A Two-Band Half-Sloper Antenna

When an off-the-wall empirical design like this works well, suspicion and skepticism are warranted. Maybe you'll agree that this sloper idea is an exception!

By Gary E. Myers,* K9CZB

The popularity of the half-sloper antenna seems to be increasing, as evidenced by recent articles in *QST*.[1,2,3] This type of antenna has some worthwhile advantages, particularly for the lower frequency operator — low-angle radiation for antennas of modest height, compactness and simplicity of construction. On the minus side, narrow bandwidths and difficulties in resonating the system have been reported.[3]

The antenna system to be described here evolved from a simple-minded attempt to design a two-band half sloper for 80- and 40-meter operation. A trap-type of antenna was selected as the design basis because of previous experience with trap antennas and because the inductive loading of the trap on the lower-frequency band allows a somewhat shorter overall length. The same inductive loading, however, was also expected to increase the antenna Q and thereby further decrease the bandwidth. For this reason I was prepared to experiment.

It is well that I was so prepared because the final form of the antenna bears little resemblance to the initial concept. But most interesting — and exciting — is the impressive bandwidth on 80 meters.

The Design

A diagram of the two-band half-sloper antenna system is shown in Fig. 1. It can be seen that there is no obvious quarter-wave dimension in the entire system. In fact, the radiator itself is a nonresonant device.

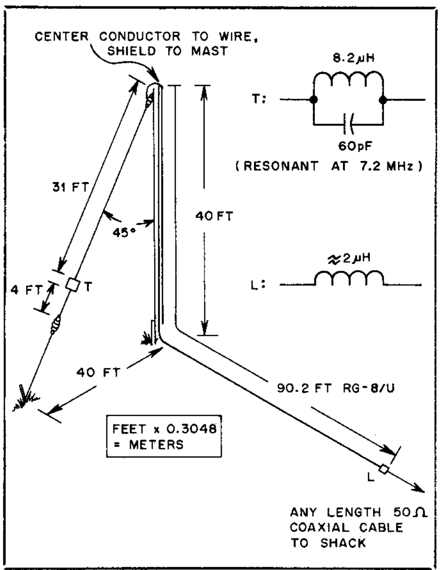

Fig. 1 — The two-band half sloper. To shield the transmission line from the antenna field, the line is routed up the inside of the support mast, which is grounded. Inductor L is needed to resonate the system.

Initial attempts to prune the wires to resonance resulted only in a mound of wire clippings and one frustrated amateur. After many hours of cut-and-try experimentation, accompanied by a growing, gut-level appreciation for what apparently was happening, the magic combination of wire lengths and trap component values was found. Impedances of 40 − j80 ohms at 7.2 MHz and 60 − j40 ohms at 3.6 MHz were measured with a noise bridge. It was then a simple matter to cancel out these capacitive reactances with an inductor.

For convenience, the inductor was placed in the transmission line, rather than at the feed point — final "tweaking" of the system is more easily performed on the ground than at 40 feet (12.2 m) in the air. A Smith Chart exercise shows that the SWR on the transmission line between the feed point and inductor L is 5:1 at 7.2 MHz and 2:1 at 3.6 MHz. When RG-8/U is used, the additional loss incurred because of these SWRs is less than 0.5 dB at 7.2 MHz and is almost nonexistent at 3.6 MHz.

Performance

This antenna performs very well. Operation at K9CZB is primarily 80-meter cw, with some 40-meter ssb. Power output is nominally 100 watts. Signal reports on 80 have been uniformly good, with comments such as U R LOUDEST 9 ON BAND and VY FB SIG, VY STRONG. Voice operation on 40 has also resulted in good signal reports, although the praise has not been so lavish. This is my only 80/40-meter antenna, so direct comparisons were not possible. However, it appears to greatly outperform two previous antennas, a

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[1]Notes appear on page 35.

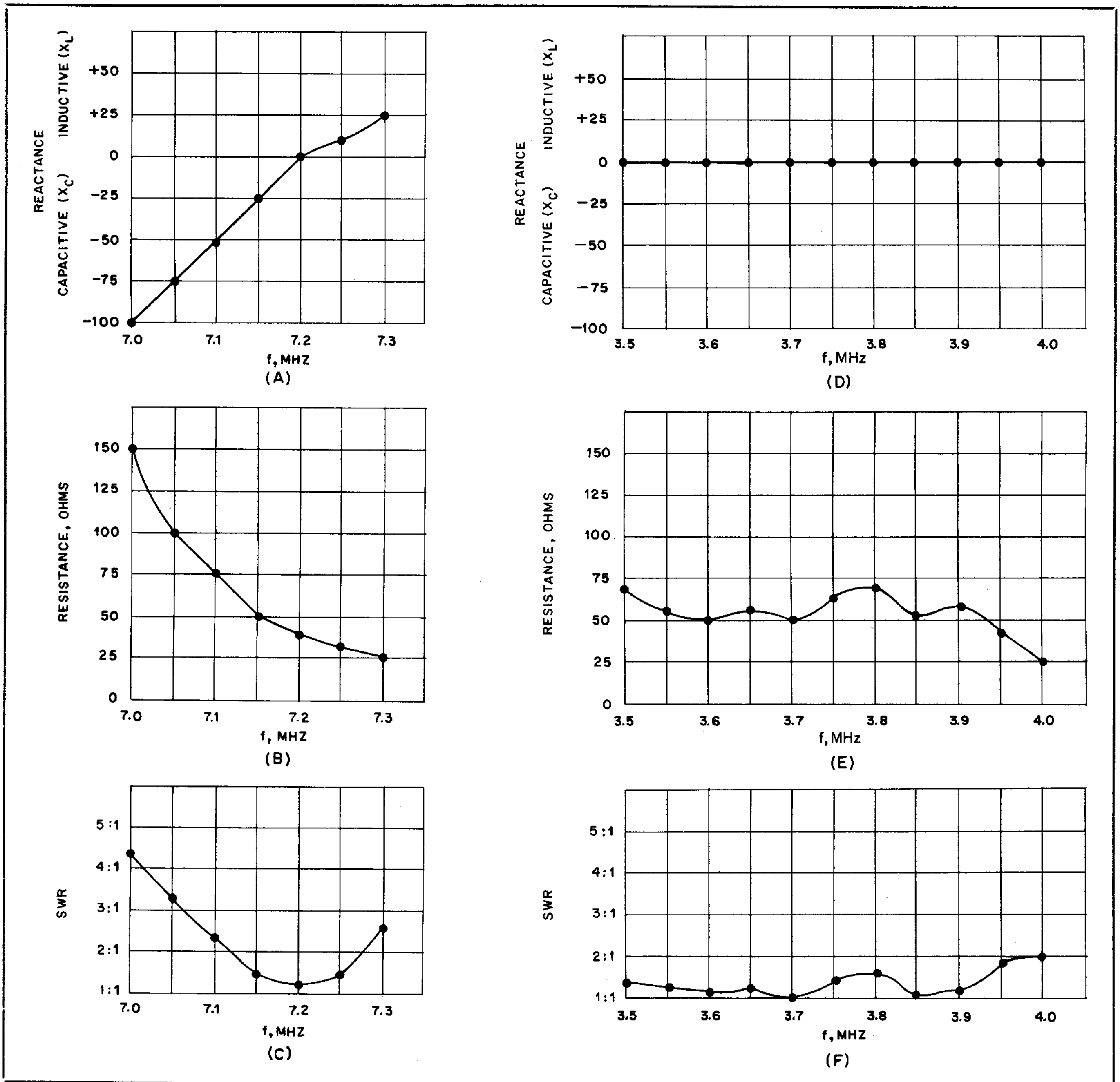


Fig. 2 — Loading characteristics of the antenna. The SWR curves were determined from a Smith Chart. Impedance values were measured with a noise bridge.

160-foot (48.8 m) end-fed wire and a trap dipole, both strung 30 feet (9.1 m) above ground. All in all, it is about what I expected from a half sloper.

This kind of performance is nice, but nothing to write an article about, since that has already been done. The real performance story about this antenna can be summed up in one word: bandwidth. A glance at the SWR curves in Fig. 2 will open the eyes of any 80-meter operator. As far as I know, this is unheard-of bandwidth for such a simple and compact antenna. It is a real treat to QSY 400 kHz and see the SWR meter needle barely move. This isn't a low-Q antenna — it's a *no*-Q antenna! The bandwidth on 40 is far less impressive and is, in fact, similar to what has been reported previously for half slopers.

Construction

During experiments with prototypes of this antenna, I noticed some sensitivity to feed-line placement and length. Therefore, in later versions I ran the feed line up the *inside* of the support mast to shield it from the antenna field. This precaution seems to be effective, for no such sensitivity has been observed since. (I can't help but wonder if this might improve the behavior of any cantankerous half sloper.) If a nonmetallic support is used, or if there is no possibility of placing the feed line inside the support, double-shielded coaxial cable should serve equally well, provided the outer braid is connected to the inner braid at the top of the tower and a ground is connected to the outer braid at the bottom of the tower.

I used standard 10-foot (3.05-m) TV mast sections for my support, simply because they were on hand. This results in a very flimsy and flexible mast in a 40-foot length, though. The first 20 feet must be

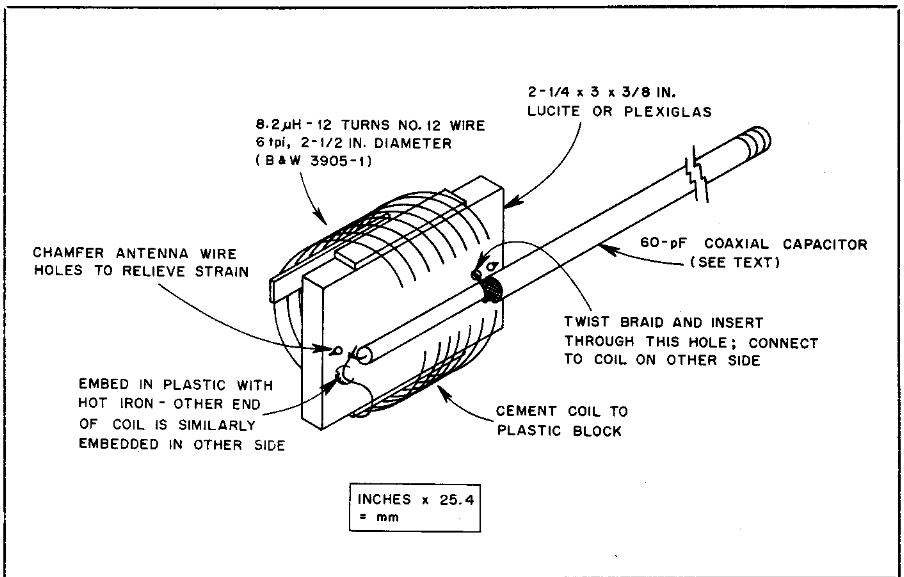


Fig. 3 — A simple, sturdy trap. The coaxial capacitor should be taped to the antenna wire after installation. It is not necessary to enclose the trap.

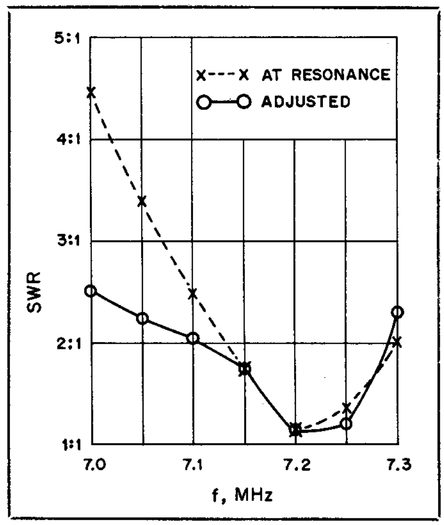


Fig. 4 — SWR curve for 40 meters, showing the effect of tapping L and adjusting feed-line length between L and the transmitter to obtain the best SWR curve. Such adjustments have little effect on 80-meter characteristics.

doubled up with long U-bolts if the mast is to be walked up. The price of six sections of TV mast is about the same as a 36-foot (11-m) telescoping push-up mast, but the latter is much sturdier and far easier to erect. If support materials are not already on hand, the telescoping mast is the better choice. I should mention that I took the trouble to bond all sections of mast together electrically to ensure good conductivity and to guard against TVI from rectification at joints after inevitable corrosion sets in. The base of the mast should be grounded. Effects from the guy wires can largely be avoided by breaking them into nonresonant lengths with strain insulators placed at the mast and every 19 feet thereafter.

The inductance and capacitance values shown in Fig. 1 must be used for the trap. Construction techniques for the trap are covered in *The ARRL Antenna Book*.[4] A novel and inexpensive method of trap construction has been described by WB9OQM.[5] I built my trap using the method shown in Fig. 3. Traps made in this fashion are much stronger than they appear. I've never had one break, even in high winds that caused property damage. In this antenna, however, the radiator also serves as one of the top guys. For that reason the trap was reinforced. Two 3/16-inch (4.8-mm) thick pieces of plastic were used with three layers of glass cloth and epoxy sandwiched between them. A rotary wire brush serves well to rough up the inner surfaces of the plastic to ensure good adhesion. However, one may use coarse sandpaper for that purpose. Glass cloth and epoxy are sold as a repair kit in many hardware stores.

Before the antenna wires are connected, the trap must be tuned to resonance. A dip meter or noise bridge can be used to measure the resonant frequency. Start with about 30 inches (762 mm) of RG-8/U for the coaxial capacitor. After connecting it to the coil, as shown, 26 or 27 inches (660 or 686 mm) of braid will remain. At this point, the resonant frequency should be below 7.0 MHz. Trim the braid at the far end, a little at a time, snipping off the center conductor as you go. Recheck the resonant frequency each time. As 7.2 MHz is approached, continue trimming the braid, but stop cutting the center conductor. To increase the leakage path, the polyethylene dielectric should extend beyond the braid 1/8 to 3/16 inch (3.2 to 4.8 mm) when the trap is resonated at 7.2 MHz. Very close to 24 inches (610 mm) of braid should remain at completion. Tightly tape this end with several layers of plastic electrical tape.

The component values for this trap are exactly the same as those used in the W3DZZ trap dipole,[4] so there are several commercially made traps that may be suitable for this antenna. Traps made for a five-band, two-trap dipole, 108 feet (32.9 m) long should have the proper values of capacitance and inductance.

In any antenna system, the radiator feed point impedance repeats itself every half wavelength along the transmission line. Inductor L must be inserted in the transmission line at a half-wave point in order to exactly cancel the capacitive reactance of this antenna system. It is, of course, advantageous to place L as close to the feed point as possible in order to minimize losses. A half wavelength at the lower frequency is as close as you can get without going to the feed point itself. The 90.2-foot (28-m) length of RG-8/U shown in Fig. 1 is an electrical half wavelength at 3.6 MHz for solid polyethylene dielectric coaxial cable *only*. If cable having a velocity factor other than 0.66 (e.g., foam-dielectric coaxial cable) is used, this length will have to be recalculated from the equation

$$\ell = 492\ V/3.6 \text{ feet}$$

(Feet × 0.305 = m)

In this equation, V is the velocity factor of the cable to be used. Only RG-8/U or a similar type such as RG-213/U should be employed for this section of the transmission line in order to keep the losses low. If you don't mind a dB or so of loss on 40 meters, RG-58/U is acceptable. The loss on 80 meters will be negligible in any case.

The value of inductor L should be 1.75 µH, but I recommend that a coil having about 3-µH inductance be used to allow some latitude for final tune-up of the system. I mounted 12 turns of a no. 3018 Miniductor (1-1/4 inch or 32 mm in diameter, 8 turns per inch or every 25 mm) in a small Minibox with SO-239 coaxial connectors placed at each end. After tapping the coil for the best SWR curve on 40 meters, the entire assembly was sealed and waterproofed with bathtub caulk.

Tune-up

As seems to be characteristic of half slopers, this antenna can be very touchy to tune up. If the length of transmission line between the radiator and L is not an exact integral multiple of a half wavelength at 3.6 MHz, tune-up can be a real "can of worms." Since the oft-quoted value of 0.66 for the velocity factor of standard RG-8/U is only a nominal value and can vary appreciably from brand to brand (in cheap cable from lot to lot), this length should be determined with a noise bridge.

If a noise bridge is not available, the following procedure may be tried. Cut this section of cable about 6 feet (1.8 m) shorter than the calculated length. Prepare a section of RG-58/U, 12 feet long, with solderless connectors on each end. Connect it to both the shortened feed line, using a PL-258 double female connector, and to L. Tap L to obtain the best combination of SWRs at 3.6 and 7.2 MHz. Record the SWR figures and tap position.

Now shorten the RG-58/U by 6 inches and repeat — and repeat — until you are certain you have passed through the point where the SWR values simultaneously bottom out at both frequencies. Prepare a length of RG-58/U (from the same lot) exactly as long as the best experimental length, using permanent coaxial connectors. Seal and waterproof all connections. RG-58/U is recommended for relative ease of pruning. If you don't mind unsoldering a PL-259 each time, RG-8 could be used. However, the additional loss from such a short section of RG-58/U will be infinitesimal at these frequencies.

This procedure is obviously tedious, but it is necessary to obtain good performance on 40 if a noise bridge is not available.[6] In fact, some adjustment of this section of transmission line may be necessary even if a noise bridge is used to measure the electrical length to obtain optimum two-band performance. The exact half wavelength should always be used as a starting point, in any case.

Strangely enough, the above procedures are necessary only to optimize 40-meter performance. My experience has been that merely cutting the half-wavelength section of transmission line to the calculated length, then tapping L to obtain the best SWR at 3.6 MHz, is sufficient to obtain a ratio of 2:1 or less over the entire 80/75-meter band. So tune for 40, and 80 should take care of itself.

Once the antenna system has been resonated, it may pay to experiment with the value of L and the length of transmission line between L and the transmitter. Changing these values will change the shape of the 40-meter SWR curve somewhat. By so experimenting, you may be able to tailor the shape of the 40-meter SWR curve to your operating preference. Don't expect miracles, though, for the range of adjustment seems to be small. Fig. 4 illustrates the results of such an effort. These adjustments will have very little effect on 80-meter bandwidth within the range of acceptable SWR on 40 meters.

Further Thoughts

The first prototype was constructed close to my house, and I was therefore concerned that the performance might not be reproducible. The next prototype was erected in a far corner of my yard, over 100 feet from the house and even farther from any other structures or conductors. The final version was similarly located. Except for final tune-up parameters, all three behaved almost identically, even though a number of physical changes was made each time. As a final test of the soundness of the design, I built scaled versions for 40/20 and 20/10 meters. They exhibited very similar characteristics, although all parameters of the system seem to become very critical as the design frequency is increased.

The first two 80/40-meter systems were built using a 30-foot (9.1-m) mast, yet their behavior was not markedly different from the final version with a 40-foot (12.1-m) mast. Since the mast is an electrical part of the system, and since proximity to ground must play some role in the performance of the antenna, other heights, and supports that have beams attached, may yield different results.

The reactance of the trap at 3.6 MHz is 245 ohms. Therefore, there is a possibility of constructing an 80-meter-only version of this antenna by using a 10.8-μH inductor in place of the trap. This has not been tried, however.

Scaling up to 160/80 meters is an attractive possibility. Conceivably, a mast height as low as 50 feet (15.2 m) could be used. A starting point would be the doubling of all wire lengths, and using a 16.4-μH coil with a 120-pF capacitor for the trap to preserve the 245-ohms reactance at 1.8 MHz.

There also seems to be a possibility that a slight increase in trap capacitor value, to resonate the tap at 7.1 or 7.15 MHz, might allow better coverage of 40 cw, but probably at the expense of the phone portion of the band. Such a change might have little effect on 80-meter bandwidth, but another round of cut-and-try could prove necessary.

Conclusions

At this point, this is still an experimental design. Further development may eventually allow a cut-to-formula type of construction, but until that happens, be prepared to experiment. The dimensions given in Fig. 1 will put you in the ball park and should yield immediate results on 80.

The convenience of Transmatchless operation over all of 80/75, plus a reasonable portion of 40, coupled with an excellent radiated signal, is ample repayment even for many hours of cutting and trying. Once tuned up, this antenna is very well behaved and enjoyable to use. I would like to hear from others who construct antennas based on this design. QST

Notes

[1]Hopps, "A 75-Meter DX Antenna," *QST*, March 1979, p. 44.
[2]Atchley, "Putting the Quarter-Wave Sloper to Work on 160," *QST*, July 1979, p. 19.
[3]DeMaw, "Additional Notes on the Half Sloper," *QST*, July 1979, p. 20.
[4]*The ARRL Antenna Book*, 13th edition, 1974.
[5]Mathison, "Inexpensive Traps for Wire Antennas," *QST*, February 1977.
[6][Editor's Note: A third alternative is to use a dip meter to determine an exact half wavelength of line. See Downs, "Measuring Transmission-Line Velocity Factor," *QST*, June 1979.]

Strays

I would like to get in touch with . . .

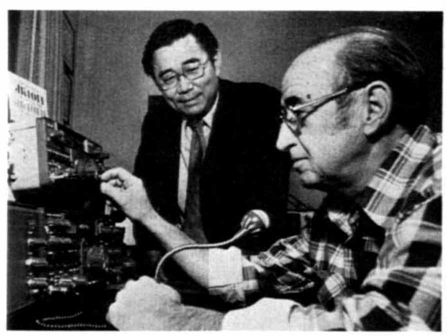
☐ amateurs with 2-meter gear to assist with the 1980 New York Special Olympics, to be held Friday, Saturday and Sunday, June 13-15, at Elmira, NY. Many amateurs are needed at the site. About 10,000 visitors from all over the U.S. are expected for the weekend. Contact Hal Mandel, WB2FSX, c/o NY State Special Olympics, 307 East Church St., Elmira, NY 14901, tel. 607-733-7359, evenings.

SISTER CITIES — INTERNATIONAL FRIENDSHIP THROUGH AMATEUR RADIO

☐ What do Fukaya City, Japan, and Fremont, California, have in common? Both cities were organized from five smaller cities; have dynamic growth-oriented, youthful leadership; have a Route 17 nearby; are semi-agricultural communities specializing in commercially grown flowers; and have residents that are interested in Amateur Radio.

Bob McGihon, WB6DMB, of Fremont, has had regular contacts with Tak, JK1OFI, and Akko Ohata, JK1OFH, of Fukaya City. Recently, Tak, speaking for his city's mayor, asked McGihon if Fremont would like to become Fukaya City's sister city. Several members of Fremont's South Bay Amateur Radio Association (SBARA) worked with the Sister City Committee of Fremont to make the necessary arrangements.

The result? Mr. Ohata was the guest of honor at the January Grand Ball, held at the Castlewood Country Club, in Pleasanton, California, to celebrate the union of the two cities. Nightly 0200 UTC contacts keep hams from the sister cities in touch with each other. — *submitted by Jane D. Bell, WD6GKN*



Dr. Walter Hashimoto (left) carried official "sister city" papers from Fremont, California to the sister city, Fukaya City, Japan. Bob McGihon, WB6DMB, helps friends in the sister cities keep in touch with each other through Amateur Radio. *(photo by Dino Vournas)*