made of standard four- to six-foot ground rods, three of the radials could be also connected to these rods to give just a little bit better efficiency.




"Oh yes . . .
I'll need a quart bottle
for the base insulator . . ."

## tune-up

Tune-up is simply a matter of matching the feedline to the vertical element. Use a clip-lead and tap the feedline along the loading coil until the best match (lowest swr) is obtained. It should be possible to obtain an swr under 1.5:1 for approximately a 300-kHz section of the band. However, like all shortened antennas, the swr won't be this low across the whole band, and some provision will have to be made for retuning if you make a radical change in operating frequency, such as shifting from the low CW section to the higher part of the phone allocation.

## performance

Although the vertical antenna seems to be more useful for DX work because of its lower angle of radiation, this shortened version has good efficiency at the higher angles and has proved to be an excellent antenna for all-around work on this band. My thanks to my good friend VE1KK for passing along the design information and operational results that formed the basis for this article.

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# cw selectivity with crystal bypassing

You can improve selectivity in your ssb transceiver with this simple filter— a no-holes modification scheme

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

**If you are like most** amateurs who own commercially built equipment, chances are you skip over modification articles no matter how good the circuit improvement might be. But if the modification can be added without drastic changes, then perhaps you might be interested.

This article describes just such a circuit. By using existing controls on your ssb transceiver or receiver you can enjoy the benefit of added selectivity for cw reception. The circuit is simple and effective. All you will need are a crystal, a switching diode, and a couple of resistors and capacitors. No holes to drill, no extensive digging into the existing equipment, and no worries about defacing panels or chassis. Although primarily intended for transistor or IC stages, this selectivity circuit will work with some sets using tubes.

## adding cw selectivity

Adding a crystal filter in the i-f section of a transceiver or receiver, particularly to improve cw reception, often presents problems. The conventional approach is to break the signal connection between the i-f stages to insert the crystal filter. This requires some means of switching out the crystal filter when it's not desired. Also, unless the i-f strip has sufficient reserve gain, the insertion of the filter may cause a serious decrease in sensitivity.

The crystal bypass filter presented here was developed to overcome most of these problems. It's particularly applicable to ssb transceivers, which require better selectivity on cw than provided by the ssb filter. The ssb filter provides good skirt selectivity so all that's needed for good cw reception is a single crystal filter whose frequency is centered in the transceiver's filter passband. The crystal bypass filter and the ssb filter work in tandem.

This method won't give quite as good results as a six-pole, 400-Hz cw filter, but it will provide better cw reception under crowded band conditions than is possible by using the ssb filter alone.

The only other simpler way to provide cw selectivity would be with an outboard audio filter. The one great disadvantage of this method is that the agc can't be disabled in any present-day transceiver, so strong signals entering the ssb filter still control agc action, although the audio filter makes them inaudible.

## crystal bypassing

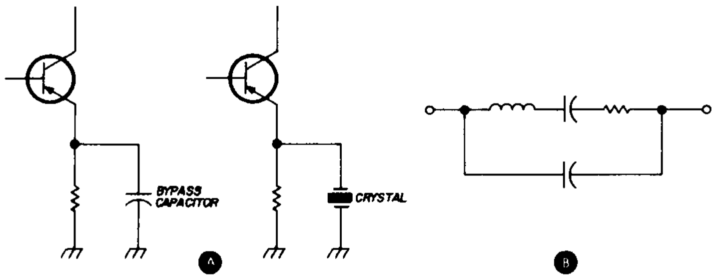
The simple idea of crystal bypassing is shown in **fig. 1A**. The emitter swamping resistor bypass capacitor provides no selectivity and, in fact, is chosen so the emitter is grounded for ac through an extremely small reactance at frequencies the stage is expected to amplify. If the swamping resistor were not bypassed, increased signal input would produce bias across the swamping resistor opposite to the forward emitter-base bias, and stage gain would decrease considerably. This degenerative effect is used sometimes to stabilize a stage, and also is the basis for many compressor circuits.

## equivalent circuit

The equivalent electrical circuit of a crystal is shown in **fig. 1B**. It has two resonance modes, one formed by the parallel LC combination (high impedance) and one formed by the series LC combination (low impedance). The two resonant frequencies are very close together. While the series-resonant condition can't be externally influenced, the parallel-resonant condition is easily affected by wiring and crystal holder capacitance.

If the emitter bypass capacitor is replaced by a crystal, the series-resonant mode of the crystal will ground the emitter for ac at only one frequency. At all other frequencies, the stage will be highly degenerative and operate at reduced gain. The degree to which the crystal grounds the emitter will determine the loss introduced by the crystal. With crystals of high Q, which have very low equivalent resistance at their series-resonant frequency, the loss is small. In fact, it's conceivable that if an i-f stage were inadequately bypassed to start with, the crystal bypass might cause the stage gain to increase at the crystal frequency. On the other hand, if i-f stage gain is independent of the bypass capacitor, the crystal bypass wouldn't provide significant selectivity.

**fig. 1. Capacitance and crystal bypassing of a common-emitter stage (A). Equivalent electrical circuit of the crystal is shown in B.**




## practical application

The bypass capacitor should first be lifted from ground to determine whether the crystal bypass method might be effective with a particular amplifier stage. The reduction in gain will indicate the broadness of the crystal response. If there is little gain reduction, signals outside the crystal passband will come through at about the same level as those in the passband. If a considerable reduction in gain occurs and the bypass capacitor is fairly large (0.1 μF or so), indicating the circuit is of low impedance, crystal bypassing will work well.

With conventional grounded-emitter transistor circuits, crystal bypassing will be most effective. However, other bypass capacitors can be tried until the most effective gain control action is found.

**Fig. 2A** shows how crystal bypassing can be added to an existing i-f amplifier. The crystal is inserted between the existing emitter bypass capacitor and ground. The capacitor should be increased to 0.1 μF if it's not this value already. An spst switch shorts out the crystal for normal operation. Although the coax cable (**fig. 2A**) should be as short as possible, it's capacitance doesn't affect the circuit greatly. Cable capacitance primarily affects the parallel resonant mode of the crystal, since the cable is shunted across the crystal.

**Fig. 2B,** a variation of the circuit in **fig. 2A,** was tried on an SB-34 transceiver. Diode switching eliminates an rf-cable run from the emitter and takes advantage of a switch position already provided on the front panel. A similar scheme should be possible with many other transceivers. Switch S1 transfers the meter from a 1-ohm shunt in the amplifier plate lead to an rf output-level circuit. The diode is connected to the switch arm that goes between ground and the plate-voltage line; thus forward bias is either applied to or removed from the diode. When forward-biased, the diode shorts the crystal for normal reception. The 1-megohm series resistor limits the diode forward current to about 500 μA.

The considerations outlined above also apply to crystal bypassing in vacuum-tube i-f stages. However, the problem here is that voltage levels are usually high enough to damage most crystals. The series capacitor between crystal and emitter in **fig. 2A** will act as a dc blocking capacitor when inserted between the i-f tube plate circuit and crystal. If the capacitor is large enough, the crystal frequency won't be affected. A value between 0.1 and 0.25 μF should be about right.

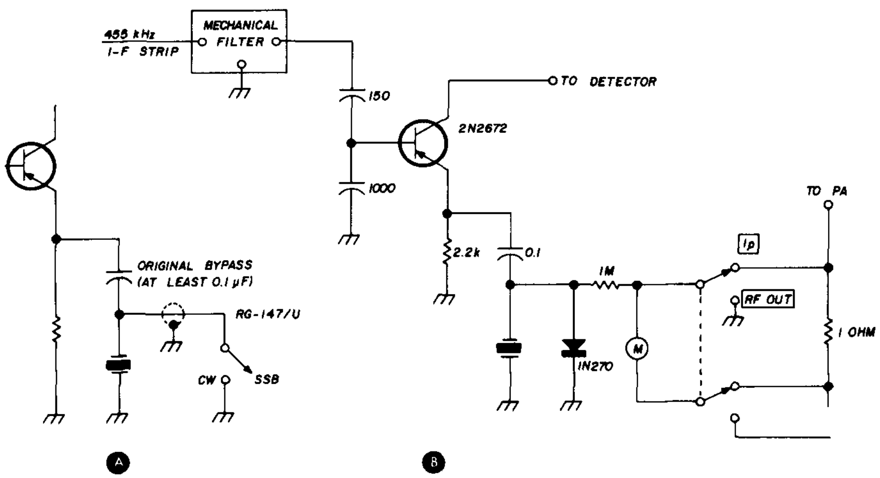



**fig. 2. Simple switch-controlled bypass circuit (A). A diode-switched crystal bypass for an SB-34 transceiver is shown in B.**

## a final word

If you would like to add better cw selectivity to your ssb equipment, by all means consider the crystal bypassing scheme presented here. The circuit won't work in all ssb gear, but you can determine this easily enough as described previously. Careful examination of the front-panel control functions on most equipment should reveal one that will perform the auxiliary job of a crystal switch. A no-holes modification can then be added to provide real cw selectivity at the expense of only a few components.

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## TOP OF THE YAESU F LINE


# THE FT DX 400 TRANSCEIVER

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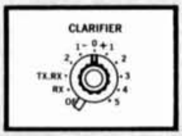
Design features include double conversion system for both transmit and receive functions resulting in, drift free operation, high sensitivity and image rejection • Switch selected metering • The FT dx 400 utilizes 18 tubes and 42 silicon semi-conductors in hybrid circuits designed to optimize the natural 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.

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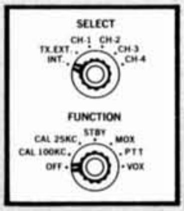


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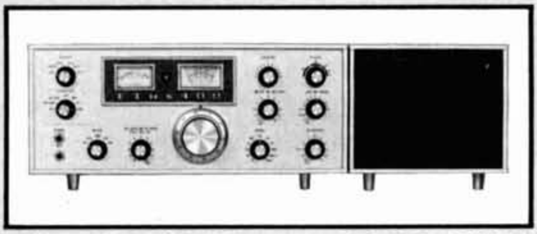

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# the homebrew art

Bill Hayward, WØPEM, 3408 Monterey Street, St. Joseph, Missouri 64507

**"The transmitter here is** homebrew; the receiver here is homebrew." Remember when you used to hear that on the air? But today all you hear is, "The rig here is a Super Sky Model 10,000 Transceiver." Everyone then knows what it is.

## What has happened to homebrewing?

First let's look and see what has happened to ham radio in the last 15 years. Single sideband, transistors, integrated circuits and the switch to transceivers have come into widespread use. But are these reasons not to homebrew? I don't think so. Now let's look at the marks against homebrewing: Takes time; can't find the parts; costs too much; doesn't look good; can't build ssb gear because I don't understand it; don't know anything about transistors. Let's take these one at a time and see how hard they really are.

### time

It takes time; truly it does take time to do most anything, but if a few hours were set aside each week for a homebrew project, you could soon have it built. The more time you allow for the project the quicker it will get done. A receiver, transmitter or transceiver will take a lot more time than an swr bridge. So remember this when you start a project, and don't expect that receiver you might be building to be working in a day or two.

### parts

This is sort of the same old thing, law of supply and demand. If you don't buy parts, the stores won't stock them. "Well then," you ask, "where can I get parts?" Allied Radio or Newark in Chicago, or Lafayette in New York, seem to have the best selection of parts. Sometimes Allied's regular catalog doesn't list some items, but their industrial catalog does. So if you build a lot it might pay to get an industrial catalog.

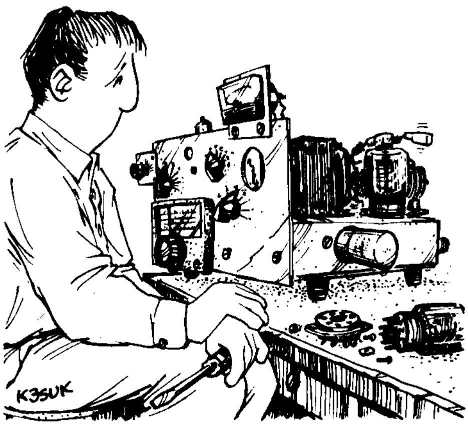
### cost

The cost factor will vary, depending upon the size of your junk box. A homebrew rig doesn't have to cost a third of what a store-bought one would. If you don't have any parts to build with, maybe a trip to the local surplus store could help you. Sometimes a horsetrading trip to a local ham could net you some parts he's going to throw out. Either new or surplus parts will work, so the cost of homebrew equipment can be what you can afford.

### appearance

A piece of homebrewed gear can look as good as you want it to. A little extra time and thought given to planning the layout, before any holes are cut, can make all the difference in the world as far as looks are concerned. Of course, the better a piece of equipment looks, the better it was laid out. So take that little extra time needed to make it look like a factory-built rig.

You can't build single sideband gear? If you've built a-m gear, you sure in the world can build ssb gear. Single sideband is much easier to build. Some will disagree




**A little extra time and thought given to planning the layout before any holes are cut can make all the difference in the world.**

with me here, but you don't have the big modulators, big power supplies, big cabinets, and big TVI problems with ssb that you do with a-m transmitters.

Single sideband transmitters use either the filter or phasing method, but the trend today is toward the filters.[1]

## transistors

You don't know anything about transistors—you can't build with them? They're easier to wire than tubes because they have only three leads whereas a tube may have up to seven. The transistor requires no filaments so it operates cooler than a tube.

How can you find out about transistors? You might try some of the books on the market today. A good one is "Basic Theory and Application of Transistors;" it is TM-11-690 and costs only $1.25 from the Government Printing Office in Washington, D.C. It will give you a good basic understanding of transistors. Or you might try one of the new self-instruction programmed books on transistors. Maybe you could even take a course from one of the electronics schools in transistor theory. The ham who says he doesn't know about transistors doesn't **want** to learn about them.

## design

You ask, "Where do I come up with a design?" I do R and C—Read and Copy. I start first with a list of things I want in a transmitter, then start looking through old magazines to see if I can find something close to what I want. Maybe I find one thing in one magazine; something else in another. I then combine the two into what I want.

Now that you have down on paper what you're going to build, you start looking through the junk box for parts, or maybe even make a trip to a friend's junk box. You find out then you don't have to order as many parts as you thought you would.

## heat up the soldering iron

Then comes the big day when you start drilling holes. Make sure your layout is correct, because you are only building one transmitter, not four or five, and you can't afford to make mistakes.

Now that the holes are all drilled, you start mounting parts; then comes the wiring. Take your time here, because it'll pay off in the long run. If you get tired after wiring for a while, set the work aside for a day or two, then go back to it. But be sure and **keep notes.** They will come in handy when you go back to wiring.

**Usually I find one thing in one magazine, something else in another.**

## the final check

It will take time and patience to get the equipment in proper working order. But the extra time spent on tuning up and alignment will make for a better-sounding transmitter. The final-final test, of course, will be the on-the-air reports.

The next time you're on the air, and someone wants to know what that good-sounding rig is, you can say with pride, "the rig here is homebrewed."

If you're thinking about buying a new receiver, transmitter, or transceiver, why not think of the homebrew route? Not only will you be saving money, but you can learn what goes on behind that panel. And, after all, isn't that what amateur radio really is?

### reference

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**ham radio**

# propagation predictions for june

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

**Perhaps you've judged from** some of my past columns that I believe that there's much more to amateur radio than just communicating. This month's column is written for those amateurs who have a spark of the oldtime spirit of exploration of the unknown that brought amateur radio to its position of eminence. Let us revel a bit in these past glories.

The history of radio is replete with examples of contributions by amateur experimenters to science. In the beginning, there was Guglielmo Marconi. Although his later experiments were financed, and he was never a licensed amateur, his experiments were truly in the spirit and tradition of amateur radio.*

Marconi's transatlantic tests took place on wavelengths of 1000 to 2000 meters in 1901, in spite of the belief by most eminent scientists of the day that wireless communication was limited to the horizon. Kennelly and Heaviside independently postulated the existence of electrically conducting reflecting layers in 1902 to explain Marconi's results, and Balfour Stewart had predicted their existence more than 20 years previously to explain variations in the earth's magnetic field. However, the existence of these layers was not verified by experiments until 1925.

In the meantime many physicists were attempting to explain long distance propagation as being due to diffraction so they felt that the longer waves were the most useful. The Radio Act of 1912 restricted radio amateur operation to those "useless" wavelengths below 200 meters.

One of the earliest cooperative radio amateur scientific studies was the ARRL Bureau of Standards fading tests held on 250 meters in 1920. In 1921 and 1922 the ARRL sponsored successful transatlantic tests on 200 meters and in 1923, two-way transatlantic communications took place with Leon Deloy, 8AB, in France on 100 meters. The race to the short waves was on, and the science of ionospheric physics was born.

In the 1930's, correlations of the effects of meteorological conditions on vhf were made by Marconi in the Mediterranean and later by Ross Hull of the ARRL using radio amateur observations. Also, amateur reports of long-distance 5-meter contacts led J. A. Pierce, W1JFO, of Harvard University, to establish the cause as sporadic-E. Pierce also correctly identified meteors as being the cause of transcient hf propagation bursts inside the skip zone.

In the late 1940's, **CQ** magazine sponsored Radio Amateur Scientific Observations to map the motion of sporadic-E clouds using amateur 50 MHz observations.[2,3,4,5] Radio amateurs also contributed to science by reports of vhf reflections from the aurora.[6,7] Dr. O. G. Villard, Jr., W6QYT, at Stanford University introduced the radio amateur to such postwar developments as backscatter sounding,[8] meteor scatter communication,[9] artificial sporadic-E layers[10] and widespread use of single sideband.

Perhaps one of the greatest postwar amateur discoveries was that of trans-

* If you haven't read George Jacob's articles on Marconi[1] or the other excellent historical articles on "Men In Radio" in CQ magazine, you should. Also highly recommended are ARRL's historical articles, "Fifty Years of ARRL," which appeared in *QST* in 1964 and Clinton B. DeSoto's "200 Meters and Down."

equatorial propagation of vhf signals at night during years of high solar activity.[11] The National Bureau of Standards requested amateur observations of their South American 50 MHz beacon transmissions during the International Geophysical Year (IGY),[12] and the ARRL-IGY-PRP (International Geophysical Year Propagation Research Project)[13,14,15] brought together amateur observations of anomalous vhf ionospheric propagation from all over the world.

In 1957, J. Chambers, W6NLZ, and R. Thomas, KH6UK, demonstrated that 144-MHz tropospheric vhf contacts could be made over water as far as 2540 miles and in succeeding years repeated the feat on 220 MHz and 432 MHz (one-way). In 1959 and 1960, R. Mellen, W1IJD, and C. Milner, W1FVY, demonstrated that 50-MHz signals could be propagated for distances as great as 2500 miles from Ice Island T3 through the auroral zone to the northern contiguous United States.[16,17]

More recently, other than the OSCAR tests, amateur contributions to the state-of-the-art have left something to be desired. You may argue that, "These days true contributions to the state-of-the-art are made by large groups of well-financed researchers in government and industry; these days radio amateurs are at least ten years behind and many tens of dB's below the state of the art."

Perhaps you stand too much in awe of big technology. Sure, interesting discoveries **are** being made with facilities well beyond the capabilities of amateur radio. However, in over ten years of radio-propagation research I have been surprised by how much can be done by the properly motivated and educated "little guy."

Some of us just take up space on the bands; some of us **do** communicate; some of us do perform public service. A few of us may, once or twice in our lives, make a small contribution to science, or even an MSB (Major Scientific Breakthrough). At times most of us observe various geophysical phenomena—through frosted-over glasses. All that stands between just observing and actually contributing to science are perception, imagination, perseverance, and some skill, tempered with knowledge. For example, thousands of amateurs probably observed noise from outer space before Carl Jansky and Grote Reber, (W9GFZ),[18,19,20] but Jansky and Reber had the necessary combination of mental ingredients and technology to make the discovery of cosmic noise in the 1920's, and eventually to carry the observations through to start the science of radio astronomy.

Lately, I had the occasion to talk with a scientist of note who shall remain unnamed, and I asked him about using amateur observations of some upcoming ionospheric chemical releases. His reaction was negative, not for security reasons, but because he felt that the useful amount of information gained would be more than balanced out by the job of sorting through misinformation. One major factor for this was the lack of satisfactory prelaunch communications to amateurs on previous tests of this sort.

Would you believe it? If not, listen in to some W1AW broadcasts or Project OSCAR broadcasts. Soon you too will come to the conclusion that we are a long way from having a reliable 24-hour-a-day amateur radio communications system. And that is, unfortunately, the nature of the radio amateur service.

## long delay echoes

There are still some scientists that have not lost faith in radio amateur observations. Dr. O. G. Villard, Jr., W6QYT, has recently enlisted the aid of the Northern and Southern California DX clubs in collecting reports of long delay echoes which may have been observed by radio amateurs in the hf bands. He is particularly interested in signals that last for two seconds or more, and is not interested in the frequently encountered round-the-world echo.

In 1928, C. Störmer in Norway heard echos with delays of 3 to 5 seconds on transmissions from a station at Eindhoven, Netherlands on 30 meters operated by fellow ionospheric scientist B. Van der Pol. He telegraphed Van der Pol, who listened and heard the echoes himself. Störmer thought the echoes were due to reflections from solar ionized particle streams, while Van der Pol thought them due to great group retardation in the ionosphere.[21,22] Other scientists had other theories; E. V. Appleton thought the echoes may have originated from the signal circulating the earth repeatedly,[23] P. O. Pederson thought they may have been due to trapping of electrons along geomagnetic field lines,[24] and N. Janco thought they may have been due to trapping between ionospheric E and F layers.[25]

During the 1929 solar eclipse A. E. Kennelly observed echoes with delays between 1 and 30 seconds on 25 meters.[26] Since 1934, reports of long delay echoes have been infrequent and have come only from radio amateurs. One systematic attempt to study the echoes was made in 1947 at Cambridge University in England, but it was unsuccessful.[27] For this reason, and the unsatisfactory possible explanations of this effect, most scientists today are inclined to discount the observations as imaginary.

However, the situation has changed within the past two years. Laboratory experiments with plasmas by Dr. F. W. Crawford at Stanford have indicated that microwave signals may be stored in a plasma and retrieved after an appreciable time delay. If the laboratory results could be extrapolated to the ionosphere, the delays would be tens of seconds and thus there is an awakened interest in long delay echoes.

Dr. Villard would like to hear from radio amateurs who have heard echoes of this sort on their or other station's signals with as much of the particulars as can be remembered. Tape recordings of such an effect are most welcome. The desired information includes call signs, addresses, date and time, frequency, modulation type, transmitter power output, antenna type, gain, direction of fire and height above ground, and estimated duration of echo and characteristics of same, such as Doppler shifts, fading, strength or multiple echoes. In addition Dr. Villard would be interested in knowing your occupation and the year you obtained your first license. Reports should be sent to:

Dr. O. G. Villard, Jr.
Radioscience Laboratory
Stanford University
Stanford, California 94305

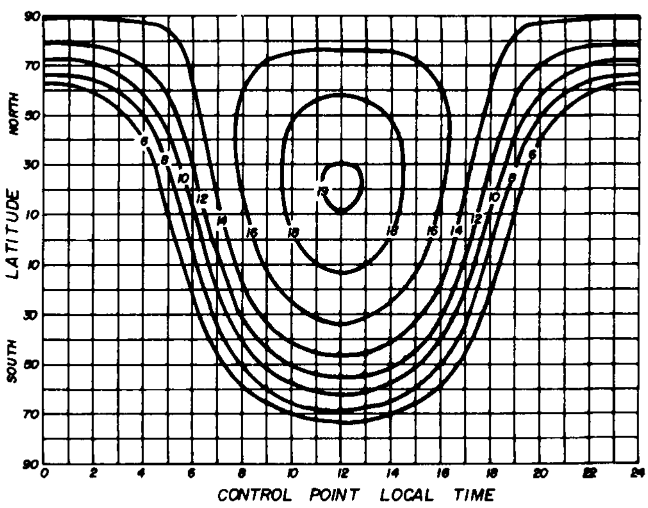
## sporadic-E

I am interested in obtaining reports of 144-MHz sporadic-E and reports of 50-MHz sporadic-E under 400 miles at times when 144 MHz was open for sporadic-E last summer. I am also interested in reports of 50-MHz multiple-hop sporadic-E over distances greater than 2800 miles.

## six-meter propagation during february and march

On February 2nd from 2215 to 2300Z, six meters was reported open for F2-layer backscatter between Northern and Southern California, Arizona and Kansas. WB6NTL in Sacramento reportedly worked a KP4 near 2230Z. On February 14th, ZB2BC, Gibraltar, reportedly heard ZE1AZG (beacon

**fig. 1. Time chart of median E-layer for June 1969 predicted for the regular daytime E-layer.**



station at Port Victoria, Rhodesia on 50.050) near local noon.

Solar activity increased drastically during the last week of the month. From February 20 to 27 the daily sunspot number was in excess of 200 and as high as 300, up substantially from earlier weeks. An active region on the sun near 12 degrees N. Latitude produced several solar flares of importance on February 24th at 2300Z, on February 25th at 0900Z, on February 26th at 0421Z, and on February 27th at 1358Z. Severe ionospheric disturbances followed the flares of the 25th and 27th.

Ionospheric physicists have found that the particles emitted from the sun during a solar flare are confined to streams and that the probability of the earth intercepting the stream from any given flare is small. Once a stream has bridged the gap from sun to earth, however, it forms a well conducting track through which subsequent flares may more easily shoot particles. This appears to have been the case during the period of February 27 through March 2, 1969.

On February 27th, W5RCT near Dallas, Texas reports working XE1AAN and hearing ZK1AA's beacon on 50.100 between 0135 and 0315Z, peaking as high as 40 dB over the noise at 0200Z and fading down into the noise between 0232 and 0259Z. March 1st was the beginning of the transequatorial season for CE3QG at Santiago, Chile when he worked into Colorado, Texas, New Mexico

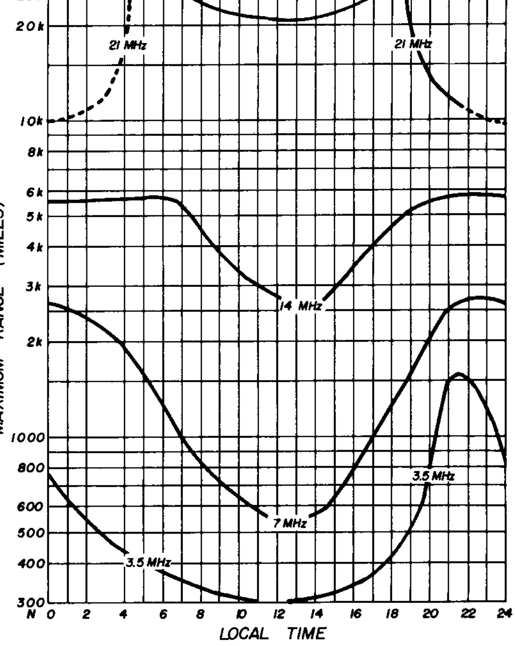
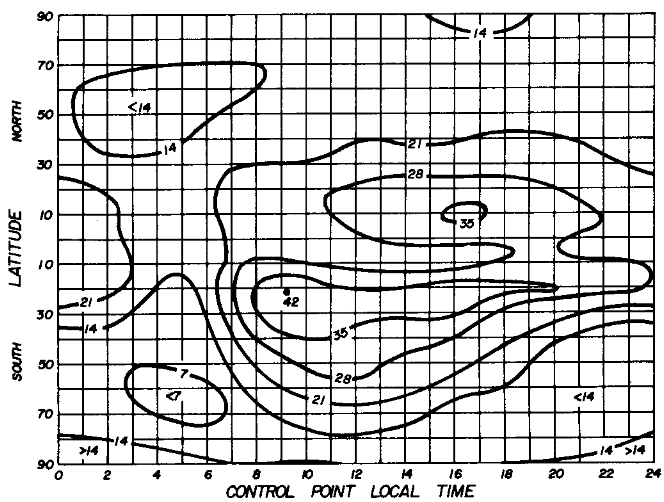



**fig. 3. Maximum range to the north from 38° N. latitude as limited by absorption, atmospheric noise and system parameters (100 watts CW to typical antennas).**

and Arizona. Sporadic-E was also present between these states and California. In addition, some fuzzy-sounding signals from locals were heard out of the northeast that resembled aurora. Most of this was between 0400 and 0600Z on March 2.

On the afternoon of March 8, there was a 50-MHz F2 opening between California and Hawaii for three hours with KH6EQF reported, "very loud." Backscatter was also reported between Northern and Southern California.

**fig. 2. Time chart of median F2 muf for June 1969 from ITS predictions centered on a longitude of 90° W.**



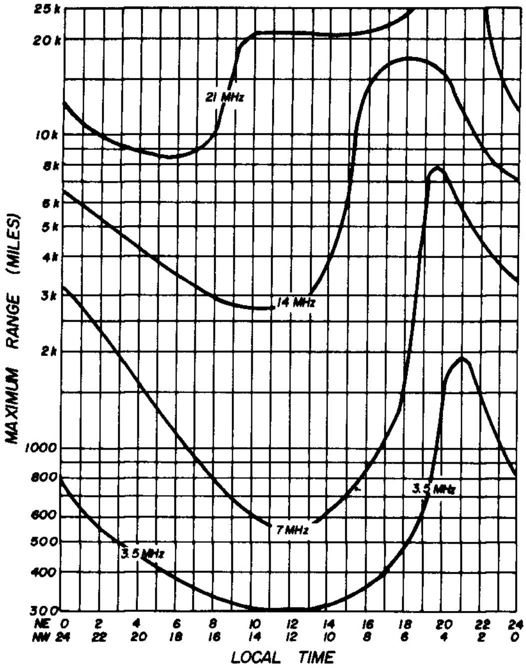



fig. 4. Maximum range to the northeast (top time scale) and to the northwest (bottom time scale) from 38° N. latitude.

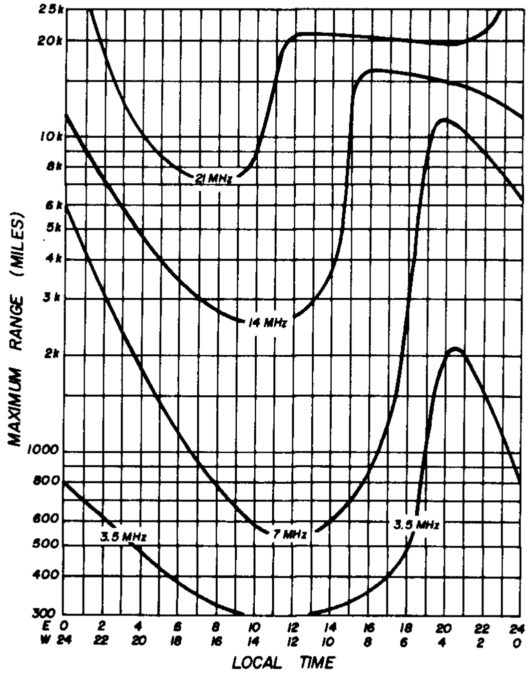



fig. 5. Maximum range to the east (top time scale) and to the west (bottom time scale) from 38° N. latitude.

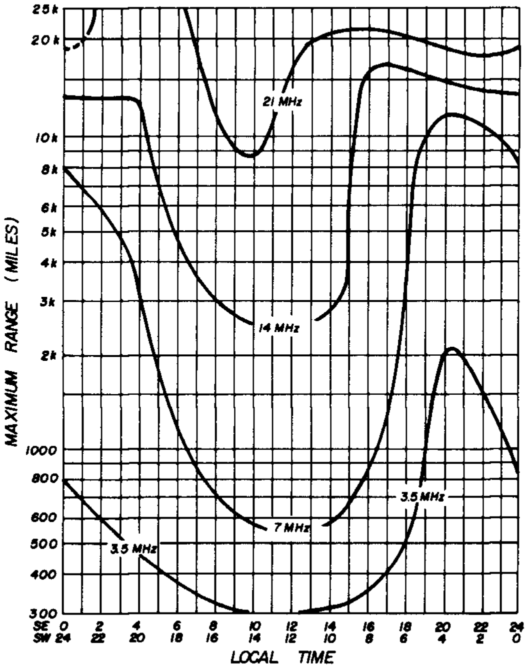



fig. 6. Maximum range to the southeast (top time scale) and to the southwest (bottom time scale) from 38° N. latitude.

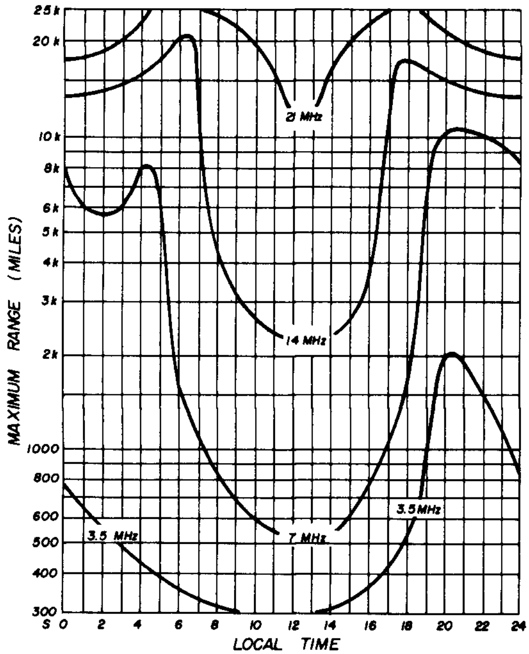



fig. 7. Maximum range to the south from 38° N. latitude.

## 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, find your control point and read the frequency from the F2-layer muf time chart. Your F2-layer control point is 1200 mies away from your station in the direction of propagation; this is about an 18-degree difference in latitude for a north-south path, or 1½ hours time difference for an east-west path.**

**2. To determine the path muf for a path under 2500 miles, the control point is at the path midpoint, and a correction factor is applied to the 2500 mile muf. These correction factors are plotted in fig. 7 of the August 1968 column.**

**3. During summer daytime, the path muf for a path shorter than 1200 miles may be set by E-layer propagation. To determine if this is so, refer to the E-layer muf time chart and the chart of muf reduction factor vs distance in this month's column. Note, however, that sporadic-E will probably result in zero skip distance on 7 MHz and skip distances under 400 miles on 14 MHz very frequently during daylight *and evening hours.***

**4. The F2-layer will probably be effectively shielded by the E-layer for operating frequencies below 70 percent of the predicted E-layer muf.**

**5. Over any particular path involving more than one hop, the path muf is the lower of yours and the other station's control-point muf. The muf time charts may be treated as muf contour maps. (The F2-layer chart has significant errors outside the range of longitudes between 45°W. and 135°W.) As such, each hour is the equivalent of 15° of longitude. A map drawn to the same scale can be overlayed and positioned to the right or left to show the variation of the muf contour map with time. Curved lines may be drawn on the overlay representing great circle paths, as found from a globe or "Ionospheric Radio Propagation," printed by the U. S. Government Printing Office.**

**6. 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.* Also *note* that this month the noise curves have not been assumed to be symmetrical about local noon. Thus when the curves are used to predict propagation to the west they may be in error due to this lack of symmetry. These curves are based on a unity signal-to-noise ratio of a 6-kHz bandwidth with 100 watts output and antenna gains (over an isotrope) of 6 dB for 20 and 15 meters, 0 dB for 40 meters, and −6 dB for 80 meters at each station.**

## propagation for june

Summertime conditions described in last month's column will be with us for several more months. In short, this means more noise on 80 and 40 meters and 20 meters at night, and more absorption on the same bands during the daytime. The inability to do much DX'ing on these bands near midday will be due as much to shielding of the F2-layer by the E-layer as due to absorption.

It takes a lot of E-layer hops to cover more than transcontinental distances at respectful elevation angles, and each hop gets absorbed more than a longer F2-layer hop. As a result best DX will be during twilight and darkness hours.

Although 15 meters is primarily a daytime band it may remain open well towards local midnight. Some mornings the MUF may not quite reach 21 MHz, or all you may be able to work is South Americans. You should be able to work polar paths that do not reach latitudes higher than 60 degrees north latitude for a fair fraction of the days of the month. Don't look for much F2-layer propagation between the East and West Coasts on 28 MHz during the month. There will be double-hop and sporadic-E occasionally, and regular openings to the Southern Hemisphere, however.

June is the big month for sporadic-E on 50 MHz (and perhaps on 144 MHz). In addition, there are daylight meteor showers scheduled for June 4th-6th (Perdeids), June 8th (Arietids) and June 30th-July 2nd (Taurids), and the nightime showers, Scorpids (June 2-17) and Pons Winnecke (June 27-30). Judging by the connection shown between sporadic-E and meteor ionization in last month's column, these dates might bear watching for widespread sporadic-E as well.

The F2-layer muf time chart was derived from "Ionospheric Predictions" for a longitude of 90° W. These predictions are published monthly by the Institute of Telecommunications Sciences (ITS), Boulder, Colorado, and are 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 will be noted due to change in absorption and change in noise levels throughout the 48 contiguous United States. Somewhat greater ranges should be expected over paths further from the sub-solar point (more northerly latitudes during daylight).

The predictions given in this column are for median conditions. On any particular day, muf's may be as much as 10 percent 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.

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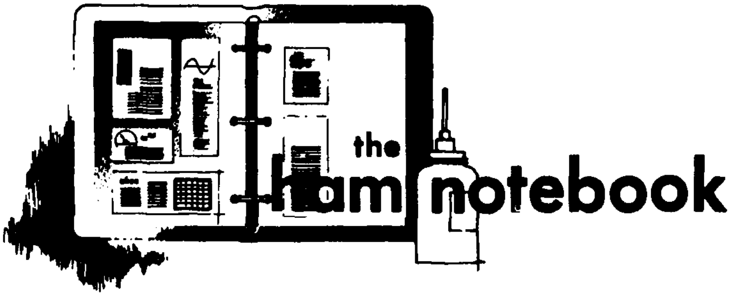
Many of the references concerning radio amateur work in radio science prior to the Second World War have not been cited because they are not generally available and because the historical summaries in more recent issues of *QST* and *CQ* adequately cover this early period.

**ham radio**




# tone encoder and secondary frequency oscillator

**While working on various RTTY** and fm selective-call projects, the need for an accurate stabile tone source became apparent. The device shown here is presently programmed for eight frequencies, provides a good sinewave output and is quite stable over a wide range of temperature, voltage and loading. The oscillator has been duplicated by a number of amateurs and used as a digital selective-call encoder on many of the West Coast repeaters. Its reliability and stability have been proven under all types of field conditions. Further, the unit can be easily modified to provide tone-burst operation.

It should be obvious that to obtain frequency accuracy closer than 1%, a frequency counter must be used. However, close to 1% accuracy can be expected for the frequencies listed with combinations of good quality Mylar capacitors.

For burst use, return the negative common to the push-to-talk line instead of ground; add a zener regulator for power or use a dry battery. Connect the two diodes and the RC network as shown in the box in **fig. 1.** For mobile operation, be sure **not** to ground or

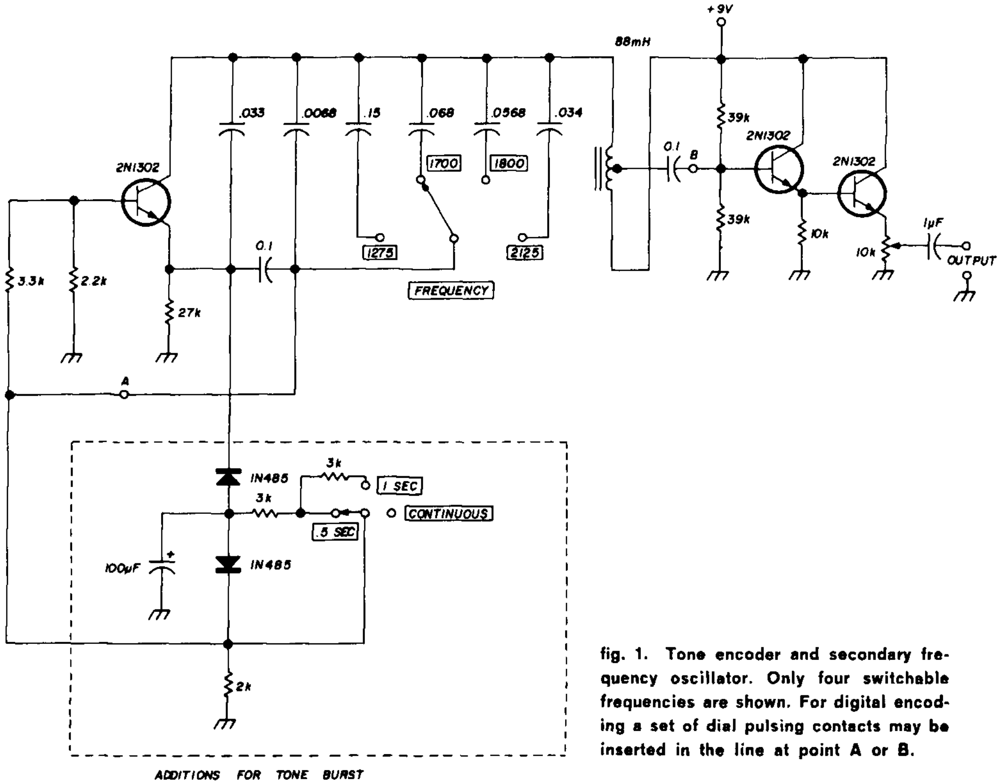



**fig. 1. Tone encoder and secondary frequency oscillator. Only four switchable frequencies are shown. For digital encoding a set of dial pulsing contacts may be inserted in the line at point A or B.**

**table 1. Frequencies and tuning capacitors used in the tone encoder built by WB6YQC.**

| Channel | Design Frequency (Hz) | Measured Frequency (Hz) | Capacitance (μF) | Use |
|---|---|---|---|---|
| 1 | 1275 | 1271.5 | 0.150 | RTTY space frequency* |
| 2 | 1700 | 1699.6 | 0.068 | RTTY mid-band* |
| 3 | 1800 | 1803.0 | 0.0568 | selective-call tone |
| 4 | 2125 | 2125.8 | 0.0340 | RTTY mark frequency* |
| 5 | 2400 | 2401.4 | 0.0181 | selective-call tone |
| 6 | 2550 | 2551.4 | 0.0106 | RTTY mid-band |
| 7 | 2700 | 2704.1 | 0.0071 | selective-call tone |
| 8 | 2975 | 2973.3 | 0.0001 | RTTY space frequency |

*wide shift fsk/ssb transmitter.

common **anything** except through the audio return line to the transceiver.

Digital encoding can be easily obtained by inserting a set of dial pulsing contacts in series with the 3.3k oscillator base-bias resister, or in series with the 0.1 μF oscillator output coupling capacitor. The unloaded output voltage is in excess of 2 V rms above 1700 Hz. With a 100-ohm load, the output drops to 300 mV rms, still enough to provide full deviation in most fm rigs.

The frequencies I used are shown in **table 1** but other tones can be easily substituted for your particular requirements. Printed circuit boards for the basic oscillator circuit are available from the treasurer of the Grizzly Peak VHF Radio Club, Post Office Box 1333, Richmond, California 94802 for $1.50 each. I would like to extend my thanks to WA6UFW who did the initial design work with the basic oscillator.

**David M. Stahley, K8AUH**

## grounding

If you're plagued by excessive receiver noise, a hot microphone, or rf around the shack, better check your ground connection. If your house was built after about 1960, you may be lacking a simple metal-to-metal connection if you depend upon a cold water pipe for a ground. Most builders have been using various forms of polyvinyl pipe to bring water in to a given location in the house where it is connected to standard metal fittings. The contractor saves a pile of money with this approach but you haven't got a ground; play it safe and use a good ground rod.

**Elliott Kanter, W9KXJ**

## incremental tuning for the heath HW-100

The addition of incremental tuning to a ssb transceiver is an ideal and often needed refinement. It allows the receiver to be shifted a few kHz above or below the transmitting frequency. This helps when someone has trouble zero-beating your frequency or when you're in a roundtable where someone is inevitably off frequency. It can eliminate the embarrassing problem of tuning for the off-frequency station and then suddenly finding yourself equally off zero beat. It is especially handy where there may be a highpitched voice—you can tune for personal listening comfort without affecting your own transmit frequency.

In the receive position, with the incremental tuning switch on, varying the dc bias on the varicap diode causes the capacitance to change within the range of the incremental tuning control. With the transceiver in the tune position (or transmitting), the antenna changeover relay (through contacts 3, 7 and 11) disconnects the manual tuning voltage and inserts a calibrate voltage in its place. This sets the capacitance of the varicap at the center frequency position of the incremental tuning control. A shift of 2 kHz either side of center can be obtained with the values shown in the schematic.

The bias voltage is derived from the +150 V regulated supply. The voltage is dropped to +12 V and regulated by the 47k, 1-watt resistor and a 1N963B zener diode; this keeps the voltage steady on both transmit and receive. The photo shows how the components may be mounted in an already well packed area.

The calibrate pot is mounted just to the side of the final tank cage in an existing 5/16-inch hole. (This hole will have to be enlarged to 3/8-inch to accommodate most pots.) Mount a 2-lug terminal strip (Cinch-Jones 52) on the underside of the chassis near the pot. A 47k, 1-watt resistor is placed between pin 1 of the OA2 (V18) to the closest tie point with the zener diode going from the same tie point to ground. The incremental tuning pot on the front panel is mounted to the right of the meter at the same height as the tuning controls to maintain a neat panel layout. You can get an extra knob from Heath to match the original equipment (part number 462-191 $.70). A sub-miniature spdt switch is mounted above the pot. Decal numbers may be added to indicate 1- and 2-kHz deviations from the center.

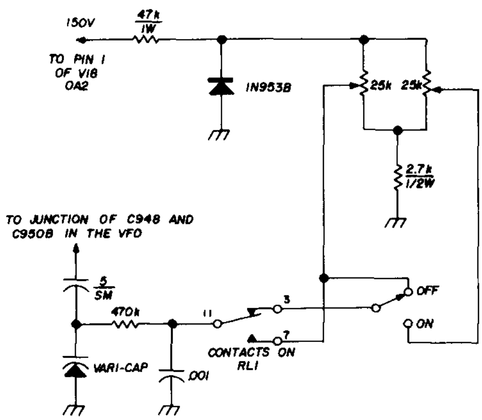
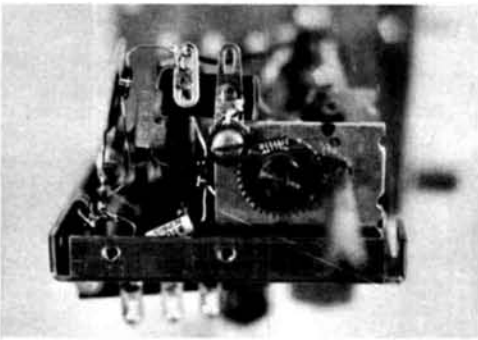



**fig. 2. Receiver incremental tuning for the HW-100. The two 25k pots should have linear tapers.**

A five-conductor color coded cable can be made up to wire between the chassis and the front panel controls. This cable can be passed through an existing 1/4-inch hole in the i-f circuit board.

Mount a one-terminal Cinch-Jones 51A terminal strip to the left of the backlash gear on the vfo capacitor; straighten the ground lug. Mount the varicap from the ungrounded lug to ground and mount the 5-pF mica capacitor from the same ungrounded lug to the junction of C948 and C950B.

Mount a two-terminal Cinch-Jones 52A terminal strip just in back of the vfo capacitor on the stud holding the vfo coil. Mount the 470k, ½-watt resistor between ungrounded terminals, by-passing one end of the resistor with a .001 disc ceramic to ground and connecting a wire between the other end of the resistor and the terminal strip mounted on the vfo. Leave enough slack in the rigid wire to clear the rotor. Connect a wire to the bypassed end of the 470k resistor and pass it through a hole in the top of the vfo chassis to a Cinch-Jones 53 terminal strip mounted on top.



**Varicap installation.**

To calibrate the two pots for the same receive and transmit frequency, set the front panel pot (number 1) to its center position. Set the number 2 pot (mounted near the final tank cage) to its approximate center. With the incremental tuning switch turned on, set the mode switch to CW and tune the vfo dial to zero beat the crystal calibrator. Put the incremental tuning switch in the off position and adjust the number-2 pot to zero beat without touching the vfo dial. With this calibration completed you should receive and transmit on the same frequency. Some minor correction in dial accuracy will have to be made to allow for slight added capacitance, but it is minor.

**Bill McCracken, K1GUU**

# new products

## two-meter fm transceiver

Two-meter fm is becoming very popular in many areas, and new two-meter fm repeaters are popping up all over the country. A new entry in the fm transceiver market is the FDFM-2S manufactured by the Inoue Communications Equipment Corporation. The FDFM-2S is completely solid state and built around modular computer techniques so it's rugged and has good interstage shielding. The unit features three sets of transmit/receive frequencies that are selectable from the front panel; power supply is 12 to 24.5 Vdc so it's a natural for mobile operation.

The receiver is dual conversion with a fet rf amplifier and adjustable squelch; sensitivity is less than 1 $\mu$V for 20 dB signal-plus-noise-to-noise ratio, and spurious responses are 60 dB down. The transmitter section runs 10 watts input (5 watts out), has frequency deviation less than 25 kHz and built-in push-to-talk. The FDFM-2S comes complete with microphone, battery pack, six crystals of your choice, mobile mounting bracket, power connectors and manual; $295.95. Also available are the 2-watt FDFM-2 two-meter fm transceiver and 2-watt FDAM-3 six-meter a-m/fm transceiver with vfo. For more information write to Varitronics Incorporated, 4109 North 39th Street, Phoenix, Arizona 85018.

## new galaxy transceiver

Galaxy Electronics has announced a completely new transceiver, the GT-550, and a complete line of matching accessories. The GT-550 is a five-band ssb and CW transceiver that features 550 watts input on ssb (360 watts input on CW). Optional accessories include an ac power supply, mobile power supply, phone patch, cw filter, vox, crystal calibrator and mobile mounting bracket. The new Galaxy line of matching equipment includes the LA linear amplifier, rf console, remote vfo and speaker console. Price of the basic GT-550 transceiver is $449. For an illustrated brochure with full specifications on the complete Galaxy line, write to Galaxy Electronics, 10 South 34th Street, Council Bluffs, Iowa 51501.

## new arrl handbook really revised

If you're one of the thousands who found out about the 1968 ARRL Handbook too late (It was sold out by August; they usually expect to have copies left in February), you'll be happy to hear that the 1969 edition is now available. Last year's **Radio Amateur's Handbook** was extensively revised by Doug DeMaw, W1CER, to incorporate modern solid-state circuits and practices. Its success proves both the need for revision and its satisfaction. The new 1969 edition is even better. Apparently, as is necessary in such a comprehensive work, the theory is being revised a few chapters at a time, while practical construction projects are changed more easily.

The big news is that in addition to the excellent basic chapter on semiconductors, other chapters incorporate semiconductor circuits (along with vacuum-tube circuits). The receiving chapter includes bipolar, fet and IC detectors, mixers, oscillators, rf and i-f amplifiers, Q multipliers and other circuits. Specific construction projects are included. The transmitting chapter has not been revised as extensively—yet—but a number of practical transistor transmitters and vfo's will interest you. The audio section now includes many solid-state circuits, and the code chapter an IC keyer.

The chapter on power supplies incorporates the information required to design reliable high-voltage power supplies with silicon diodes, and a number of low-voltage supplies are included for transistor gear. The vhf receiving chapter is outstanding. It reflects the latest amateur practice: fet's, bipolar transistors, even IC's. There's not a project using vacuum tubes in it! The simple 6- and 2-meter converters are excellent successors to the nuvistor converters that were the mainstays of vhf hams for many years, and the preamp for 23 cm should satisfy the real experimenter.

The vhf-transmitting chapter includes a clean-looking practical varactor tripler for 70 cm, and, it should be noted, efficient vacuum tube amplifiers for 70 and 23 cm. (I don't know of any transistors good for 500 W at 432 MHz!)

The section on portable and mobile gear is full of simple solid-state gear that should interest any ham: transceivers for 6 and 2, and a transmitter and converter for 160 m. Other chapters also include semiconductor gear. This discussion of the solid-state content of the handbook is simply intended to emphasize the extensive revisions Doug has made to incorporate modern practice.

The book also covers much other new material, plus the invaluable data that has always made the ARRL handbook a necessity in every ham shack. Now, moreover, it appears that a new handbook every three or four years isn't enough. The 1969 edition is a new book; even if you have a '68 copy, you'll want it. $4 from the American Radio Relay League, 225 Main Street, Newington, Connecticut 06111, or try your local distributor.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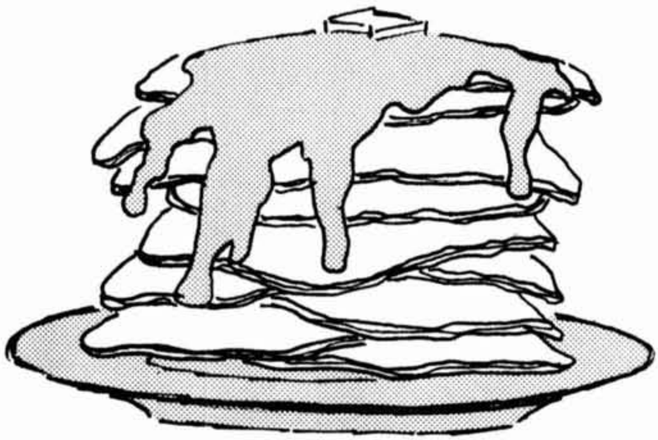

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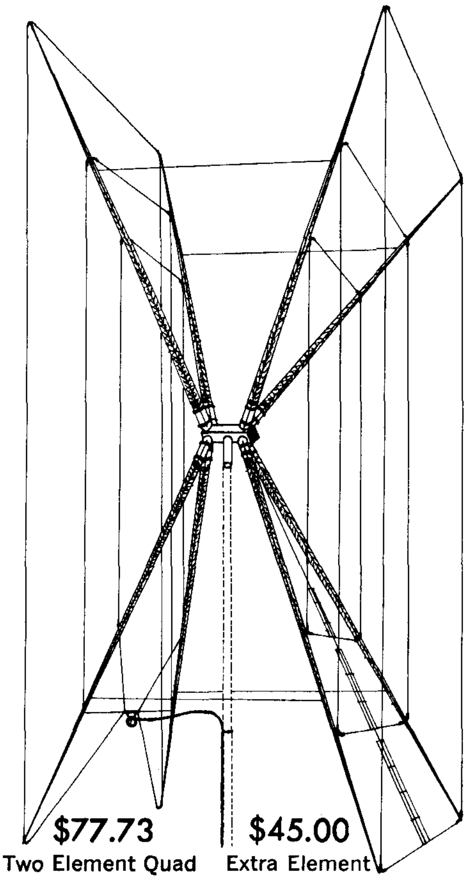

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**FOR SALE: HT-37** 100 watts, HT-41 1000 watts both $375.00 and Heath SB 300 rcvr. $175.00. M. Rexsen, W2FEI, 493 Oxford Rd., Cedarhurst, N. Y. 11516, tel. 516 295-5411.

**THE AUGUSTA (MAINE) AMATEUR RADIO CLUB** will hold their 10th Annual Hamfest at the Calumet Club in Augusta, Maine on Route 104 on 15 June, preceded with an open house and get together on Saturday evening the 14th at the same location. Preregistration adults $4.25, Children under 12 $3.25. At the door $5.00.

**THE SIXTH ANNUAL PENN-CENTRAL HAMFEST** by the West Branch and Milton groups will be held Sunday, June 8, starting 12:00 noon, at the Union Township Volunteer Firemen Grounds, on Route 15, Winfield, Pa. Informal, picnic style, no speeches, no banquet, snack bar handy or bring your own lunch, come and go as you please. Auction, contests, swapping, gabfest. Free parking, both indoor and outdoor facilities provided. Harmonics and XYL's invited too. $2.00 registration at the gate, XYL and children free. Exhibits welcome. For information contact: Milo H. Frey, K3MSG, Quarry Road, Muncy, Pa. 17756.

**THE PALMETTO AMATEUR RADIO CLUB** announces its Second Annual Hamfest to be held indoors at the State Fair Grounds, Columbia, South Carolina, on June 1, 1969. A Dutch supper is in the planning for the night before. The Hamfest will feature prizes, swapping, a transmitter building contest, home brew contest, antique radio display, FM and MARS Forums, and bingo for the XYLS. More information may be obtained from C. W. Moorer, K4FNT, 227 Castle Drive, West Columbia, South Carolina 29169.

**MANUALS** — TS-323/UR, TS-173/UR, TS-186D/UP, BC-638A, R-274/FRR, $5.00 each. Many others. SASE brings reply. Sam Consalvo, 4905 Roanne Drive, Washington, DC 20021.

**HAVE KNIGHT T150 TRANSMITTER** for sale. Also Lafayette receiver KT-320. R. B. Grubb, 40 Woodland Avenue, New Cumberland, Pa. 17070.

**39th — ARRL WEST GULF** Division Convention August 15, 16 & 17, Amarillo, Texas. For an ideal summertime weekend of ideas, fellowship, entertainment, fun (and maybe good luck) you can't miss at $10.50 for registration. W5WX Panhandle Amateur Radio Club, Box 5453, Amarillo, Texas 79107.

**CUSTOM QSL CARDS.** Send for free samples. Enclose 10¢ for postage/handling. RO-HO Enterprises, 2817C 190th Street, Redondo Beach, California 90278.

**KWM-1, 516-F2 AC** supply noise blanker. Looks and works like a new piece of gear, $350.00. RME 126 tunable converter, $125.00. Seneca UHF I, 2 and 6 meter transmitter, $125.00. Manuals for all included. Peter Unchur W2URM, RFD 5, Amsterdam, NY 12010.

**WRL'S USED GEAR** has trial-terms-guarantee! KWM1 — $299.95; Swan 240 — $179.95; TR3 — $399.95; SB34 — $319.95; Galaxy V — $229.95; Galaxy VmK2 — $279.95; HX50 — $199.95; Invader 200 — $249.95; Galaxy 2000 plus linear $329.95; Ameco R5 — $59.95; HR20 — $79.95. Hundreds more. Free "blue-book". WRL, Box 919, Council Bluffs, Iowa 51501.

**SOMERSET COUNTY HAMFEST** — June 8, Casebeer Church Grove, Route 219, 7 miles north of Somerset, Pa. (9 a.m.-5 p.m.) Write Theodore J. Leonberger, K3RCI, Rd. 2, Rockwood, Pa. 15557.

**DRAKE T4X-B/R4B.** Mint condition. Factory cartons and manuals, $650.00. H. Woerner, 2256 Mission Lane, Bellbrook, Ohio 45305.

**LANCASTER HAMFEST** — sponsored by Lancaster & Fairfield County ARC at Derby Downs, one mile south of Lancaster, Ohio, on BIS Road, Route 793, June 8th. Gigantic Swap Shop. $1.00 registration with gifts every half hour. Main gift drawing. Good food at reasonable prices. Write P. O. Box 3, Lancaster, Ohio 43130.

**7500 PIV DIODES** 500MA Mfgrs. spec sheet included. $4.95 Postpaid. Registered check or M. O. K1AGB, 92 Grove, Plainville, Mass. 02762.

**FOR SALE:** 75S3-C #11877, $595. 75S3-B #16895, $475. 75S3-B #15066, 0.5 & 2.1 kcs, $550. 75S3 #10679, $400. KWM-2 #12566, (latest series), 516F-2, $850. 32S-1 #11023, 516F-2, $450. 312B-4, cables, $135. KWM-1, 516F-1, $250. Noise Blanker (75S-1), $50. Noise Blanker (KWM-2), $75. 351D-2 mount, $75. SR-400, HA-20, P-500-AC, P-500-DC, MR-500, all near-new, $895. HT-32-A, $275. HT-32-B, $375. 4CX1-1000-A, (new), $100. Eldico SSB-1000-F, spare (new) 4CX-300's, $250. Henry 2K-2 (spare 3-400-Z, $575. Amplifier (4-1000-A) with Heath KS-1 p. s., $200. James W. Craig, W1FBG, 29 Sherburne Avenue, Portsmouth, N. H. 03801. Phone: 603-436-9062.

**ELECTRONIC INVENTORS!** Your inventions professionally prepared for the patent office. Send name and address for sealed information. DRC, 215-28 Spencer Ave., Queens Village, N. Y. 11427.

**BERMUDA AMATEUR RADIO CONTEST** — Sponsored by the Radio Society of Bermuda. Phone: 0001 GMT June 22nd to 0200 GMT June 23rd. C.W. 0001 GMT July 20th to 0200 GMT July 21st. Following amateur bands: 3.5, 7, 14, 21 & 28MhZ. Single operator stations only. U. S. and Canadian stations will give RS or RST report. VP9 stations will give RS or RST report plus Parish. (A station in Hamilton Parish would give 59 Hamilton or 599 Ham.) Any number of transmitters and receivers will be allowed and competitors may use the maximum power permitted. Awards: A free ticket to Bermuda and return plus one week at the Carlton Beach Hotel for the winner and a friend of his or her choice. (Note: There will be two winners, one for each section.) For complete details write Box 73, Devonshire, Bermuda.

**FOR SALE:** UTC, LS-185 Plate Transformer. Multi-tapped 110/220 primary. Tapped secondary for DC voltages. 3.5 KV to 1 KV from filter at 1.2 Amps., CCS. Weight 230 pounds. Price $350.00 UTC, LS-691, Modulation transformer for CL. "B" 250TH's, 833A's etc. Tapped output range 4.5K to 2K ohms load. Oil filled. Weight 350 pounds. Delivers 1,000 watts distortionless audio under CCS rating. Price $300.00. UTC, LS-103 Modulation Reactor. Companion unit for LS-691. Price $50.00. UTC, LS-49 Driver transformer. Various tubes to 838, 805, etc. grids. Matches 805's to CL. "B" 250TH or 833A grids. Weight 15 pounds. Price $30.00. UTC, LS-6 Driver transformer. Various tube to 805, 845, etc., grids. Weight 7.5 pounds. Price $25.00. UTC, LS-10 Line to grid transformer. Weight 3 pounds. Price $17.50. UTC, CG-512 Line to CL. "B" 250TH, 450TH, etc., grids. Price $15.00. All units perfect. Will be boxed and shipped with freight and insurance paid by buyer. George W. Smith, Jr., W5HIP/W5DPS, Route 1 - Box 137 Pottsboro, Texas 75076.

**3-D OFFICIAL MOON MAP** 53" x 48" in color $2.25 for radio shacks, dens and offices. H. Morgan, 883-C Diana, Akron, Ohio 44307.

**FILTER CONDENSERS**: Aerovox Oil Filled 100 mfd. @ 3000vdc Condensers. $30.00 each. Basil J. Weaver, 1821-C Avenue M, Lubbock, Texas 79401.

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This system was made by Canadian Tire to sell for $35.00. These are Brand New fully wired surplus, not rejects. The extra high voltage coil provides smoother running at high speeds and longer plug life, and the lower current through the points makes for longer point life and faster winter starts. Special connector allows instant change over to conventional ignition. Fully Guaranteed, with instructions ready to install for 6 or 12 volt negative ground car. CLOSE OUT SPECIAL DTI .................. $10.00 p.p.

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**DIGITAL COUNTER — TO 1 MILLION**

These count on a pulse of electricity. Used, but in like new condition. Originally designed to count number of copies made on an office copier. New cost was $30.00. Yours for 10% of that cost. Use it to count anything you want. Keep track of number of people coming into a store — number of copies made or parts made, number of turns on coils of transformers, unlimited possibilities. Made by Durant. 6Y, 115 V AC, 60 cycles, 7 watts. Speed 1000 CPM, Figures 9/64" wide x 3/16" high. Black on white background. Size 1 3/8" x 2 9/10" x 3 3/4". DDC-300 ....... $3.00 p.p.

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**DELAY LINE**

This delay line gives up to 1.0 useconds delay in 10 increments of 0.1 microseconds. The characteristic impedance is 300 ohms input and output. This impedance is excellent for twisted pairs, and is a very useful variable compensation for "race" in I.C. logic. On handy plug-in card. DL-200 ............. $1.50 p.p.

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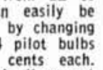
**BRAND NEW DIGITAL READOUTS**



These Digital Readouts are selling for $44. new, and our competitors are selling USED ones from $16. to $22. today. These are BRAND NEW Surplus. Use these readouts anywhere you want numerical displays such as Digital Clocks, counters, all kinds of applications. The 1/2" wide x 1" high numericals are projected on the front plastic screen which is lighted from behind by 12 # 1820 bulbs. The contrast is so good they are easily read even in a brightly lighted room. Operation is from 12 to 28 volts. This Readout can easily be converted to 6 volt operation by changing the # 1820 bulbs to # 44 pilot bulbs at a nominal cost of ten cents each. The lamp housing has a quick disconnect feature for instant replacement of any burned bulb. 12 message positions. Two formats are available. One format has the numerals 0 to 7 plus the symbols +, −, Tp and Tx. The other format has numerals 0 to 9, plus symbols + and −. The format could be changed to read PM, for example, by using a little ingenuity and reworking the screen which is readily accessible. Panel mounts on two 6/32 tapped holes. O/A 2 1/2" high x 1 1/2" wide x 5 3/8" deep. Manufactured by Industrial Electronic Engineers.

DR 0 — 9 $9.50 p.p.
DR 0 — 7 $6.50 p.p.

**SOLID STATE BARGAINS**
**$1.25 EACH P.P.**

Any 5 items for $5.00 P.P. Diodes (RUE) 1 amp 800V 6 for $1.25 — Silicon trigger diode (AVAL SW) 3 for $1.25* — Bi-switch 7 amp AC control 3 for $1.25* — Terminal boards 4" x 5" with 75 terminals each side (RUE) 3 for $1.25 — Silicon diodes in heat sink 25 amp 200V $1.25 — Xformer input 120V 60 Hz out 6.3V 1 amp $1.25 — 750 watts AC phase control solid state parts & instructions $1.25 — Plug in socket & PC board 4.5" x 6" $1.25 — Zener diodes 1N429 3 for $1.25 — Zener diodes 10 volt (RUE) 4 for $1.25. *When both of these are purchased instructions for making AC phase control are supplied. RUE — removed from new equipment.

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**KOILED KORDS**

Cord extends from 11" to 54". The heavy stranded conductors of these cords makes them ideal as microphone or telephone cords. Eliminate those tangled cords that fray and wear out in a short time. Spade terminal and strain relief on one end as shown. KK 2 for $1.00 p.p.

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**1000 MFD-TANTALUM CAPACITOR**

Buy a brand new high capacitance Tantalum capacitor for less than the price of an equivalent aluminum foil unit. You gain the advantages of small size, high reliability, infinite life, and high temperature operation. Don't let the Electrolytic Capacitor be the largest size and least reliable component in the next home project or replacement. Regular net price of these units is $72.00. Brand new Tantalum Capacitors:

1000 Mfd @ 50
VDC-TC1000 ............ $2.25 p.p.
400 Mfd @ 75
VDC-TC 400 ............ $1.75 p.p.

---

**GEIGER COUNTER - GOV'T SURPLUS**

"CD" Type Radiation Survey Detectors are in like new condition, with instruction manual, and straps. Picture shows typical unit. Bright yellow plastic case, waterproofed. Meter readings may be made from 0.01r/hr to 50r/hr. Units are clean and are offered untested as is at a low price of $10.00 less batteries, battery price about $1.50. With life of 400 hrs. or intermittent operation. CD MD. No. 710 GC 710 ...... $10.00 p.p.

**POOR MAN'S HI-FI HEADPHONES**

The Canadian Air Force has surplus also and we were fortunate to obtain over 500 headsets from them and are passing the savings on to you. They are unused and in the original cartons. The headphone elements are actually miniature speakers, as pictured, and this is the way Hi-Fi phones are constructed. Will give excellent fidelity with either voice or music. They have rubber pads with chamois-type covering, metal headband, cord and plug. 4 to 16 ohm impedance for use with any radio or TV, etc., by attaching to the speaker leads. May be converted to "stereo" by making connections at each ear phone. This is a real bargain for quality RCAF head sets. RCAF HP ............ $3.00 p.p.

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**NOISE CANCELLING MICROPHONE**

Late government issue MX51UR noise cancelling bandwidth limited carbon microphone. Originally used on boom in front of pilots helmet. This microphone is excellent for use where communications must be maintained even at high ambient noise levels. Included is a schematic showing proper way to bias microphone in transistor circuits. Also included is two transistor amplifier circuit. Capable of driving speakers. Brand new and in original packaging recent manufacture. At the astounding low price of 2 for $1.00. NCM .......... $2.50 pp.

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**750 WATT, SPEED MOTOR CONTROL — LIGHT DIMMER KIT**

This easily constructed project can be used as a light dimmer or to control the speed of AC/DC tools up to 7 amps. We furnish the 7 amp Bi-switch, trigger diode, variable pot, ferrite core and wire for the transformer, capacitors, resistors and instructions. You supply the housing. ACPC-1000 ... $2.50 p.p.

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**COMPUTER GRADE CAPACITORS**

Due to a special buy of only one size, we can offer this capacitor at an unbelievable low price of 3 for $1.50. This is a convenient size for power supply filters. Low ESR & leakage currents. Long life. Plastic insulating tube withstands military environment conditions. The regular list price of these is over $3.00. 400CGC-400 .......... $1.50 plus $1.00 Postage and handling.

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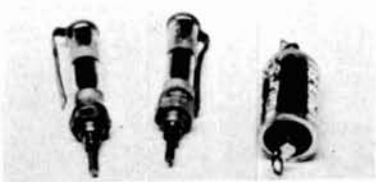
## CRYSTAL ELIMINATOR

Brand new, made for PolyTronics CB rig. Permits tuning the entire CB band without crystals. Good deal for conversion to other CB rigs. Built-in DB meter, NuVista circuit. With diagram. .......... **$5.50**

## FERRITE CORES

Experimenters package, various sizes. Used in transistor VFO, transistor power supply xfmr core, RF suppression, toroidal tank coil, etc.

**5 sizes only $1.00 the package**



## RF FILTER

From HAWK MISSILE termination contract. Good for 5 amps, 600 volt, 10 cycles to 500 mc, insertion loss 60 DB-plus, low pass pi-network type, excellent as feed-thru filter in converters, transmitters. Hermetically sealed inside are 2 toroidal chokes and 4 low induct. caps. #41102 .......... **$1.00 each, 6 for $5.00**

## PISTON CAPS

Corning glass, direct traverse type, min. Q at max. C—500 at 50MC. 500 volt breakdown. Capacitance range 1-8 uufd. Brand new military surplus ..... **3 for $1.00 or $3.00 per doz.**

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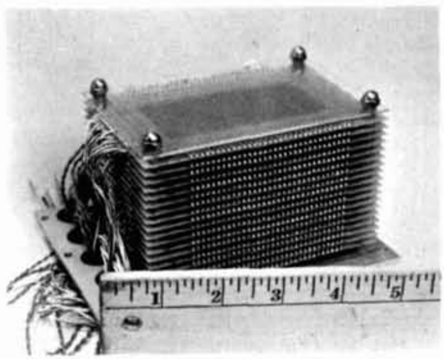
**Customer pays all shipping**
New catalog #69 now ready
Send 25¢ handling & postage charge.


## $10 TRANSISTOR IGNITION $10

Complete electronic 2 transistor dual ignition system for cars, boats, trucks. Fully wired harness, dual primary coil, instant changeover from transistor to conventional or back. Neg. ground, 6 or 12 volt system. Complete with instructions, ready to install. Original price $35, now only $10.00 ppd.



## MEMORY CORE PLANES

Ultra compact memory core stack. Complete, perfect condition. Stack of 18 planes wired, each plane 2040 cores (32x64). Only 2 stacks available. .......... $100 each

## INTEGRATED CIRCUITS FAIRCHILD

711 Dual Comp. Amp., 2.00 ea, 12/20.00
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Diff. Amp. 12M2 . . 1.00 ea, 12/10.00
#7M6 flat pak, w/schematic, 6NPN transistors in package, . . . . 3/1.00

**1.00 each or $10.00 dozen**

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| Dual Input Gate | 2-903 |
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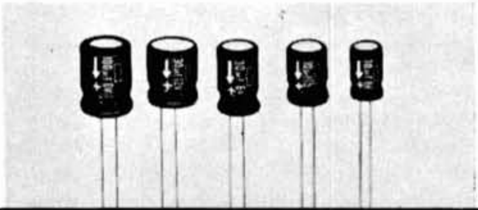
Clocked flip flop . . 1.00 ea, 12/10.00

## DECIMAL COUNTER


Electronic indicating decade, vacuum tube type, 4 tubes. Displays 0-9 counting input pulses. One unit may be used to drive another. Removed from equipment, w/tubes, w/ schematic. **$8.00 each, 2/$15.00, 10/$60.00**



## TRANSISTOR CAPS

| Volts | Mfd | Each | 12 |
|---|---|---|---|
| 25 | 1 | $ .10 | $ 1.00 |
| 15 | 5 | .10 | 1.00 |
| 15 | 10 | .12 | 1.20 |
| 15 | 500 | .20 | 2.00 |
| 12 | 15 | .12 | 1.20 |
| 12 | 150 | .15 | 1.50 |
| 8 | 300 | .20 | 2.00 |
| 6 | 10 | .09 | .90 |
| 6 | 30 | .10 | 1.00 |
| 6 | 50 | .12 | 1.20 |
| 6 | 200 | .15 | 1.50 |

Your choice of the above as listed . . . or . . . grab-bag our choice, **10 different $1.10**

## CB CRYSTALS

The following CB crystals offered at 50¢ each, you pick 'em. Or, we will give a grab bag of **6 different (no choice) $1.50**

TRANSMIT: 1-2-3-4-5-6-7-8-9-10-11-12-13-14-17
RECEIVE: 6-7-9-11-13-15-17-18-19

## 3400 VOLT CT XFMR 800 WATTS

Brute of a transformer, Arnold core. 115 volt 60 cycle input, output of 3400 VCT.

**$10.00 each; 6 for $50.00**

## IBM WIRED MEMORY FRAMES.

Removed from high priced computors. Exlnt condition.

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| **4,000 Wired Core Plane** | **$ 9.00** |
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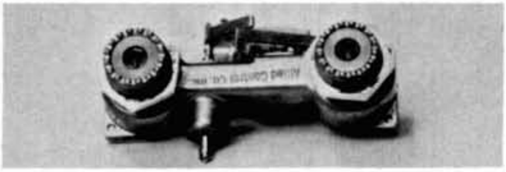
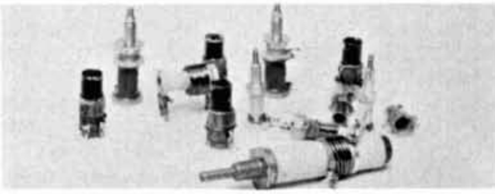


## COAX SWITCH

Unused coaxial switch, 12 volt coil, standard UHF fittings. Made by Allied Control. ........ **$5.00**


## LOW PASS FILTER

Brand new, w/UHF fittings, good for 100 watts, up to 30mc. 52 or 72 ohm line, attenuation min of 60 db from 35 mc thru FM & TV bands. ........ **$4.00**



## SLUG TUNED COILS

For PC board and one hole mount. Grab bag of 8 various types, ceramic, lucite, some with windings (easily removed to replace with your own). A good $5.00 value for only ........ **8 for $1.00**
........ **50 for $5.00**

## HRO COILS

Used, good cond. Look like HRO 50 or 60. The following available A-B-C-D-E-F-HJ AD.
........ **each $10.00**

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| 753 w/751 AC | $139.00 |
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| RV-1 | $49.00 |
| **GONSET** | |
| G-63 | $89.00 |
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| G-76 and AC | $99.00 |
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| HT-37 | $179.00 |
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| SX-73 | $249.00 |
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| SB-110Aw/HP-23 | $319.00 |
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| HE-45w/HE-61 VFO | $59.00 |
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| NC-300w/Ameco CB-6 Converter | $79.00 |
| NCX-5w/NCX-A | $395.00 |
| NC-270 | $95.00 |
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