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A Brass Horn For X-Band

—simple 10.5 GHz antenna

Articles I've written about antennas for an X-band (10.5 GHz) transceiver and the "Smokey Detector"[3] have brought many questions to my desk. One question in particular, asking where the horn used in the tune-up procedure for the Smokey Detector was procured, was the impetus for this construction article. Another question asked about the use of rectangularly-shaped waveguide antennas as signal sources for equipment using circular polarized horns.

When microwave communications in the amateur segment of X band became my prime interest, equipment — mostly waveguide components — was easily found on the surplus market. Signal generators consisting of klystrons and power supplies were readily available after World War II, as were all of the nice goodies like slotted lines, detectors, and precision attenuators. Many gain standard horns found their way to this market but were ignored, and the famous Polaplexor was used instead. That wonderful source of components has dried up, and so we are now forced to borrow from a friendly microwave man or do our own construction.

Horn antennas and all of the other equipment you will need to operate in this exciting band, you can construct yourself. You don't need a machine shop and a lot of cash to buy the parts. Patience and careful use of simple hand tools provided the first experimenters with these items, and so they can provide for you. I made my own pyramidal horn, and here is how you can make a copy of it.

Fig. 1.

Before I get into the construction details, I will answer the second question mentioned above. Certainly there will be a signal loss over the path between a circular polarized horn and a rectangular or linear transmitter. The Smokey Detector tune-up procedure used these dissimilar polarizations because path loss was not a problem over the short distance used. This practice is not encouraged for regular communication unless you feel that long CQs will afford you the answers from the midnight DX on this band.

A search through well-known references related to microwave antennas revealed that a pyramidal horn would provide a pattern in either plane which is nearly uniform. This is the reason why

it was chosen over the more easily constructed sectoral horn. These references are listed at the conclusion of this article and will also assist you in confirming the pattern measurement.

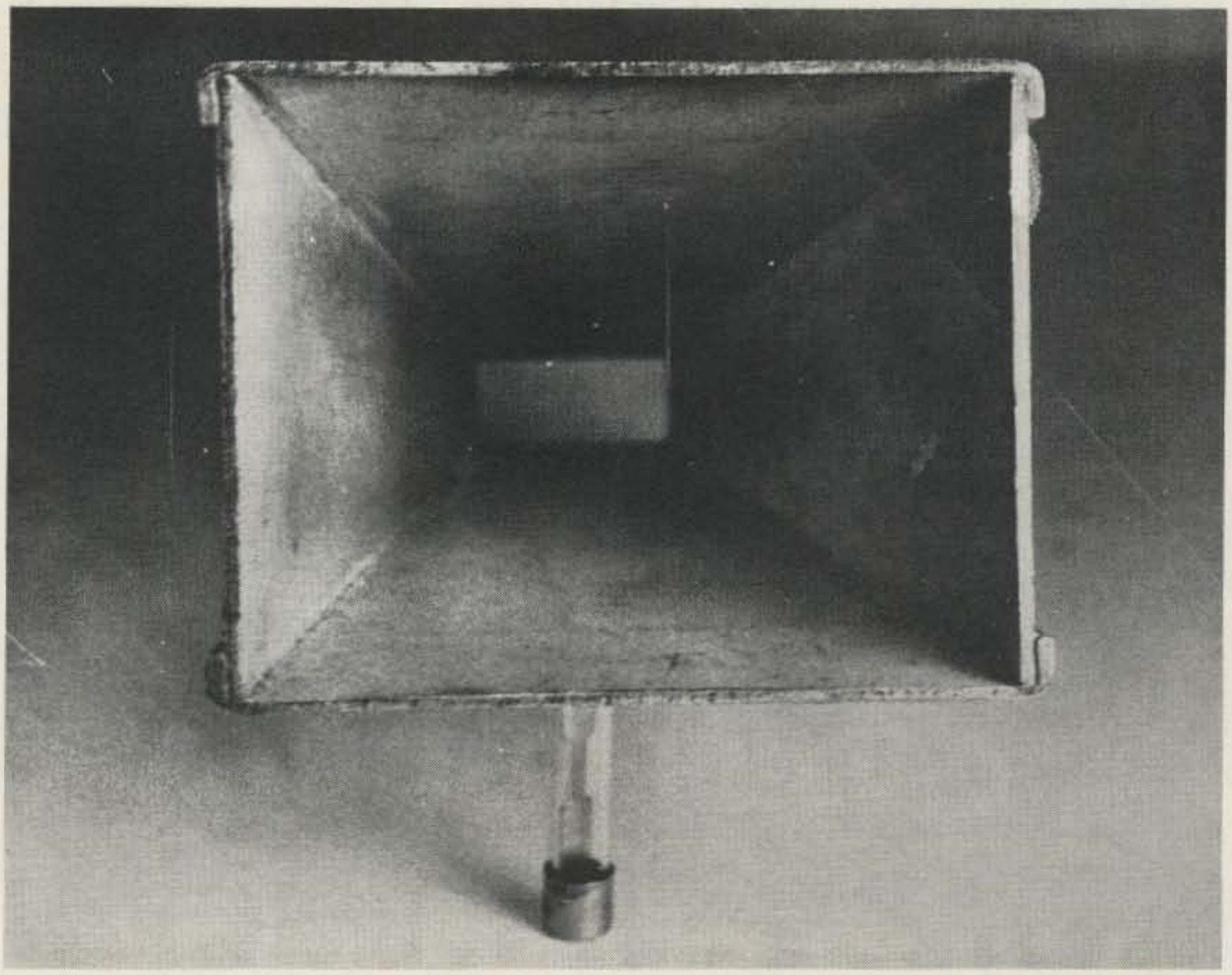
The construction materials needed are .046"-thick brass sheet, soft solder, and one ½- x 1-inch waveguide flange (UG-135/U). The inside dimensions of the flange are exactly ½ x 1 inch. (A 1.25" departure from the dimensions shown will result in a lot of file waving at the corners of the waveguide end of the horn.) The dimensions of the waveguide end are exactly those of a section of WR-90 small X-band waveguide.

A piece of hardwood two inches long, cut to a rectangular shape which will slide fit into a section of small X-band guide, will be required. This piece will serve as a clamping support when the final assembly and soldering takes place. Be sure that the piece is true over the full length and that the corners are smooth, or it will stick when you try to remove it. Starting dimensions for this jig are those shown at the throat of the horn in View A of Fig. 1.

The sheet brass for the sidewalls of the horn must be flat. If it is not, you will find that the horn will be very hard to assemble, because all edge surfaces must touch during the final assembly. Be sure that this material is clean and shiny. A small ball of steel wool can be used on the edge surfaces to insure that it is. When you attempt the final assembly, you will appreciate this extra effort.

Lay out the plates for all sides on the clean sheet brass. Scribe the positions of the bend lines clearly. If possible, use DyChem, a blue dye, on the brass so that the lines can be seen easily. Remember to wash off the dye with alcohol before attempting to solder. Allow twice the thickness of the material for each bend point.

The dimensions given in View C (Fig. 1) do not include the material needed for a solder flap, so allow at least 3/8" more material for this purpose. Also, cut 45 degree "pinks" in the flaps at the junction of the horn flare and the beginning of the 1-inch waveguide section.



Mouth view of an X-band horn. This shows how the folds are made. Note the smooth inside surface.

The use of a sheet metal shear and brake will simplify the next few operations, but, if these tools are not available, two pieces of 1" angle iron and a large vise will serve to do the job. The cutting should be done with a fine-bladed hacksaw. The edges of the cuts can then be smoothed with a file.

Cut two pieces, as shown in View B (Fig. 1), for the H-plane sides of the horn. Place one of these pieces on a flat surface, and clamp it securely to the surface with a C-clamp located at the intersection of the waveguide section and the end of the flare. Place a thick piece of metal under the C-clamp foot on the bending line, as indicated in View B. Now, using another larger piece of metal or a large putty knife, lift up sharply at the mouth end of this section to produce a bend at the clamped end. The height of the bend must be 13/64". The metal is springy and will take some pushing and pulling to achieve the correct height. Care must be exercised during this process so that you don't deform the walls with bends or deep scratches.

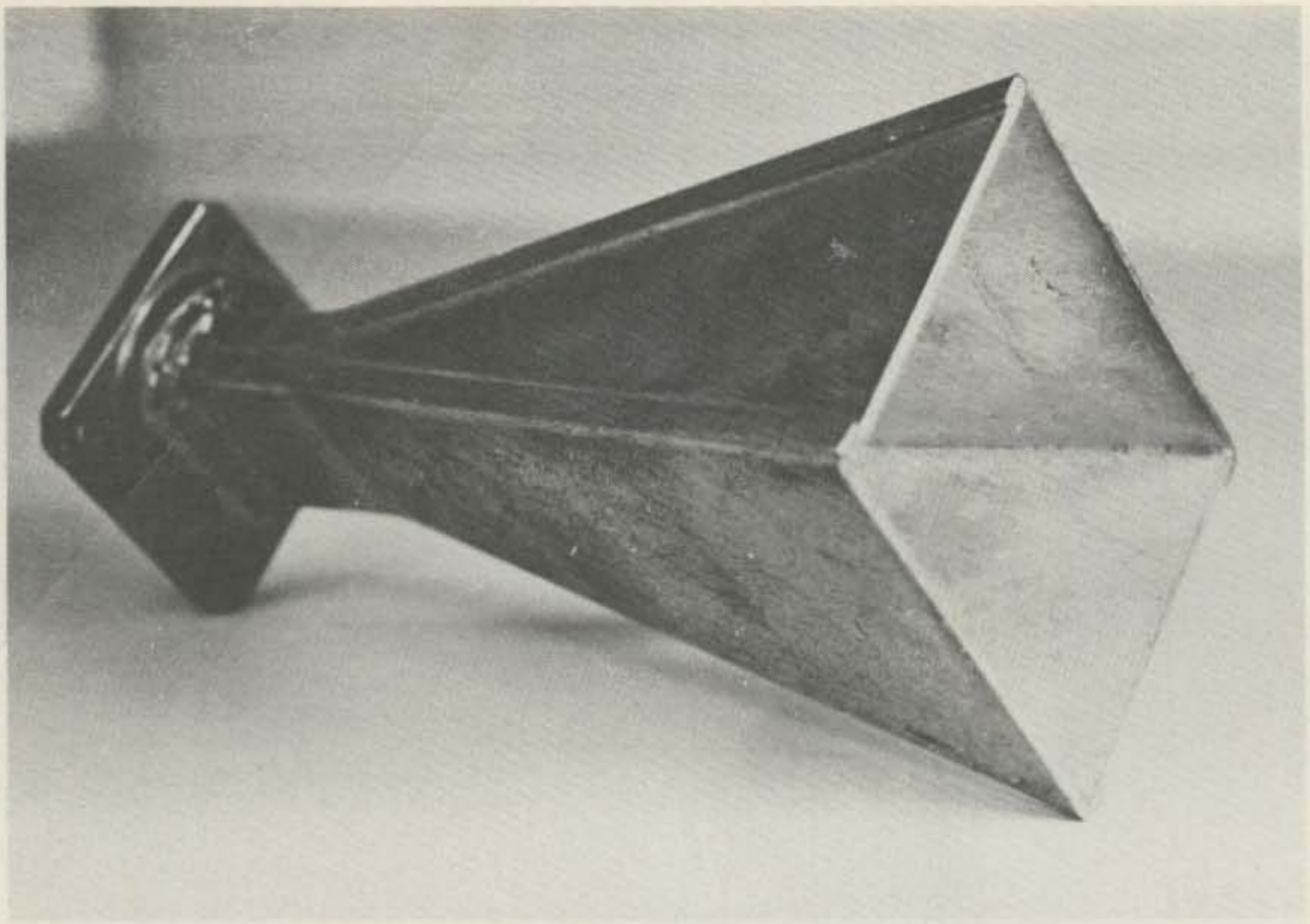
Follow the same procedure for the three remaining sections of brass.

When all of the forming bends have been completed, the solder flap bends are next. This job is done in two moves. Place the aforementioned sections of angle iron in the vise jaws. Then station the waveguide end of one E-plane plate between the angle irons so that the bend line of the flap is in position for a bend to 90 degrees.

To make this bend, allowances have been made for the thickness of the material, if you have followed the layout instructions. If not, the width dimension will come out wrong. Check now, and save some grief. When you have determined that the measurements are the proper dimensions, make these bends so that they are square, right-angle bends. If the bend is too shallow, it will make the horn flare wider in one plane, and, of course, if it is too great a bend, the opposite effect will be the result. A 90-degree bend, therefore, is the desired angle.

After completing the waveguide bends just described, complete the horn flare flap bends on the E-plane section. Do both pieces at this time.

Check that the bending you've done has resulted in square and true wall sections, and make sure all the edges are clean and ready for solder. Apply a moderate amount of acid soldering paste to the inside of the flap bends. Now place the previously-prepared wood jig inside of the E-plane waveguide bends of one section. Slip the two H-plane wall sections into place on each side of the jig block. The last piece is the



Pyramidal horn. This oblique view of the horn shows the assembly and the addition of a choke flange.

other section of the E-plane wall. Use a C-clamp to hold the whole assembly together by clamping across the E-plane section of the waveguide. Small pieces of thin aluminum sheet can be bent to form cross braces at the inside of the mouth of the horn and will aid in the soldering process. (A piece of wood shaped to fit in position will also do the trick.)

Clamp the outside edges near the end of the flare where the flaps meet the matching side. If you do not provide a firm clamp at these points, when the metal is heated for soldering, it will flex. If you are satisfied that the horn is clamped well enough, you are ready to solder it.

The easiest way to solder the assembled horn is to stand it up on the face of the open-flared end on an electric hot plate. It will take much longer to do the job than with a blowtorch or propane soldering iron, but the heat will be more uniform and the control over the way the solder will flow is better.

When the horn has been heated enough, which will be indicated by the color of the metal where the soldering paste makes contact, place a piece of wire solder on one seam in a stroking action. The solder will run into the seam and down to the open flare. Make sure that just enough solder has filled up each seam to join electrically the seam edges. Use the solder sparingly; too much will cause lumps which will have to be removed. Control the heat by lowering the stove temperature, but keep it just hot enough so that the solder will run.

When this task is complete, turn off the heat and let the whole assembly cool off. Do not lift it off the heater and cool it quickly under water; flexure of the seams can open them.

Remove all jigs and clamps. Carefully inspect the seams to see that there are no gaps in the solder. If there are, the assembly will have to be reheated and the soldering trick repeated. If the soldering procedure has provided a solid connection between all parts of the seams and there are no gaps, fit the flange to the open waveguide end and solder it in place squarely. Be careful not to disturb the previously soldered seams.

The completed horn should be washed in very hot water to remove all traces of the acid solder paste. It then may be painted with Krylon paint to keep the brass from corroding. Do not paint the flange face.

Testing the horn to determine its gain and field pattern requires the use of a signal generator, an attenuator, and two other similar radiating devices.

Connect one of the radiators to the signal source output and the second to the attenuator and a suitable receiving indicator. The separation between the two test setups at this frequency must be 10 feet. The path between them should be free from obstructions and reflections. A pair of ladders six feet high will serve, if two flat surfaces are placed on the top of them. Fasten the radiating horn firmly directed toward the second platform where the second setup must be arranged so that it can be rotated horizontally about the axis of the transmitting horn. A scale laid out on a piece of polar graph paper will assist in locating the half-power points of the horn.

Turn on the equipment. Check that the receiving setup is performing and that sufficient signal is detected when the attenuator is set to 10 dB. Now find the true axis, and make a mark on the plot sheet. Turn the attenuator to the 10 dB position, and note the indicator level. Now rotate the receiving device to approximately 10 degrees off the true axis and note the level. Readjust the attenuator to bring up the level to equal what it was when the device was on the true axis, and note the attenuator difference. You are looking for the level which corresponds to the 3 dB or half-power points. It will probably take several tries using this technique to locate this position. When it is located, move in the opposite direction from the true axis, and locate the opposite half-power point. Mark this on the polar plot sheet.

When the measurements of the two similar radiating devices have been completed, substitute your new horn for the receiving device. Make sure that it is receiving in the correct plane. When it is in place, direct it toward the transmitting radiator centering the true axis through the center of the horn. You will see that the receiving indicator is off scale, or at least reading upscale, showing that the horn has gain. Reduce the indicator reading by adjusting the attenuator so that the indicator reads the same level as the original measurement. Note the attenuator reading, and be sure to note which plane the measurement was taken in. This difference is roughly the gain over the original radiator. If the comparison radiator's gain is known, then you may quote accurately the gain which will be near 13 dB power gain.

Repeat the same procedure in the other plane, al-

ways making sure that the antennas are in the same plane. Cross polarization will be easily detected by the very weak signal received.

This completes the construction of the horn and its measurements. You should have an antenna with a beamwidth of nearly ten degrees to the half-power points in the E-plane and a little wider in the H-plane.

The references which appear at the end of the article are required reading if you are going to attempt this project.

I must sound a note of caution regarding a problem which may be encountered when power exceeds the milliwatt region. It is a well-known fact that radiation from antennas or waveguides which produce an illumination over human tissues in excess of 10 milliwatts per square centimeter can cause serious damage to exposed tissues. Persons who work on military radar can appraise you of this danger and the many lectures they receive about the subject. The most important warning I remember, which I received during my training, was "Don't look into the antenna or into a waveguide." Cataracts on your eyes may be the result. So be careful; don't look into horns or waveguides or, for that matter, any of the UHF antennas you use. Some excellent reading on the subject is listed in the references.

I hope to hear you on 10.445 GHz. I keep a sked with WA1IKR at 0010 UCT on Thursdays to beat the QRM problems. See you there. ■

References

1. Silver, *Radiation Lab Series,* Vol. 12, Sections 15-9.
2. Krauss W8JK, *Antennas,* Chapter 13, Section 13-6.
3. Olberg W1SNN, "Mobile Smokey Detector," *73,* Holiday, 1976.
4. Brodeur, "A Reporter At Large – Microwaves," December 13 and 20, 1976, *New Yorker Magazine.*

Social Events

from page 149

c/o Sue Hagedon WB8GWQ, 1340 Brainard Woods Drive, Dayton OH 45459.

TUCSON AZ
APR 28-30

The Tucson Hamfest will be held on April 28-30, at the Ramada Inn (just off north I-10). It will feature technical sessions with demonstrations, microprocessors, solar poser, QRP, fast/slow scan, RTTY, remote base, etc. There will be prizes, ladies' programs, a banquet, exhibits, and a swap meet. It is sponsored by the Old Pueblo Radio Club. For information, write: OPRC, 1361 E. Edlin, Tucson AZ 85711.

SPOKANE WA
APR 29

SWAP-FEST '78 will be held all day on Saturday, April 29, at the Spokane Interstate Fairgrounds. Flea market, mini-auctions throughout the day, contests, family picnic, major evening auction, some most-unusual radio exhibits, valuable prizes. Sponsored by the Inland Empire area amateur clubs. Talk-in on any area repeater. Write: SWAP-FEST '78, PO Box 3606, Spokane WA 99220.

MEADVILLE PA
MAY 6

The 4th Annual Northwestern Pennsylvania Hamfest will be held on May 6th at the Crawford County Fairgrounds, Meadville PA. Gates open at 8:00. $2 prize ticket required for admission – $1 to display. Children free. Hourly door prizes; refreshments; commercial displays welcome. Indoors if rain. Talk-in on 04/64 and 52. Details: CARS, PO Box 653, Meadville PA 16335.

LAS VEGAS NV
MAY 12-14

The 23rd Annual West Coast VHF Conference will be held at the Stardust Hotel, Las Vegas Strip at Convention Center Drive.

Conference highlights: technical program arranged by the San Bernadino Microwave Society, hospitality room, informal technical and operating sessions, noise figure measurements contest, antenna gain measurements contest, prize drawing, 24-hour adult entertainment! World-famous resort hotel with all facilities. Look for the Stardust sign east of I-15. Take the Sahara Ave. or Dunes-Flamingo exit. Advance registration fee is $4.00 per person ($5.00 at the door). Make checks payable to: West Coast VHF Conference, 510 South Rose St., Las Vegas NV 89106.

DEERFIELD NH
MAY 13

The Hosstraders net will hold its fifth annual tailgate swapfest Saturday, May 13, at the Deerfield, New Hampshire, fairgrounds (covered building in case of rain). Admission is one dollar; no commission or percentage. Commercial dealers are welcome at the same rate. Excess revenues benefit Boston Burns Unit of the Shriners' Hospital for Crippled Children. Last year we donated $430.80. Talk-in on .52, 146.40-147.00, 3940 kHz. If you have questions, send SASE to Joe Demaso K1ROG, Star Rt., Box 56, Bucksport, ME 04416 or Norm Blake WA1IVB, P.O. Box 32, Cornish, ME 04020 or check the Hosstraders net on Sundays at 4 pm on 3940 kHz.

WEST LIBERTY OH
MAY 14

The Champaign Logan Amateur Radio Club, Inc., will hold its annual hamfest on Sunday, May 14, 1978, at the West Liberty Lions Park, West Liberty, Ohio. Free admission; trunk sales; tables are $1.00. Door prizes. Talk-in on 146.52.

WARMINSTER PA
MAY 14

The Warminster Amateur Radio Club's fourth annual "HAMMART," flea market, and auction will be held on Sunday, May 14, from 9 am to 4 pm at William Tennent Senior High School, Street Road (Route 132), 2 miles east of York Road (Route 263), Warminster, Bucks County PA. Registration is $1.00, tailgating $2.00 additional. No indoor selling; bring your own tables. Talk-in on 146.16-76 and 146.52. For further information, write: Horace Carter K3KT, 38 Hickory Lane, Doylestown PA 18901 or call (215)-345-6816.

WABASH IN
MAY 21

The Wabash County Amateur Radio Club's 10th annual hamfest will be held on Sunday, May 21, 1978, rain or shine, at the Wabash County 4-H fairgrounds in Wabash. Large flea market (no table or setup charge), technical forums, bingo, free parking, and lots of good food at reasonable prices. Advance admission is $2.00; $2.50 at the gate. Children under 12 free. Write Dave Nagel WD9BDZ, 555 Valley Brook Lane, Wabash, IN 46992.

COLUMBIA SC
MAY 21-22

The Carolina Repeater Society is sponsoring the Columbia Hamfest on Saturday and Sunday, May 21 and 22, from 9 am to 5 pm at the Jamil Shrine Temple located 1 mile west of I-20 on I-26. Large air-conditioned building with plenty of free on-site parking, a flea market, dealers, and activities. Talk-in on 34/94. Combined admission and drawing tickets are available for $3.00 in advance or $3.50 at the door. Contact Larry Johnson WA4VOJ, 1520 Atlantic Dr., Columbia SC 29210, or phone (803)-772-7984 or (803)-788-1308.

ERLANGER KY
MAY 28

The Kentucky Ham-O-Rama will be held on Sunday, May 28 (Memorial Day weekend), at Erlanger Lions Club Park, Erlanger, Kentucky. It's 7 minutes south of Cincinnati, Ohio, 1 mile off I-75 south, the Donaldson Road exit. Talk-in on 146.19-79 repeater, 52-52 simplex. There will be prizes, exhibits, and a flea market. For information: NKARC, Box 31, Ft. Mitchell KY 41017, or phone (606)-331-4922.

FT TUTHILL AZ
JULY 28-30

The Amateur Radio Council of Arizona will present the annual Ft. Tuthill Hamfest on July 28, 29, and 30th, 1978. Come on out in the cool pine country of Arizona, and join our western barbeque, prize drawings, and tech sessions. For further details or pre-registration forms, contact PO Box 11642, Phoenix AZ 85061.