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Communications Specialists TE-64 Tone Encoder

Heath HM-2141 VHF Wattmeter

Kenwood TL-922 Linear Amplifier

Conducted By Paul K. Pagel,* N1FB

Kenwood TL-922A Linear Amplifier

In compliance with the FCC 10-meter amplifier ban, Kenwood has introduced the TL-922A, a 1-kW cw, 2-kW PEP ssb, linear amplifier. The power supply is included in the 68 lb (31 kg) heavyweight package, and can be wired for a 240- or 120-volt ac input. Naturally, unless a very "stiff" 120-V service is available (that can supply 28 A peak!), connecting the '922A to 240 volts is recommended. The amplifier uses a pair of Eimac 3-500Z zero-bias triodes in the ubiquitous parallel, grounded-grid configuration. Band-switched pi-network input circuits are employed.

Fig. 1 — An interior view of the Kenwood TL-922A linear amplifier. In the power-supply compartment on the left, the massive high-voltage transformer is visible at the rear. A second transformer, which supplies filament, relay and lamp voltages, is located under the circuit board at the front.

Cooling

An efficient system for cooling much of the circuitry (including the power supply) has been provided by the designers. Kenwood states that the amplifier will withstand a continuous key-down input of 1 kW for 10 minutes. They're right; the amplifier remained cool and unflustered throughout a 10-minute key-down test. The plates of the 3-500Z tubes hardly showed any color! In the remote event that the temperature of the high-voltage transformer rises to an unsafe value (145°C, according to Kenwood), a thermistor embedded in the transformer windings will disable the T/R relay and lock the amplifier in the standby mode. Kenwood has taken yet another measure to assure thorough cooling: When the amplifier is turned off, the fan remains on for about two minutes, then shuts off automatically. A note of caution: No screen is provided at the air outlet to prevent errant fingers from becoming entangled in the plastic fan blades. A metal rf shield is installed on the *inside* at the rear of the fan, however.

Operating and Aesthetic Considerations

The '922A is a very attractive and ruggedly built piece of equipment. The cabinet is finished in Kenwood gray, and the two side panels are heavy die castings. A metal handle is provided on each side panel, which makes it somewhat easier to move this large unit from workbench to operating table.

All the controls have a good "feel"; the plate-tuning control has a vernier drive for tuning ease. The T-R relay is rather large and seemed noisier than other linear-amplifier relays I have heard. The enclosure for the 240/120-V selection terminal block and the fan protrudes from the rear panel somewhat. Since all the connectors and terminals are below this protuberance, they were blocked from sight in my crowded station set up. I had to make all the connections to the unit by touch.

Getting the TL-922A on 10 Meters

Outside the United States, this amplifier is known as the TL-922 (no *A* suffix), and covers the 160- through 10-meter bands. In the USA the *A* suffix means that 10-meter coverage has been deleted. Fortunately for the amateur who wants to wear his "shoes" on 10 meters too, the '922A can be restored to six-band coverage.

Kenwood engineers have cleverly "absorbed" the unneeded 10-meter input coil into the 15-meter input network. This simplifies the conversion considerably.

To begin the modification, the 10-meter coil and five capacitors are removed from the 15-meter network, and a single 120-pF, 500-V capacitor is added to complete the new 15-meter network. See Fig. 2. The newly freed 10-meter coil is now wired to the 10-meter band-switch position, and another 120-pF, 500-V capacitor is added to complete the 10-meter input network. A setscrew is removed from behind the band-switch knob to allow the switch to rotate into the 10-meter position. Last, a jumper is installed on the band switch, which allows the pi network to resonate on 10 meters. The '922A is now a 160-10 meter amplifier; it lacks only front-panel 10-meter labels for the band switch and TUNE control.

Loose Ends

The '922A has double protection against accidental contact with the high-voltage supply. Removing the upper case cover disconnects power from the primary of the high-voltage transformer. Removing an inside shield plate to gain access to the rf compartment shorts the high-voltage supply bus to ground.

An adjustable negative-going alc output is provided which, when connected to a compatible exciter (all Kenwood exciters are compatible), can prevent overdriving the amplifier. To test the usefulness of the alc output, a Kenwood TS-120S transceiver was borrowed for use with the amplifier. When carefully adjusted, the alc limited the drive from the exciter to the level just required for a 1-kW dc input. It was then no longer necessary to worry about

*Assistant Technical Editor, *QST*

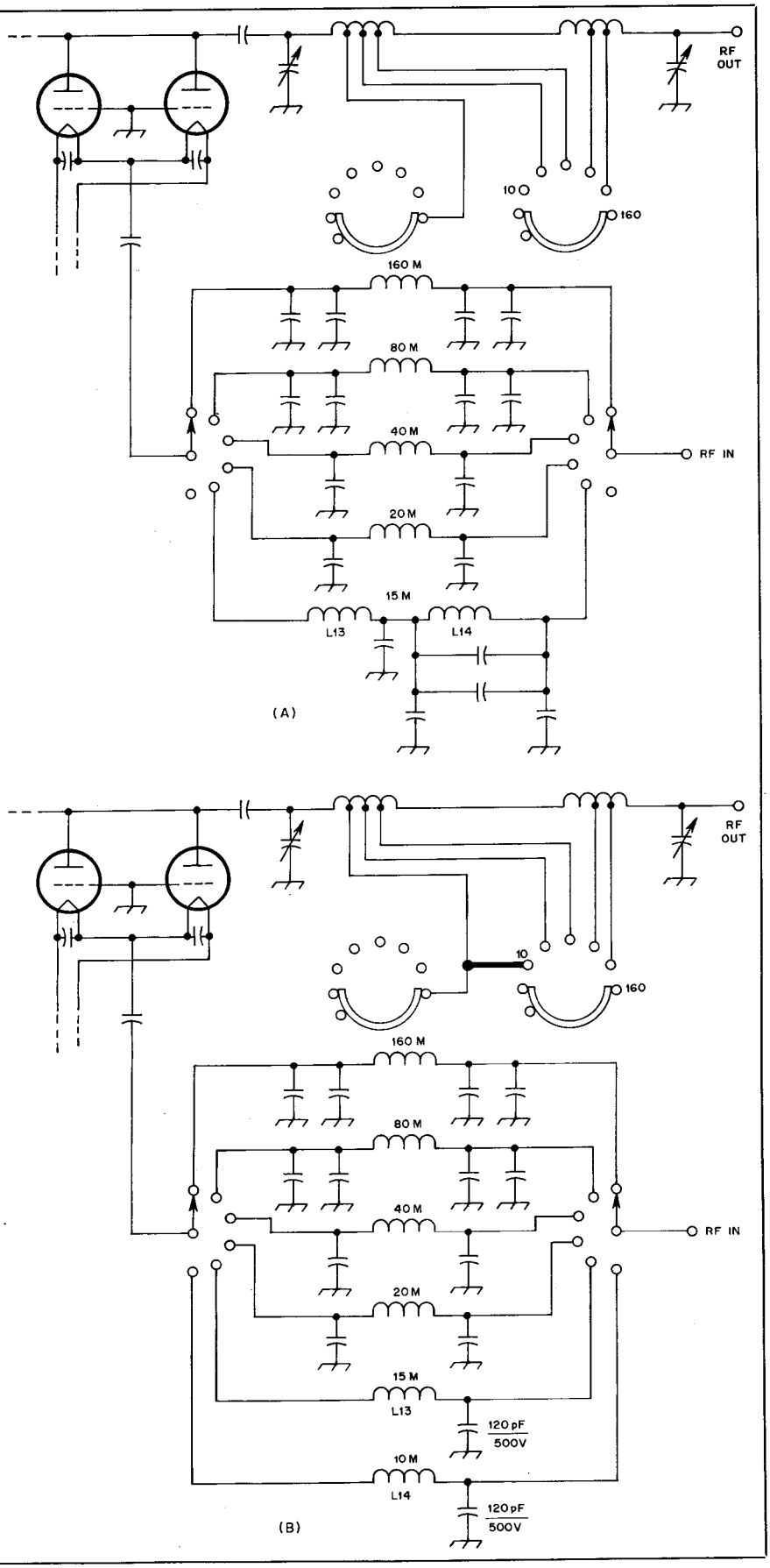

Fig. 2 — A simplified partial schematic diagram of the TL-922 amplifier band-switching arrangements. The original circuit is shown in A. The changes, to convert the '922A to a six-band amplifier, shown in B, are the addition of a jumper wire (the heavy line) in the output pi network, and modifications to the 15- and 10-meter input circuits. Part numbers shown are those assigned by Kenwood.

Kenwood TL-922A Linear Amplifier

Manufacturer's Claimed Specifications

Size (HWD): 7-1/2 × 15-3/8 × 16 inches (190 × 390 × 407 mm).
Power requirements: 120 V, 28 A; 240 V, 14 A; 50/60 Hz.
Input impedance: 50 ohms unbalanced at better than 1.5:1 SWR.*
Driving power required: 80 W nominal, 120 W maximum.*
Duty cycle: Ssb, continuous for 30 minutes. Cw and RTTY, key-down continuous for 10 minutes.
Frequency range: The 1.8- through 21-MHz amateur bands.
Price class: $1200.
Manufacturer: Trio-Kenwood Communications Inc., 1111 West Walnut, Compton, CA 90220.
*See Table 1 for results of ARRL lab measurements.

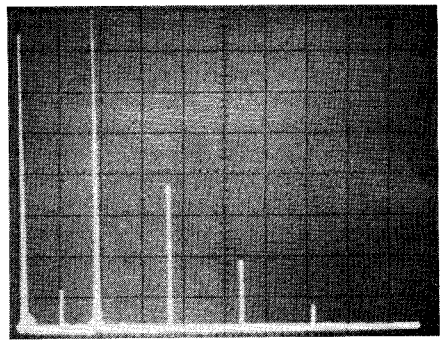

Fig. 3 — This photograph shows the spectral output of the TL-922A operating at a 1-kW dc input on 80 meters, which presented the worst case for spectral purity. The horizontal scale is 2 MHz per division and the vertical is 10 dB per division. The second harmonic is down about 43 dB, meeting FCC requirements.

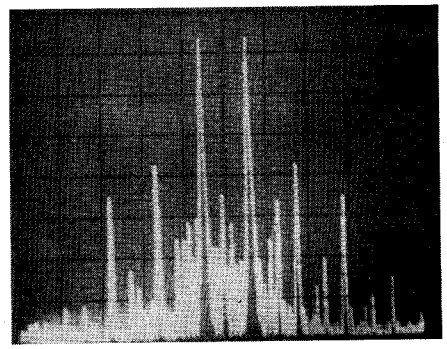

Fig. 4 — A two-tone IMD photograph of the TL-922A operating on 20 meters. The horizontal scale is 1 kHz per division and the vertical scale is 10 dB per division. Third-order products are down 37 dB; fifth-order products are down 45 dB from the PEP level.

exceeding the legal limit, or overdriving the amplifier. Unfortunately, the system gain varied slightly from band to band, so a perfect setting on one band was never optimum on another.

Speaking of loose ends, while the '922A certainly is excellent evidence that "they can still build 'em like they used to," they don't necessarily solder 'em like they used to. When the amplifier was opened for installation of the

Table 1

Results of TL-922A Tests Performed in the ARRL Laboratory

Band	Power Input (watts)	Power Output (watts)	Efficiency (%)	Drive Power Required (watts)	Input SWR
160	1000	680	68	84	1.49:1
160	2000	1300	65	100+	
80	1000	750	75	110	1.63:1
80	2000	1490	75	100+	
40	1000	780	78	86	1.20:1
40	2000	1550	78	100+	
20	1000	720	72	73	1.58:1
20	2000	1480	74	100+	
15	1000	630	63	66	1.23:1
15	2000	1540	77	100+	
10	1000	680	68	73	1.37:1
10	2000	1500	75	100+	

power tubes (they come packed in a separate carton), an unsoldered wire on the "meter unit" circuit board was noticed. The wire was neatly wrapped around its terminal, but was completely untouched by solder!

One evening while using the amplifier on 80-meter cw, an rf arc occurred somewhere in the final-amplifier compartment. It persisted for a few seconds, and then burned itself out. After removing the covers and poking around a bit, I discovered the cause of the undesired electrical activity: A metal strap connected to a pi-network coil tap had arced through its insulation to the chassis. Of course, I repositioned the strap to prevent further problems, but in so doing, I disturbed the coaxial cable which connects the pi-network output to the T-R relay. The center conductor had apparently been only tacked to the pi-network output, because it broke loose with only the slightest prodding. I'm glad I discovered this before any serious damage was done!

Despite the irregularities just mentioned, my overall impression of this amplifier is quite favorable. Its operation was smooth, predictable and stable. This, coupled with the relatively inexpensive cost of replacement tubes, makes it a very desirable station accessory. — *John C. Pelham, W1JA*

HEATH HM-2141 VHF WATTMETER

☐ This station accessory measures rf power in the frequency range of 50 to 175 MHz, which makes it useful on the 6- and 2-meter amateur bands. In normal operation, the left-hand meter indicates reflected power in two selectable ranges: 0 to 10 and 0 to 100 watts. The right-hand meter reads forward power in the ranges of 0 to 30 and 0 to 300 watts. Owners of efficient kilowatt amplifiers will no doubt be disappointed that a higher power range isn't included. Another mode of operation may be selected in which the '2141 will calculate the SWR: The right-hand meter indicates forward power and the left-hand meter reads reflected power on a scale calibrated from 1:1 to 3:1.

This versatile instrument can also measure peak-envelope power on ssb or a-m (or cw, for that matter). A peak-detecting and holding circuit using a quad op-amp IC is employed. This circuit is powered by a 9-volt transistor-radio battery. The battery is used only when the PEP-AVG switch is in the PEP position, so one must remember to return the switch to the AVG position when the wattmeter is not in use. If the SWR sensitivity control is rotated fully counterclockwise to an unmarked calibrate position, and the PEP-AVG switch is in the PEP position, the battery voltage may be checked on the right-hand meter. Alternatively, an ac adapter to take the place of the battery may be purchased from Heath.

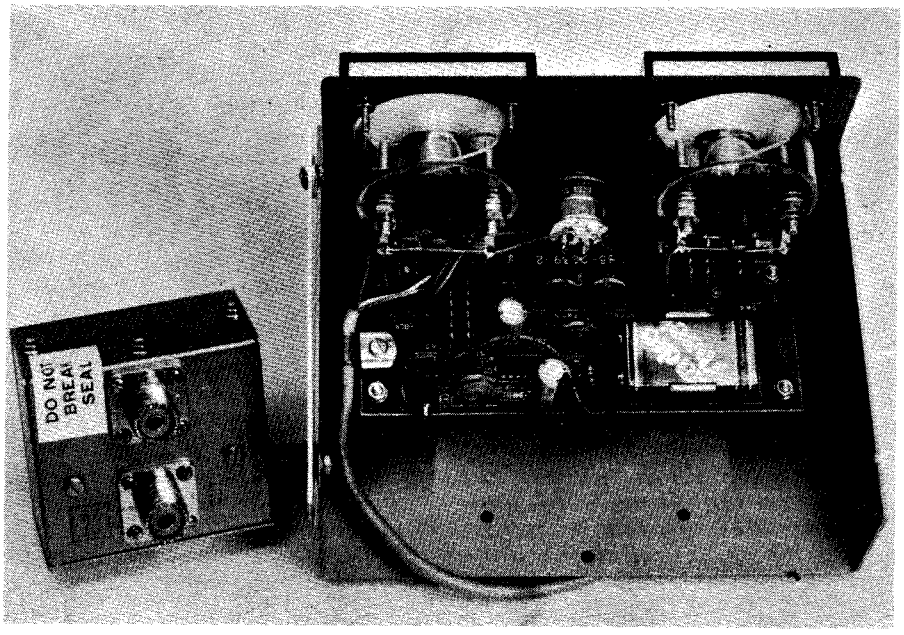

Fig. 5 — The Heath HM-2141 wattmeter is shown here (with top cover removed) with its remote sensor. The sensor can be attached inside the rear of the case, and the wattmeter used as a single, integral unit.

Building the Kit

Following the superbly written Heathkit instructions, I completed the assembly of this kit in exactly two hours, including time to test each resistor, capacitor and diode with an ohmmeter, and calibrate the PEP circuits. (Testing components is standard procedure whenever I build a kit — defective parts are *much* easier to spot when checked apart from the rest of the circuit!) All Heathkits I had built previously used a phenolic material for all the circuit boards. I was impressed by the neat glass-epoxy circuit board used in this kit; solder resist applied to the foil side of the board made it easy to conserve solder while obtaining a good-looking result.

The remote sensor is assembled, calibrated and sealed at the factory. The instructions contain warnings that breaking the seal can void the warranty.

Using and Testing the Meter

When assembly was finished, I had one leftover nut, one lockwasher, a small amount of solder and a completed wattmeter for my efforts. The unit worked perfectly the first time it was used, and continued to function without a snag. I observed only one minor operating inconvenience: I feel that Heath should have used toggle or slide switches instead of the four push-button switches located under the meters. When the front panel is viewed from directly in front (as it should be viewed to avoid parallax error when reading the meters) it is very difficult to tell if the buttons are in or out in my dimly lighted shack. Toggle or slide switches would have obviated this difficulty.

The unit was tested in the ARRL laboratory with the aid of a Bird wattmeter and a 50-ohm dummy load. A power level of 10.0 watts (according to the Bird meter) was used on 50 and 144 MHz. The HM-2141 indicated 9.9 watts on 6 meters and 9.1 watts on 2 meters. Heath's specification of ±7.5% of the full-scale reading on the 30-, 100- and 300-watt scales translates to ±2.25 watts on the 30-watt scale that was used. The maximum 0.9-watt error on 2 meters is well within this specification. The dimensions of the meter unit (HWD) are: 4-1/8 × 7-1/2 × 6-3/8 inches (105 × 191 × 162 mm). The price class of the HM-2141 is $75. It is available from Heath Company, Benton Harbor, MI 49022 or from Heathkit retail stores. — *John C. Pelham, W1JA*

COMMUNICATIONS SPECIALISTS TE-64 TONE ENCODER

☐ You mention PL[1] to most hams who are active on fm and the reaction is usually negative,

[1]PL stands for Private Line; both terms are registered trade marks of Motorola. General Electric refers to a similar system as Channel Guard. The generic name is Continuous Tone Coded Squelch System, which is cumbersome, even in its abbreviated form, CTCSS. Since PL is used as the generic term in popular amateur parlance, we have chosen to use it here.

Communications Specialists TE-64 Tone Encoder

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency accuracy (subaudible) — ±0.1 Hz maximum, −40 to +85° C.	±0.1 Hz at room temperature.
Frequency stability (audible) — ±1 Hz maximum, −40 to +85° C.	±1 Hz at room temperature.
Output level — 5-V pk-pk, adjustable, flat to within 1.5 dB over range selected.	5.2-V pk-pk, adjustable, flat to within 1 dB over range selected.
Wave shape — Sine wave.	Sine wave.
Power requirement — 8 mA at 6- to 30-V dc (may be operated by adding internal 9-V transistor battery.)	
Reverse polarity protection built in.	
Off position for no tone output	
Size of case without mounting bracket — 5-1/4 × 3-1/3 × 1-2/3 inch (133 × 85 × 43 mm).	
Weight — 8 oz (0.2 kg).	
Color — Black.	
Price Class — $80.	

if not down-right hostile. A long time ago, back in the dawning ages of amateur fm operation, frequency space was not at a premium, even in southern California. A few groups picked up on PL-type operation at the time with the expressed or implied attitude of "if you ain't one of us superior, super-select, ultra-cool, noble snobs, get your crummy rig off OUR frequency and don't ever darken OUR repeater with your presence again." Nice guys, huh? These *gentlemen* soon received the contempt that they had courted and earned with their supercilious behavior. Unfortunately, in the process PL took it on the chin along with these clods. Hence, the general disdain for PL in the amateur circles.

This column is devoted to product review and not ancient history or contemporary social theory of the air waves, so what gives, you say. To appreciate the beauty of the Communications Specialists TE-64 Tone Encoder, you must look beyond how things *are* to how they *might be*. It is my belief that amateur fm-ers are now in a position where they are "cutting off their noses to spite their faces." PL may offer some cheap, practical solutions to problems resulting from the crowded spectrum — particularly 2-meter fm and 10-meter fm.

A PL tone is any one of the 32 standard tones ranging from 67.0 to 203.5 Hz. This group is generally referred to as the subaudible group — subaudible because the tones are set at a very low deviation (usually around 500 Hz in a 5 kHz system) and because the corresponding receiver generally has a high-pass filter installed in the audio chain to attenuate these low frequencies. The tone is activated when the microphone button is pressed and stays on during the entire transmission.

In a PL system, the receiver is equipped with a decoder that is set to recognize the presence or lack of the PL tone. The PL decoder controls a switch that is paralled with the standard squelch switch. Typically, in a commercial installation, the user has the option of choosing either standard or PL squelch. However, it is simple to parallel them such that either a PL signal or a non-PL signal will open the receiver. Art Reis, K9XI, described a system using this concept whereby the receiver required a non-PL signal to have 20 dB of quieting to open the receiver, while a PL signal would open it at less than 0.15 microvolt.[2] Objectively viewed, the old anti-PL argument that PL keeps the transients out doesn't hold up. It just keeps the unwanted weak signals out.

The other valid argument against PL *was* that one had to install an encoder and purchase a "reed" or similar device for each PL tone to be used. To change from one PL tone to another was time-consuming and expensive. Now, through the same magic that brings you 800 channels in the palm of your hand, there is a device that inexpensively provides you with your choice of any of the standard tones at the turn of a switch. Punch another button and you have the standard "tone-burst" or audible tones plus the tones making up the "touch-tone" system. Again, objectively viewed, the second anti-PL argument does not stand up.

Small Package, Smaller Contents

Upon first seeing the outside of the TE-64, I was struck by the complexity of the front panel. The selector knob has 32 lines extending out to 32 sets of dual tone markings — one each for subaudible and audible tones. There is also a push switch that allows the user to choose between the audible and the subaudible groups. Surely, such a small package with so much on the front panel must be jammed full of circuitry inside.

After loosening the two thumbwheel retaining screws, I removed the top cover and was shocked! This small package could have been made a lot smaller! There are three 8-pin ICs (dual op amps), one 18-pin IC (a Communications Specialists' proprietary chip that does all the fancy work), a 1-MHz crystal and a handful of resistors and capacitors. The two switches are the largest components by far. I do not know of any fm radio (including portables) that does not have enough room in it for the electronics of this device to fit into.

As in most other areas of the U.S., none of the 2-meter repeaters in the Hartford area are equipped for PL operation. I did connect the TE-64 to a 10-meter fm rig and used it to access a couple of 10-meter repeaters. Although the instructions for installation are not overly detailed, anyone familiar with the workings of an fm transmitter and having the schematic diagram for the transmitter in question should have no trouble in satisfactorily attaching the TE-64 to his transmitter. If tone-burst operation (audible) is desired, the user should find it even easier to connect the TE-64 to his transmitter.

In addition to limited on-the-air tests with the unit, we ran it through its paces in the lab. An oscilloscope connected to the output showed that the TE-64 produces sine waves for both the subaudible and the audible groups. There are separate outputs for each group and separate level controls which are completely independent of each other. We did not notice distortion of the waveform at any setting of either level control. The audible group is set up as a "burst" when power is first applied. By merely clipping one jumper, the audible group becomes continuous instead of "burst." Obviously, one could replace the jumper with an spst switch. The "burst" is factory set at about one-half second, but this can be altered by changing one resistor.

I used an Optoelectronics 8010-1.3 frequency counter to check for accuracy. In all cases, the TE-64 was within 0.1 Hz of the specified frequency. It has been my experience with commercial decoders that most will "recognize" a tone that is within 1.5 Hz of the specified frequency. Unfortunately, the ARRL lab does not have facilities for checking equipment at temperature extremes, so no data is available on the amount of drift, if any, as temperature varies. The TE-64 was left running for over an hour with no discernable drift. It seems reasonable to conclude that the accuracy is more than adequate for general amateur use.

Do you find yourself turning off your 2-meter rig because the repeater is constantly keying up on weak signals — signals that are not intended for your repeater anyway? Are you annoyed by the noise and static that comes crashing through your repeater during marginal band openings? Dual squelch systems combined with low-cost, high-technology devices such as the TE-64 may be the answer you are looking for. We can maintain an open, friendly attitude to transients (in the best spirit of Amateur Radio) and keep 2-meter fm a noise-free, static-free, pleasant-to-listen-to, local communications medium. Of course some hams are so rigid in their thinking that they seem to take a perverse delight in "cutting off their noses to spite their faces." — *Pete O'Dell, AE8Q* QST

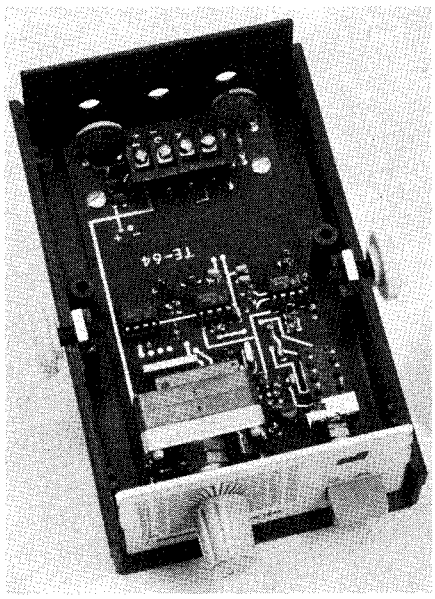

Fig. 6 — The interior view of the TE-64 reveals a rather spacious layout. External connections are made by means of the terminal board located at the rear of the unit.

[2]Reis, "Should Repeaters Use Subaudible Tones?" *73 Magazine*, July 1978, p. 102.