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Heath SA-2500 Antenna Tuner

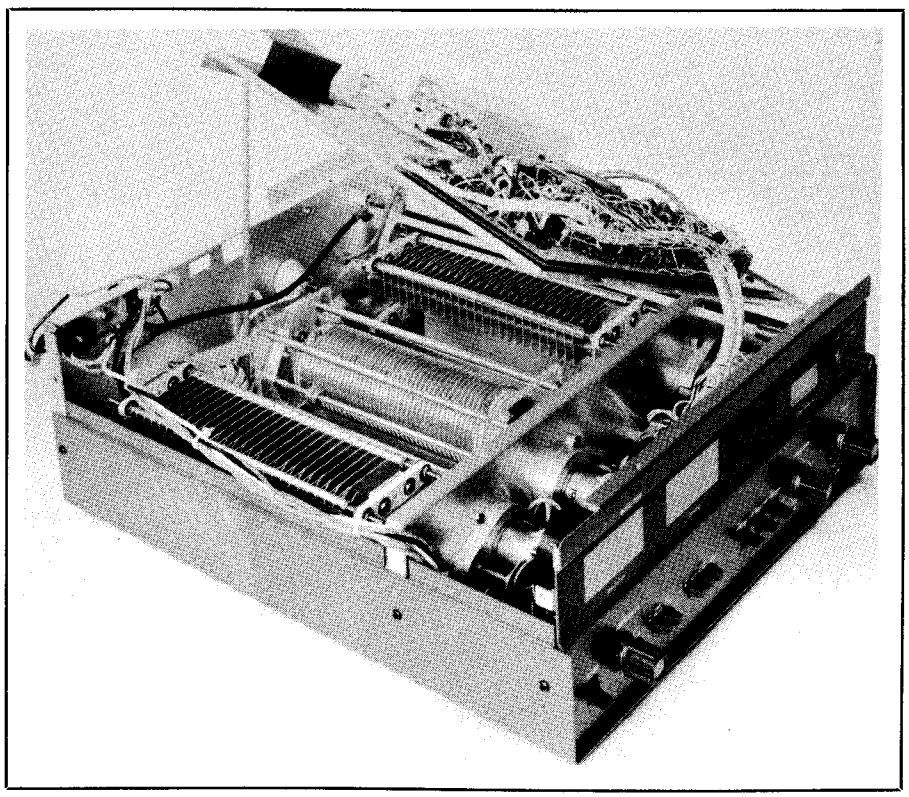
KLM Electronics, Inc. 2M-16LBX 2-Meter Beam

Product Review

Conducted By Paul K. Pagel,* N1FB

Heath SA-2500 Antenna Tuner

What is it that contains transistors, diodes, SCRs, resistors, inductors, motors, switches, a power transformer, optical interruptors, variable and fixed capacitors, and a pair of meters? If you said "a transceiver," you're wrong. If you said "a Heath SA-2500 antenna-matching network," you've cheated and looked at the picture and title of this review! Yes, the SA-2500 contains all of that, and more.



The SA-2500 with the top shield propped up to permit a peek at the tuning capacitors and roller inductor. A section of the 4:1 balun appears between the rear ends of the transmitter capacitor (foreground) and the roller inductor.

Description

The SA-2500 is the newest of Heath's antenna-matching networks. At the heart of the unit is the T-network/balun arrangement Heath has used in the SA-2060 and SA-2060A. The information contained in the SA-2060 review (Product Review, July 1982, *QST*, pp. 40-41) pertaining to the matching-network and the antenna-switching arrangement may be applied to the SA-2500 as well. Outside of the matching-network and antenna-switching circuits, the rest of the '2500 is different: This unit uses motorized control of the two variable capacitors and inductor (there are no knobs to turn at the ends of the variable-capacitor or inductor shafts) and an auto-ranging power-metering circuit is featured.

By means of a front-panel rotary switch, you can locally select any one of 18 preset roller-inductor positions. If your transmitter or transceiver band-change function is equipped for remote control of external devices by providing a switch closure to ground, it can remotely control the SA-2500. From a remote location, one of nine presets from one of two banks can be chosen. Panel indicators inform you when the roller inductor, transmitter or antenna capacitors are being adjusted, how many active inductor turns are being used and which power-meter ranges are currently active. There's also an audible warning (the unit has a 2-inch speaker) when the SWR exceeds an operator-selected maximum.

Front-Panel Controls

The POWER switch is at the extreme left. It switches on or off the 117-V line for the internal power supply or externally applied 12-V dc power for the matching network.

Power output, reflected power and SWR are indicated on two meters. An automatic, factory-calibrated ranging circuit switches the forward-power meter between 200- and 2000-W maximum scales while changing the reflected-power-meter ranges between 50- and 500-W scale maximums. HI and LOW indicators to the right of the FORWARD meter inform you which power range is selected by the auto-ranging wattmeter circuit. The power-range circuit changes from the 200-W to 2-kW range at the 200-W power level, but the power must drop below 200 W (typically 180-190 W) before the circuit will return to the 200-W range.

SWR between 1:1 and 3:1 is read directly from the REFLECTED meter when the SWR-REFLD switch is pushed in. When that switch is in the outer position, reflected power is indicated on the same meter. A SENSITIVITY control beneath the meters permits adjusting the reflected-power meter SET point to full scale. To do this, the SET-FWD switch and SWR-REF switch must be locked in their inner positions. With the SET-FWD switch in the outer position, the FORWARD meter provides forward-power readings.

Local manual tuning is accomplished using three up/down, spring-return, front-panel lever switches: one to control the motor of each capacitor (TRANSMITTER and ANTENNA), and one for the rotary-inductor (INDUCTOR) motor. All motors are bidirectional. Three illuminated icons are used to indicate which of the three variable components are being moved at any time. The capacitor-control circuits have a 50%-mesh default; this is their resting position and where they will be positioned under manual control unless deliberately rotated to another position.

Although there is no specific default setting for the inductor, a number of operator-selectable preset positions may be chosen. These inductor positions are selected by the BAND switch, discussed later.

To the right of the TRANSMITTER/INDUCTOR/ANTENNA switches is the TUNE SWR control. This potentiometer is used to preset an acceptable operator-selected SWR maximum (between 1.5 and 3) for the antenna in use. Two other switches are used in conjunction with the TUNE SWR control. When pushed in, the AUDIO ALARM switch enables a circuit to provide a 1- to 2-second aural indication that the SWR seen by the matching network exceeds the setting of the TUNE SWR control and that the automatic-tuning circuits cannot obtain a match within 20 seconds. Simultaneously, a visual alarm indication is presented by the illumination of another icon. The AUTO switch enables automatic antenna-matching network action when pushed in. Manual control is selected with that switch in the outer position.

The LINEAR switch comes into play if you intend to use a power amplifier in the lineup and wish to use the AUTO mode. Basically, it's used to bypass the amplifier while the antenna-

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matching network is tuning for minimum SWR.

The 10-position (160-10 meters and REMOTE) BAND switch and concentrically mounted LOW/HIGH lever switch provide for selection of as many as 18 different preset roller-inductor positions. You may, however, elect to use all 18 presets on a single band. Using the presets shortens the amount of tune-up time required. (It takes approximately 1 minute 20 seconds for the roller to travel from one end of the inductor to the other.) The preset inductor positions are chosen by you during the adjustment phase of construction, and may be reconfigured at any time. In the REMOTE position, you may select nine of the 18 presets, the HIGH/LOW switch determining which of the two sets of nine presets is chosen.

The COAX switch at the upper-right of the front panel is used to select routing of RF power output to one of three coaxial output connectors or a feedthrough insulator used for single-wire-fed antenna connection. One of the three coaxial-connector positions bypasses the matching network. This position may be used for selection of a resonant antenna or a dummy load.

Rear-Panel Connections

COAX 1, COAX 2 and BYPASS are the connectors just mentioned. They, and the INPUT RF connector, are mounted on the shielded box that houses the RF output switch and the SWR/power-meter sensor. Beneath the box is a large feedthrough insulator used for single-wire-fed antennas. If you've included the balun option, there'll be two more feedthrough insulators alongside the single-wire antenna connection. These points are used to connect the matching network to balanced feed lines. (If you haven't installed the balun option, the panel holes are filled with large metal plugs during assembly.) Next to the balanced-feed-line connectors is the GROUND post.

A 9-pin Molex connector provides for remote BAND switch connections. When the BAND switch is in the REMOTE position, grounding the appropriate socket pin selects one of the previously discussed inductor presets. If your transceiver has the proper provisions, you can have it control the matching network.

You may power the matching network with an external 12-V dc power supply capable of providing 1 A. A 2-pin connector is mounted on the rear panel for that purpose. Next to it is another 2-pin connector labeled ANT RELAY. The exciter amplifier-control relay is wired in series with this connector. It is through this jack that the matching-network LINEAR switch and internal relay operate. Finally, there's a fuse holder and a strain relief that allows passage of the ac line cord.

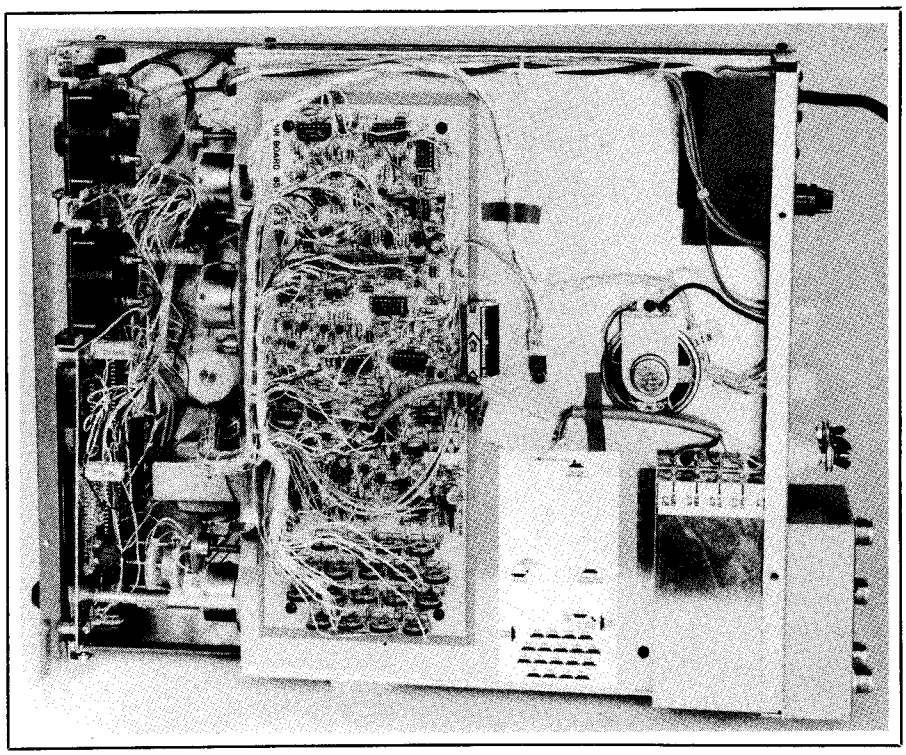

Fig. 1 — The Heath SA-2500 with the top cover removed. At the lower left, the display board may be seen mounted immediately behind the front panel. In between the front-panel-mounted components and the main circuit board, from bottom to top, are the antenna-capacitor drive motor and slotted photo-interrupter disc, the power transformer, the gear drive for the turns-counter potentiometer, the inductor drive motor and, finally, the transmitter capacitor drive motor and slotted photo-interrupter disc. At the bottom of the main circuit board are the inductor preset controls; to the right of them is a chart indicating the function of the trimmer potentiometers on the main circuit board. The Molex connector between the main circuit board and the shield box near the rear panel is the modification I made to permit easy access to the foil side of the main circuit board. A voltage regulator is chassis-mounted above the Molex connector between the circuit board and the speaker; I penned "UP" on the small connector to avoid improper attachment to the regulator. A fiber shield in the upper-right corner of the chassis covers the fuse holder/ac-line connections.

Construction

The Manuals

I can only imagine the work involved in producing instruction manuals for kit assembly; it must be a formidable task! This kit is supported by a pair of manuals and a large, easy-to-read schematic diagram. The main assembly/instruction manual is 143 pages long and contains everything you need to know about the SA-2500. The large (16 × 10½ in) pictorial manual provides you with detailed views of all assembly stages. There are also a few large sheets bearing detailed identification of strip-packaged components. Before beginning assembly of the kit, I had to make some changes and additions to the assembly/instruction manual and the accompanying pictorial manual. I later found a couple of schematic-diagram errors and notified Heath of them; these will be discussed later.

Getting It Together

This kit required approximately 27½ hours to assemble. "Stuffing" the circuit boards alone took me almost 12½ hours. Two circuit boards are included in the kit. A 7- × 3¼-in DISPLAY board contains a microcontroller, a four-digit gas display tube, several other ICs and supporting components. The MAIN board measures 12 × 4¾ in. This board contains a large number of components, and despite all precautions, it's easy to make a mistake — I speak from experience!

During construction, you may select a blue- or amber-colored digital readout for the inductor turns counter. I opted for the amber readout; it's simply a matter of installing an amber-colored filter on the backside of the front panel. Once the digital display was illuminated, however, I discovered the "amber" color is closer to green.

Assembly proceeded smoothly. In some instances, such as with the variable-capacitor ceramic end insulators and plate spacers, Heath supplied an extra piece for good measure. Only one part was missing: a cork washer for one of the large feedthrough insulators supplied by an outside vendor. Heath quickly sent not only the washer, but a new insulator package.

An adhesive-backed decorative label is used to cover the upper part of the front panel. This strip has plastic windows for the meters, a turns counter and inductor/capacitor action indicators. Before removing the paper from the adhesive backing, make sure the windows are clean. Otherwise, you may find too late that you've left fingerprints or dust on the inside of the windows.

If you have (or think you will have) need for balanced-line feed, I'd recommend you purchase the SA-2500-1 balun accessory with the SA-2500. It's a bit easier to install the balun as part of the initial construction process. Otherwise, you'll have to partially disassemble the '2500 to add the balun.

Adjustment and testing consumed approximately five hours — primarily because I ran into a bit of difficulty when it came to setting the inductor presets and the turns counter. Surely a design problem; I'd checked everything! But no, the problem was traced to a mix-up in installing R451 and R453. The first is a 4.3-kΩ resistor, the second a 432-Ω resistor. The first three color-coded bands are the same (yellow, orange, red), but the smaller resistor also has a black band immediately after the red one. How I managed to mix them up I don't know. Heath has done everything they can to help builders avoid that sort of error: The parts are cut one at a time from a strip during assembly, the installation steps are separated by the installation of two other resistors and the parts' locations are charted. In any case, this mix-up created two voltage-divider

problems which, in turn, made it impossible to correctly set the inductor presets.

Once the voltage-divider problem was cured, I had to redo the turns counter adjustment. Because of the tolerance of the potentiometers used in the turns-counter circuit, I found it difficult to get precise 00.0 and 40.0 turns indications on the digital readout, and had to perform the adjustment procedure several times. After the turns counter was set, the inductor preset adjustments fell into place.

But, alas, another builder-produced problem raised its head when it came to the automatic SWR circuit adjustment procedure. That problem was traced to an unsoldered resistor connection. That fixed, the '2500 was up and running.

The only adjustment area that may cause some builders concern is the automatic power-ranging circuit. This is because the recommended range change-over point is 200 W. Since most transceivers produce an output of only 100 W or so, you'll have to insert an amplifier in the line to bring the power level up to 200 W. You can set the change-over point at anything less than 200 W, however. Essentially, all you'll lose by doing so is a bit of resolution during power-output measurement, and that shouldn't present any real problems.

Heath SA2500 Auto-Tune Antenna Tuner

Manufacturer's Specifications	*Measured in ARRL Lab*
Frequency range: 1.8-30 MHz.	As specified.
Input power-handling capability: SSB, 2 kW (peak); CW, 1 kW.	As specified.
Wattmeter accuracy (full scale):	
200/2 kW FWD, 500 W REFLD, ±5% (avg.)	As specified.
50 W REFLD, ±7.5% (avg.)	As specified.
Insertion SWR: Less than 1.1:1.	0.05 dB.
Automatic tuning requirements: Cycle time, approx. 15 sec; input power level to obtain SWR SET, 35 W.	As specified.
Power requirements: 120-V ac, 250 mA (internal supply); 12-V dc, 1 A maximum (external supply).	
Dimensions: 6¾ × 14½ × 20 in (171 x 368 × 508 mm) HWD.	
Weight: 19 lb (8.6 kg).	

Performance

A comparison of the manufacturer's specifications and measurements made in the ARRL lab is shown in the accompanying table. Although my antenna requirements are modest (a tribander and a 40-meter dipole), I put the network through its paces matching those antennas on a multitude of frequencies for which they were not designed. (I don't recommend the practice of doing this with a tribander and lots of power — it could damage the traps.)

It didn't take me long to get accustomed to using the SA-2500. The preset inductor selections eliminate the need to rotate one of the controls, and the automatically controlled capacitors find their marks rapidly. If the BAND switch is placed in the REMOTE position, you must have a ground connection applied to one of the pins of the appropriate Molex connector. If you don't, the roller-inductor motor will be energized and will continue to attempt to turn the inductor — even when it reaches the rearmost position.

Because the preset inductor positions must be used to position the inductor when it's in the automatic mode, the nomenclature "automatic" may be inexact. As the SA-2500 is configured, it cannot automatically use the total roller inductor range during its attempts to match the transmitter to an unknown load. In this sense, "semi-automatic" seems more appropriate. Remember, you should use minimum power during the antenna-matching procedure. This will avoid possible component damage and lessen QRM.

Comments

I did find a couple of errors on the schematic diagram. Pins 3 and 4 of the optical interrupters are reversed. The instructions for connecting pins 1 and 4 of these devices (on page 71) are correct. Also, the indicated wire colors leading to the INDUCTOR POSITION control (R6) are mislabeled. Wire colors for lugs 1, 2 and 3 should be shown as WHT-ORG, WHT-YEL and WHT-GRN, respectively.

When manually controlling the '2500, you may find situations where you have to have a quick finger on the switches. This would occur, for instance, if you want to bring the SWR-meter needle as close to zero as possible; you may pass through the minimum SWR point a couple of times before you're satisfied. Also, when you're nearing the ends of the roller inductor, you'll want to be sure not to overshoot the end turn and disengage the roller. With a bit of practice, using up/down switches instead of cranking knobs becomes second nature.

Heath cautions that the inductor roller should not be run past the end of the wire turns at either end. This is good advice, as the motor does not have enough torque to bring the roller back onto the wire turn. Therefore, you'll have to manually reposition the roller should you fail to heed the warning. This detracking problem has been around since the advent of the SA-2040, and it's unfortunate that nothing has been done to prevent this from happening. I attempted to solve the problem by placing large solder blobs at both ends of the inductor turns. So far, this modification has proven effective. If you should decide to do something similar (remember your warranty!), be careful not to get solder between the inductor turns, and do not make the blob too large — it may interfere with the inductor support bars or the shoulder of the roller and prevent the roller from advancing.

During my main-circuit-board troubleshooting experience, I found it difficult to get to the bottom side of the board without unsoldering the five leads connected between the board and the SWR/wattmeter circuit. To make access a bit easier, I cut the connecting cable in half and installed a 6-pin (one pin unused) Molex connector. (These are available at Radio Shack; part numbers 274-226 and 274-236.) Then all I had to do was unplug the connector, leaving the soldered connections undisturbed, and I had free access to the bottom of the board.

Shortly after the SA-2500 was placed in operation, the antenna-capacitor indicator lamp failed. Though I searched three parts catalogs for a listing of the no. 2174 lamp and its current requirements, I could not find one. Some replacement bulbs were requested from Heath and arrived promptly. I was informed by Heath that the lamps each draw 40 mA! That surprised me. The 12-V, 25-mA bulb available from Radio Shack (272-1141) might be a suitable replacement.

There are some transceivers that feature built-in automatic antenna-matching networks, but these are limited to a maximum power-handling capability of 100 to 200 W. If you're going to be running much more power than that, want a heavy-duty matching network and are looking for automatic (or semiautomatic) control, you should consider the SA-2500. It's available from the Heath Company, Benton Harbor, MI 49022, tel. 800-253-0570. Price class: SA-2500, $600; SA-2500-1 balun accessory, $40. — *Paul K. Pagel, N1FB*

KLM ELECTRONICS, INC. 2M-16LBX 2-METER BEAM

☐ As interest in VHF operation grows, so does interest in high-performance VHF antennas and equipment. KLM is no stranger to the VHF crowd. This California-based company has been known for high-performance antennas for the past decade. Over the years, KLM antennas have grown in length and changed in design; these improvements are reflected in the 16LBX.

This antenna is based on design and development work done by DL6WU, whose high-performance beams are widely known in Europe. Amateurs on this side of the Atlantic have recently become familiar with his work, and KLM is the first U.S. manufacturer to bring these high-gain, low-side-lobe designs to the marketplace.

The 2M-16LBX arrived at ARRL Hq. in a surprisingly small package. The elements were securely bundled together, and the hardware was packaged in separate bags, so it didn't take long to determine that everything was present and accounted for. KLM included an itemized packing slip that was checked off as the box was packed at the factory, further ensuring a complete antenna. Nothing is more frustrating to a builder anxious to get a new antenna into the air than missing parts.

Hardware

KLM provided first-class hardware with this antenna. The nuts, bolts and lockwashers are all stainless steel. All holes were deburred, and the general machine work was above average for a commercially manufactured antenna.

The 2M16LBX features a tapered 28-ft boom.[1] The tapering is said to reduce wind loading while

[1]m = ft × 0.3048; mm = in × 25.4.

providing adequate strength. The center of the boom is made from two 5-ft lengths of 1½-in-OD aluminum tubing spliced with a 2-ft section of 1-3/8-in-OD tubing. One end of each 1½-in section is swaged to accept a 5-ft section of 1¼-in OD tubing. The 1¼-in sections are in turn swaged to accept 5-ft sections of 1-in-OD tubing.

A 3/16-in-thick aluminum plate comprises the boom-to-mast bracket. Plated steel U-bolts and saddles (with stainless-steel nuts) secure the plate to boom and mast. The mast U-bolts provided fit pipes ranging from 1½ to 2 in OD. A truss made from nonconductive guy cable supports the boom. This truss attaches to the mast approximately 1 foot above the boom and is necessary to prevent boom sag. Turnbuckles allow proper tensioning of the boom support cables.

All parasitic elements are made from 3/16-in aluminum rod. These elements are mounted through the boom and are insulated from it by plastic shoulder washers — a big improvement over previous KLM element-mounting schemes. Pushnuts secure the elements once they are in place.

The 16LBX employs a log-cell driven element to achieve a low SWR across the band. The two driven elements are interconnected by aluminum straps. These elements, made from 3/8-in aluminum tubing, mount on top of the boom and are insulated from it by molded plastic blocks. The feed-point impedance is 200 ohms, so KLM includes a 4:1 balun made from RG-303 coaxial cable. This cable features silver-plated conductors and Teflon dielectric, so it weathers well.

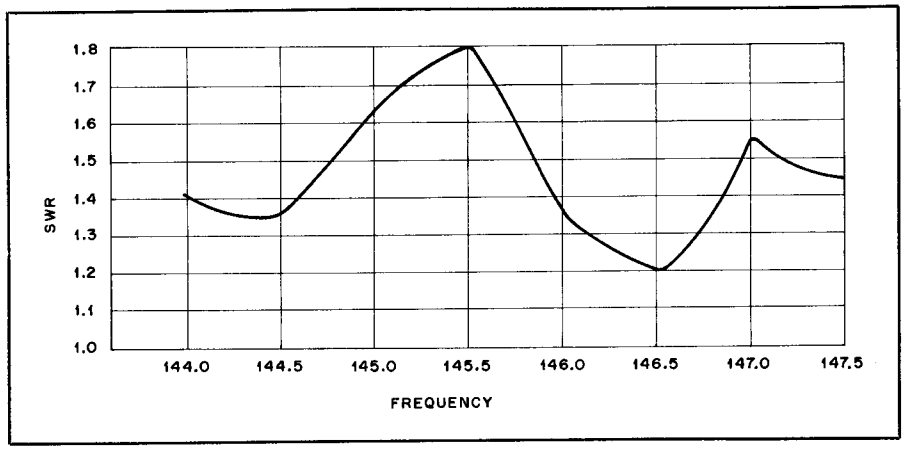

Fig. 3 — SWR curve of the KLM 2M16LBX 2-meter beam.

KLM 2M16LBX 2-Meter Beam

Manufacturer's Claimed Specifications	*ARRL Evaluation*
Frequency of operation: 143-148 MHz.	As specified.
Longest element: 40.625 in.	As specified.
Boom length: 28 ft 1 in.	As specified
Weight: 10 lb.	As specified.
Turning radius: 185 in.	As specified.
Wind load: 1.75 sq. ft (horizontally polarized); 2.44 sq. ft (vertically polarized).	Not measured.
SWR: Not specified.	See Fig. 3.

Assembly

It took me about three hours to assemble the 2M16LBX. The instruction manual is clear, and there are sufficient illustrations to guide the builder. The boom is assembled first. Although the tubing did not fit together snugly, the boom was sturdy once all the hardware was tightened. I was pleased to see that all of the holes were drilled properly, so the screws went in easily.

The parasitic elements taper continuously — that is, the reflector is the longest element, and the elements get progressively shorter; the last director is the shortest element. This feature made it simple to determine which element went where. It eliminated the tedious and accurate measurements usually associated with VHF antennas. The insulators fit snugly, so the elements feel secure.

The only departure I made from the manual was the way I centered the elements in the boom. KLM supplies a chart showing the center point for each element. Rather than try to measure from element tip to the center of the boom, I measured the length of element protruding from each side of the boom and adjusted the element until the length was equal on each side. I was able to center each element perfectly with minimum work.

After completing the element and boom assembly, I put some RTV silicone sealant over each nut to keep the hardware in place. The coaxial feed line connects to solder lugs, so it is especially important to do a good weatherproofing job to keep water out.

Installing the 2M16LBX was easy. Although the antenna is long, the short elements make it easy to guide around guy wires. The boom is quite flexible without the truss, so I had to be careful not to place excessive stress on it. I installed the review antenna above a 20-meter Yagi at 110 feet and fed it with 130 feet of hardline.

On-the-air testing indicates that KLM has a real winner here. During the review period, I worked many stations in the first, second, third and fourth call areas, as well as in VE1, VE2 and VE3. The pattern is clean, so I have little trouble hearing weaker stations even with several "big gun" 2-meter stations within my line of sight.

If you're after a high-performance 2-meter antenna, this one's worth a close look. Price class: $120. Manufacturer: KLM Electronics, Inc., P.O. Box 816, Morgan Hill, CA 95037. — *Mark Wilson, AA2Z*

Strays

***QST* congratulates...**

☐ the following radio amateurs on 50 years as a member of ARRL:

- Kermit R. McCardle, W4BTA, of Louisville, Kentucky
- John V. Ellison, WØERZ, of Kirkwood, Missouri
- Albert C. Gifford, K4DUZ, of Bradenton, Florida

RTTY ART CONTEST

☐ Are you a RTTY operator with a creative streak? The Wireless Institute of Australia is sponsoring the International RTTY Art Competition as part of its 75th anniversary celebration. Entries must not contain more than three underlinings, and must be submitted with a hard-copy printout and Baudot tape. The three categories are best hand-generated original RTTY picture by a non-VK; best hand-generated original by a VK; and best hand-generated or computer-generated nonoriginal. Entries, which must be received no later than August 31, 1985, should be sent to WIA 75 RTTY Art Competition, Wireless Institute of Australia, 412 Brunswick St., Fitzroy, Victoria 3065, Australia.

ROANOKE PLANNING SESSION MAY 11-12

☐ This year's Roanoke Division League Planning Session, sponsored by the Raleigh and Cary North Carolina Radio Clubs, will be held May 11-12 at the Ramada Inn South, U.S. Hwy. 1, Apex, North Carolina. Among the topics to be discussed are ARRL Section-level activities, technical and legal matters, and the Volunteer Examiner Program. All ARRL members are invited, and clubs are urged to send a representative. Preregistration information is available from LPM-85, Sherman Starnes, W4TZU, Rte. 1, Box 99, Franklinton, NC 27525.

I would like to get in touch with...

☐ any amateurs capable of working space communications who are interested in assisting with a research project. Independent Space Research Group, P.O. Box 1246, Troy, NY 12180.