Product Review Column from *QST* Magazine

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Cushcraft 32-19 "Boomer" and 324-QK Stacking Kit

Datak Titles

Heath SA-2040 Antenna Tuner

Optoelectronics TRMS-5000 DMM/Thermometer

Tedco Model 1 QRP Transceiver

Product Review

Conducted By Paul K. Pagel,* N1FB

Optoelectronics TRMS:5000 DMM/Thermometer

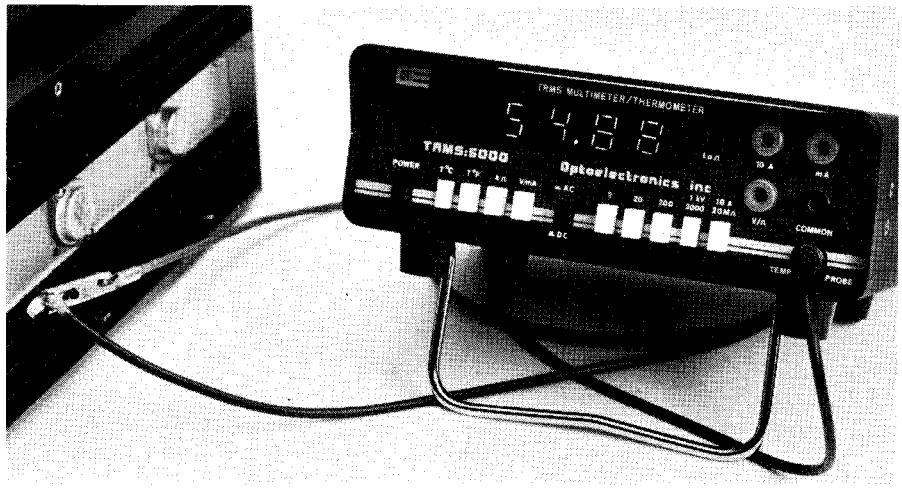
The TRMS:5000 is a digital VOM and thermometer having 4-1/2 digits of resolution. The "half" means that the most significant digit can only be a "one" or a "zero," and if it's a zero, it's blanked. It can measure voltages up to 1-kV dc or ac (pk-pk), currents up to 10 A, resistances up to 20 mΩ, and temperatures from −50 to +150° C (−67 to 200° F). The '5000 is a laboratory-grade instrument and is guaranteed to hold calibration for one year.

The letters in the model designation mean "true root-mean-square." Typical VOMs have rectifier circuits to convert ac to dc for measurement and display. These circuits usually produce a dc voltage equal to the *average* ac amplitude. For a pure sine wave, rms and average are the same thing. In other waveforms, that's not the case. The ratio of the peak voltage to the rms voltage is called the *crest factor*. A sine wave has a crest factor of $\sqrt{2}$. The TRMS:5000 displays the true rms voltage of waveforms having crest factors up to three.

An abbreviated table of specifications appears with this review, but if you're not familiar with DMMs, the specs can be confusing. Several factors affect the accuracy of the meter, including errors in the voltage reference source, the A/D converter, the time base and the attenuator network. An accuracy specification (such as ±0.04% + one count) accounts for all of the possible sources of error. If the meter reads 1.5000 V, the actual voltage could be as low as 1.4993 or as high as 1.5007. The *resolution* (100 μV) exceeds the accuracy of the measurement. If somebody offers you a meter having 1 microvolt resolution, don't get excited, because unless it has comparable accuracy, the last few digits are worthless. The last digit of the TRMS:5000 is useful for monitoring relative voltage changes. A meter having one more meaningful digit would cost at least twice as much as the TRMS:5000 because it would need a temperature-controlled reference element and a TCXO or crystal oven in the counter time base.

Successful use of test equipment requires an understanding of its limitations. For current measurements, Optoelectronics specifies a *burden* of 2 volts, meaning the TRMS:5000 may introduce 2 volts of potential drop in a series circuit. You couldn't use a 10-A range to monitor the current drain of your mobile transceiver, because the voltage drop would radically alter the ouput impedance match and cause the transceiver to draw less current and possibly malfunction. A better way to employ the TRMS:5000 in this application would be to install a calibrated brass shunt in the power lead and monitor the voltage across it. A couple of volts won't make much difference when measuring the plate current of a tube type of transmitter, but you can run into trouble here too if you're not careful. The "common" measurement terminal is floating with respect to the chassis.

*Assistant Technical Editor



A tilt-up bail brings the TRMS:5000 readout to a convenient level during use. In this photograph, the unit is being used to measure the heat sink temperature of a 25-A power supply. The display indicates 54.88° C.

Optoelectronics TRMS:5000

Abbreviated Manufacturer's Claimed Specifications

Dc voltage

Range	*Accuracy*
2 V	± (0.04% + 1 count)
up to 1000 V	± (0.04% + 2 counts)

Ac voltage (45 Hz - 10 kHz)

Range	*Accuracy*
all up to 1000 V	± (0.35% + 15 counts)

Crest Factor: 3
Useful frequency range: 45 Hz to 250 kHz

Current

Frequency Range	*Accuracy*
Dc	± (0.6% + 2 counts)
45 Hz to 10 kHz	± (1% + 2 counts)
10 kHz to 40 kHz	± (1.5% + 2 counts)

Temperature

Range	*Resolution*	*Accuracy*
−50 to +150° C	0.01°	±0.5°
−67 to +199° F	0.01°	±0.9°

General

Maximum input voltage: 1040 V pk-pk
Input impedance: 10 MΩ in parallel with 80 pF
Temperature and time range for rated accuracy: 18 to 28° C for one year.
Power requirements: 9 to 12 V dc @ 300 mA (wall-plug supply comes with meter)
Dimensions: 3-1/4 × 7-1/4 × 6-3/4 inches (83 × 184 × 171 mm) (H × W × D)
Weight: 2 lb (0.9 kg)
Price class: $300
rechargeable battery option: $25
Supplier: Optoelectronics, Inc., 5821 N.E. 14 Ave., Ft. Lauderdale, FL 33334, Tel. 1-800-327-5912.

You can ground the chassis for noise reduction purposes, but the common terminal can withstand only 600 V with respect to the chassis. If you measure current in a high-voltage lead, enclose the meter in a plastic bag and power it with batteries.

Resistance measurements on the 20-MΩ range call for some patience, because the settling time is about 10 seconds. Readings taken on the lower ranges stabilize in two seconds or less. A rear-panel switch selects resistance probe potentials of 0.5 and 1.5 volts. The high-voltage position provides the greatest accuracy, but the low-voltage feature is useful for in-circuit measurements without forward-biasing-silicon semiconductor junctions. A front-panel LED alerts the operator to the low-voltage condition.

The thermometer function is fairly simple but not completely goof proof. The case of the temperature transducer can survive 200 volts with respect to the voltmeter common. To use the probe over its full rated temperature range, you should replace the cable with a Teflon one. The owner's manual advises avoiding strong acids when using the temperature probe. I assume this means don't dunk it in your pc-board etching tank.

Checkout

What about the meter's electromagnetic compatibility — how will it get along in your ham shack? The time base for the A/D converter and counter begins with a 3.84-MHz crystal oscillator. (They could have picked a better frequency!) The signal radiation isn't strong though, and grounding the DMM chassis to my transceiver made the signal drop into the noise. My real concern was the 555 timer operating at 20 kHz for the negative power supply. I searched for 20-kHz markers throughout the hf bands but didn't hear any. I

did hear some white noise, but that too disappeared when I connected the DMM chassis to the transceiver. The meter wasn't disturbed by 50 watts of rf on all hf bands.

A DMM can't replace your old, trusty analog VOM in every application, but it can certainly increase the number and accuracy of the electrical measurements you make. If you acquire an Optoelectronics TRMS:5000, you will have a professional instrument with which to advance the state of the amateur art. — *George Woodward, W1RN*

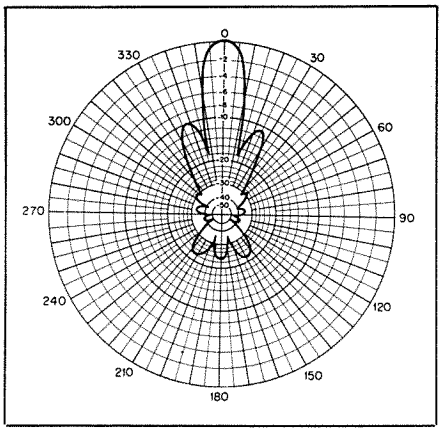
[Editor's Note: The instrument submitted for review was in kit form. Shortly before the review was originally scheduled to appear in this column, we were informed that, because of several engineering and other changes, the kit version was being discontinued. Optoelectronics has offered buyers who reference this *QST* review a discount price of $270 for the factory assembled TRMS:5000, complete with a one year parts and labor guarantee.]

CUSHCRAFT 32-19 "BOOMER" AND 324-QK STACKING KIT

☐ Moonbounce, or EME (earth-moon-earth) communication, requires a transmitting, receiving and antenna setup which can bridge a round-trip distance of about 450,000 miles (725,000 km) and also make up for the losses caused by the moon's surface being a very imperfect reflector. Also, as I was about to discover, it requires a great deal of patience.

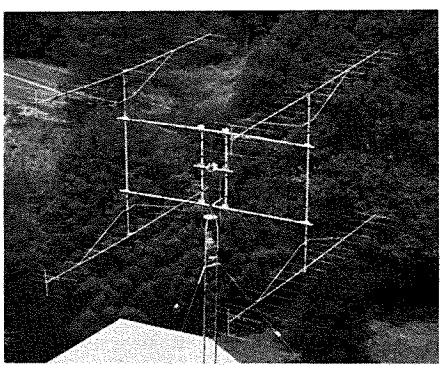
Cushcraft supplied four 19-element antennas and a 324-QK stacking kit, which consists of an "H" frame of 2-inch (51-mm) and 1-7/8-inch (47.6-mm) aluminum tubing and an RG-8/U coaxial cable harness and power divider for combining and phasing the four antennas. The frame spaces the antennas 14 ft (4.25 m) horizontally and 12 ft (3.66 m) vertically. Materials are furnished for weatherproofing the cable connectors, which is a very nice touch. The cables are all precut and terminated in male uhf connectors. Each antenna weighs about 12 pounds (5.5 kg). The hardware is all stainless steel, and all of the elements (with the exception of the driven element) are 3/16-inch (4.76 mm) solid aluminum rod. On the driven element, which is made from 1/2-inch (12.7 mm) aluminum tubing, a T match replaces the old gamma match used on earlier Cushcraft designs. The boom of each antenna is 3.2 λ long, or 22 feet (6.7 meters), and is made from 1-1/8-inch (28.6-mm) and 1-inch (25.4-mm) dia tubing. Fifteen directors, the driven element, and one reflector are spaced evenly along this boom, and two more reflectors are mounted above and below the boom at the rear of the antenna. A boom brace is provided to keep the boom from sagging. Presence of the brace means you cannot mount the antenna for vertical polarization, but Cushcraft has other models for the fm operator. The 32-19 is not intended to be used above 146 MHz.

Assembling the first antenna took more than two hours, but by the time the third and fourth were being put together our time was down to 1-1/4 hours unassisted and 45 minutes with two of us working together. That was the easy part; the difficult part was getting the whole assembly to the top of the 70-foot guyed tower. After that, we had a 90-pound (45.4 kg) aluminum array, occupying almost 5000 cubic feet (140 m^3) of air space, to wrestle into place on the elevation rotator which was already bolted to the mast. (As supplied, the "H" frame is designed for mounting on a vertical pipe with a diameter of up to 2 inches (50.8 mm). Some additional tubing and brackets are needed to mount it on an elevation rotator.) Most moonbouncers have the good sense to mount their antennas less than 20 feet (6 m) off the ground; now I know why!



This diagram shows the radiation pattern at 144.15 MHz of the array of four Cushcraft 32-19 "Boomers" as installed at K1ZZ. For this test, a signal was fed into a 3-element Yagi mounted at the same height as the center of the array (72 feet, or 22 meters), and about 30 wavelengths away. Then a laboratory 1-dB step attenuator was used to maintain a constant S-meter reading on a receiver connected to the array under test as the array was rotated. The pattern shown is reasonably representative of the array's performance, but tests performed under different conditions might yield slightly different results. Numbers around the perimeter indicate degrees; the concentric scale represents dB relative to the peak of the major lobe. See July 1980 *QST*, page 26, for an explanation of this method of depicting antenna patterns.

By the time everything was tightened down it was getting dark, the ARRL International EME Contest was about to start, and we had not had time to hook up the W1VD-designed low-noise preamp and transmit-receive relay system which was to be mounted at the top of the tower. (You'll have to wait for the 1981 *Handbook* for details on that!) So, we spent the couple of hours before moonset listening with the preamp down in the shack at the wrong end of about 2 dB of feed-line loss. Even with that handicap, we were elated to hear W7FN in Washington and a couple of other stations which could not be positively identified because of fading. About the only problem we had with the antenna was that it was not perfectly balanced mechanically; the elevation rotator could go up but had a tough time coming back down to the horizon. This was remedied by adding a counterweight on the front of the array.



This view of the four Cushcraft 32-19 "Boomers" as installed at K1ZZ was taken from the 90-foot level of another tower on the property. Two 6-foot (1.8 m) lengths of 2-inch (50.8 mm) aluminum tubing (not supplied with the 324-QK stacking kit) are used to mount the array on the elevation rotator. *(W1VD photo)*

From the first, we were hearing signals very well — once the preamp was put at the antenna where it belonged, part-time listening over the two contest weekends yielded positive identification of a dozen stations, and partial calls on a number of others which we could have deciphered had we known who was active on the band. However, with more than 500 watts at the antenna we had heard our own echoes just once and had made no QSOs, though we had answered some CQs during the contest. The problem was *fading*, caused by changes in polarization as the signal passed through the ionosphere (Faraday rotation). Somewhat disappointed, we checked in with the 2-meter EME group that meets on 14.345 MHz at 1700 UTC on weekends. The welcome we received could not have been warmer. Conditions aren't very good at the moment, we were told; the fact that you're hearing *anything* means the system is working. A couple of people who obviously did not need Connecticut volunteered to run schedules, and on the third try we had a solid exchange with VE7BQH in the log and on tape, followed almost immediately by W7FN. Then K4PKV (who also uses four Boomers) asked for a sked on the fourth of July, and we celebrated the day with another QSO — our first with a station using an antenna as "small" as ours. EME provides "the ultimate antenna test range" — and, obviously, our tests with the Boomer show that it works!

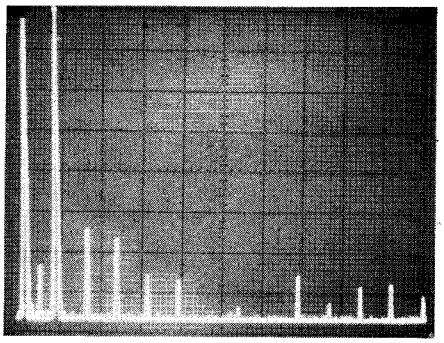
Not too many people are going to make an investment like this just to try 2-meter moonbounce, so we wanted to see how well the antenna would work in normal terrestrial operation. We were a bit skeptical because of the narrow beamwidth: As you can see from Fig. 1, if the antenna is pointed more than 5° off the mark, you're well down the side of the major lobe. From Hartford, this means that if the array is pointed toward northern New Jersey you don't hear much from southern New Jersey, and vice versa. This makes round-table QSOs a bit tricky! On the other hand, for weak-signal DXing there is no substitute for antenna gain, and there's not way to *get* gain without compressing the main lobe. We didn't have time for a full effort in the June VHF QSO Party, but two hours of multiplier hunting on cw late Saturday afternoon yielded 21 sections. And K8NXI in Ohio popped through with his 100 watts the following morning. The only other New England station he worked on 2 meters in the contest was W2SZ/1, a station with a 3400-foot (1036-m) height advantage! The disappointment of the weekend was missing what should have been an easy North Carolina multiplier, probably because the antenna was seldom pointed that far south.

For most of us, one or two Yagis is all that's manageable for 144 MHz. We haven't tried the Boomer in that configuration, but for a four-bay array to work this well, each antenna must be an effective performer by itself. Of course, the mechanical problems of installing and rotating a smaller array would be much less, and the expense of the H frame would be eliminated. As supplied, the T match is set up

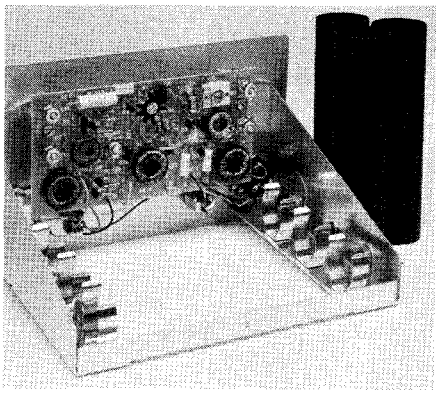
for 50-ohm unbalanced feed, but it could be readjusted for 75-ohm feed if there were some reason for doing so. Incidentally, as installed the antenna met the manufacturer's SWR claims of 1.2:1 or less, and it was essentially flat across the 2-MHz bandwidth.

The 32-19 Boomer is a high-performance antenna made with high-quality hardware which, if properly installed, should give years of effective service. You don't need to work moonbounce to appreciate its performance, but the fact that four of them make an effective EME system should remove any doubts as to its capabilities!

Retail price class of the individual antennas is $100, and of the stacking kit, $440. Manufacturer: Cushcraft Corporation, P. O. Box 4680, Manchester, NH 03108. — *David Sumner, K1ZZ*



Spectral output of the Tedco Model 1. Vertical divisions are 10 dB; horizontal divisions are 5 MHz each. Indicated power output is 1 watt at a frequency of 3750 kHz. The second harmonic is approximately 54 dB down from the fundamental. The Model 1 complies with current FCC specifications regarding spectral purity.



The inside of the Tedco Model 1. The complete transceiver is on the single pc board. To the right of the unit are the tubes into which the batteries are placed and set inside the chassis battery clips.

TEDCO MODEL 1

☐ Tedco's Model 1 is a QRP cw-only transceiver that operates within the Novice portion of the 80-meter band. The unit covers the frequency range of 3685 to 3755 kHz. As may be seen in the photograph, the entire transceiver, with the exception of the battery supply, is contained on a single glass-epoxy pc board. The unit is housed in a wooden enclosure covered with wood-grained vinyl. Nine D-cell batteries (not supplied) are divided among three cardboard tubes and placed in the three rows of battery clips provided on the chassis rear. The instruction manual is lengthy and includes a complete circuit description, initial checkout procedures, operational hints, and maintenance and troubleshooting information.

Tedco Model 1

Manufacturer's Claimed Specifications	*Measured in ARRL lab*
Rf power output: 0.5 watt.	1 watt into 50-ohm load.
Harmonics: More than 30 dB down.	More than 54 dB down.
Frequency drift: Less than 30 ppm/° C	Less than 30 ppm at room temperature.
Chirp: Less than 10 Hz.	30 Hz.
Receiver sensitivity at 50 ohms: Less than 1 μV for 10 dB S + N/N	≤1 μV @ 50 ohms.

Size: 5 × 9 × 8 inches (127 × 229 × 203 mm) HWD.
Weight: 1 pound.
Price class: $80.
Manufacturer: Tedco, 9 Canonicus Ave., Newport, RI 02840.

The Receiver Section

The receiver is a direct-conversion type employing a total of six transistors: Two operate as a common-base differential-pair rf amplifier, two are in a similar configuration as a product detector and the last two comprise the audio amplifier stages. A simple L-C audio filter is centered at a frequency of 750 Hz. A BEAT SELECT control (RIT) permits tuning the receiver independently ±750 Hz from the transmitted (center) frequency. The tuning of this control is quite smooth.

Headphone operation is dictated because of the low audio power output (5 mW) available. Monaural 'phones with each earpiece presenting an 8-ohm impedance are recommended to be used with a 1/4-inch (2.5 mm), three-conductor plug (not provided). If a two-conductor plug is used, it is inserted only part way into the jack. This is inconvenient, however, as the plug will not fit snugly into the jack, and movement of the headphone cord causes the plug to lose contact. The result: no audio. After a while, this can become quite aggravating. The T-R switching is arranged so that the built-in sidetone signal will be heard in the headphones during transmitter keying.

The Transmitter Section

A single FET is used in the master-oscillator circuit, which operates as both the VFO for the transmitter and the BFO for the receiver. One pole of the toggle switch used for the T-R switch selects either one of two capacitors to ensure that the receive and transmit frequencies are the same when the receiver BEAT SELECT control is set at zero (mid-position).

Following the VFO is a single IC (CA3020A) which furnishes both the buffer and final amplifier stages for the transmitter. The output transistors of the IC will deliver 1/2 watt of output power. A single transistor is used to generate a 750-Hz sidetone signal during keying.

The antenna output coupling is geared toward balanced loads with a 300-ohm impedance; the operator is cautioned against creating an unbalanced condition. (Such a restriction appears to be an inconvenience to most station operations since the use of low-impedance unbalanced coaxial lines is quite prevalent today. There is a way to accommodate the use of coax, however, which will be explained later.) Components to construct a peak-reading rf voltmeter are included with the transceiver to aid in transmitter tune-up.

Operation

Tedco advises not to use an ac-operated power supply with the Model 1 because of the susceptibility of the unit to hum pickup. This was verified at my station. When an attempt was made to use such a supply, the audible hum in the headphones masked most of the incoming signals and made operating intolerable. Attempting to connect everything to one common station ground resulted in ground loops which made conditions even worse. Battery operation eliminated the hum problem entirely.

Since my station is geared to the use of 50-ohm coaxial cable, it was necessary to change the 300-ohm balanced output to 50-ohm unbalanced. This was accomplished by unwinding 6 turns of the output link from the toroid and using a 1:1 balun. (This procedure does add another lossy element to the picture, however — an undesirable circumstance when QRP operation is contemplated.) There is no antenna-connection jack at the rear of the cabinet: The antenna connecting leads must pass through the rear of the cabinet to thumbscrew terminals on the pc board; the key-lead connections have to be similarly made.

It was noted that hand capacitance affected the VFO frequency slightly. Attaching a station ground to the chassis reduced this effect. Maindial accuracy is quite good, well within 1 kHz. The transmitter will transmit with the T-R switch in the receive position, but this is immediately noticeable since there is no sidetone audible and keying clicks (because of receiver overload) are evidenced in the headphones.

Observations

Operating in the Novice portion of the 80-meter band on a weekend evening with this amount of power and a direct-conversion receiver is quite a challenge. Although this unit is intended for the Novice operator, I'd definitely not recommend it for the *beginning* Novice — he or she usually has enough things to think about during the first 100 or so QSOs without having to resort to as-yet-unlearned QRP operating skills. Skilled, "bare bones" QRP operators might like the challenge. — *Paul K. Pagel, N1FB*

HEATH SA-2040 ANTENNA TUNER

☐ It took approximately eight hours to bring the SA-2040 from shipping carton to finished product. Before assembly began, a number of corrections had to be transferred from the errata sheet and pages had to be added to the manual. From that point on, the whole process flowed smoothly. Nary a nut or bolt was missing from the kit; in fact, a few extra parts were included. Even an extra capacitor-mounting insulator is supplied in case you fail to heed the

frequent warnings about tightening the hardware and manage to break an insulator in the process. The two capacitors and some of the roller coils require assembly.

The front-panel mask has a self-adhesive backing and is made of a material called "matte clear vinylite." It really dressed up the tuner and has provisions for adding the station call letters and control-position information, which may be jotted down on an erasable logging scale. The decor is black and gray, not the usual Heath green you've been used to seeing.

Large knobs on the capacitor and inductor shafts, along with well-lubricated bearing surfaces and tension adjustments on the capacitors and inductor make control tuning quite smooth. A three-digit turns counter is coupled to the rotary inductor and driven by a pair of right-angle nylon gears attached to the controlling shafts. The rotary inductor is factory wound on a fiberglass form, and the interconnecting strapping between the major components is silver plated. Two cores, fiberglass tape and Teflon-covered wire are supplied to construct a 4:1 balun. Large feed-through insulators are provided for balanced-wire and single-wire outputs in addition to SO-239 coaxial input and output connectors. No internal bypass switching is provided.

Putting It To Use

Heath frequently stresses (in bold print) the use of control settings which use the most capacitance of both capacitors; this delivers the best harmonic attenuation. With certain antenna systems, one may find several different control combinations which produce a matched condition. However, one or more of these settings may provide little harmonic attenuation. Approximate control positions for each band (80 through 10 meters) are given in the manual for use as a starting point.

Heath's advertised specifications state that the '2040 has a "wide range" of output impedance-matching capabilities. During some initial testing, two "soft spots" showed up. Arcing occurred between the capacitor plates when attempting to match a load on 80 meters at the high-power level. The arcing was traced to improper rotor and stator plate alignment, not a fault of the tuner. After readjustment, no arcing occurred during a similar test. (The load, as was later discovered, was not within the range of impedances Heath had in mind.)

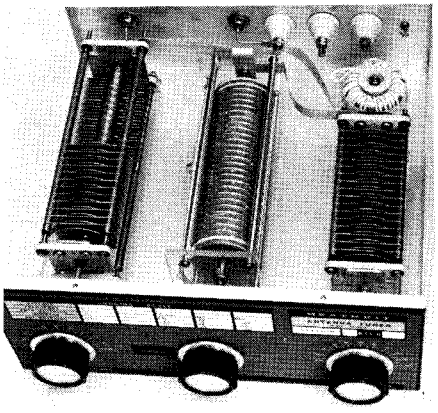
During a check of balun operation on 10 meters, the unused coaxial-output-connector insultion melted and burned briefly with a visible flame during a prolonged key-down, high-power test. Heath was notified of the situation. Simultaneously, I requested more-specific information about the impedance-matching range of the tuner. The persons to whom I spoke were quite helpful. It was learned that a similar coaxial connector failure had occurred during a field testing of another unit by one of the Heath employees and that the coaxial connectors to be supplied with later production units would have Teflon insulation. Units still in stock are supplied with the other type of connector, however, so it would behoove the prospective owner of a '2040 to check the output connector and replace it if necessary with the Teflon-insulated type as a precaution.

The detailed specifications for the SA-2040 provided by Heath are shown in the accompanying table. Lab tests showed that the Heath specifications are met. On 80 meters, insertion loss measured 0.24 dB with a 50-ohm resistive load, and the balanced-line output showed 0.6 dB of imbalance with a 250-ohm load at the terminals.

Depending upon the amount of reactance encountered with the antenna system in use and the transmitter output power level, the matching ranges of the '2040 may be exceeded without harm to the unit. Large mismatches should be avoided in any case, as they tend to increase losses within the matching network. — *Paul K. Pagel, N1FB*

Heath SA-2040 Antenna Tuner

SA-2040 Manufacturer's Claimed Specifications	*ARRL Lab Results*
Frequency range: 3 to 30 MHz.	All specifications met or exceeded (see text).
Power-handling capability: Full legal limit.	
Input impedance: 50 ohms (at matched conditions).	
Impedance transformation, 4:1 balanced line output: 100 to 1000 ohms; unbalanced output: a maximum SWR of 10:1, or impedance-matching range of 50 to 500 ohms; single-wire output: 6:1 SWR, using an odd-multiple 1/4 wavelength of wire.	
Size: 5-5/8 × 14-13/16 × 13-15/16 inches (143 × 556 × 354 mm) HWD.	
Price class: $150.	
Manufacturer: Heath Company, Benton Harbor, MI 49022.	



The interior of the Heath SA-2040 is neat and uncluttered. A heavy-duty ceramic insulator is used to support the balun, visible at the rear of the chassis.

DATAK TITLES

☐ Have you ever wondered how the fellows in the ARRL lab manage to make the *Handbook* and *QST* projects look so good? Wish you could do it at home in your own workshop? You can! A simple paint job using spray paint goes a long way toward producing a professional-looking job. The final touch, labeling the controls and switches, is a cinch — if you use dry-transfer labels and titles. While a number of different manufacturers are marketing dry-transfer letters, Datak Corporation has a line of letter sets and titles especially suited to Amateur Radio and other electronic projects.

After using Datak dry transfers on several new projects for the 1981 ARRL *Handbook*, I find Datak's "Titles for Electronic Equipment" (cat. no. 9581 and 9591), "Meter, Dial and Switch Marking Set" (cat. no. 968) and the 1/8-inch (3.2-mm) alphabet sets to be the most useful for general work. Alphabet sets are also available in 1/4- and 1/2-inch (6.4- and 12.7-mm) sizes in white, black and gold.

Using the dry-transfer letters is easy if you work carefully. They must be aligned properly the first time. Once they have been pressed in place, moving them is impossible. They are best applied after painting but before any controls or switches are mounted. I place a sheet of paper over the panel, taped to the unpainted edges. This protects the paint and serves as an alignment guide. With the letter in position, rubbing it lightly will transfer it to the panel. When all the labels have been applied, burnishing them by placing a sheet of paper over them and rubbing the surface will fix them firmly in place.

In addition to the letter and title sets, Datak has a wide variety of other useful products, such as dry-transfer, etch-resist patterns and tapes, as well as etchant for making printed-circuit boards.

The process for making a board with these products is simple. A copper-clad board is first carefully cleaned, then the required patterns for transistors and ICs are applied directly to the copper surface. This is done in the same manner that letters are applied to a panel. Inter-connections are formed by applying etch-resist tape between the pads. When the circuit layout is complete, the board is placed in the etchant bath. Half an hour later, the finished board, ready for drilling, is removed. The only difficulty I have had with this method of making circuit boards is a slight under-cutting of the etch-resist tape. Careful application of the tape will minimize the problem.

All of these products are described in the Datak catalog in addition to many other marking sets, drafting aids and materials for making your next workshop project look as good as it works. Datak products are available at many electronic parts suppliers and through most major mail-order supply houses. Price range for the title and letter sets: $1.50 to $6. Datak Corporation, 65 71st St., Guttenberg, NJ 07093. — *George Collins, ADØW*

Some of the Datak products designed to help your latest project acquire a professional appearance.