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Broder Logic Trainer Model 100

Heath HM-2140 Dual HF Wattmeter

Trio-Kenwood TS-120S HF SSB Transceiver

Product Review

Conducted By Paul K. Pagel,* N1FB

The Trio-Kenwood TS-120S HF SSB Transceiver

The Kenwood TS-120S ssb/cw five-band transceiver is shown here with the matching PS-30 power supply, VFO-120 remote VFO and SP-120 external speaker. The combination makes a compact, flexible station whether mobile, portable or fixed.

Kenwood has welcomed another member (baby brother to the TS-820S), the TS-120S, to the ever-growing family. It's easy to see the Kenwood folks had mobile operation in mind when they designed the TS-120S. The size, weight and operating voltage required for the '120 make it ideal for use in land, air and maritime mobile service. Portable and fixed-station operation are readily achieved with an ac-operated supply. Weighing in at a mere 12.3 lbs (5.6 kg), the transceiver proper may be carried as hand baggage aboard an aircraft while the power supply is sent along with the luggage. Or, that added weight may be left behind and the rig operated from any 13.8-V dc source capable of supplying approximately 20 A of peak current.

The matching PS-30 power supply is hefty. In addition to supplying the required voltage and current demands of the '120S, a terminal block at the rear of the unit provides a source of 13.8 V dc at 5 A for powering other units. For example, a 144-MHz or 220-MHz transceiver might be powered from that source. Thus, only one supply would be needed for both hf and vhf/uhf capability.

The '120 has both analog and digital readout, RIT, i-f shift, built-in VOX, 25-kHz calibrator, provisions for crystal control, an internal speaker (with provisions for an external speaker), and a noise blanker designed to eliminate ignition-type noises. Additionally, the design of the '120 is of the "no-tune" variety — set the band switch and operate! How simple can you get?

This rig is broadbanded from 3.5 MHz to 30 MHz: The power output of the transceiver is so constant from one end of a chosen band to the other, it appears as though you're looking at the output of a battery! The measured output power is in excess of 100 watts from 80 through 15 meters. It provides 85 watts across the whole 10-meter band.

With the optional VFO 120 (note the VFO 520 or VFO 820 cannot be used), cross-frequency flexibility is optimum. The remote VFO also has receiver incremental tuning (RIT) and a "T-F" function. The T-F function allows the operator to check the *transmit* frequency for occupancy while in the receive mode and operating "split" cross-frequency. This is done by simply pushing the T-F button; it requires no receiver tuning. Both the main and remote VFOs are gear-driven from the main tuning knobs: No backlash was noted during use. Obviously, the digital display is the primary method of frequency readout. The analog dial may be used as an alternative, but is not as accurate. While the knob skirt has 1-kHz markings which track fairly well, the analog frequency dial (graduated in 10-kHz increments) on both the transceiver and the remote VFO was found to differ by approximately 3.5 kHz from the digital display.

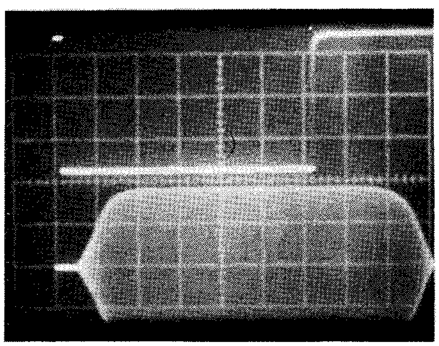

Fig. 1 — The keyed cw waveform of the Kenwood TS-120S. The test was performed on 80 meters. Horizontal divisions are each 5 milliseconds. The upper waveform displays the actual key-down time. Roughly seven (7) ms after key-up, the wave starts to decay. With such smoothly rounded leading and trailing edges, no clicks will be generated. The weighting is "heavy," however, because of the time lag between key-up and the decay of the wave.

The transceiver will tune approximately 60 to 70 kHz outside of each 500-kHz range. This may prove of some worth to MARS operators. Depending on the band in use, the digital display will indicate the frequency of either the high or low end of the tuning range normally, but the opposite end will be awkward digits once the 500-kHz edge is passed. For example, on the 7-MHz band, the upper limit is displayed as 7.562.7 while the lower limit (below the band edge of 7.0000 MHz) appears as 929.2. On 28.5 MHz, the upper limit (past the correctly displayed 28.9000 MHz) will show as 062.7 while the lower limit is displayed as 28.429.1. The analog dial scale is blank beyond the 0 and 500 marks, but the knob skirt markings may be used, and "mental mathematics" performed to ascertain the frequency. The transceiver will function in both receive and transmit over the entire range. With the band switch at the WWV/JJY position, transmission is inhibited, but the receiver is operable for 15-MHz WWV reception.

While operating ssb, nice sharp peaks were noted on the monitor 'scope. The audio quality reports received were excellent, even when using a relatively inexpensive microphone. There is no speech-processing unit built into the '120S.

Some transceivers are designed for ssb

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operation and leave cw as a kind of afterthought. It was difficult to argue against the performance of the TS-120S. The only item we felt was missing was full break-in (QSK) operation as opposed to the "semi-break-in" incorporated into this and most other transceivers. While running "full-bore" cw on 40 meters, the '120S proved itself a pleasure to operate. VOX keying was quick and reliable (unlike some others) and the clicking of the T-R relay was found to be not unduly loud. When wearing headphones, the operator may be totally unaware of the relay noise. If manual switching is desired, the conveniently located (for right-handed operators) send-receive switch may be used. It is off to the left side of the transceiver and clear of other controls. PTT is, of course, available.

The key jack presents +9 V to the key, so if a transistor-output keyer is used, ensure that the proper polarity is available. The keyed waveshape is shown in Fig. 1. The 'scope presentation of the transceiver output shows smoothly rounded leading and trailing edges. It was not possible to make the keying too "hard" even when attempting to over-drive the rig. The weighting is a bit heavy, however.

The cw monitor note (800 Hz) reflects the "heaviness" of the keying; if high-speed cw is used, the note might tend to sound somewhat "mushy" above 40 wpm. The sidetone volume is adjustable by means of an internally located pot; the cover must be removed from the transceiver for access to this control. No trace of hum could be found on the signal and the dynamic regulation of the power supply was such that no dips or overshoots were noted on the waveform.

Although there is no agc-selection switch on the '120, Kenwood remembered the cw operator once again. When the mode switch is changed from ssb to cw, the agc action of the TS-120S is altered. A faster agc time constant is employed on cw, while the desired slower action will be noted on ssb.

While certainly the IF SHIFT feature is an asset to ssb operation, coupled with the optional 500-Hz cw filter (YK-88C) and RIT, it is a most effective means of reducing QRM while on cw. This function is a welcome carry-over from the TS-820S and the R-820, both reviewed earlier in *QST*.[1,2] Installation of the cw filter takes less than 15 minutes. The filter is simply soldered to the pc board in the allotted space and a jumper plug (for diode switching of the filters) is moved to an adjacent socket. The addition of the cw filter may be desired if cw operation of any magnitude is planned.

The rear panel of the '120S supports the antenna connector, key jack, external-speaker jack, power connector, a hefty grounding terminal and two DIN connectors. One of the DIN connectors is used for cabling of the remote VFO (optional) while the other is a remote jack for use in connecting a linear amplifier or other equipment. A good portion of the rear panel is occupied by a heat sink and pluggable cooling fan, both used to allow the final amplifier transistors to "breathe" properly. The fan is notably quiet and operates only when the heat-sink temperature reaches a specific level. After an hour-long cw QSO at full output, the heat sink was warm to the touch. The heat sink at the rear of the PS-30 power supply was somewhat warmer than that of the transceiver, but not hot enough to cause injury if contacted inadvertently. Both heat sinks should be kept free of surrounding objects, however, to allow for good ventilation during operation. If for some reason the TS-120S heat-sink temperature should rise abnormally, protection circuitry incorporated in the rig will return it automatically to the receive mode until it has cooled properly. The final amplifier transistors are further protected against high VSWR levels. If the VSWR should climb too high, the output power of the transmitter is lowered by reducing drive to the final amplifiers. The owner's manual recommends the VSWR be below 1.5:1 and that a Transmatch be used for impedance matching between the transceiver and antenna when greater mismatches are encountered.

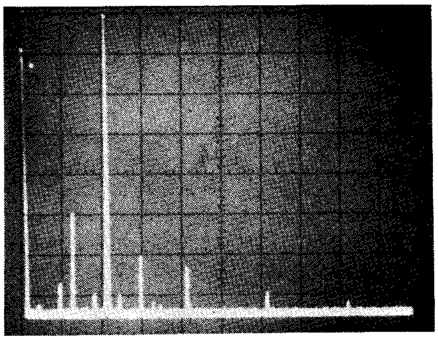


Fig. 2 — A spectral photograph of the transmitter output of the TS-120S operating on 21 MHz at rated cw input power. The vertical divisions are each 10 dB. The horizontal divisions are each 10 MHz. The synthesizer spur at approximately 10.5 MHz is down approximately 49 dB. Other spurs are at least 60 dB down. The TS-120S meets the present FCC requirements for spectral purity.

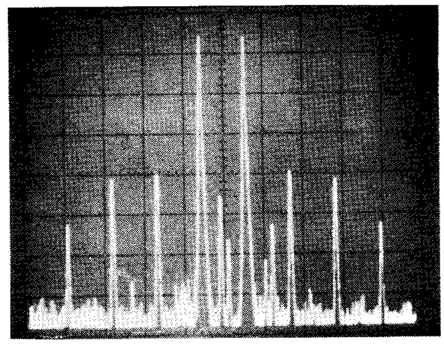


Fig. 3 — This photo represents full-power, 7-MHz, two-tone testing of the TS-120S. Each vertical division is 10 dB. The horizontal divisions are 1 kHz each. Third-order products are approximately 36 dB down from the full PEP output level. All measurements were taken in the ARRL lab.

The Receiver Circuit

The receiver section of the '120S employs a single-conversion scheme with an i-f of 8.83 MHz. Signals arriving at the antenna are met by an i-f trap then impedance-matched by a wide-band transformer for application to a bandpass filter. This filter is common to both reception and transmission. No preselector peaking is required. From here, the signal is fed to two MOSFET rf amplifiers, providing approximately 20 dB of amplification. At the

TS-120S Manufacturer's Claimed Specifications

Frequency range: 80-meter band — 3.50-4.00 MHz.
40-meter band — 7.00-7.30 MHz.
20-meter band — 14.00-14.35 MHz.
15-meter band — 21.00-21.45 MHz.
10-meter band — 28.00-29.70 MHz.
WWV — 15.0 MHz.
Mode: Ssb/cw.
Grounding: Negative ground only.
Power requirements: Receive — 0.7 A 13.8 V dc; Transmit — 18 A 13.8 V dc.
Final power input: 80- to 15-m band — 200 W PEP for ssb operation.
160 W dc for cw operation.
10-m band — 160 W PEP for ssb operation.
140 W dc for cw operation.
Audio input impedance: 500 Ω — 50 kΩ.
Audio output impedance: 4 Ω — 16 Ω.
Audio output: More than 1.5 watts (with less than 10% distortion) into an 8-ohm load.
Rf output impedance: 50 Ω.
Frequency stability: within 100 Hz during any 30-minute period after warmup.
Within ± 1 kHz during the first hour after 1 minute of warmup.
Carrier suppression: Carrier better than 40 dB down from the output signal.
Sideband suppression: Unwanted sideband is better than 50 dB down from the output signal.
Spurious radiation: Better than 40 dB down from output signal.
Harmonic radiation: Better than 40 dB down from output signal.
Image ratio: Image frequency better than 50 dB down from the output signal.
I-f rejection: I-f frequency is 70 dB or more down from output signal.
Receiver sensitivity: 0.25 μV at 10 dB S + N/N or better.
Receiver selectivity: Ssb — 2.4 kHz (−6 dB) 4.2 kHz (−60 dB). *Cw 0.5 kHz (−6 dB)
1.5 kHz (−60 dB).
Semiconductors: IC — 26. FET — 16. Transistor — 90. Diode — 142.
Dimensions (WHD): 9-1/2 × 3-3/4 × 11-9/16 inch (241 × 94 × 293 mm).
Weight: 12.3 lbs (5.6 kg).
Color: Gold-brown.
Price class: $700.
Manufacturer: Trio-Kenwood Communications, Inc. 1111 West Walnut, Compton, CA 90220.
*Optional cw filter installed.

[1]DeMaw, "Product Review," *QST*, September 1976.
[2]Rusgrove, "Product Review," *QST*, July 1979.

mixer, the signals meet the VCO output from the PLL and are converted to the i-f. Ceramic filters, noise blanker, crystal filter and three stages of i-f amplification are next in the path of the signal. A diode-ring demodulator and successive audio amplifiers are the last steps taken before the signal is heard in the speaker/headphones.

The Transmitter Circuit

Both high- and low-impedance microphones may be used with the TS-120S. The mic gain control is simply adjusted to a higher level when low-impedance microphones are used. After amplification the audio is passed to the balanced modulator. The resulting double-sideband signal at the i-f (8.83 MHz) is filtered to remove the unwanted sideband. After further amplification the signal is fed to a MOSFET balanced mixer, combined with the VCO output and converted to the final transmitted frequency. The BPF (bandpass filter) removes spurious signal components and the "scrubbed" signal is amplified in three stages in the wideband amplifier. The driver and push-pull final amplifiers then pass the signal through an rf filter and on to the antenna.

Some Notes

A few typographical and transliteration errors were found in the text of the owner's manual. It reminded the reviewer of the earlier years when imported amateur equipment was just making headway. From an operational point of view, the manual covers all areas well. Unfortunately, the only page devoted to troubleshooting is aimed solely at *operational* failures, not those caused by defective components. A comprehensive service manual is available from Kenwood, and would be a worthwhile investment, however.

With a dummy load connected to the transceiver, spurious responses ("birdies") were found in the receiver every 100 kHz across each band and a couple of other spots on the dial. Most of them were very low level responses (the strongest ones being at the extreme ends of the bands); in no case did any of them cause the S meter to deflect. In fact, with an antenna connected, the atmospheric and band noises coupled with the incoming signals masked all but a few. The responses would probably not be noticeable under most circumstances and should not cause any difficulty in reception.

While the '120 was being used at one location only two blocks away from W1AW, receiver overloading was experienced from the strong signal of that station. There is no front-end attenuator provided on the transceiver, which might have offered some assistance under these strong-signal conditions. In a suburban environment away from such strong local signals, no problems with receiver overloading were encountered. The receiver was checked in the ARRL lab and the following figures were obtained: noise floor −139 dBm, blocking dynamic range 108 dB, IMD dynamic range 75 dB. These figures develop an input intercept figure of −26.5 dBm. These are worst-case numbers developed on 80 meters using the optional 500-Hz cw filter. Noise-blanker operation did not degrade these figures. Transmitter tests performed in the ARRL lab with a spectrum analyzer resulted in the displays shown in the accompanying photographs. See Figs. 2 and 3. — *Paul K. Pagel, N1FB*

HEATH HM-2140 DUAL HF WATTMETER

If you are a post-holiday shopper looking to spend the contents of that modest cash kitty your YL gave you as a Yuletide gift, either the Heath HM-2140 or the HM-2141 dual-meter wattmeter is worth your consideration. The principal difference between these two instruments is that the -2140 monitors forward and reflected power over the range of 1.8 to 30 MHz, while the -2141 is designed for the range of 50 to 175 MHz.

Being interested mainly in the lower-frequency amateur bands, I chose to construct the HM-2140 wattmeter. I've not been disappointed.

As shown in the accompanying photograph, Heath has packaged the HM-2140 in an attractive metal enclosure, with two large, rectangular panel meters that provide good visibility. These are used to monitor forward and reflected power besides displaying the VSWR measurement. Additionally, provision is made for reading either PEP or average power. Let this desk-top instrument rest beside your other equipment and you'll notice how it catches the eye of visiting amateurs.

Although Heath engineers have designed the HM-2140 for use in the Amateur Radio bands, it can be employed for other services which operate between 1.8 and 30 MHz. No additional plug-in modules are required to obtain full use of this device within this frequency range.

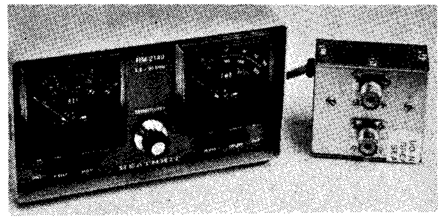
The HM-2140 meets the needs of the operator who is satisfied with low power, or the one who insists on operating transmitting gear full bore at the top legal power limit. Two meter scales are furnished for forward-power indication. The lower scale covers up to 200 watts PEP; the upper range is for power up to 2000 watts PEP. Push-button switching is provided for accommodating either low or high power. There are three scales on the meter: the low range, PEP up to 50 watts; the high range, up to 500 watts reflected PEP; and VSWR covering from 1:1 to 3:1. Push-button switching provides convenient changeover for measuring average or peak-envelope power. The circuit is designed to work into a 50-ohm line.

Because this Heath instrument contains an integrated circuit, a small amount of power is required for its operation. This may be provided by an internally mounted 9-V battery or an external Heath GRA-43-1 converter supply. This optional ac power source may be ordered separately. An LM-324 quad operational amplifier IC serves as an integral part of the peak envelope power-indicating circuit. This has a low supply-current drain (800 μA). Frequent replacement of the battery should not be necessary. Condition of the battery may be checked readily by the metering circuit.

About the Circuit

There are two main areas in the PEP-indicating circuit. The first is a peak detector with gain and the second is a unity-gain buffer network with an offset adjustment. This arrangement preserves the calibration of the rf sensor and contributes to reliable adjustment of the meter.

A practical feature of the HM-2140 that I like is the remote sensing unit. This part of the wattmeter is connected in series with the antenna transmission line for sampling the rf fed to the antenna system. The sensor is connected to the wattmeter by means of a flexible umbilical cable that avoids connecting clumsy coaxial cables directly to the wattmeter. Use of the sensor at a remote position, however, is optional, for the HM-2140 is so designed that the sensor can be placed inside the wattmeter enclosure if the operator so desires. This part of the HM-2140, incidentally, is factory wired and calibrated. Instructions stipulate that the sensor is not to be adjusted. Doing so or otherwise tampering with the sensor can void the warranty.



There is no sacrifice of portability with this new Heath HM-2140 dual wattmeter. The net weight is 4 pounds (1.82 kg). Overall dimensions (HWD) are 4-1/8 × 7-1/2 × 6-3/8 inches (inches × 25.4 = mm). Heath has priced the HM-2140 in the $70 class. It may be purchased from the Heath Company, Benton Harbor, MI 49022, or from Heathkit retail stores.

Comments

Constructing the HM-2140 provided me with two evenings of enjoyment. The carefully planned instructions were thorough, with a well-arranged order of assembly. I liked the workmanship of the Heath circuit board, which contributed to the delight of assembling the wattmeter.

Gratified that the unit passed the initial "smoke test," I proceeded to give it two weeks of on-the-air testing, followed by laboratory testing with a Bird wattmeter. For checking the low-power range, a steady 50-watt signal was fed through the HM-2140 into a 50-ohm dummy load. Band-by-band behavior was observed from 160 through 10 meters. The major scale markings of the Heath wattmeter coincided with the Bird meter indications in each case. A slight difference could be noted for the in-between indications, yet these are within the manufacturer's tolerance ratings.

To note how the HM-2140 behaved where excessive reactance is involved, a deliberately *large* amount was introduced while operating on 10 meters. This caused the reflected power calibration potentiometer in the sensor to heat, apparently as the result of an unwanted resonance that developed in conjunction with an internal ferrite bead. This is not viewed as a fault of the device, however.

The final test involved a high-power run while using a linear amplifier. The HM-2140 performed equally well at this power level.

Readers who are unfamiliar with in-line rf power metering will benefit by reading Doug DeMaw's discussion of practical considerations for this type of instrumentation. His article appeared in December 1969 *QST*. He explains the design philosophy of such circuitry including the basic Bruene configuration. The latter was introduced in April 1959 *QST*. The HM-2140 is based on these principles. Additional information may be found in *The ARRL Antenna Anthology* published in 1978. — *Stu Leland, W1JEC*

THE BRODER LOGIC TRAINER MODEL 100

". . . with no previous logic experience [students] may achieve a very high level of competency in minimum time. . . ." I'm the ideal reviewer, then, because I know nothing about logic circuitry but am anxious to learn. That was my first reaction to this training device. My second reaction was, "What a *neat* gadget!" It is fun to play with and that is the first sign of a good learning device — it piques the old curiosity.

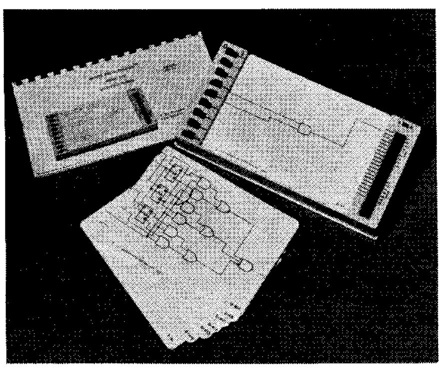
The Broder Logic Trainer is housed in a small box with eight on/off switches on the left and 20 LCD display bars to the right. A set of cards fits into the space between. Each card has a circuit printed on it. The student determines the on/off state necessary at the input to work the problem correctly. If the student is right, an LCD display bar appears at the output (see the photo).

The Broder Logic Trainer also comes with a manual that provides a learning text and answers to the program cards. The text and cards cover gates and sequential logic, including flip-flops, counters and shift registers. The text has additional short sections and a few problem cards on binary adding, Boolean algebra, logic component voltage, logic families, noice immunity, troubleshooting, clock frequency, switch circuit problems, Venn diagrams and symbolic logic.

How well does it work? In going through the manual I found I had no problem with the section on gates, which comprises about one half (20) of the cards. The text is clear and with a little practice, the correct display bars appeared at the output.

Sequential logic was a different story, however. The explanations in the text were not adequate for this reviewer's understanding. At this point, I began using a large classroom text as my main source of information and the manual and cards as a supplement. This worked fine. Again I began to see LCD displays in the right places.

The hands-on approach of this gadget is a great idea. I found that I learned rapidly and retained the knowledge longer when I had the immediate feedback of the LCD display to confirm that I'd worked the problem correctly. Perhaps someone who has a little background in logic — say, home computers or the like — would not have needed another text. I found that I did. While this doesn't in any way make the Broder Logic Trainer a less-useful device, it is probably not a complete course for the inexperienced. It is, however, an excellent workbook and supplement to any logic course. It would be of great help to anyone undertaking home study or attending a course that has no lab time available. It's definitely an enjoyable and effective way to learn. The Broder Logic Trainer, Model 100. L. J. Broder Enterprises, Inc., 3192 Darvany Dr., Dallas, TX 75220. Price: $69.95 with manual and 9-V battery. — *Jeanette M. S. Zaimes, AB1P*



The Broder Logic Trainer in action. In this photograph, a total of three bars may be seen on the LCD display. As explained in the instruction manual, only the bar pointed to by the problem output (the uppermost in this picture) is significant. The other bars are disregarded.

New Books

□ *Morse, Marconi and You*, by Irwin Math. Published by Charles Scribner's Sons, New York, NY. Hard cover, 7-3/4 × 9-1/4 inches, 80 pages, $8.95.

The idea behind this book is excellent: to take the reader through the fundamentals of electricity and radio electronics theory by providing easy-to-understand projects accompanied by clear, elementary text. Despite its small size and a sprinkling of errors, the book hits its mark.

After disposing of communications before radio in three pages, the author delves into the fundamentals of electricity. The first construction project is a simple flashlight circuit. From here, the reader is led through other projects, culminating in a "versatile shortwave receiver." Although it doesn't seem likely that a youngster who knew little about radio electronics when beginning this book could successfully build this sophisticated project without assistance, that may not be a serious drawback. First of all, a careful reading of the six-page chapter provides a solid introduction to the principles of a regenerative receiver. Secondly, it certainly doesn't hurt to encourage a beginner to seek help from more-experienced friends or relatives.

The building projects between the simple flashlight and the receiver are often useful and always educational. They include an electromagnet, telegraph set, telephone and the author's specialty — a light-beam communications system. This project will be a bit too much to chew on for most youngsters, but will make absorbing reading for everyone unfamiliar with communication via light waves.

The author, WA2NDM, is well versed in Amateur Radio, having written a column in *CQ* for several years. While he devotes only a couple of pages to Amateur Radio *per se*, Math's book is a decent introduction to the hobby. The progression of projects, from a telegraph key to the shortwave receiver, gives the reader a solid foundation on which to expand his or her knowledge of radio.

There are a few problems that detract from the book's effectiveness. There is no explanation of the difference between ac and dc, for example. Theory explanations are purposely brief, but a single sentence would have sufficed. The table of international Morse code characters has three flaws: It is written in the now less-accepted dot-dash form and both the U and the W are represented as two dots and a dash. In addition, it omits the useful double dash in favor of the seldom-used comma. Both ARRL and *Ham Radio Horizons* are victimized by careless errors: The author suggests writing to the "Amateur" Radio Relay League for information on a Novice course, and *Ham Radio Horizons* is said to be published in "Greenvale," NH.

A redeeming feature is the artwork — 77 figures, many of which show pictorial representations of circuit components. The large number of figures also makes the book's relatively hefty price tag a bit easier to bear.

Aimed at youngsters and others who have yet to develop a serious interest in electronics, this small book will provide many hours of enjoyment. The author feels that hands-on experience is preferable to detailed explanations of electronic principles. He may just have a point! — *Joel P. Kleinman, WA1ZUY*

□ *Man-Made Radio Noise,* by Edward N. Skomal. Published by Van Nostrand Reinhold, a division of Litton Educational Publishing, Inc., New York, NY. Hard cover, 6 × 9 inches, 342 pages plus index, 148 illustrations, $19.95.

Man-made radio noise, so familiar to radio amateurs, is a form of pollution that affects services beyond our treasured hobby. Fortunately, more and more attention is being devoted to the noise problem. In-depth studies are being conducted in a continuing effort to better understand the nature of such interference with the hope that someday much of it can be eliminated. QST readers who wish to sample current thinking about radio noise will do well to examine Edward N. Skomal's recent book. The author has been studying natural and man-made noise since 1964. His investigations include experimental studies, theoretical developments of generation and propagation processes and the evaluation of noise as it affects radio communication. He is indeed well qualified. His credits include membership in the IEEE, the International Union of Radio Scientists and the American Physical Society. Additionally, he has served on an advisory committee to the Office of the President on national telecommunications planning. Currently he works for the Aerospace Corporation in El Segundo, CA.

Man-Made Radio Noise contains information for both the engineering and nonengineering reader. After explaining basic terms and defining the difference between manmade and naturally occurring noise, the author deals with other forms, including automotive ignition noise, and how separate sources produce interference that combines into a composite pattern found in most urban areas. Mr. Skomal provides sufficient information so that predictions of average power, quasi-peak and peak-noise field intensity can be confidently made.

The book contains chapters on electric power generation and transmission line noise, interference caused by industrial, scientific, medical, consumer and transportation equipment. The author even delves into elevated and airborne incidental noise. The latter sections are based on data gathered at heights up to 26,000 feet over major cities on three continents.

There is a broad scope of information in *Man-Made Radio Noise.* It is not a "nuts and bolts" hands-on treatment of cures for interference. Rather, it is more theoretical. If you like the challenge of calculus to enrich your understanding, Mr. Skomal has included a liberal amount to tease your brain. Look this book over the next time you are in your favorite book store or public library. — *Stu Leland, W1JEC*