Build a Gossamer Quad

Can the wire loops of a quad antenna survive without being supported by several hundred pounds of tower, mast, boom, spiders and spreaders? Sure! A seven-pound "gossamer quad" will sway in the wind, but it won't break.

By R. F. Thompson,* W3ODJ, ZF2CD

Gossamer antennas may become popular alternatives to the massive tower/mast/boom structures usually associated with beam antennas for the 10-, 15- and 20-meter bands. Rapidly rising costs of metal towers have caused some radio amateurs to look for other ways of supporting beam antennas at effective heights. Since the weight of a beam antenna is a principal factor, ways of making the antenna lighter are to be considered. The minimal weight of the gossamer places this antenna in the foreground in this respect. The essential parts of a two-element monoband quad are the two copper-wire loops that weigh less than 2 pounds (kg = lb × 0.4536). Conventional use of several hundred pounds of "passive" metal to support a few pounds of "active" copper seems absurd.

This article describes the evolution and construction of a two-element gossamer quad that began as a vacation exercise and has since developed into the main 20-meter antenna at W3ODJ. Presently, the antenna is made of copper wire, four wooden poles and a fiberglass pole. Two trees and a pair of nylon ropes elevate the antenna 50 ft (meters = feet × 0.3048) in the air. Another pair of ropes provides a means for steering the antenna around the compass. Although the total weight of the antenna is less than 10 lb, it has survived all weather to date, including winds reported to exceed 50 mi/h. It can be fabricated to fit into a ski case for easy transport.

Gossamer Evolution

Over the years, many radio amateurs have put up dipole antennas between trees, hoisting simple rigging into or over tall trees by throwing weighted lines, casting with rod and reel or launching a light leader line with bow and arrow.[1] Gossamer design begins with the observation that the same light rigging supporting a dipole can support one or more additional dipoles as well. If the dipoles are kept parallel and spaced properly, then a fixed-direction wire Yagi beam can be made. A recent example of a three-element gossamer Yagi is the "Ten Dollar Disposable 15-Meter Beam," described by Bruce Burnham, C6ADN, in November 1980 *QST*.[2] He supported his Yagi between two trees by means of two ropes. Two lengths of PVC tubing kept the three wire elements properly spaced and parallel. His gossamer beam survived Hurricane David with only minor damage.

Considered as a mechanical structure, a

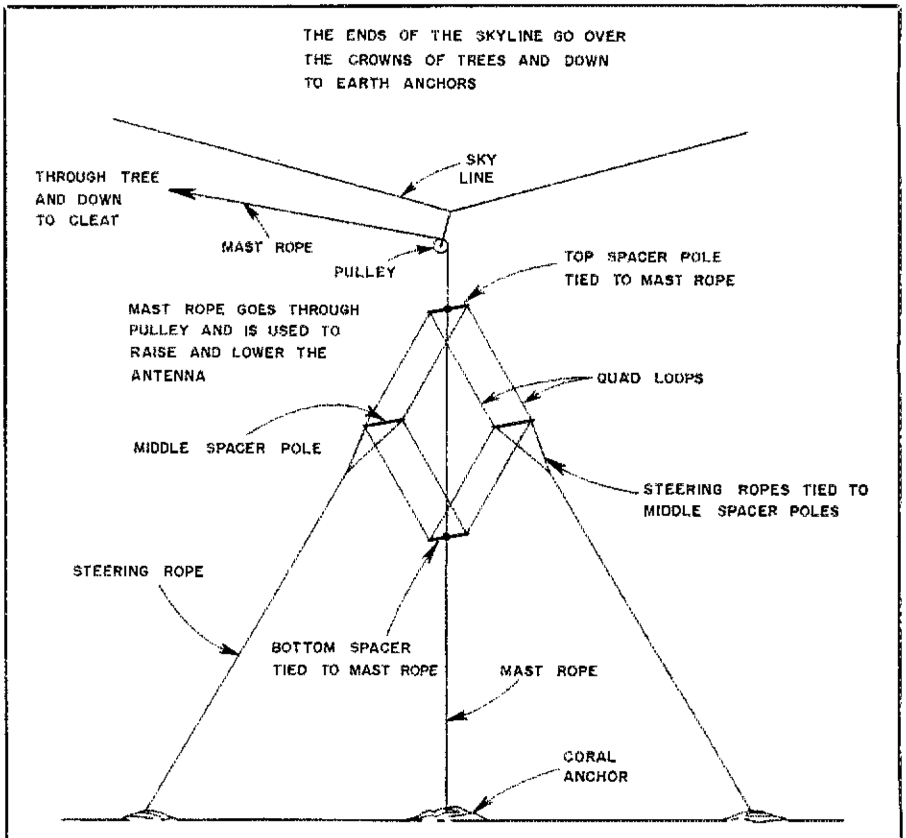

Fig. 1 — The two-element, 20-meter Cayman quad. Quad loops are pulled out into a diamond shape by the steering lines. The spacer poles are 9 feet long. The distance between opposite spacers (not critical) is 25 feet. See text for loop dimensions. Feed point for the driven element is at the bottom. A quarter-wave, 75-ohm matching section (not shown) is used.

[1]Notes on page 31.

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dipole antenna rigged between two trees is a suspension wire holding up several pounds of coaxial cable. Replace the dipole wire with rope and the center insulator with a pulley and you have a "sky line" and "sky hook" that can hold up the several pound weight of a gossamer quad antenna. The quad hangs like a pendulum from the pulley. A pendulum is naturally stable; displace it from equilibrium and gravity restores it to equilibrium. Conventional quads are supported by a tower that, to some degree, acts as an inverted pendulum. An inverted pendulum is unstable; displace it from equilibrium and gravity pulls it down. Towers must be massive to overcome the instability. By simply replacing the massive tower with a thin mast-rope, the gossamer quad gains natural stability, construction is simplified and the expense of owning a quad is greatly reduced.

Since the antenna is supported from above, tension in the wire loops can support light spacer poles that separate the loops and keep them parallel. Thus, the loops are both mechanical and electrical elements in the gossamer quad. The top and bottom spacer poles are tied to the mast rope, which extends upward through the pulley for hoisting the antenna to the sky line.

Prototype — The Cayman Quad

In June 1980, Paul Schmid (W4HET, ZF2BN) and I made a vacation DXpedition to Grand Cayman Island. Our Cayman QTH provided tall trees and a wide clearing, just right for gossamer experiments. One end of a 40-meter dipole was rigged by nylon rope stretching 50 ft across a clearing to a pine tree. A pulley at the midpoint of that sky line was the sky hook for a 20-meter gossamer quad.

On the flight to Cayman, I took eight quarter-inch diameter wooden rods as carry-on luggage, all taped together rather like a poor man's walking stick. Pairs of these sticks joined by 1-ft lengths of snug-fitting PVC tubing were used as 9-ft spacers between two quad loops. All the PVC tubing, wire, coils of rope and coaxial cable had been packed with clothing in a suitcase. The sides of the loops were pulled into a diamond shape by light ropes sloping down to the ground and held in place with large sand-filled conch shells and shards of coral. (See Fig. 1.) The first time the antenna was pulled up to the sky line, it was obvious that the top spacer would not support the antenna. As a replacement, two mop handles obtained from a local supermarket were spliced together with filament tape and placed in the antenna. The completed array included 1.75 pounds of copper wire, plus approximately 5 pounds of rope, PVC tubing and sticks. The entire quad weighed less than a pair of heavy-duty spiders used in conventional quads.

There are two noteworthy features of this Cayman design. The Cayman quad can be rotated by picking up the conch and coral and then walking in a circle. Furthermore, the entire antenna can be assembled on the ground and pulled up to the sky line by the mast rope that passes through the pulley. Any part of the antenna can be lowered rapidly to shoulder height for adjustment or repair.

On the ground, the assembled Cayman quad looked like a great fragile tangle. Winds gusting from the sea delayed the first hoisting, but that delay later seemed unnecessary because once the antenna was pulled up to the sky line, the quad withstood winds the likes of which are seldom experienced in Maryland. The dynamic stability (ability to withstand strong winds) of the Cayman quad was impressive. Neither the copper wire nor the 9-foot sticks had significant wind resistance.

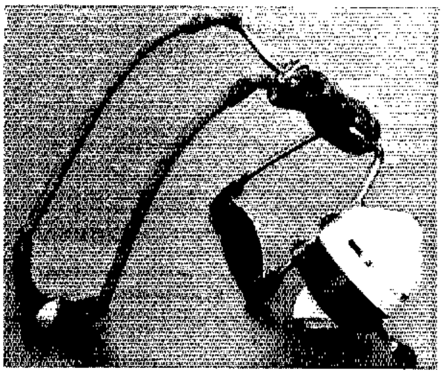
The bottoms of the loops were only 6 feet above the sand, but the quad was a great performer. Paul was working numerous European stations when the quad was ready for the first test. We therefore aimed the antenna at Europe, a move that enabled us to compare it with a vertical antenna located on the beach. When switching rapidly between the two antennas, received signals from Europe were at least two S units stronger on the quad.

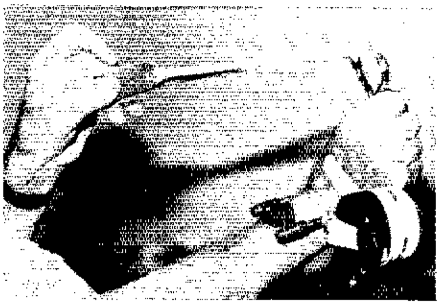
This was the first 20-meter beam I had ever used. It gave such great performance for so little money and effort that I decided to try it at home. I left the disposable walking-stick spacers on Cayman, repacked the wire and ropes, and hand carried the large conch shells on the flight home (they make great gifts!).

Gossamer Construction

Back home, the Cayman quad was installed between two oak trees at a height of 50 ft. The sky line was launched by taping light monofilament nylon fishing line (15-lb test) to an arrow that was then shot over the tree crowns by means of an archery bow. This light leader line in turn served to pull the ends of the 1/4-in. nylon sky line over the crowns and down to the earth anchors.[3] Another nylon rope goes through the pulley that is attached to the sky line. From the pulley this rope extends vertically down to become the "mast rope" on which the antenna is constructed. The other end of this rope passes over the nearest tree, and then down to a cleat. This end of the rope is used to pull the antenna up or lower it. If the hoisting end of the mast rope is returned straight down from the pulley, the vertical load on the sky line is doubled, and the additional sky-line sag would cause an unnecessary loss of antenna height.

The antenna is so easy to raise or lower that several design changes resulted in the antenna's becoming a remotely controlled rotating quad. Now, the top spacer is a





Small hose clamps are used to attach a casting reel to the wrist bracket of a slingshot. Monofilament nylon line tied to a 1-ounce (0.8 g) sinker is easily shot over any tree. The line can be rewound for repeated shots, and it is used to pull a heavier line over the tree when a suitable path through the tree is found.

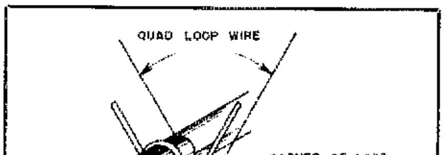


Fig. 2 — The quad loops are secured to the spacers by entwining the loop wire with solid copper wire that has been formed into grooves in the wooden spacers. The spacer ends are first wrapped with Scotch-88 tape, and the grooves are then formed by placing the shaft of a round nail or drill on the tape and "whacking" it with a hammer.

1-1/4 in. (mm = inches × 25.4) diameter wooden closet pole. The lower spacers are made of 3/4-in. square wood stock. Each of these is treated with two coats of white latex paint. Insulators for attaching the quad loops were formed by wrapping Scotch-88 electrical tape around the ends of the spacers (Fig. 2). A groove was formed in the wood beneath the tape by placing a nail lengthwise (not the point) on the tape and striking the side of the nail with a hammer. A short length of no. 14 solid copper wire was formed into the groove and twisted tightly, leaving the free ends 3 or 4 inches beyond the twist. During construction, the quad loops were fastened to the spacers by twisting these free ends around the loop wire.

At first, the steering lines were anchored by bricks on a large steering circle, but several backyard obstacles prevented 360° rotation. A smaller circle without obstacles could be used if the steering lines did not have to pull the loops into a diamond shape. Therefore, one major addition to the Cayman design is a 27-ft spreader (Fig. 3), which pushes the two middle spacers to opposite corners of the diamond. This pole consists of two telescoping fiberglass poles that extend from 6 to 16 ft. These weigh only 1.25 lb each. Skylane Products Co.[4] filled our order for them. Aluminum angle stock and hose clamps are used to join the poles end-to-end. The telescoping sections are extended and clamped for a combined length of 27 ft.

Both middle spacers are strapped to wood blocks drilled for snug passage of a short length of copper water pipe having one capped end (Fig. 4). Hose clamps fix the position of the block on the pipe. The spacers are mounted on the spreader by slipping the copper tubes over the ends of the spreader pole. This spreader and the top and bottom spacers can be tied to double bowlines in the mast rope. If you are not too familiar with double bowlines, ask a Boy Scout or Girl Scout, check a Scout manual or seek the aid of a mountain climber. Practical information on ropes and knots may also be found in books on mountaineering. Knowledge of knot tying and ropes can be most useful in constructing a gossamer and other antennas.[5] With the spreader pole in place, the steering lines can be brought to opposite points on a 13-ft-diameter circle on the ground. The steering procedure becomes much easier by tying the steering lines to the ends of a pole and pinning the center of the pole with a cinder block. Then the steering procedure is simply a matter of removing the block, rotating the pole and replacing the block.

Recent improvements include the placement of a vertical cedar pole under the center of the antenna, installation of a rotator atop the pole and putting a 13-ft steering pole on an 18-in. wooden mast attached to the rotator. A small length of PVC tubing is strapped to the short mast. The mast rope is passed through this tubing and is wrapped around the cleat on the cedar post to immobilize the pendulum. Light ropes are attached from the center of the bottom spacer out to the ends of the steering pole, and from the rotator mast out to the ends of the bottom spacer.

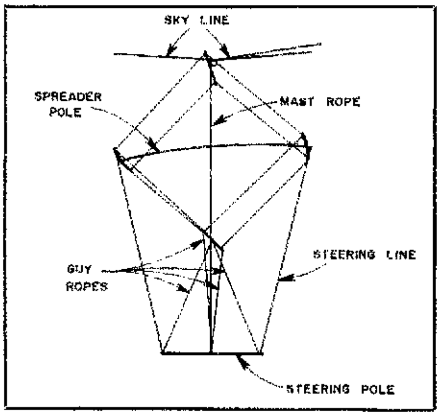


Fig. 3 — The gossamer quad is a slightly modified Cayman quad. Less steering room is needed if a spreader pole is added to push the loops into a diamond shape. The steering lines can be tied to a steering pole anchored on the ground or attached to a rotator. Guy ropes between the bottom spacer and steering pole steady the diamond in strong winds.

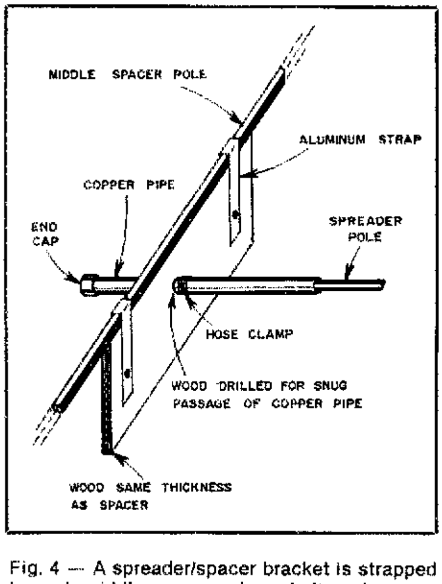


Fig. 4 — A spreader/spacer bracket is strapped to each middle spacer pole and slipped over the ends of the spreader pole. A hose clamp limits the motion of the board on the pipe.

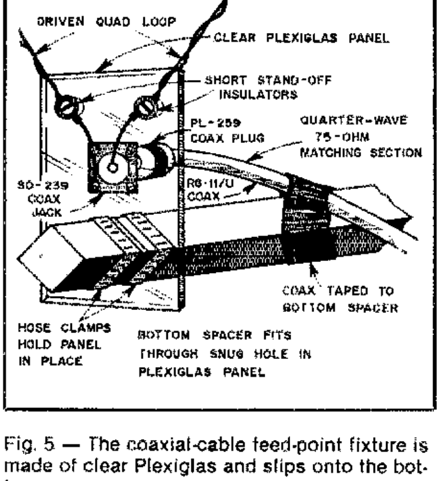


Fig. 5 — The coaxial-cable feed-point fixture is made of clear Plexiglas and slips onto the bottom spacer.

These four guy lines steady the lower part of the antenna and help maintain the diamond shape in strong winds. Although the steering pole for this antenna is 14 ft above ground, any height above heads and clotheslines would be satisfactory.

Cutting, Shaping and Feeding Loops

Quad dimensions are not very critical.[6] The loops are cut to length and spaced for f = 14 MHz according to published formulas.[7]

Length of one side of driven radiator: 250/f = 17.86 ft.

Length of one side of closed reflector: 258/f = 18.43 ft.

Spacing between loops: 118/f = 8.43 ft.

The loop wires are twisted to mark the four corners. (See Fig. 2). When the loops are formed into a diamond with square corners, the horizontal and vertical diagonals are close to 25 ft long. The spreader pole has to be 27 ft long to overcome spreader-pole droop and to allow for the spreader-spacer brackets. But again, this is not critical. In fact, the quad might have more gain if the vertical diagonal is longer than the horizontal diagonal (side lengths same as above). Loop gain depends on the separation between current maxima. These occur at the top and bottom corners when a diamond loop is fed at the bottom corner. Folke Rasvall, SM5AGM, has been told by his computer that a one-wavelength diamond with equal diagonals ought to have 1-dB gain relative to a half-wave dipole[8] (the corresponding element in a Yagi beam antenna). But if the vertical diagonal is made three times longer than the horizontal diagonal, so that the loop looks like a thin ARRL emblem, then the loop ought to have about 1.7-dB gain. The trade-off is more gain at the expense of reduced bandwidth and lower input impedance. The spreader pole on a 3 to 1 diamond would be only about 12 ft long, and the feed point would be 35 ft below the top spacer.

A quarter-wave section of 75-ohm coaxial cable was carefully pruned to 14 MHz using a grid-dip meter. This matching section is inserted between the 50-ohm feed line and the feed point at the bottom corner of the radiator loop. (See Fig. 5.) Minimum SWR ocurs below 14 MHz. The loops could be shortened to improve the SWR profile over the 20-meter band. What the transmitter "sees" is a standing-wave ratio of 1.4 to 1 at 14 MHz, and 1.9 to 1 at 14.35 MHz. No attempt has been made to optimize the quad for gain or front-to-back ratio, but when it is aimed correctly the received signals are usually two S units stronger on the quad than on either a vertical or a dipole.

Trees and Ropes

One ice storm lowered the quad two feet, the height loss resulting from drooping tree crowns and a sagging sky line. But, because the mast rope and guy lines are rigged for rapid adjustment, the antenna can be trimmed in a few minutes for prevailing conditions. The mast rope is wrapped around the cleat on the cedar post. Clothesline tighteners having spring-loaded cam wedges are used to adjust the guy lines.

Trees "eat" rope. Prolonged abrasions from rough tree bark can eventually sever the rope. To minimize wear, ropes should be routed for the least contact with the tree. The abrasion problem can be reduced by choosing suitable rope. A given amount of abrasion weakens a thin rope relatively more than a thicker rope. Good manila rope loses more strength to abrasion than does good nylon rope, but some inferior nylon ropes have poor abrasion resistance.[9] Several hundred feet of 1/8-in utility nylon takes little space in a suitcase and is probably adequate for a temporary expedition installation. For a permanent antenna, however, a good choice is 1/4-in. Mountain Climbing Goldline, an economical, high-quality nylon rope of three-strand, hard-lay construction, which (as this is written) costs about 15 cents per foot. It is sold by Recreational Equipment, Inc., Seattle, WA 98188.

Recently, Alan Hack, WA5VLX, suggested that the best way to get an antenna into a tree is to use a slingshot and casting reel combination such as developed by Robert Cowan, K5QIN.[10] In rerouting the mast rope I found that method definitely superior to using a bow and arrow. A one-ounce sinker painted yellow makes highly visible ammunition for the sling shot. Load the reel with fluorescent monofilament nylon, and the path through the tree is easier to see.

Comments

The gossamer quad is not a rigid structure. It bends against a strong wind rather like the venerable oaks that support the sky line. The steering is soft, and the antenna yaws at sudden gusts. No doubt there exist locations subjected to frequent gales where gossamer antennas often might be useless, but in Waldorf, Maryland, the author's quad has remained 100% usable in all weather experienced to date.

Some local ordinances against having beam antennas might not apply to a gossamer quad since there is no "unsightly" tower, and no mast or boom. One thin sky line below the tree line is less conspicuous than a dark swath of telephone or power lines, and a light-colored sky line is virtually invisible in many aspects of daylight. It is usually difficult to see the loop wires. Often the spacer poles seem to float magically in the air.

The quad will reward all efforts to rig it as high above ground as possible, but it does not have to be very high to outperform dipole and vertical antennas. Any radio amateur who can get a dipole 40 ft or more in the air can rig a sky line in its place. If there is a suitable clearing under the sky line, a two-element gossamer quad can replace the dipole and provide noticeably better results.

Acknowledgment

Paul Schmid (W4HET, ZF2BN), helped reactivate W3ODJ after many years. His enthusiasm for operating on Cayman convinced the author to join in the fun. Paul also encouraged the writing of this article. Thanks, Paul! QST

Notes

[1] *The ARRL Antenna Book* (Newington, CT: ARRL, 1976).
[2] B. Burnham, "A 15-Meter Beam for $10," *QST*, Nov. 1980.
[3] See Note 1.
[4] Skylane Products, 406 Bon Aire Ave., Temple Terrace, FL, 33617.
[5] W. Wheelock, *Ropes, Knots and Slings for Climbers* (La Siesta Press, 1967). Available from Recreational Equipment, Inc., Box C-88125, Seattle, WA 98188. Price in 1980: about $2.
[6] See Note 1.
[7] W. Orr, *All About Cubical Quad Antennas* (Wilton, CT: Radio Publications, Inc.).
[8] F. Rasvall, "The Gain of the Quad," *Radio Communication*, Aug. 1980, p. 784.
[9] H. Manning (Editor), *Mountaineering*, 2nd ed. (Seattle: The Mountaineers, 1967).
[10] A. Hack, "The Best Way to Get an Antenna into a Tree," *Ham Radio*, March 1981, p. 84.

Strays

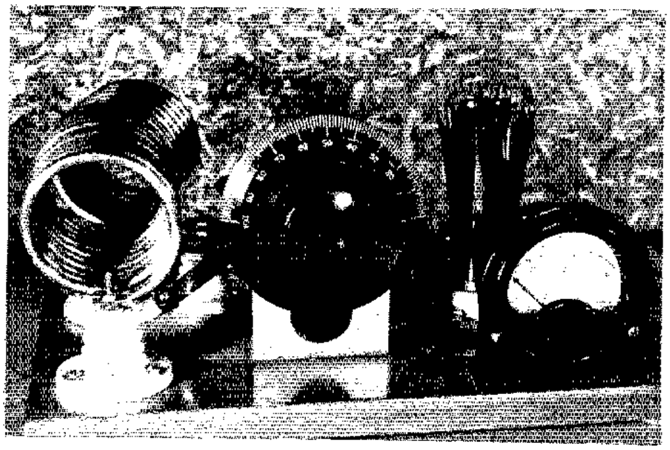
I would like to get in touch with . . .

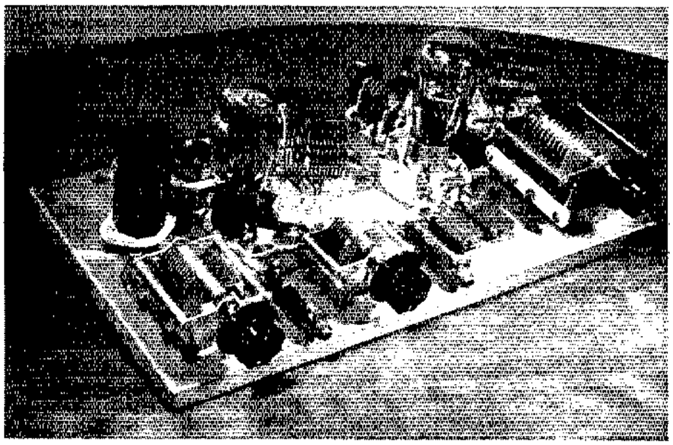
☐ anyone who has a collection or file of troubleshooting and maintenance information about the Heath SB-303 receiver and the Heath SB-401 transmitter. I will pay reproduction and postage costs. John Carter, KT6R, 412 Jamaica Way, Bakersfield, CA 93308.

☐ amateurs with a knowledge of and interest in the old WRL Galaxy V transceivers and accessories. Mike Flowers, KA3FJD, 1022 Woodland Way, Hagerstown, MD 21740.

☐ amateurs with information about the HW 12-22-32 Triband conversion made by Dynalab. Jim Fyles, WBØCZI, 820 El Paso Blvd., Denver, CO 80221.

☐ hams who are also teachers of electricity, electronics or industrial arts courses, to start an 80-meter net to discuss new projects. John Nenning, Industrial Arts, W. D. High School-Beckman Annex, Dyersville, IA 52240.





Gary Legel, N6TO, built these replicas of his first transmitters, a 59 Tri-Tet crystal oscillator and 301 amplifier (left), and the more modern Hartley 210 (right). Interest in nostalgic equipment is rising, and rigs such as these are cropping up with greater frequency. *(photos courtesy N6TO)*