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Title: Twelve-Foot Stressed Parabolic Dish, A
Author: Richard Knadle, Jr., K2RIW

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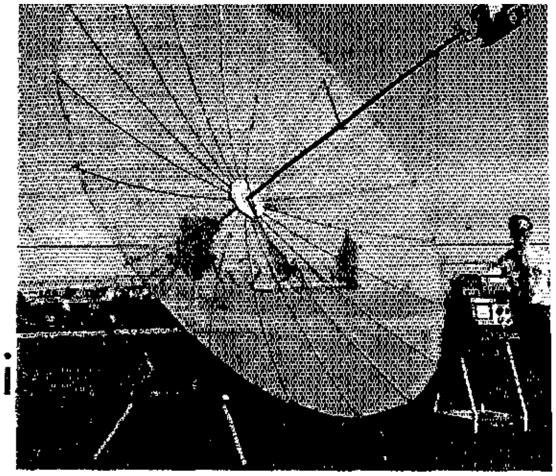
The stressed parabolic dish setup for 2287.5-MHz Apollo reception. A preamplifier is taped to the feed horn.



A Twelve-Foot Stressed Parabolic Di

BY RICHARD T. KNADLE, JR.,* K2RIW

VERY FEW ANTENNAS evoke as much interest among uhf amateurs as the parabolic dish, and for good reason. First, the parabola and its cousins – Cassegrain, hog horn, and Gregorian – are probably the ultimate in high-gain antennas. The highest-gain antenna in the world (148 dB) is a parabola. This is the 200-inch Mt. Palomar telescope. (The very short wave length of light rays causes such a high gain to be realizable.) Secondly, the efficiency of the parabola does not change as it gets larger. With collinear arrays, the loss of the phasing harness increases as the size increases. The corresponding component of the parabola is lossless air between the feed horn and the reflecting surface. If there are few surface errors, the efficiency of the system stays constant regardless of antenna size.

Some amateurs reject parabolic antennas because of the belief that these are all heavy, hard to construct, have large wind-loading surfaces, and require precise surface accuracies. However, with modern construction techniques, a prudent choice of materials, and an understanding of accuracy requirements, these disadvantages can be largely overcome. A parabola may be constructed with a 0.6 f/d (focal length/diameter) ratio, producing a rather flat dish making it easy to surface and allowing the use of recent advances in high-efficiency feed horns. This results in greater gain for a given size of dish over conventional designs.

The Technique

The usually heavy structure which supports the surface of most parabolic dish antennas has been replaced in this design by aluminum spokes bent into a near-parabolic shape by string. These dielectric strings serve the triple function of guying the focal point, bending the spokes, and reducing the error at the dish perimeter (as well as at the center) to zero. By contrast, in conventional designs, the dish perimeter, which has a greater surface area

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[1] Wilson, and Knadle, "Houston, This Is Apollo. . ," *QST*, June, 1972.

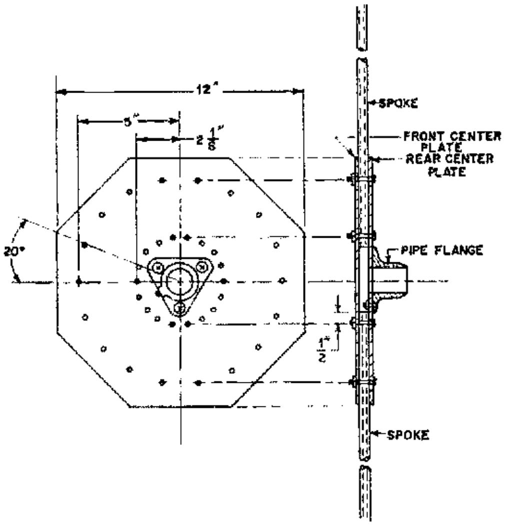
[2] The near field (distance at which gain can be accurately measured) of this antenna is 398 feet on 1296 MHz. The contest range was only 150 feet; therefore, the actual gain is probably considerably higher. Parts of the surface are out of focus when a gain measurement is made at a range that is too close to the dish.

Here is an easy way to build a lightweight, portable, high-gain parabolic dish which can be used for 432- and 1296-MHz mountain topping and antenna-gain contests; on 2300 MHz it has been used to receive the Apollo 15 and 16 voice transmissions;[1] it also can be used for 3300 and 5600 MHz. The graphs allow prediction of antenna gain, accuracy requirements, and reflector screen efficiency.

A commercially built antenna was not available to the author, and therefore this dish was constructed. Its portability (disassembled it fits into the trunk of a car), ease of assembly (it takes about 45 minutes), light weight (22 pounds), and adaptability (it may be adjusted for many focal lengths by tightening the strings), makes it very valuable. The construction materials cost approximately $45.

This particular antenna has won four first-place and two second-place trophies in three consecutive antenna-gain contests by displaying 17.5 dB gain over a dipole on 432 MHz and a calculated gain of 27 dB over an isotropic source on 1296 MHz.[2] Solar noise measurements on 2300 MHz suggest a gain of 36 dB over an isotropic source.

Fig. 1 – Center plates details. Two center plates are bolted together to hold the spokes in place.



than the center, is furthest from the supporting center hub so it often has the greatest error. This error is pronounced when the wind blows. Here, each of the spokes is basically a cantilevered beam with end loading. The equations of beam bending predict a near-perfect parabolic curve for extremely small deflections. Unfortunately, the deflections in this dish are not that small and the loading is not perpendicular. For these reasons, mathematical prediction of the resultant curve is quite difficult. A much better solution is to measure the surface error with a template and make the necessary correction by bending each of the spokes to fit. The uncorrected surface is accurate enough for 432- and 1296-MHz use. All of the aforementioned trophies taken by this parabola in antenna-gain contests were won using a completely natural surface with no error correction.

By placing the transmission line inside the central pipe which supports the feed horn, the area of the shadows or blockages on the reflector surface is much smaller than in other feeding and supporting systems, thus increasing gain. For 1296 MHz a backfire feed horn was constructed to take full advantage of this feature. On 432 MHz I have found that a dipole and reflector assembly produces 1.5 dB additional gain over a corner-reflector type feed horn. Since the preamplifier is located right at the horn on 2300 MHz, a conventional feed horn may be used.

Construction

Care must be exercised when drilling holes in the connecting center plates so that assembly difficulty will not be experienced later. See Fig. 1. A notch in each plate will allow them to be assembled in the same relative position. The two plates should be clamped together and drilled at the same time. Each of the 18 one-half-inch diameter aluminum spokes has two No. 28 holes drilled at its root to accept 6-32 machine screws which go through the center plates. The 6-foot long spokes are created by cutting in half standard 12-foot lengths of tubing. A fixture built from a block of aluminum assures that the holes are drilled in exactly the same position in each spoke. The front and back center plates constitute an I-beam-like structure, which gives the dish center considerable rigidity. Fig. 2 shows a side view of the complete antenna. Aluminum alloy (6061-T6) is used for the spokes while 2024-T3 aluminum alloy serves for the center plates. Aluminum has approximately three times the strength-to-weight ratio of wood used in other designs.[3] Additionally, aluminum does not become water-logged or warped. The end of each of the 18 spokes has an eyebolt facing the dish focus point which serves a double purpose: to accept the No. 9 galvanized fence wire which is routed through the screw eyes to define the dish perimeter, and to facilitate rapid assembly by accepting the S-hooks which are tied to the end of each of the lengths of 130-pound test Dacron fishing string. The string bends the spokes into a parabolic curve. Dacron was chosen because it has the same chemical formula as Mylar. This is a low-stretch material which keeps the dish from changing shape. The galvanized perimeter wire has a five-inch overlap area which is bound together with bailing wire after the spokes have been hooked to the strings.

The aluminum window screening is bent over the perimeter wire to hold it in place. At the suggestion of WB2HXQ, the window screening is now placed on the back of the spokes, thus achieving greater surface accuracy. It was thought originally that the spokes in front of the screening might cause surface perturbations and decrease the gain. However, the total spoke area is small. Placing the aluminum screening in front of the spokes requires the use of 200 pieces of bailing wire to hold the screening in place.This procedure in-

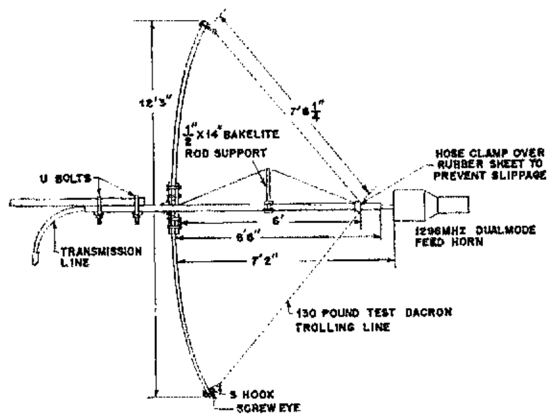


Fig. 2 – Side view of the stressed parabolic dish.

[3] Katz, K2UYH, "Simple Parabolic Antenna Design," *CQ*, August 1966 p. 10.

TABLE I

Materials List for the 12-foot Dish

1. Aluminum tubing, 12-feet × 1/2-inch OD × .049-inch wall, 6061-T6 alloy, 9 required to make 18 spokes.
2. Octagonal mounting plates 12 × 12 × 1/8 inches, 2024-T3 alloy, 2 required.
3. 1-1/4-inch ID pipe flange with setscrews.
4. 1-1/4 inches × 8 feet, TV mast tubing, 2 required.
5. Aluminum window screening, 4 × 50 feet.
6. 130-pound test Dacron trolling line from Finney Sports, 2910 Glansman Rd., Toledo, OH 43614, $3.80 for a 100-yard spool.
7. 38 feet of No. 9 galvanized fence wire (perimeter), Montgomery Ward Farm and Garden Catalog.
8. Two Hose Clamps 1-1/2 inch, two U bolts, 1/2 inches × 14 inches Bakelite rod or dowel, water-pipe grounding clamp, 18 eye bolts, 18 S

creased the assembly time by at least an hour. For contest and mountaintop operating (when the screening is on the back of the spokes) no other fastening technique is required than bending the screen overlap around the wire perimeter.

Surface

A four-foot-wide roll of aluminum screening 50 feet long is cut into appropriate lengths and laid parallel with a 2-inch overlap between the top of the unbent spokes and hub assembly. The overlap seams are sewn together on one half of the dish using heavy Dacron thread and a sailmaker's curved needle. Every seam was sewn twice, once on each edge of the overlapped area. The seams on the other half were left open to accommodate the increased overlap which occurs when the spokes are bent into a parabola. The perimeter of the screening then is trimmed. Notches are cut in the three-inch overlap to accept the screw eyes and S-hooks. The first time this dish was assembled, the screening strips were anchored to the inside surface of the dish and the seams sewn in this position. It is easier to fabricate the surface by placing the screen on the back of the dish frame with the structure inverted. The spokes are sufficiently strong to support the complete weight of the dish when the perimeter is resting on the ground.

The 4-foot wide strips of aluminum screening conform to the compound bend of the parabolic shape very easily. If the seams are placed parallel to the *E*-field polarization of the feed horn, minimum feedthrough will occur. This feedthrough, even if the seams are placed perpendicular to the *E*-field, is so small that it is negligible. Some constructors may be tempted to cut the screening into pie-shaped sections. This procedure will increase the seam area and construction time considerably. The dish surface appears most pleasing from the front when the screening perimeter is slipped between the spokes and is then folded back over the perimeter wire. When disassembly is desired, the screening is removed in one piece, folded in half, and rolled.

The Horn and Support Structure

The feed horn is supported by the 1-1/4-inch aluminum television mast. The transmission line which is inserted into this tubing is connected first to the front of the feed horn which then slides back into the tubing for support. A setscrew assures that no further movement of the feed horn occurs. During antenna-gain competition, the setscrew is omitted allowing the 1/2-inch semirigid (CATV cable) transmission line to move in or out while adjusting the focal length for maximum gain. The TV mast is held firmly at the center plates by the two setscrews attached to the pipe flange which is mounted on the rear plate. On 2300 Mhz the dish is focused for best gain by loosening these setscrews on the pipe flange and sliding the dish along the TV mast tubing (the dish is moved instead of the feed horn).

All of the fishing strings are held in position by attaching them to a hose clamp which is permanently connected to the TV tubing. A piece of rubber sheet under the hose clamp prevents slippage and keeps the hose clamp from cutting the fishing string. A second hose clamp is mounted below the first as double protection against slippage.

The high-efficiency 1296-MHz dual-mode feed horn, detailed in Fig. 3, weighs 5-3/4 pounds. This weight causes some bending of the mast tubing, however this is corrected by a 1/2-inch diameter Bakelite support. It is mounted to a pipe grounding clamp with an 8-32 screw inserted in the end of the rod. The Bakelite rod and grounding clamp are mounted midway between the hose clamp and the center plates on the mast. A double run of fishing string slipped over the notched upper end of the Bakelite rod counteracts bending.

The success of high-efficiency parabolic antennas is determined primarily by the feed-horn effectiveness. The multiple diameter of this feed horn may seem unusual. This newly designed and patented dual-mode feed, by Dick Turrin,[4,5] achieves efficiency by launching two different kinds of waveguide modes simultaneously, which causes the dish illumination to be more constant than conventional designs. The illumination drops off rapidly at the perimeter, reducing spillover. The feedback lobes are reduced by at least 35 dB because the current at the feed perimeter is almost zero; the phase center of the feed system stays constant across the angles of the dish reflector. The larger diameter section is a phase corrector and should not be changed in length. Theory predicts that almost no increase in dish efficiency can be achieved without increasing the feed size in a way that would increase complexity, as well as blockage. The feed is optimized for a 0.6 f/d dish. The dimensions of the feeds are slightly modified from

4 Turrin, "Technical Report No. 5, "A Paraboloidal Reflector Antenna for 1296 MHz," *The Crawford Hill VHF Club – W2NFA*, Holmdel, N.J.,1970, p. 13.

5 Turrin, Patent No. 3,413,641, "Dual Mode Antenna."

the original design in order to accommodate the cans. Either feed type can be constructed for other frequencies by changing the scale of all dimensions.

Multiband Use

Many amateurs construct multiple-band antennas by putting two dishes back to back on the same tower. This is inefficient. The parabolic reflector is a completely frequency-independent surface and studies have shown[6] that a 0.6 f/d surface can be steered seven beamwidths by moving only the feed horn from side to side before the gain diminishes one dB. Therefore, the best dual-band antenna can be built by mounting separate horns side by side. At worst the antenna may have to be moved a few degrees (usually less than a beamwidth) when switching between horns, and the unused horn increases the shadow area slightly. In fact, the same surface can function simultaneously on two frequencies making cross-band operation possible with the same dish.

Assembly Order

1) A single spoke is held upright behind the rear mounting plate with the screw eye facing up. Two 6-32 machine screws are pushed through the holes in the rear mounting plate, through the two holes of the spoke, and into the corresponding holes of the upper mounting plate. Lock washers and nuts are placed on the machine screws and hand tightened.

2) The remaining spokes are placed between the machine screw holes. Make sure that each screw eye faces upward. Machine screws, lock washers, and nuts are used to mount all 18 spokes.

3) The 6-32 nuts are tightened using a socket wrench.

4) The mast tubing is attached to the spoke assembly, positioned properly, and locked down with the setscrews on the pipe flange at the rear center plate.

5) The ends of two pieces of fishing string (which go over the Bakelite rod support) are tied to a screw eye at the forward center plate.

6) The dish is laid on the ground in an upright position and No. 9 gauge galvanized wire is threaded through the eyebolts. The overlapping ends are lashed together with bailing wire.

7) The dish is placed on the ground in an inverted position with the focus downward. The screening is placed on the back of the dish and the screening perimeter is fastened as previously described.

8) The extension mast tubing (with counterweight) is connected to the center plate with U bolts.

9) The dish is mounted on a support (if one is used) and the transmission line is routed through the tubing and attached to the horn.

Parabola Gain Versus Errors

"How accurate must a parabolic surface be?" is a frequently asked question. According to the Rayleigh limit for telescopes, little gain increase is realized by making the mirror accuracy greater than ± 1/8 wavelength peak error.[7] John Ruze of the M.I.T. Lincoln Laboratory,, among others, has derived an equation for parabolic antennas and built models to prove it.[8] The tests show that the tolerance loss can be predicted within a fraction of a dB, and less than 1 dB of gain is sacrificed with a surface error of ± 1/8 wavelength. An eighth of a wavelength is approximately three inches at 432 MHz, one inch at 1296 MHz and 1/2-inch at 2300 MHz.

Some confusion about requirements of greater than 1/8-wavelength accuracy may be the result of technical literature describing highly accurate surfaces for reasons of low side-lobe levels. We are concerned more with forward gain than low side-lobe levels; therefore, these stringent requirements do not apply. When a template is held up against a surface ± peak errors can be measured. The graphs of dish-accuracy requirements are frequently plotted in terms of rms error, which is a mathematically derived function much smaller

6 Silver, *Microwave Antenna Theory and Design*, Radiation Laboratory Series, Vol. 12, McGraw-Hill, N.Y., 1949, p. 488.

7 Conrady, *Applied Optics and Optical Design, Part Two*, Dover, N. Y. 1960, p. 626.

8 Ruze, "Antenna Tolerance Theory — A Review," *Proceedings of the IEEE*, April 1966, p. 633.

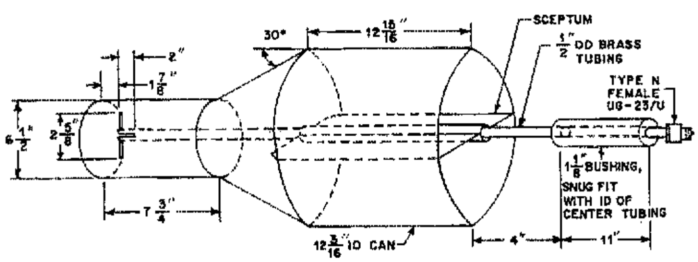


Fig. 3 — Backfire type 1296-MHz feed horn, linear polarization only. The small can is a Quaker State oil container; the large can is a 50-pound shortening container (obtained from a restaurant, "Gold Crisp" brand). Brass tubing, 1/2-inch OD, extends from UG-23/U connector to dipole. Center conductor and dielectric are obtained from 3/8-inch Alumafoam coaxial cable. The dipole is made from 3/32-inch copper rod. The sceptum and 30-degree section are made from galvanized sheet metal. Styrofoam is used to hold the sceptum in position. The primary gain is 12.2 dB over isotropic.

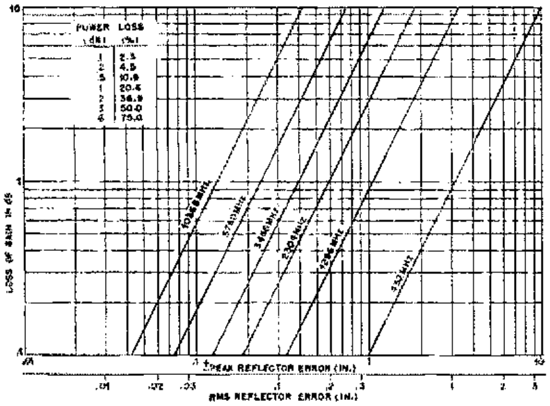


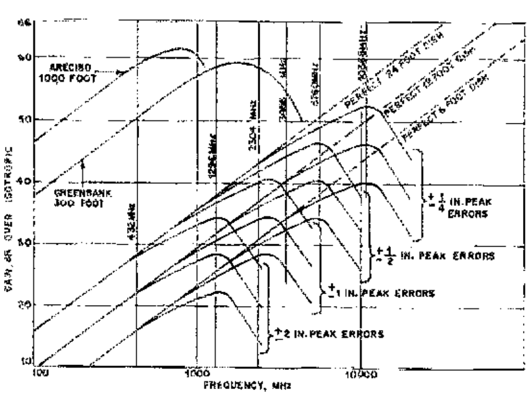
Fig. 4 — Gain loss vs. reflector error. Basic information obtained from J. Ruze, British *IEE*.

(typically 1/3) than ± peak error. These small rms accuracy requirements have discouraged many constructors who confuse them with ± peak errors.

Fig. 4 may be used to predict the resultant gain of various dish sizes with typical errors. There are a couple of surprises, as shown in Fig. 5. As the frequency is increased for a given dish, the gain increases 6-dB per octave until the tolerance errors become significant. Then gain deterioration occurs rapidly. Maximum gain is realized at the frequency where the tolerance loss is 4.3 dB.[9] Notice that at 2304 MHz, a 24-foot dish with ±2-inch peak errors has the same gain as a 6-foot dish with ±1-inch peak errors. Quite startling, when it is realized that a 24-foot dish has 16 times the area of a 6-foot dish. Each time the diameter or frequency is doubled or halved, the gain changes 6 dB. Each time all the errors are halved the frequency of maximum gain is doubled. With this information, the gain of other dish sizes with other tolerances may be predicted.

These curves are adequate to predict gain assuming a high-efficiency feed horn is used (as described earlier) which realizes 60-percent aperture efficiency. At frequencies below 1296 MHz where the horn is large and causes considerable blockage, the curves are a little optimistic. A properly built dipole and splasher feed will have about 1.5 dB less gain when used with 0.6 f/d dish than the dual-mode feed system described.

9 Ruze, "Antenna Tolerance Theory — A Review," *British IEE Conference Publication Number 21 June 1966, p. 120.*



The worst kind of surface distortion is where the surface curve in the radial direction is not parabolic but gradually departs in a smooth manner from an exact parabola. The loss of gain can be severe because a large area is involved.[10] If the surface is checked with a template, and reasonable construction techniques are employed, deviations will be under control and the curves will represent an upper limit to the gain that can be realized.

If a 24-foot dish (with ±2-inch peak errors) is being used with 432-MHz and 1296-MHz multiple feed horns, the constructor might be discouraged from trying a 2300-MHz feed because there is 15-dB gain degradation. However, the dish will have 29 dB of gain remaining on 2300 MHz, making it worthy of consideration.

The near-field range of the 12-foot 3-inch antenna is 703 feet at 2300 MHz. An antenna-testing chamber of this size is not available to the author. By using the sun as a transmitter and observing receiver noise power, it was discovered that the antenna has two main lobes about 4 degrees apart. The template showed a surface error (insufficient spoke bending at 3/4 radius) and a correction was made. A recheck showed one main lobe and the sun noise was almost 3 dB stronger.

Other Surfacing Materials

The choice of surface materials is a compromise between rf reflecting properties and wind loading. Aluminum screening, with its very fine mesh (and weighing 4.3 pounds per 100 square feet) is useful beyond X-band because of its very close spacing. It is easy to roll up and is therefore ideal for a portable dish. However, this close spacing causes it to be a 34-percent filled aperture, which will cause the wind force at 60 miles per hour to be more than 400 pounds on this 12-foot dish. Those amateurs considering a permanent installation of this dish should look into other surfacing materials.

One-inch hexagonal chicken wire, which is an 8-percent filled aperture, is very desirable for 432-MHz operation. It weighs 10 pounds per 100 square feet and exhibits 81 pounds of force with 60-mile-per-hour winds. However, measurement on a large piece reveals 6 dB feedthrough at 1296 MHz. Therefore, on 1296 MHz one fourth of the power will feed through the surface material; but this will only cause a loss of 1.3 dB forward gain. Since the low-wind-loading material will provide a 30-dB gain potential, it is a very good tradeoff. Chicken wire is very poor material for 2300 MHz and higher, since the hole dimensions become comparable to a half wavelength. As with all surfacing materials, minimum feedthrough will

10 See footnote 4.

Fig. 5 — Parabolic-antenna gain versus size, frequency, and surface errors. All curves assume 60-percent aperture efficency and 10-dB power taper. Reference: J. Ruze, British *IEE*.

occur when the *E*-field polarization is parallel to the longest dimension of the surfacing holes. Half-inch hardware cloth weighs 20 pounds per 100-square feet. It has a wind loading characteristic of 162 pounds with 60-mile-per-hour winds. The filled aperature is 16 percent and this material is useful to 2300 MHz.

A rather interesting material worthy of investigation is 1/4- inch reinforced plastic (described in Montgomery Ward Farm and Garden Catalog). It weighs only 4 pounds per 100 square feet. The plastic melts with many universal solvents such as lacquer thinner. If a careful plastic-melting job is done, what will be left is the 1/4-inch spaced aluminum wires with a small blob of plastic at each junction to hold the matrix together.

There are some general considerations to be made in selecting surface materials:

1) Joints of screening do not have to make electrical contact. The horizontal wires reflect the horizontal wave. Skew polarizations are merely a combination of horizontal and vertical components which are thus reflected by the corresponding wires of the screening. To a horizontally polarized wave, the spacing and diameter of only the horizontal wires determine the reflection coefficient (see Fig. 6). Many amateurs have the mistaken impression that screening materials that do not make electrical contact at their junctions are poor reflectors.

2) By measuring wire diameter and spacings between the wires a calculation of percentage of aperture that is filled can be made. This will be one of the major determining factors of wind pressure when the surfacing material is dry. Under ice and snow conditions smaller aperture materials may become clogged, which could make the surfacing material act as one solid sail. The ice and snow will have a rather minor effect on the reflecting properties of the surface, however.

3) Amateurs who live in areas where ice and snow are prevalent should consider a de-icing scheme such as weaving enameled wire through the screening and passing a current through it, fastening water-pipe heating tape behind the screening, or soldering heavy leads to the screening perimeter and passing current through the screening itself.

Parabolic Template

For use at 2300 MHz and higher where high surface accuracy is required, a parabolic template should be constructed to measure surface errors. A simple template was constructed (see Fig. 7) by taking a 12-foot 3-inch length of 4-foot wide tar paper and drawing a parabolic shape on it with chalk. The points for the parabolic shape were calculated at 6-inch intervals and these points were connected with a smooth curve. For those who wish to use the template with the surface material installed, the template should be cut along the chalk line and stiffened by cardboard or a wood lattice frame.

Surface-error measurements should take place with all spokes installed and deflected by the fishing strings, since some bending of the center plates does take place.

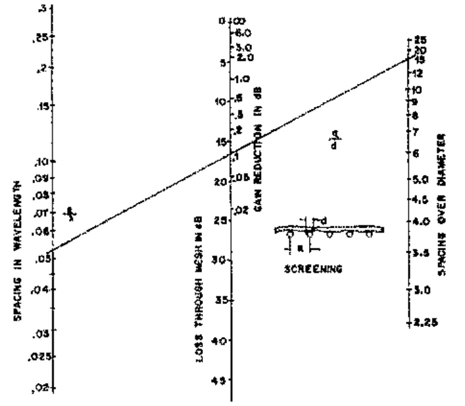


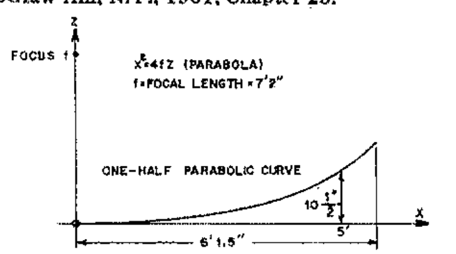
Fig. 6 — Surfacing material quality.[11]

A Feed System for 2287.5 MHz

The modification of a feed horn by W2IMU shown in Fig. 8, launches more accurate circularly polarized waves and has greater efficiency than conventional designs, since it eliminates the need for a hybrid coupler. It is optimized for a 0.6 f/d dish. When power is fed into connector No. 1 only, the 10-32 screws cause the rf to become a counterclockwise circularly polarized wave out of the horn. After bouncing off the dish this becomes a clockwise wave on either transmit or receive. Power fed into connector No. 2 becomes a ccw wave after bouncing off the dish. Therefore, for moonbounce work connect the transmitter to connector No. 1; connect the receiver to connector No. 2. For Apollo reception use only connector No. 1.

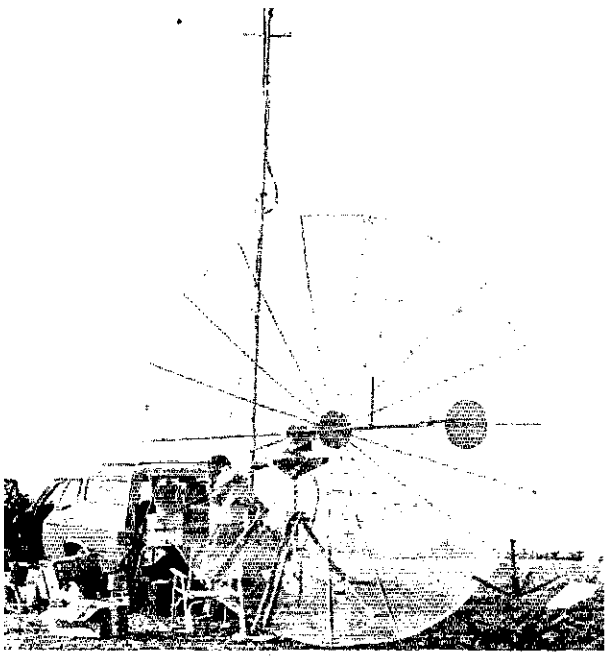
The 1/4-20 screw prevents energy from coupling between connector No. 1 and connector No. 2. If the 10-32 screws are omitted, each connector launches an ordinary linear wave. The small cans are "Scotts Oats" type from Scotland or "Camp" drain cleaner cans from the U.S., 3-3/4-inches ID. The large can is a one-gallon American paint can, 6-1/2-inches ID. The 30-degree section is galvan-

11 Jasik, *Antenna Engineering Handbook*, McGraw-Hill, N.Y., 1961, Chapter 25.



X	Z (TO NEAREST 1/16")	X	Z
.5'	1.5/16"	5.5'	12-3/4"
1.0'	7/16"	6.0'	15-1/8"
1.5'	15/16"		
2.0'	1-11/16"		
2.5'	2-5/8"		
3.0'	3-3/4"		
3.5'	5-1/8"		
4.0'	6-11/16"		
4.5'	8-1/2"		
5.0'	10-1/2"		

Fig. 7 — Parabolic template for 12-foot, 3-inch dish.



The dish may be set up in a remote location. Shown is the 432-MHz dipole and splasher feed operated from Mt. Equinox, Vermont. K2OVS is the operator in the backround.

ized sheet metal. Tabs on each end add strength and make soldering the cans together easier.

The two UG-58A/U connectors are each fastened to the cans with two 4-40 bolts and 4-40 nuts are soldered to the inside. The outside of the can is tinned in the area of each connector to assure good electrical contact. The ten 10-32 bolts are 1-1/4-inches long with 11/16-inch total length inside the can. Each bolt has a 10-32 nut soldered to the outside of the can and a second 10-32 nut placed on top as a locking device. The 1/4-20 bolt is 1-1/2-inches long with 3/4-inches inside the can. Outside is a 1/4-20 nut soldered to can and a second 1/4-20 nut added for locking purposes.

The two 1/16-inch fiber glass mounting sheets are each slotted along half of their length, slid together at a right angle and epoxy glued. All glued edges of fiber glass are first roughened with coarse sandpaper. Many very small holes are drilled into the fiber glass in the areas of metal contact.

During Apollo reception, connector No. 1 is connected to the preamplifier (if one is used) with a short piece of cable. The preamplifier output cable runs straight to the perimeter of the dish. When no preamplifier is used, consider placing the 2287.5 MHz converter at the feed horn and running power to it. This will result in a lower system noise figure since all cables are quite lossy at 2287.5 MHz.

The inside and outside of the horn may be painted with spray lacquer for preservation. The completely painted horn had a total loss from connector No. 1 to radiated circular wave out the throat of less than 0.1 dB. With this new feed, which was used on Apollo 16, greater than 9 dB of S-band sun noise was realized. The feed used on Apollo 15, pictured on page 64 of June *QST* realized only 6-1/4 dB of sun noise. This may have been caused by loss in the hybrid coupler and wire support.

Possible Variations

The stressed parabolic antenna, as described, is a new construction technique for which a patent application has been filed. Because of its newness, all of its possibilities have not been explored. For instance, a set of fishing strings or guy wires could be set up behind the dish for error correction as long as it does not permanently bend the aluminum spokes. This technique would also protect the dish against wind loading from the rear. An extended piece of TV mast would be an ideal place to hang a counterweight and attach the back guys. It would strengthen the structure.

The author wishes to acknowledge the ample assistance received from W2IMU, W2CTK, K2OVS, K2LCK, WN2MUE and WB2MLH throughout the development of this antenna. QST

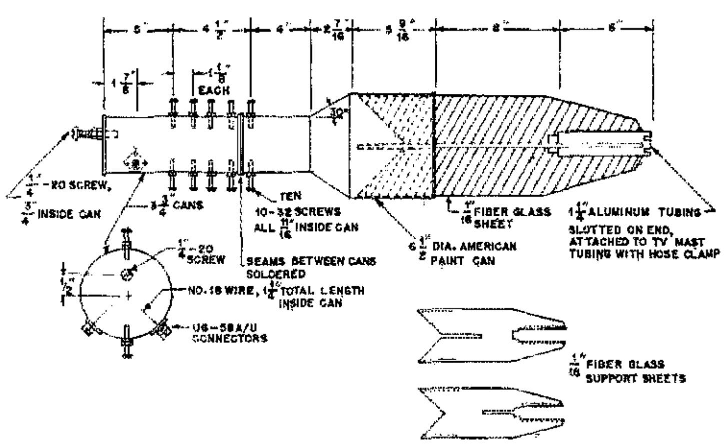


Fig. 8 — Clockwise and counterclockwise polarized 2287.5-MHz feed system; see text.