Chapter 3

Antennas

3.1 Dual Polarised Dish Feed

Walter Bohlman K3BPP - April 1975

Table 3–1: Dual Polarisation Feed Characteristics

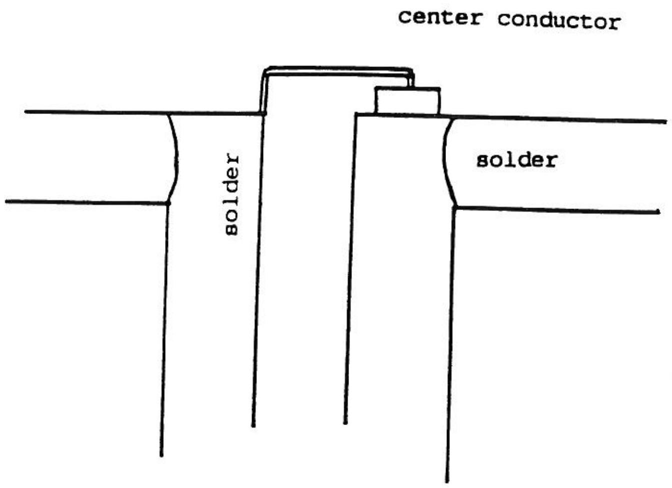
Input VSWR	< 2:1 400-490
	< 1.2:1 432 MHz
3 dB Bandwidth	E plane 61°
	H plane 57°
10dB Bandwidth	E plane 110°
	H plane 100°
Level at edge	E plane -9 dB
of .55 f/D dish	H plane -10.5 dB

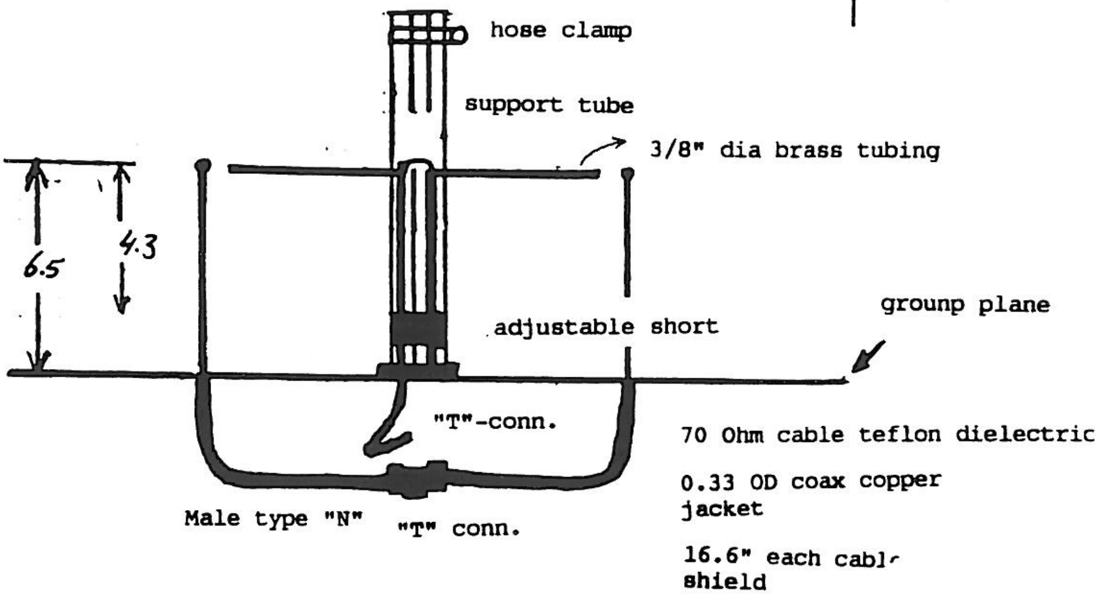
This antenna is a modification of the EIA dipole array. There are two basic advantages:

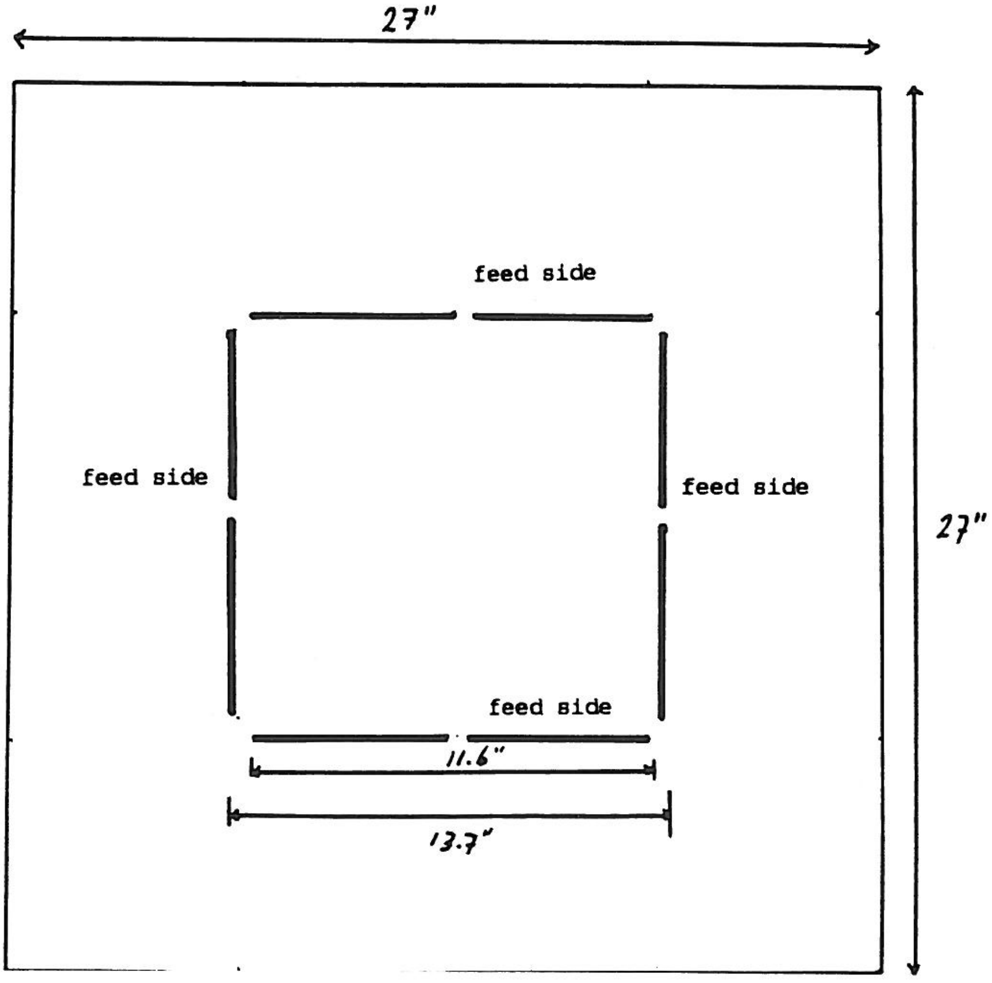
1. The feed mounts directly with a flange to a metal pipe to vertex of the dish. The feed cables are carried in this pipe and pass through a hole in the ground plane.
2. Instant polarisation diversity i.e. max loss is 3 dB for worst case Faraday rotation.

Each one of the 4 antennas is fed with an unshielded folded balun with an adjustable shorting stub (solder in place after tuning). The feed cable is 70 ohm Teflon dielectric. All four cables are exactly the same length (0.95λ) opposite pairs (i.e. parallel dipoles) are joined with "T" connectors. The output impedance at the centre of the "T" must be 100+j0 ohm to combine to give 50+j0 ohm.

Figure 3–1: Dual Polarised Feed





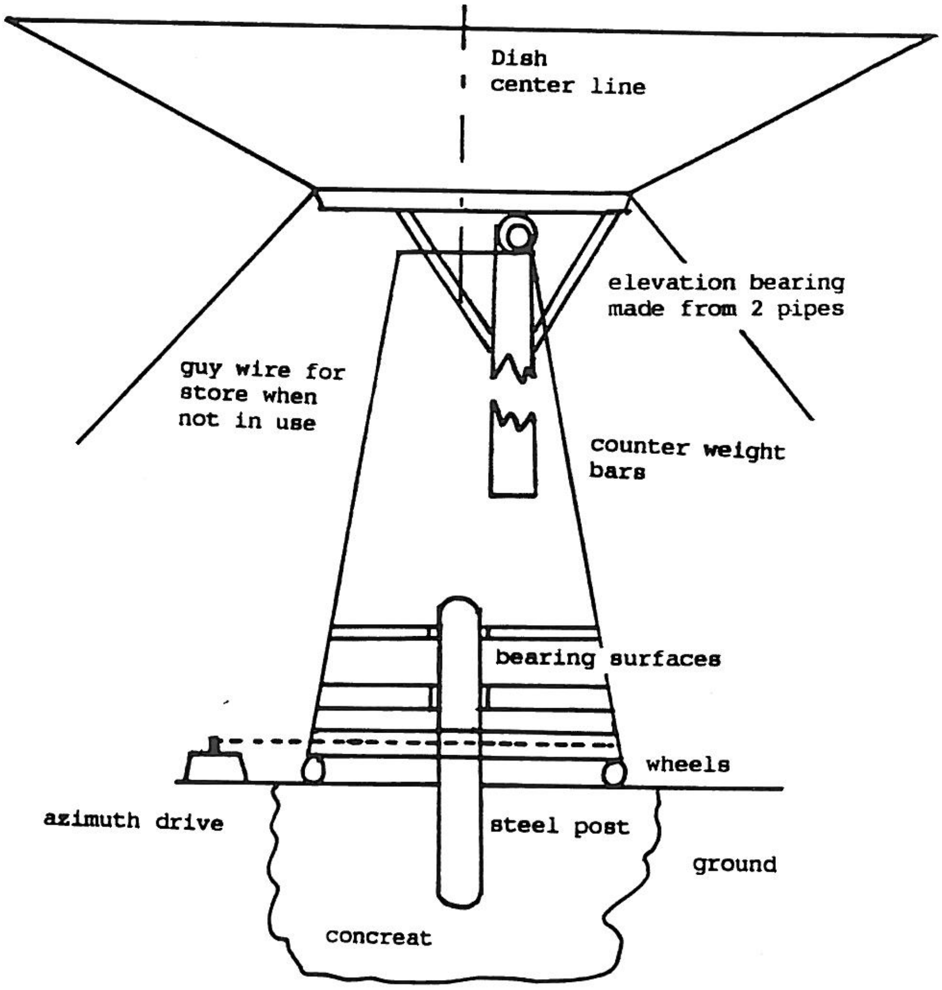


3.2 28 ft Dish Mount Details

Allen Katz K2UYH - March 1977

Figure 3–2 show the mechanical realisation of the mount of Al's 28 ft dish.

Figure 3–2: K2UYH 28 ft Dish Mount

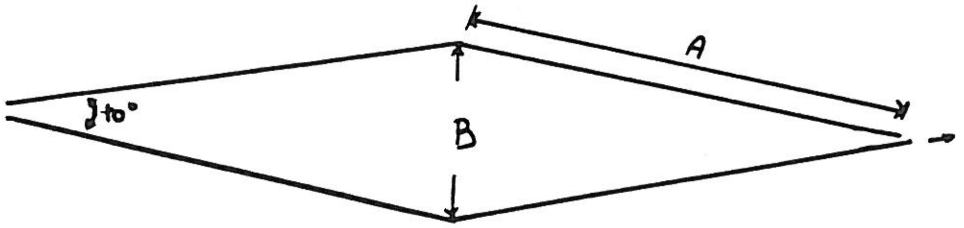


3.3 432 MHz Rhombic Antenna Design

Jack Albright K0WOW - June 1977

Last fall Jack, K0WOW copied our EME signals with a 4 dB converter using two stacked rhombics. The dimensions of these rhombics are shown in the following figure. The design is based on work done by VK3ATN (World above 50 MHz, QST, Jan. 1968) and K0MQS on 2 meters. The rhombics were stacked approximately 2 wavelengths apart and composed of #18 copper clad wire. A universal stub was used for matching. K0MQS has tried stacking up to 8 rhombics and says that a 0.9 wavelength is about optimum.

Figure 3–3: Rhombic Antenna



A = 50.25λ (=114′ at 432 MHz)
B = 20′
No termination on the open end.

3.4 432 MHz 4-way Power Divider

Jay Liebmann K5JL - September 1978

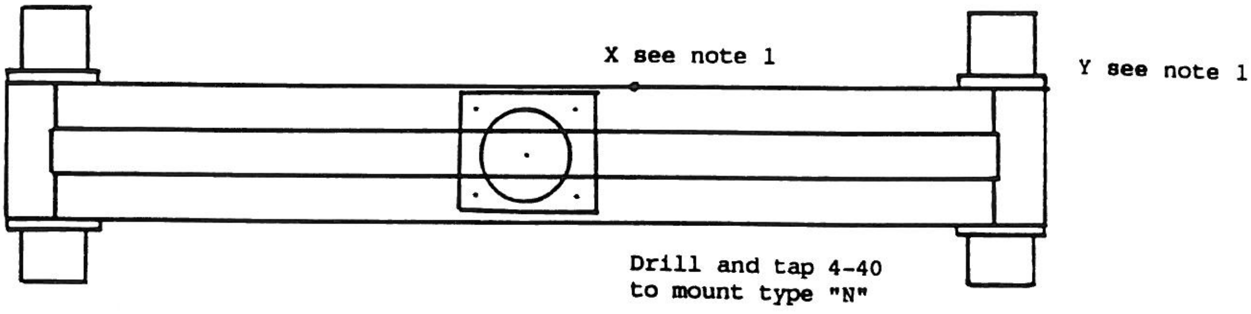
The outer conductor is made of 1 x 1" square aluminium with 1/16" walls. The inside conductor is 3/8" OD copper tubing. Make a slot inside the conductor as necessary and solder an "N" type connector to it.

For a two port divider, saw outer part off at point "X" and discard the piece from X to Y. The outer conductor is still 1x1" square aluminium 1/16" wall. The inner conductor is changed to a 1/8" OD tubing while the length is still 6 7/8".

Cut a 1 x 1" square piece of epoxy to seal the lines of the power divider and drill some small vent holes on bottom side.

For 6 port divider use 7/16" inside conductor.

Figure 3–4: 432 MHz Power Divider



3.5 432 MHz Quad Feed Design

Rusty Holshouser K4QIF - February 1979

In Figure 3–5 is shown a dish feed developed by Rusty, K4QIF. This feed uses a single quad element radiator and is optimised for a 0.45 f/D dish. It is much smaller than the dual dipole feed which is optimum for about 0.55 f/D. (Small differences in illumination do not significantly alter dish performance). We have built this feed, but have not had a chance to adequately evaluate it, because of the weather. Rusty however, seems to be having very good results with it. Instead of hardline for the λ/4 50 ohm section we used standard RG8 inside a 3/8" diameter copper tube. We continued the insulated centre portion of the RG8 above the top of the tube and bent it over adjacent to loop. The gamma capacitor was formed by running a copper strap over the insulated centre conductor and back to the loop. By vary the position (almost at the corner) and width (approx. 1/2") of the strap a near perfect 50 ohm match can be obtained.

3.6 1296/432 MHz Dual Band Feed and System

Willy Bauer LX1DB - June 1980

The Dual Band Feed consists of a combination of 2 systems:

On 432 MHz 2 dipoles on vertical and 2 dipoles on horizontal are 1/4λ over the reflector.
On 1296 MHz a dual feed for circular polarity.

Theoretical there is a difference due to the two sizes of feeds in the focal point of 17 cm (432 feed is 17 cm nearer to the dish than 1296 MHz). I put it 12 cm from the focal point of 432 MHz feeder to the 1296 MHz who has on 1296 5cm to close. (all dimension for my 9 m dia. dish).

I measured no difference in solar noise on 432 and on 1296 MHz with this system compared to a single feed system for same frequency.

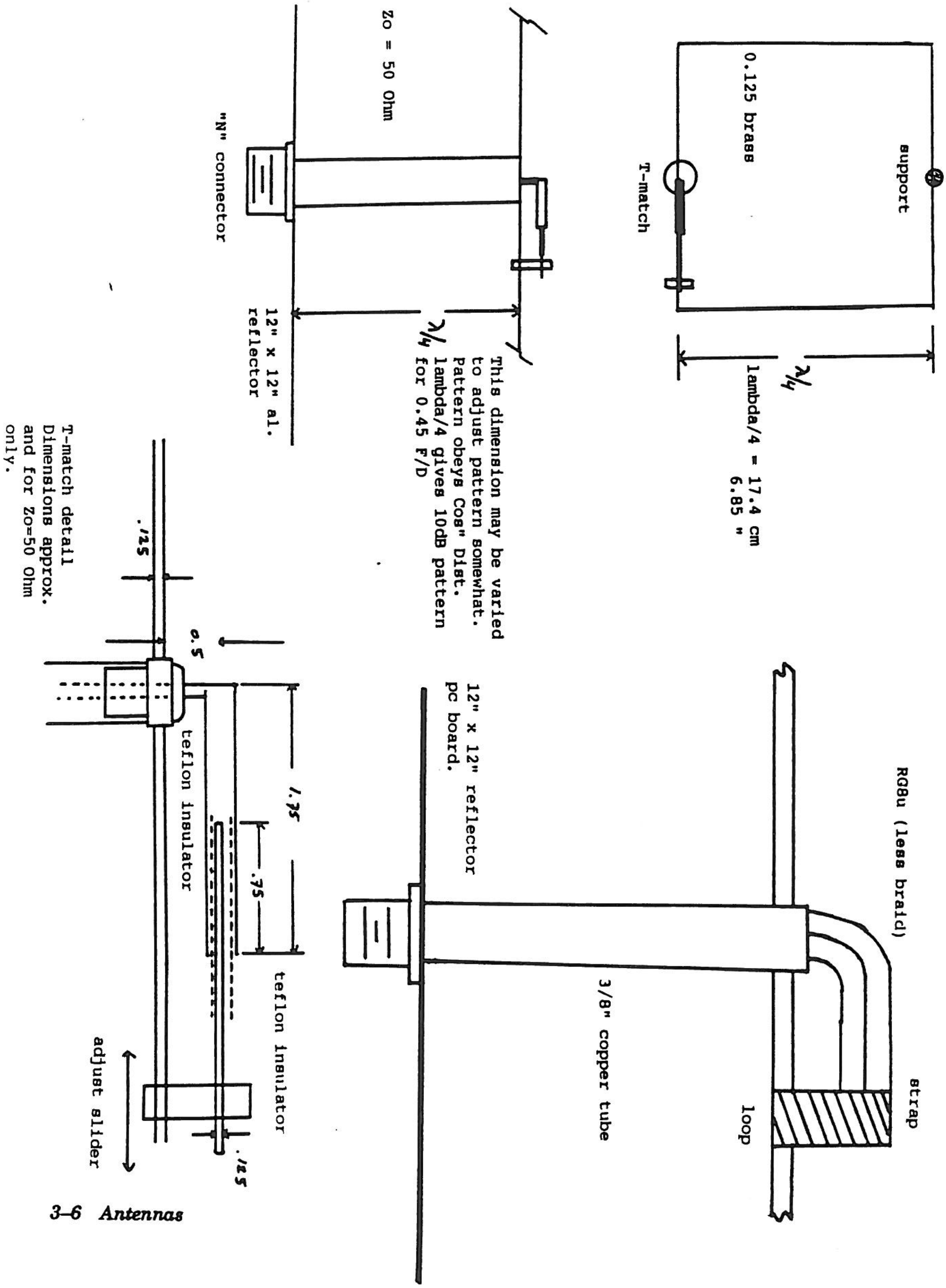
On 1296 MHz there is not the possibility to change circular polarisation direction. I am on the same standard as PA0SSB and connected so as on the drawing. On 432 I have the possibility to change any polarisation from vertical, horizontal, linear and from -Phi/4 to 0 to +Phi/4. This is my system, so as you can see there are 4 coax cables coming down. In my case L5 is RG17 and on RX L6 is RG58. The phasers PH1 and PH2 are the phasers from old slide slope TX in navigation.

3.7 DL9KR 13 El. 4λ Yagi

Jan Bruinier DL9KR - July 1980

I think it is appropriate with DL9KR's outstanding showing in the EME-contest that we have details of his 16 Quagi array this month. More than anything else the secret ingredient in Jan's success is care. I know from his correspondence over the years that he has spent countless hours optimising his system.

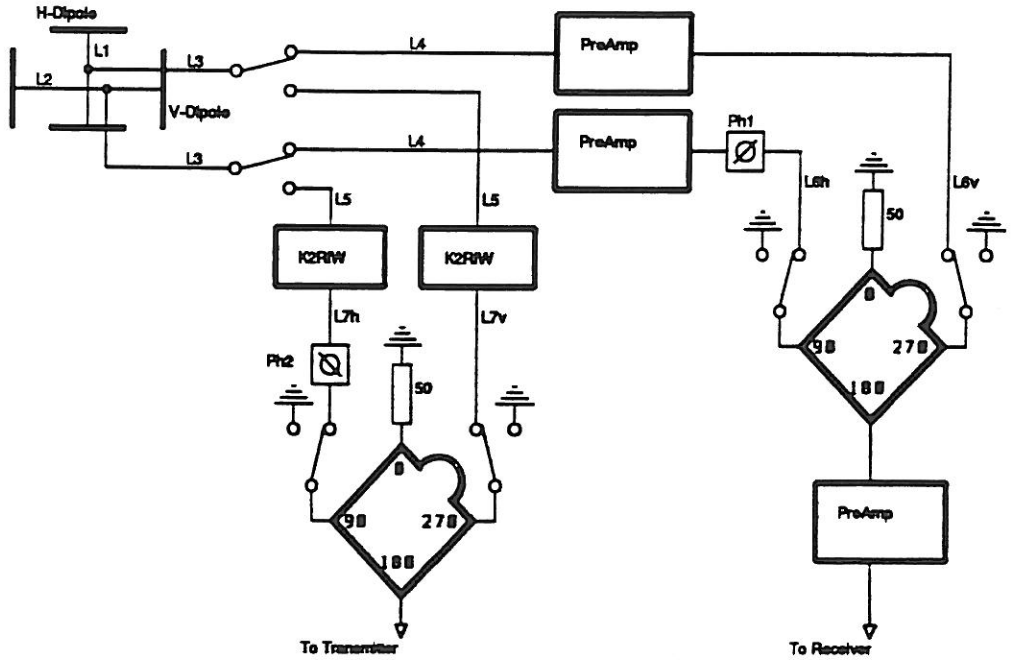
Figure 3–5: 432 MHz Quad Feed Design

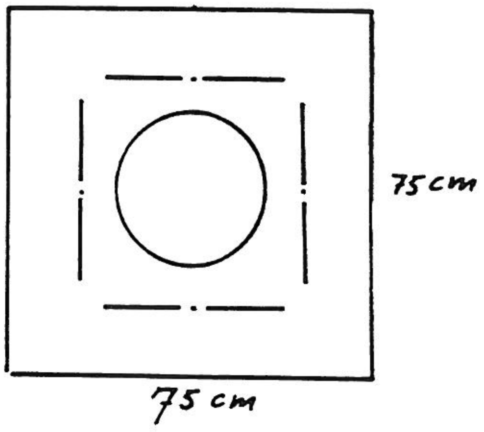


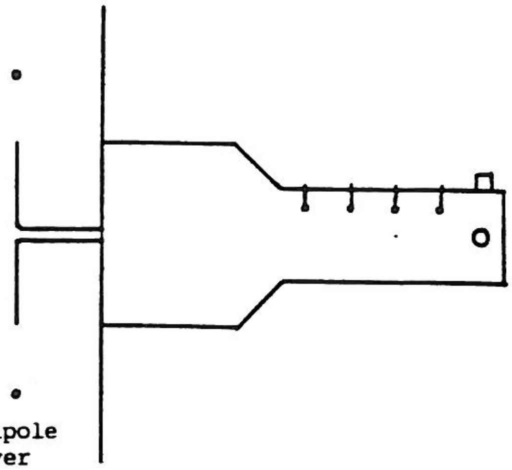
This dimension may be varied to adjust pattern somewhat. Pattern obeys Cos" Dist. lambda/4 gives 10dB pattern for 0.45 F/D

T-match detail
Dimensions approx.
and for zo=50 Ohm
only.

Figure 3–6: LX1DB Dual Band Feed





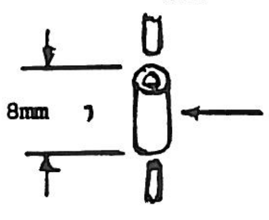


Lambda/2 dipole
lambda/4 over
reflector

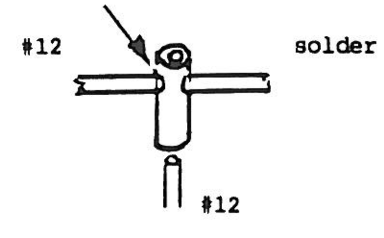
3.7.1 The open wire feeder

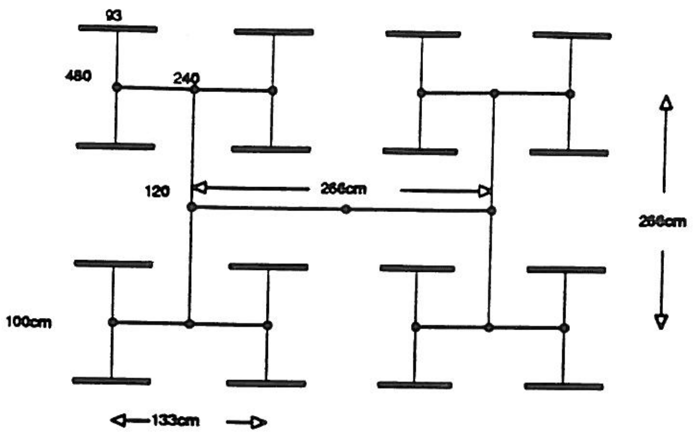
Feedline: 2 x 2 mm dia. (#12 AWG) enamelled Cu spaced 13.5 mm centre to centre by 6 mm Teflon every approx. 330 mm. Place spacers on voltage nodes where mechanically feasible for minimum moisture sensibility! Velocity factor is 0.96.

Connections



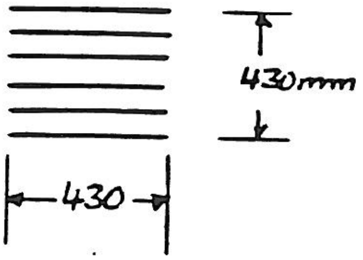
Copper tubing
2mm inner
4mm outer



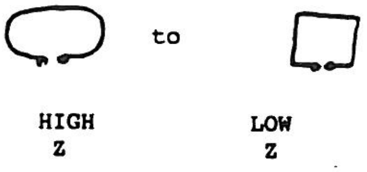


3.7.2 Modification of the N6NB Quagi

The reflector grid, consists of six 4 mm dia round aluminium elements each 430 mm long.



Driven element circumference 696 mm, Enam. #12. Adjust shape from



for best match. Matching is best done with a group of 4 Yagis, aim for 240 or 200 ohm. Change shape of driven element as above. The directors are made of #12 AWG (2 mm) Enam. Cu. wire. The lengths are valid for a wooden or fibreglass boom.

Spacing	Length	Spacing	Length
R -DE 150mm		D5-D6 242mm	D6 =295mm
DE-D1 133mm	D1 =302mm	D6-D7 287mm	D7 =293mm
D1-D2 260mm	D2 =300mm	D7-D8 233mm	D8 =292mm
D2-D3 168mm	D3 =299mm	D8-D9 270mm	D9 =291mm
D3-D4 222mm	D4 =297mm	D9-D10 270mm	D10=291mm
D4-D5 222mm	D5 =295mm	D10-D11 280mm	D11=290mm

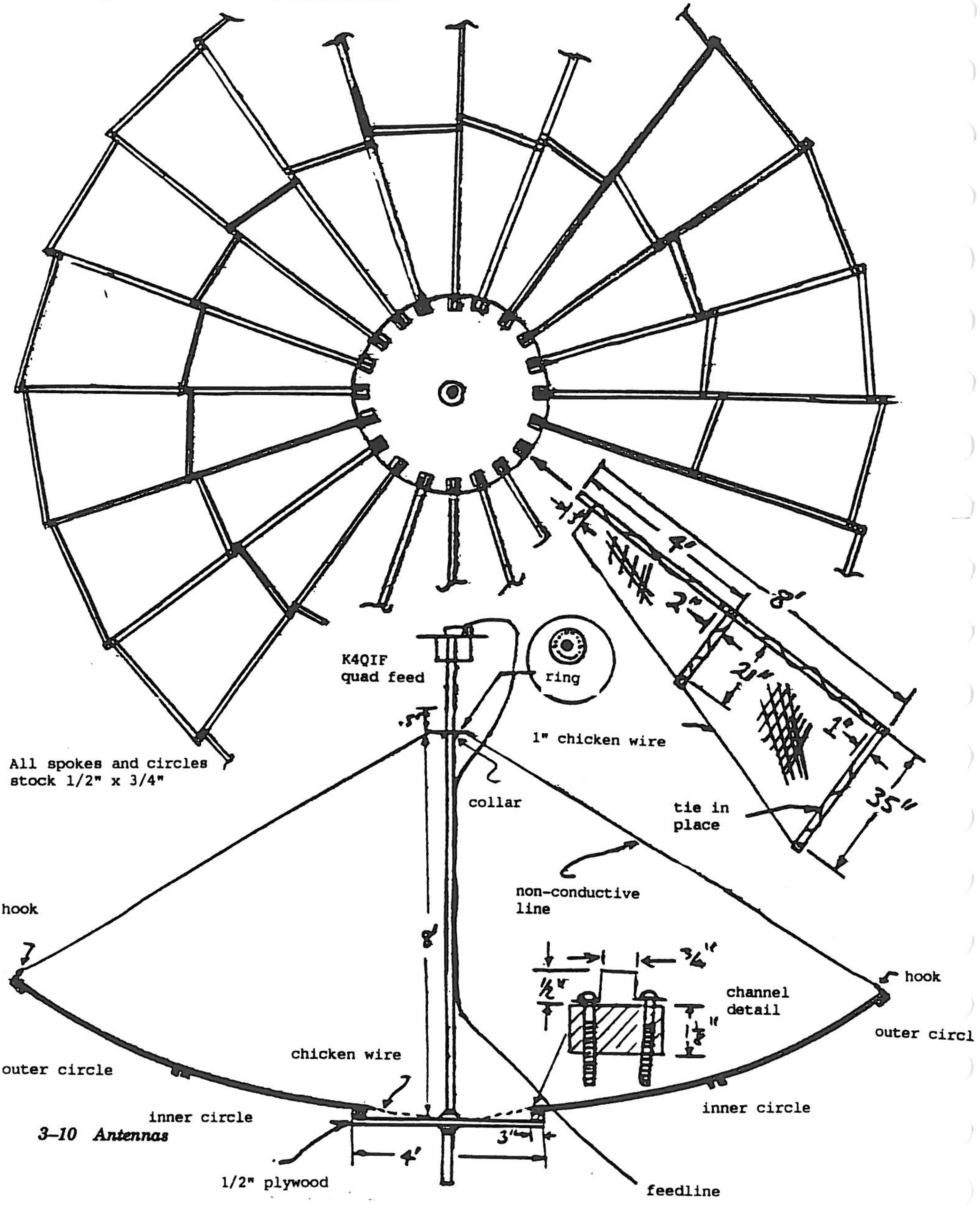
3.8 20 ft Portable Stressed Dish

Allen Katz K2UYH - October 1980

We had a lot of requests for details of the 20' dish we use portable. The following diagram should give some idea of how the dish goes together. The centre section is made from a piece of 1/2" plywood and was cut into a circle with a jig saw. The feed support and mounting pipe connect by means of 2 pipe flanges screwed together at the centre. The individual spokes of the dish are made from 1/2 x 3/4" firing strips and are attached to the centre section by means of channels. The channels were made from scrap galvanised steel stock and bent into shape. (I have been told that commercial channel stock is available). Each channel is raised 1 1/8" above the centre disk by a wooden block. This provides the desired parabolic shape. 20 Spokes were used since with this number 2 trapezoidal sections of the proper size for covering the dish can be cut from a 4 foot wide strip of chicken wire. 1" chicken wire is used (2" could be used if the dish is only used for 432 MHz and below). Two circles, one at the rim of dish and the other halfway up the spokes are used to provide additional rigidity and correct for error in the initial stress curve. These circles are formed from the same wood as the spokes. Four holes are drilled in the spokes for connecting these segments. Two for the start of each segment and two for the end where the segments over lap (see diagram). The individual segments of the circles are first attached to the spokes. The chicken wire trapezoid is then tied to the spoke and two circle segments to form a petal of the dish. The chicken wire is on the underside of the petal. The petals are transported in this form. When the dish is assembled at a portable site, the centre section is first attached to the mount and the mount positioned so that the dish is pointing straight up. The centre mast and feed are screwed into position and the support lines unrivalled. (this can be the most time consuming part of the assembly if you are not careful). The spokes (petals) are next connected to the centre section one at a time.

As each spoke is inserted a line from the centre mast is connected to its end to releave stress and position it at the (approximate) desired height. Once all the spokes are in place, the inner and outer circles are completed by connecting the segments together. (The segments are actually over-lapped with the end of one segment fastened just below the start of the next segment. This overlapping helps hold the chicken wire in place). The diameter of the dish should be set by the outer circle and not the lines from the centre of the dish. (Once circles are complete these lines should have no tension). The dish is completed by securing the chicken wire to the surface of the dish with short pieces of wire. Where ever a bulge or additional tension is required a tie wire is placed.

Figure 3–7: A Portable Stressed Dish



3.9 Long Yagi for 1296 MHz

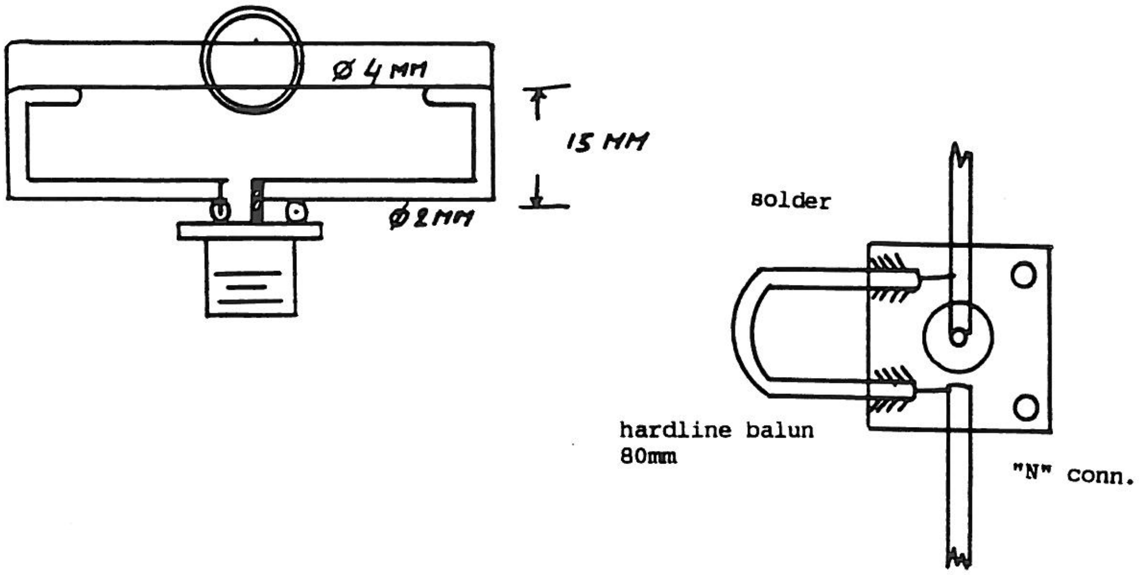
Guenther Hoch DL6WU - January 1981

Table 3–2 show the mechanical sizes of a 1296 MHz long Yagi. All elements are insulated but pass through the boom and are 4mm diameter. Construction details can be seen in Figure 3–8

Table 3–2: Sizes 1296MHz DL6WU Yagi

Spacing from RD in mm.	Element Number	Element Length mm	Spacing from RD in mm.	Element Number	Element Length mm
-52	RF	112	90	D12	85
0	RD	110	92	D13	84
19	D1	96	92	D14	84
42	D2	94	92	D15	84
50	D3	93	92	D16	83
58	D4	91	92	D17	83
65	D5	90	92	D18	83
70	D6	89	92	D19	82
73	D7	88	92	D20	82
76	D8	87	92	D21	82
80	D9	87	92	D22	81
83	D10	86	92	D23	81
86	D11	85	92	D24	81

Figure 3–8: 1296 MHz Long Yagi



3.10 Coffee Urn Feed For 1296 MHz

Rusty Holshauser K4QIF - September 1981

This feed is smaller and lighter than the IMU feedhorn used by most stations on 1296. Its only draw back is that it requires a 3 dB hybrid coupler. Rusty calls it a "Coffee Urn" feed since this is the source of his container. Any can or cylinder of approximately equal diameter can be used. The diagram should be self explanatory. The probes length are adjusted for best match with the hybrid in place. Care should be exercised to achieve a good match with the probes as near equal length as possible. The Teflon nut shown in the diagram is not electrically necessary. It purpose is to keep the probe length from changing. Metallic nuts could be equally used.

3.11 W2IMU Horn Tune-up Notes

Charles and Petra Suckling G3WDG, G4KGC - September 1981

Charlie reports that he finished up an aluminium IMU horn feed and was on 1296 with circular polarisation in August. Unfortunately they had a feed skew problem and only worked G3LTF (O/M). By the time they discovered their problem, the moon was in the trees. Charlie submits the following suggestions for IMU feed constructors:

1. Build the feedhorn carefully! Pay extra attention to the angles between the probes and probes to polarizer screws.
2. Adjust nulling post for minimum coupling between probes.
3. Adjust impedance matching by cutting probes and bending (backward and forward only), do not change the angle between the probes.
4. Repeat 2 and 3 until coupling is low (about -30 dB) and the probe VSWR is good.
5. Remove one probe and adjust polarizer for optimum circularity.
6. Do the same with the other probe (1st probe removed).
7. Put the other probe back in and recheck circularity with both probes in place. If the circularity has degraded, repeat step 2 and possibly bend probes relative to each other to reduce coupling.
8. Finally recheck impedance match.

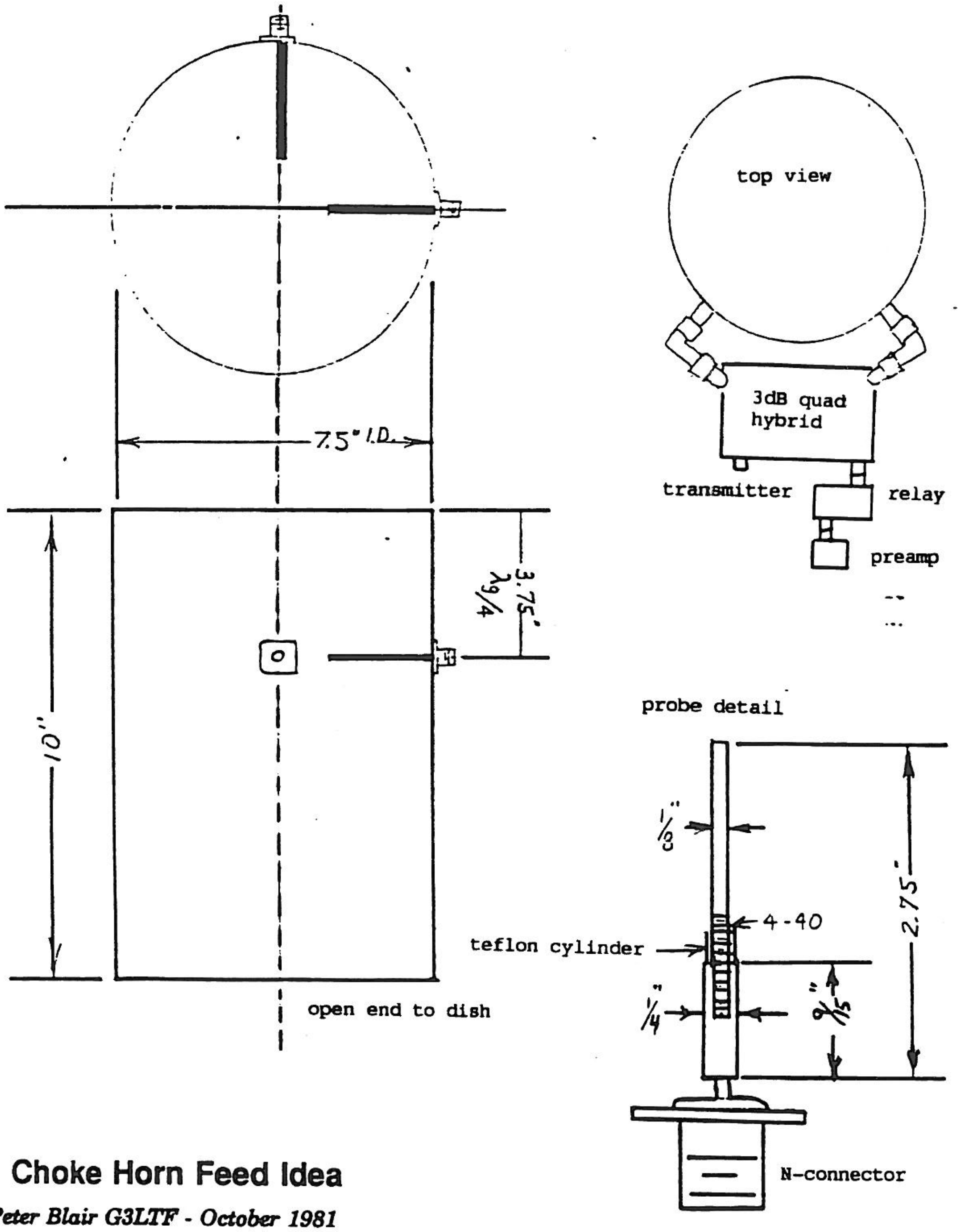
Charlie considers 3 dB of circularity "good enough". He notes: "you can sweat blood to get more but it doesn't buy you much"

3.12 1296 Feed Horn Details

Rusty Holshauser K4QIF - October 1981

Our explanation of the mechanical layout of the probes used in K4QIF's circular horn was incorrect (see last month NL). The probes are actually inbeaded in Teflon plugs, as shown in the following more detailed diagram, to create a series capacitance which shortens their electrical length.

Figure 3–9: Coffee Urn Feed For 1296 MHz



3.13 Choke Horn Feed Idea

Peter Blair G3LTF - October 1981

Peter G3LTF suggests the use of a choke section around Rusty's (K4QIF) horn (see Figure 3–11). The choke reduces backward spillage and improves the feed pattern slightly. (A number of concentric choke sections have been used to produce multimode "shaped patterns" feeds known as "Scalar Horns". These feeds offer the possibilities of higher dish efficiencies; however, to be effective a dish diameter of greater than 10 to 20 wavelengths is required because of aperture blockage and consequent diffraction effects.

Figure 3–10: K4QIF Feed Horn Details

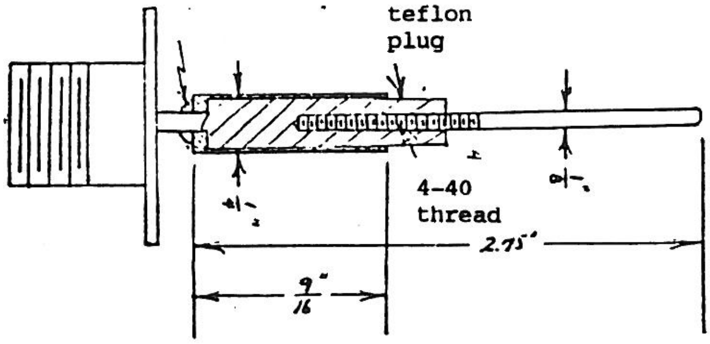
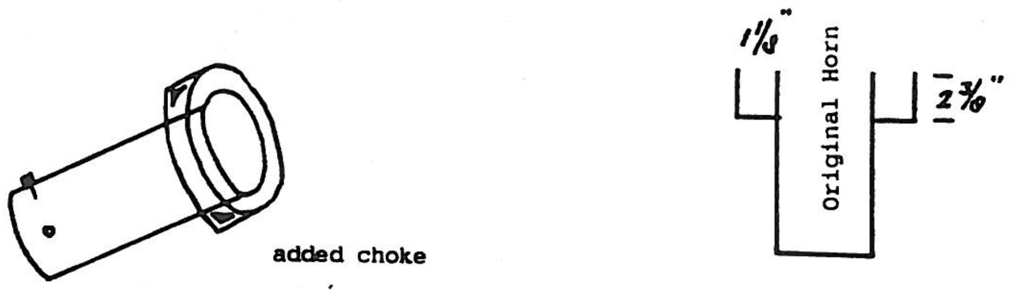


Figure 3–11: G3LTF's Feed Horn Details



G3LTF suggested improvement

On 432 such feeds are impractical. On 1296 they offer a realistic area for system improvement. (The IMU feed is just the first step toward generating a Scalar feed.

3.14 An Off-Set Fed Parabolic Reflector Antenna

Dick Turrin W2IMU - January 1982

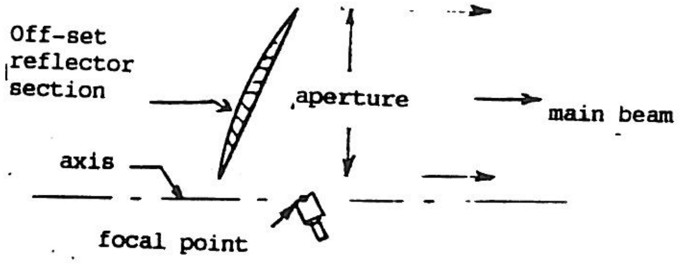
The front fed parabolic reflector or "dish" type antenna widely used in the UHF and microwave region of the radio frequency spectrum provides high gain and good efficiency. There are however several disadvantages to this standard design.

A. The prime focus feed is located directly in front of the reflector and in the centre where the aperture field intensity is highest.

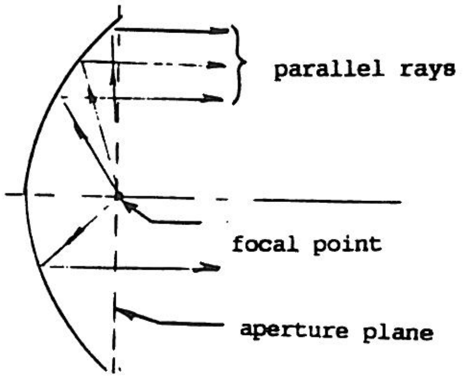
B. The feed must be supported by struts which are also in front of the reflectors aperture.

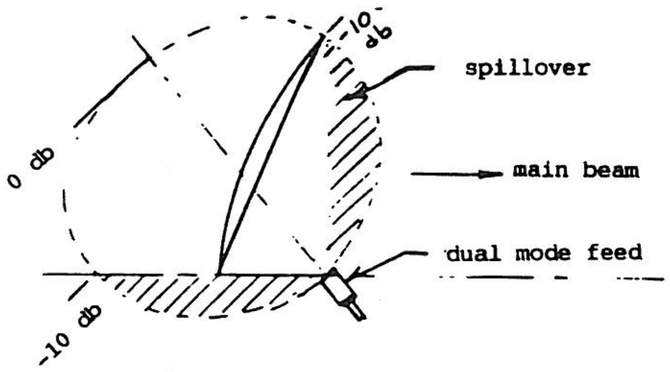
C. Cables and lines must be draped from the feed to the edge of the reflector.

A, B and C cause reflector blockage, especially the feed, with resultant loss of gain. In addition scattering from these obstacles increases antenna noise by the way of extraneous sidelobes directed towards the warm earth. With large reflector antennas required for EME service the feed is difficult to reach for adjustments. At UHF and higher frequencies it is highly desirable to minimise feedline losses, which are high, by mounting the Preamp and final power amp directly at the feed. This may result in additional blockage and scattering. While all these affects are relatively small, of the order of 1 dB in terms of antenna gain, they are definitely detriments to high performance required in EME service. All of the above disadvantages of the front fed reflector antenna can be eliminated by changing the geometry of the reflector to an off-set parabolic reflector arrangement shown below in side view.



The term off-set refers to the section of the paraboloidal reflector off-set from its axis. The feed horn aperture (phase centre) remains at the focal point but the feed radiation is aimed so as to illuminate the off-set reflector section. The particular design presented in this report is specifically for the high efficiency dual mode feed described earlier and shown here in Figure 3–12. The off-set geometry places the feed outside of the main aperture area and also closer to the ground. A more subtle of this arrangement is that since the feed is out of the main aperture, there will be no interaction between feed and reflector as there is with the front fed design. The main implication of this feature is that the transmit receive isolation can be made nearly perfect with any polarisation. The singular disadvantage of the off-set design is the different and somewhat awkward geometry.





The geometry of the off-set reflector may be developed from the front fed reflector as shown below. In the front fed design all rays of RF energy that originate at the focal point will be reflected in a direction parallel with the axis of the paraboloid. By choosing to direct rays from the focal point only towards the upper section of the paraboloid, parallel rays are still obtained but the lower section may be discarded since it is not now illuminated. The constraint on feed illumination at the edge of the reflector is still the same as with a front fed reflector, that is for maximum gain -10 dB contour of the feed radiation pattern should fall at the edge of the off-set reflector section. Since the dual-mode feed has a circular symmetric radiation characteristic, the -10 dB radiation contour may be represented by a cone whose apex lies at the reflector focal point as shown below. Several useful physical properties of this geometry which may be readily proven, are depicted by Figure 3–12.

1. The projected area of illumination of the off-set reflector in the direction of the main beam (parallel with the axis of the paraboloid) is a circular area (the aperture area).

2. The edge or rim of the off-set reflector section is elliptic and lies in a tilted plane. These properties should make it easier to visualise the physical design.

3.15 Yagi Length Gain Chart

Guenther Hoch DL6WU - January 1982

Figure 3–13 shows the Gain versus the length of Yagi antennas measured on 432 and 1296 MHz by DL6WU in October 1981.

3.16 Deep Dish Design Ideas

Dick Turrin W2IMU, Allen Katz K2UYH - March 1982

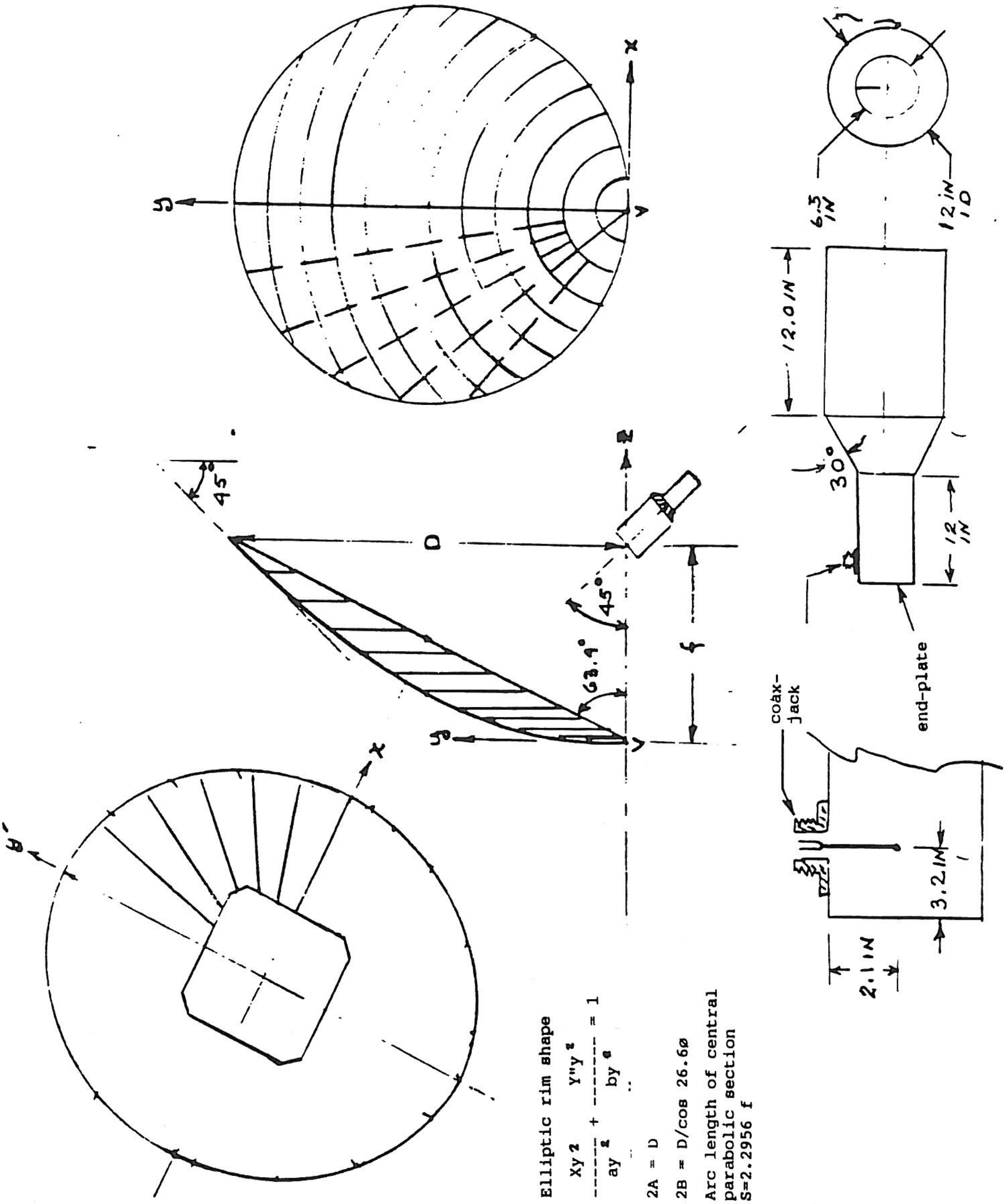
Over the years many stations have acquired deep dishes or extended shallow dishes to produce a larger but deeper one. Unfortunately for these dish owners current feed designs (for both 432 and 1296) with a relatively shallow dish (0.45 < f/D <0.6). These feeds do not work well for dishes of f/D <0.4. (Even a simple dipole reflector combination will work better than a dual dipole with a deep dish. But the non-symmetrical E-H pattern of a dipole feed makes the overall performance of a dipole feed dish inferior to a properly illuminated one.) In discussing the problem of deep dish feeds with Dick, W2IMU (who is a full time antenna designer), he suggested that "A multimode Antenna Having Equal E and H planes" described by Alvin Calvin in the Sept. 1975 IEEE Transactions on Antenna and Propagation be considered. This antenna has the highly desirable symmetrical E-H pattern of the dual mode horn and dual dipole feeds, yet has a much wider 10 dB beam width (+/- 63° rather than +/- 45°). A diagram of this antenna is shown in Figure 3–14. All dimensions are in wavelengths. Actual lengths must be calculated for the frequency of use. (At 432, one wavelength = 27 inches) Dimensions are small enough to make this feed practical for 432. Some experimentation will have to be done, as this feed has never been constructed for ham use. It should be possible to match this feed directly to a 50 ohm line by moving the point of coax connection off centre (like a gamma match) and trimming the lengths (ends) of the slot (if necessary). The sole purpose of the cavity behind the slot is act as a reflector to make the slot radiate in one direction. (A slot radiates in 2 directions like a dipole. It may be possible to replace this cavity with a single plate).

3.17 Deep Dish Feed Matching Suggestions

Piero Moroni I5TDJ - May 1982

I5TDJ of I5MSH has built up the deep dish feed described in the March 82 NL. By referring to the reference article, he found an error in the dimensions listed in the Newsletter. The diameter of the feed should have been 0.88 of a wavelength rather then the 0.98 shown in Figure 3–14. (We agree. Please note this correction.) Piero has not tested the feed in their dish yet, but reports that he had difficulties getting the feed to match on 432. He found the best solution was to place a capacitor across the slot in

Figure 3–12: Off-Set parabolic antenna geometry



Elliptic rim shape

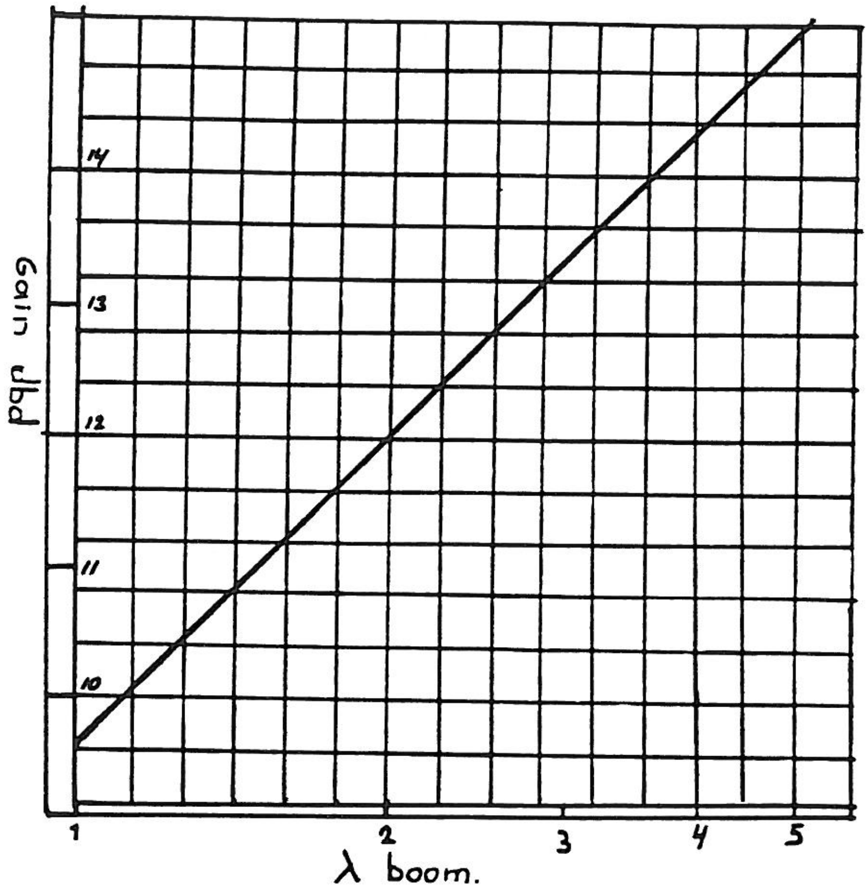
$$\frac{Xy^2}{ay^2} + \frac{Y''y^2}{by^2} = 1$$

2A = D

2B = D/cos 26.60

Arc length of central parabolic section S=2.2956 f

Figure 3–13: DL6WU Yagi Length Gain Chart



a position symmetrical to where the cable connects. (It should also be possible to match by changing the length of the slot).

3.18 8 Yagi Ring Stacking Arrangement

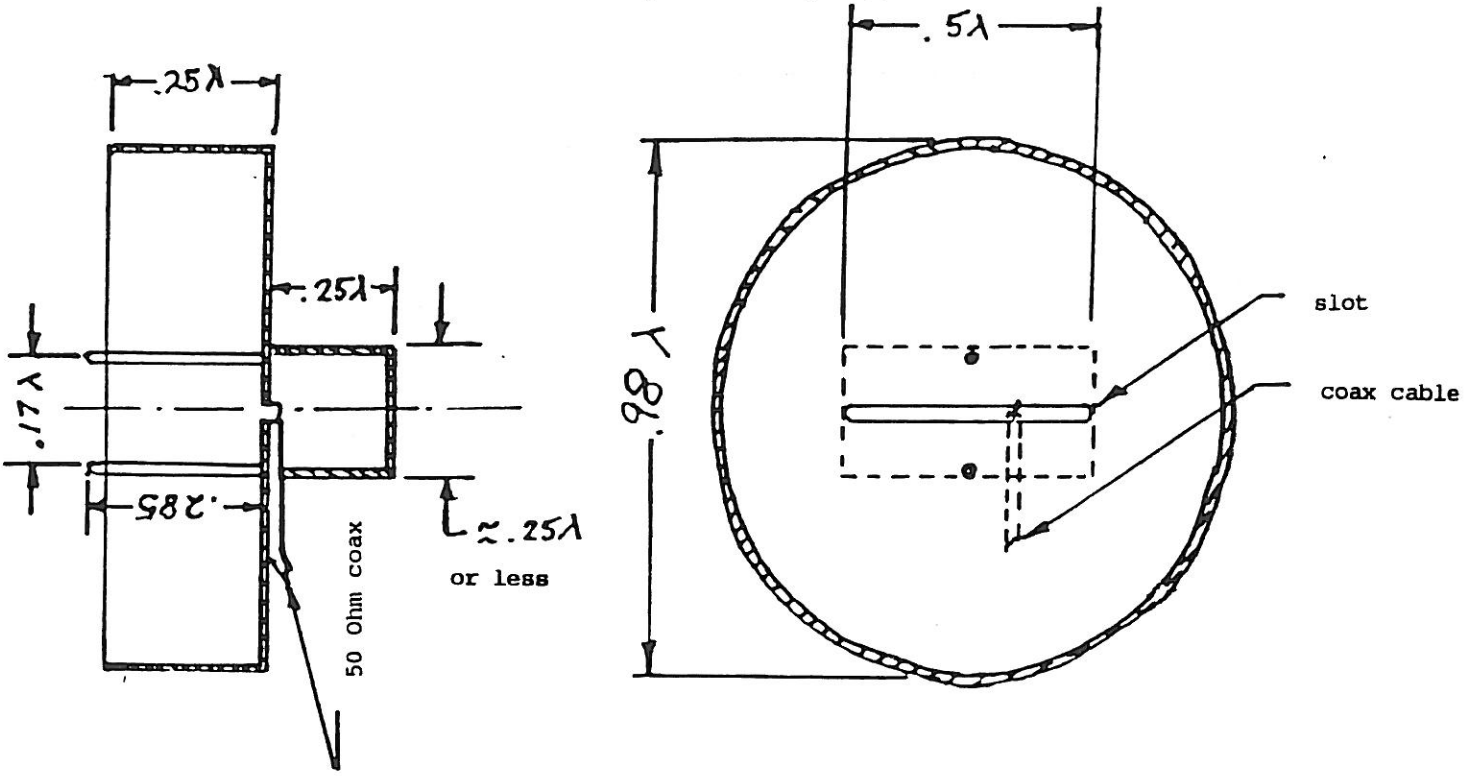
Manfred Ploetz DL7YC - July 1982

Manfred has spent a great deal of time measuring and evaluating the performance of his new array. Last fall he switched from a 16 Yagi (conventional) rectangular stacked array to an 8 Yagi circular stacking arrangement, see diagram. He had hoped that the circular stacking have made up for some loss in reducing the number of Yagis from 16 to 8. His conclusion, however, is that there is no gain advantage in using the circular pattern and lot's of cost in material and size. One advantage of the circular arrangement is that it provides space for another antenna in the centre. Manfred has placed a 2 m dish in the centre of his array which he is using to experiment with 1296 EME. He has developed a feed horn based on K4QIF's design, but using a beer urn. This feed has excellent characteristics and he promises to send design details in the future. He also stresses the criticalness of open wire feedline dimensions. He has found a 5 or 6 mm change in length (2 wavelength long lines) can make a 2.5 to 1.3 change in VSWR. He also notes that you must correct the length of the open wire feedline for the dielectric spacers. (300 ohm feedline has a 0.975 velocity factor).

Results with his new array:

- 8 x 21 El. DL6WU type Yagi (14.5 dB), 3.5 m long (length 5λ) 200 ohm feedpoint.

Figure 3–14: IEEE Multimode Feed with equal E and H planes

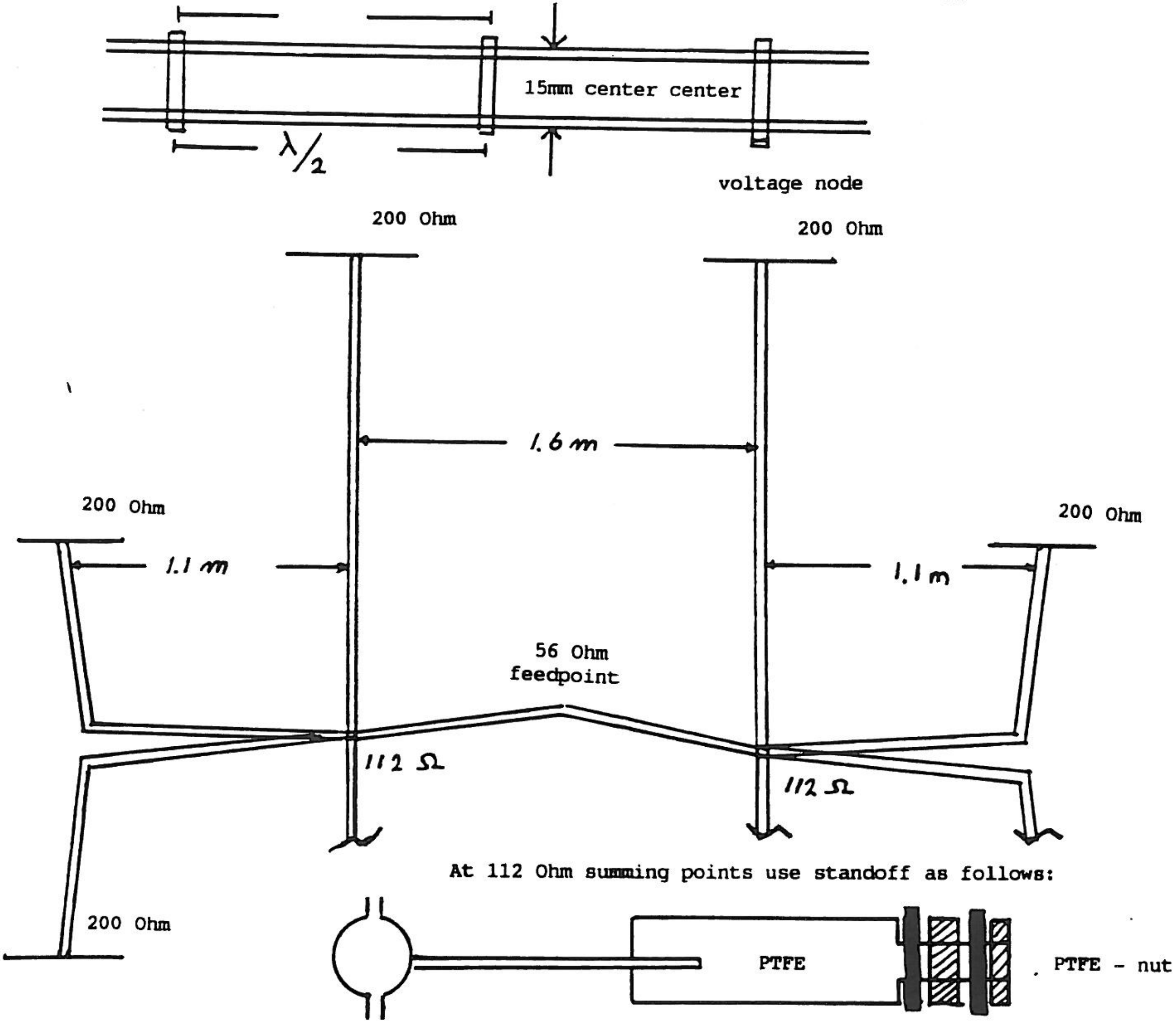


- Ring (circle) configuration 3.8 m dia, with Mitsubishi MGF1412+1400 GaAsFet Preamp, 13.5 dB Sunnoise minimum at solar flux 190 (432), Earthnoise compared to 15K = 3.8 dB, Sagittarius 4 dB, Crab Neb 3.5, Aquila 2.3 dB.
- In centre of array 2 m dia. stressed dish with DL7QY/LX1DB feed horn 1-10 GHz. No 70 cm array pattern damage. No loss of Sunnoise. Linear horizontal polarisation.
- The wide spaced 432 array has no extra gain compared to conventional design. There is only one reason to use such an array: putting into the radiation free space a 2 m long Yagi or 2 m dish.

Notes on the feedline arrangement:

1. Open feedlines 300 ohm / 2 x 2.5 mm dia. Cu wire / 15 mm Teflon spacers.
2. 8 feedlines 3 1/4 λ length - from every dipole.
3. 2 feedlines 1 1/2 λ length - from x to feedpoint. (or one side only 1λ inverted phase).
4. The velocity factor is exactly 0.97 with this type of line.
5. Balun at the feedpoint improves system performance.

Figure 3–15: 8 Yagi ring stacking arrangement



At 112 Ohm summing points use standoff as follows:

3.19 Corner Reflector and 12 El. Corner Yagi

Gene Wasson K0UDZ - August 1982

To mount the reflector I took a piece of 3/4" water pipe (steel) and sawed in two. Take one of the halves and put on the boom behind the dipole. Put in vice and crush boom to 1/2". As we have very high wind and storms I did not want to use 1/2" tubing and the use of support braces. I figured that 3/4" tubing would be self-supporting.

The distance from the corner reflector to the dipole was not found critical. I could move +/- 1/2" from the 14 1/2" setting. By crushing the boom at the dipole I maintained the correct distance between the upper and lower side of the dipole. Both had no effect on the gain of the antenna. The crushing distorted the boom a little on the side of the elements. I straightened this out by putting it across two chairs. Also crush the boom before you drill the holes for the element blocks. I used a 8' wood 2 x 4 and sawed a "V" in to use as a jig to drill the boom. Drill one hole all the way through the boom at element #12 and drive a nail into the jig to keep the boom in place. Cut off nail head. All the booms will be drilled the same with this method.

Building the corner reflector I first cut all pieces of PVC pipe about 1" longer than needed. Then cut one end of each piece on 45°. I used a piece of plywood to make a jig. I took the 4" long 1" OD aluminium tubing and placed on the board, driving nails in the board to keep it in place. Then put PVC pipe in two places. Again cut off nail heads. You may notice that the top pipe of the reflector sits a little back of the bottom pipe. In this way the vertex or centre of the reflector is centred with the elements of the beam. If the elements were through the boom then the vertex would be on the centre on the boom but as the elements are on top of the boom so must be the vertex of the reflector. Also notice that the first element of the bottom part of the reflector is closer to the 4" piece of tubing. First element of top section is spaced further away from the 4" tubing. Both elements are 2 1/2" away from the vertex.

I took a course file and roughed up the outside of the 4" piece of tubing so the epoxy glue would bond better. After getting the pieces laid out on the plywood, I used short pieces of 1/8" aluminium welding rod bent in U-shape to centre the PVC pipe on the 4" piece of tubing. I used Devcon 5 minute epoxy glue and glued pieces together. After the glue was set I used same glue and glass cloth and wrapped the connection. (So far none of the reflectors came apart.) After this holes for the elements were drilled and the reflectors were mounted on the main boom using 1/8" pop rivets.

As phasing lines spacers I used 1/2" plastic Romex staples. Remove the nails and drill out holes so that #12 wire has press fit. I put a couple of these staples in the microwave oven and there was no sign of breakdown. As a tuning stub I used 20" of open line and clipped off 1/4" at a time until SWR was flat and I could see no reflected power on my Bird wattmeter. The stub was 18 3/4" at that time.

3.20 Digital Antenna Indicator

Yoshiro Mataka JA4BLC - November 1982

The Digital Antenna Indicator in Figure 3–17 is using a ready made voltmeter kit. The DVM kit is using one LSI chip (ADD-7301), the kit is sold for about $15 in Japan. Including 4 7-segments display. Full scale reading is about 3.999 V. I use the range of 0-3.600 Volt for Azimuth and 0-0.900 Volt for Elevation. The display resolution is 0.1°, but the potentiometer resolution is 1.4° .

3.21 Deep Dish Feed Design

Al Lorenz W0HHE - December 1982

W0HHE reports excellent results with the deep dish horn feed described in the March 1982 NL. He uses the feed to excite a 2.5 f/D 20 ft dish which was produced by extending a 13 ft dish. Details of his design are shown. Al notes that tuning is critical and must be done carefully. The level of RF around the feed is extremely high when resonance (match) occurs and can cause damage to the eyes, hands and other parts of your body even at low RF levels. Please be careful. Strings should be used to pull or push the tuning capacitor flap. (Al was able to achieve a VSWR of 1.2) Al's feed is made of 0.05 copper sheet held together with bolds, nuts and solder. Copper angles are used at critical stress points. One half inch copper tubing is used for mounting the horn to the main rotating pipe of 1.5" dia. aluminium tube. He notes that the cavity behind the feed acts like a filter and eliminates the need to precede the first Preamp with a filter, even in high noise areas.

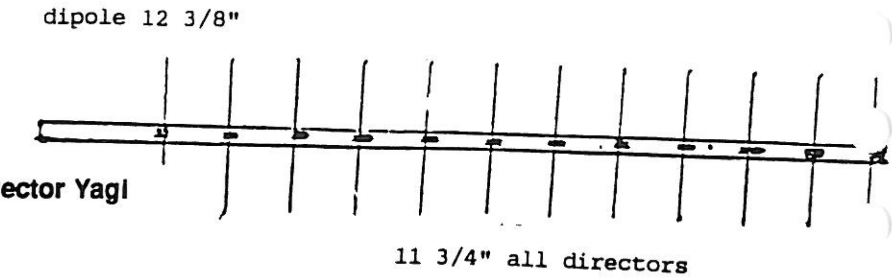
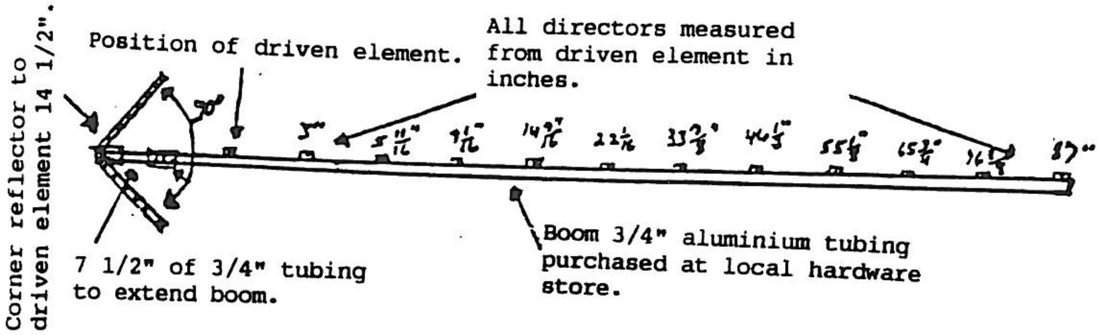
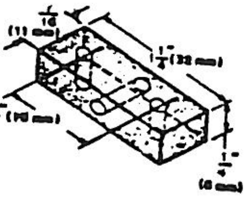
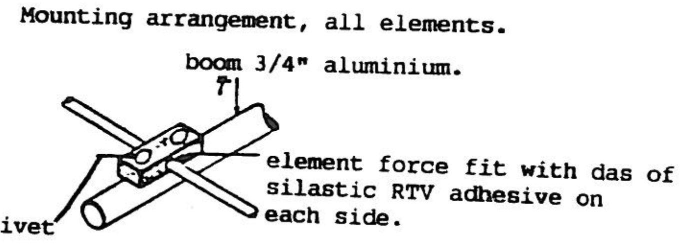
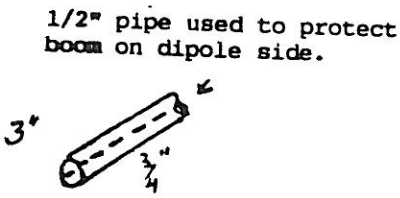


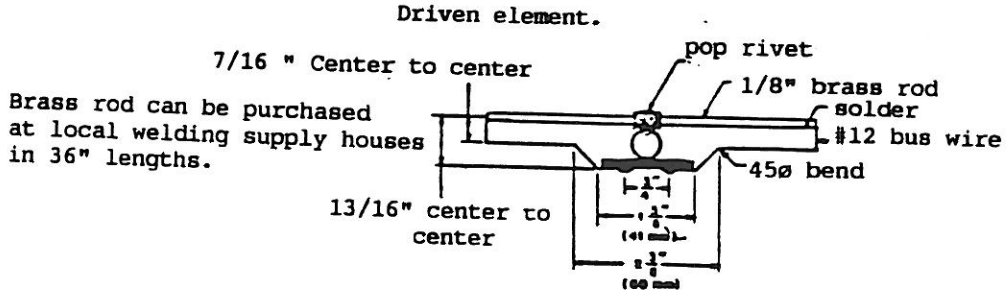
Figure 3–16: 12 Element Corner Reflector Yagi

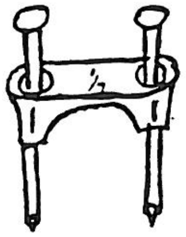


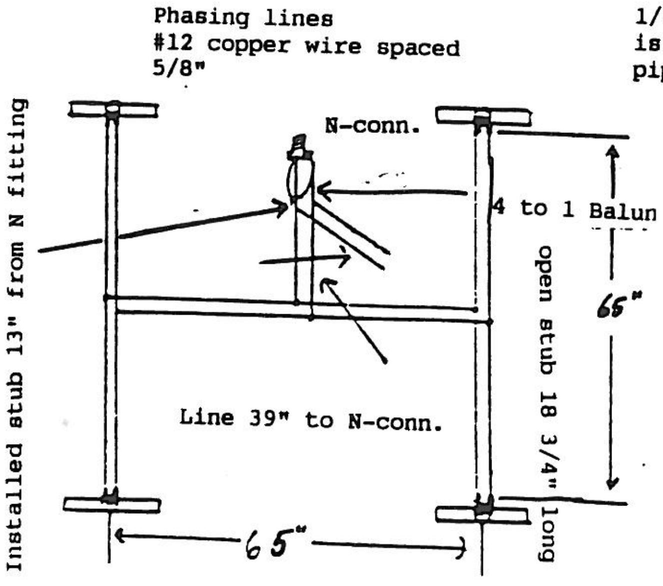












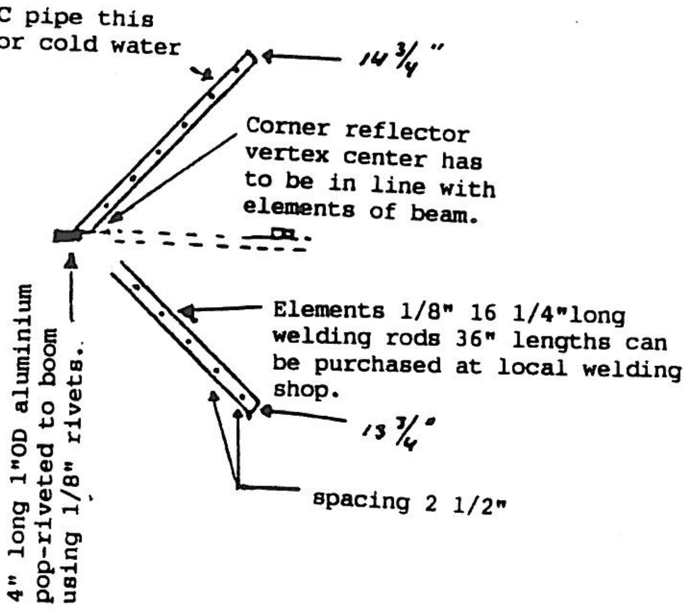
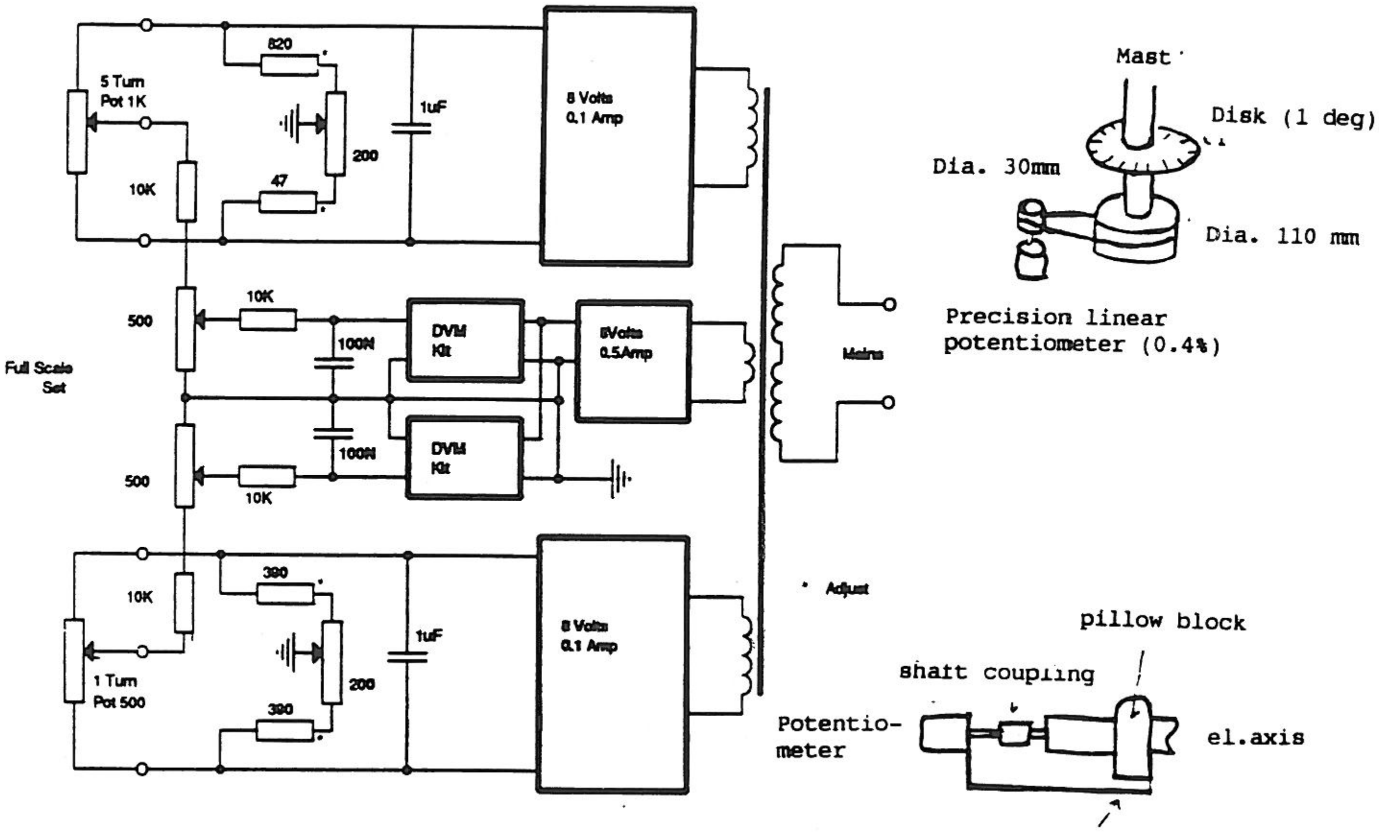


Figure 3–17: Digital Antenna Indicator



3.22 Dual Band Feed Modifications

Cor Maas VE7BBG - January 1983

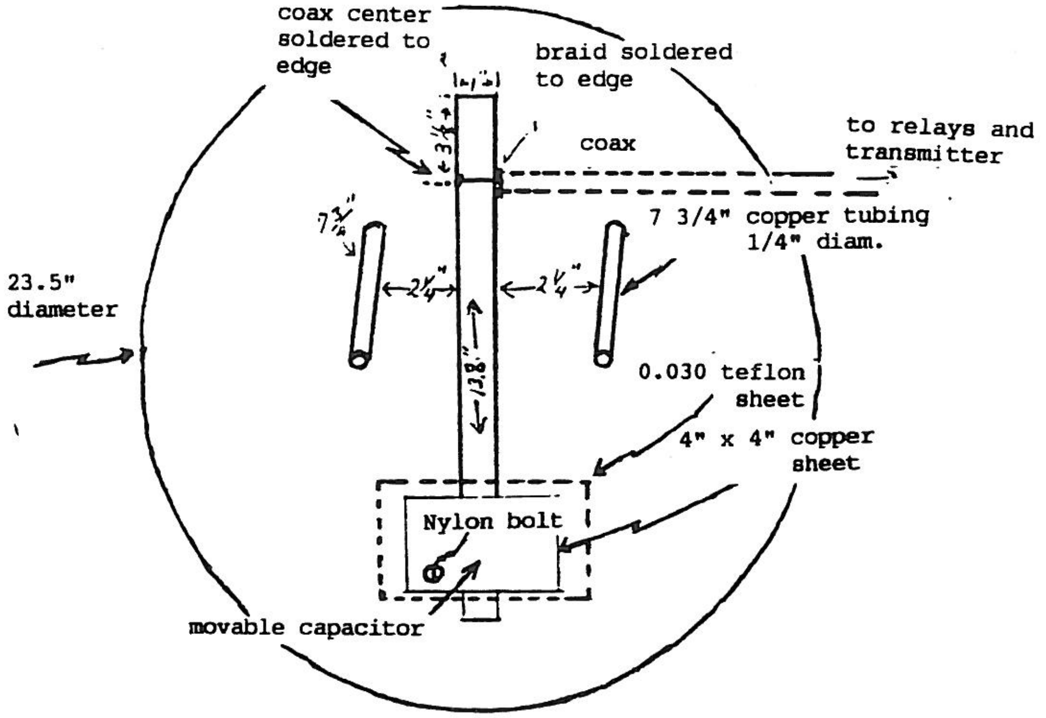
Several years ago LX1DB came up with the idea of combining the 432 dual dipole feed and the 1296 IMU horn to create a dual band feed. (June 1980 NL) Willy placed the reflector of the 432 feed at the mouth of the 1296 horn. Concern has been expressed that this combination was not optimum. Recently, Cor VE7BBG decided to investigate this feed further. (Cor was particular interested in coming up with a 1296/432 feed for use with the soon to be launched phase 3 satellite). Taking careful measurements, he found the old combination feed reduced his 1296 Sunnoise by 1.9 dB. He then experimented with moving the 432 feed back along the horn. Moving the feed back 1/4 wavelength (on 23 cm), a distance of 5.8 cm, brought his 1296 Sunnoise back up 2.3 dB producing a net gain of 0.4 dB over the horn itself. Cor feels that the RF choke effect on the 432 plane reflector may widen his pattern and provide a better illumination taper for his 0.5 f/D. He further reports that the new combination feed does not appear to significantly degrade 432 performance. (He has not provided any dB values). WB5LUA tried Cor's modification and reports similar results: 2 dB improvement on 1296 and no degration on 432. Al is very enthusiastic about the new feed.

3.23 Deep Dish Feeds, Comments and Improvements

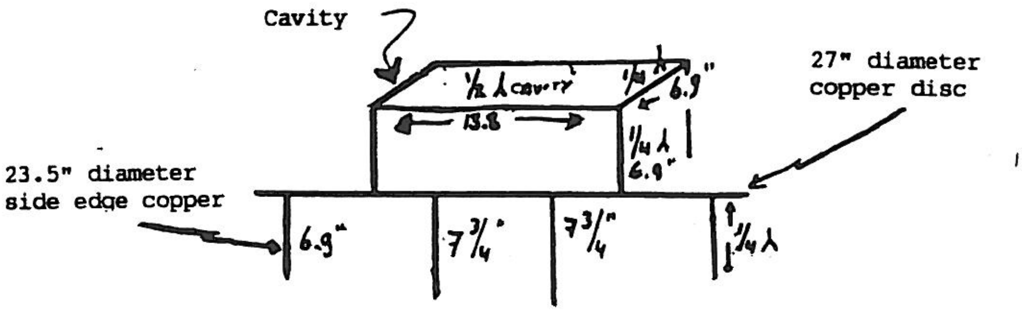
Dick Turrin W2IMU - January 1983

Dick, W2IMU has sent us a copy of a long letter he wrote to W0HHE with additional suggestion for improving the performance of the Deep Dish Horn feed (March and December 1982). Dick notes that the size of the back cavity can be reduced by making it the same cross sectional size as the slot and just a little shorter in length than a quarter wavelength in air. He recommends a slot width of 1" and a cavity depth of 6.2" (see Figure 3–19), and that the cavity be constructed from one continuous piece

Figure 3–18: W0HHE Deep dish feed design



length of slot 35 cm or 13.8"
23.5" diam. circle is a 1/4 lambda
cylinder (6.9")



of copper sheet bent into an U-shape. Dick was concerned with the size of Al's tuning flap and felt that its size might affect the feed's pattern. He suggested placing the capacitive tuner at the centre of the slot and making it stiff enough to eliminate the need for any dielectric (Teflon) - see Figure 3–20. (When this is done the slot should be made slightly shorter than a half wavelength). Dick calculated that the coaxial tap should be connected approximately 1" from the end of the slot, but noted that the length of the centre conductor extending across the one inch slot will add a significant amount of series inductance which should be resonated out if a unity matched is to be achieved. The situation is very analogous to that of a classical gamma match. He suggests placing a section of the same coax as used for the feedline on the opposite side of the slot with it's centre conductor floating (see Figure 3–21) to add the needed series capacitance. About 9 pF is required. The line length can be calculated from the cable's capacitance per unit length. Dick writes that the slot should be first adjusted (with the whole feed in place) for best VSWR. Then the length of the vertical rods should be trimmed for minimum radiation of the sides of the feed. This can be done by pointing the feed straight up and minimising the energy level at a vertical dipole located 4 to 6 Feet to the side of the feed. Finally the feed can be checked for the proper radiation pattern in the normal manner.

Figure 3–19: W2IMU Improved deep dish feed 1

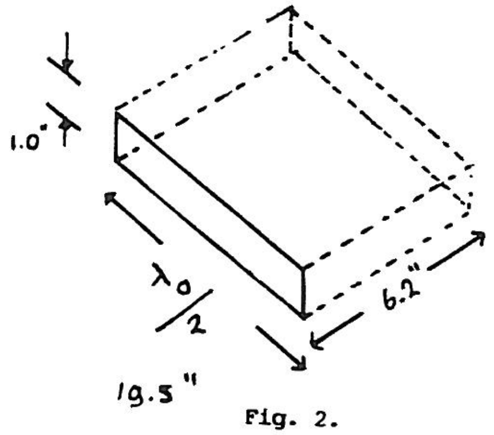


Fig. 2.

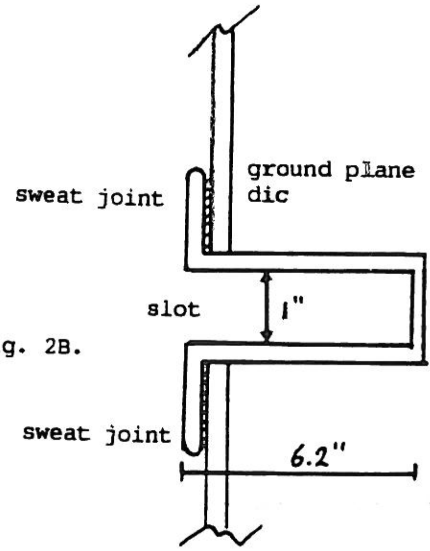


Fig. 2B.

Figure 3–20: W2IMU Improved deep dish feed 2

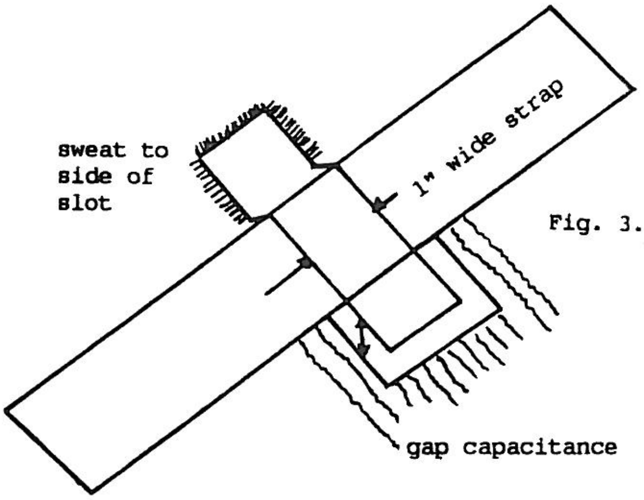
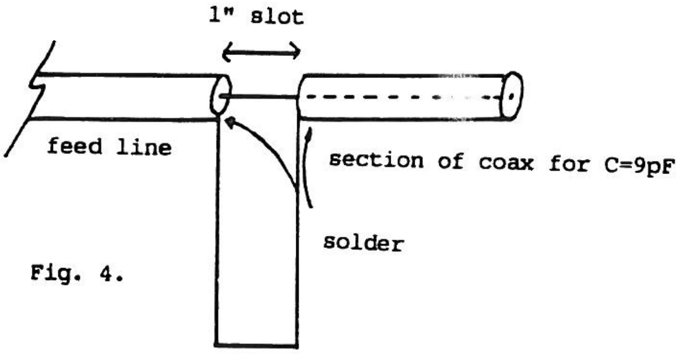


Fig. 3.

Figure 3–21: W2IMU improved deep dish feed 3



3.24 More on Deep Dish Feeds

Dick Bennett K9ZZH - March 1983

The question of the performance of the Deep Dish Feed (DDF) described several months ago in the NL continues. Dick, K9ZZH has built up a version very similar to that proposed by W2IMU. Dick's feed which is constructed from galvanised steel appears technically correct. It can be adjusted for a 1.0 VSWR and has a reasonable pattern, but does not provide any better performance than his dipole splasher feed when placed at the optimum focal point of his 0.28 f/D 18 ft dish. He gets approximately 9 dB of Sunnoise with either feed. W0HHE, on the other hand, reports significant improvement with his version of the DDF. I had understood that the two feeds were similar except for the matching configuration used. In his letter Dick states that W0HHE has also cut down the quarter cylindrical lip around the feed by 1 or 2 inches to increase the feeds beam width. This is a factor I was not aware of and should have marked effect on the feed's characteristics. I shall be interested in hearing from other stations experimenting with this feed.

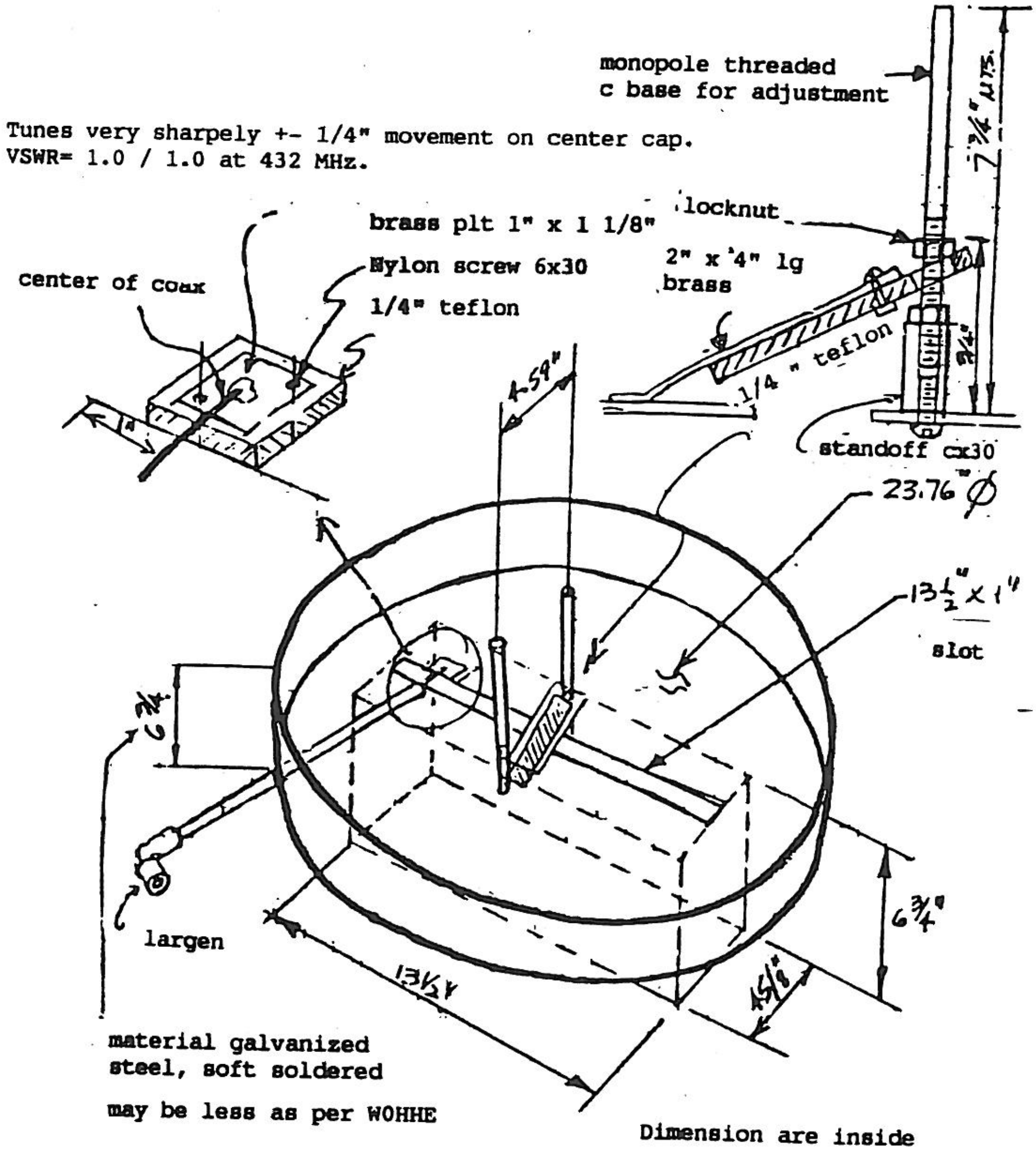
3.25 A High Gain Long Yagi for 70cm

Joe Reisert W1JR - July 1983

For quite some time I have wanted to build a really long (in terms of wavelength) Yagi for 432 MHz. Articles (refs. 1 & 2) and corresponding with Guenther Hoch, DL6WU intrigued me. Guenther was able to obtain very high gains at 23 cm, a frequency where very few conventional Yagis had been successful. Armed with DL6WU's charts, and only two days before leaving for the Central States 1981 VHF Conference in Sioux Falls, S.D., I literally threw together the materials to make a quick attempt at a 432 MHz monster. The results were an antenna with almost 2 dB more gain than a K2RIW Yagi with only slightly higher first side lobes.

Although most people know that aluminium tubing is available in 12' lengths in the U.S.A., most are unaware that 21' 1" is also a standard length. I had purchased a large supply of 3/4" square tubing in 21' 1" lengths several years ago for a still unbuilt EME array. I decided that this material is easy to drill and this length is convenient for the antenna I planned. The only other consideration would be the need for a thrust to support the boom.

Figure 3–22: K9ZZH Deep Dish Feed



Time did not permit the experimentation necessary to use an insulated thru-the-boom approach similar to the K2RIW Yagi but boom corrections were available using conventional thru-the-boom techniques from the NBS data (ref. 3.) Hence I decided to use 3/16" diameter solid aluminium rod and connect the elements directly thru-the-boom without insulators using NBS correction factors. The boom was drilled and tapped for a 4-40 screw thread directly above each element location and all elements are held in place by a 4-40 screw backed up by a 4-40 nut and star washer.

Construction details are shown on the attached sketch along with sizes and spacing information. It is suggested that the plans are followed without changes if you want to obtain the results that I have achieved. If you change the lengths, spacing or materials, you're on your own! Some minor changes in the driven element and "T" match are acceptable if VSWR are can be measured accurately since I never really finished the matching.

You may ask yourself why I would go through such effort just to prove that higher gain can be obtained if the boomlength is increased. Two immediate needs crossed my mind. On tropo I cannot put up more than four (4) 70 cm Yagis without dropping antennas for one or the other VHF/UHF bands I operate. The optimum stacking distance on this Yagi should be close to 68" in the "E" plane and 63" in the "H" plane. This only slightly larger than my present spacing and therefore, with only minor changes, I can increase my gain by 2 dB without additional power dividers while still operating all the other VHF/UHF bands. Also it has been proven that four (4) 13 to 15 foot Yagis make marginal EME QSO's with bigger stations. Four of these Yagis should be able to almost match the gain of an array of 8 shorter Yagis and hence put EME more in the realm of possibilities for some persons who do not have the space or want to spend all the money on a 8 Yagi array.

Finally let me express my thanks to Guenther Hoch, DL6WU for all the information and encouragement he extended to me the last few years. Without his help this Yagi design would not have been possible.

References:

1. "Yagi antennas" By DL6WU, VHF Communications, 3/1977
2. "More gain with Yagi antennas" By DL6WU, VHF Communications, 4/1977
3. "How to design Yagi antennas" By W1JR, Ham Radio, August 1977

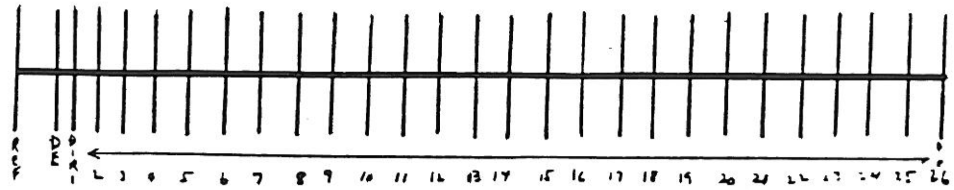
Table 3–3: W1JR 28 El. 70cm Yagi Performance (Very Preliminary)

Freq: 432 MHz	BW(E) : 20°	Boomlength: 9.25λ (21.1")
Gain: +/- 19 dBi	BW(H): 22°	
F/B 20 dB	sidelobes > 15 dB	
Stacking	E-Plane 68" (2.5°)	H-Plane 63"(2.3°)

Notes:

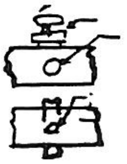
1. Design based on information from DL6WU see references on attached writeup.
2. Dimensional tolerances should be kept to +/- 0.031" with a maximum of +/- 0.061" error.
3. Lengths are in inches and include boom corrections. Lengths may be rounded off to nearest fraction of an inch as long as note 2 above is not violated. It is best to shorten directors and lengthen reflector when rounding of lengths.
4. Spacings are in inches and referenced from rear boom to prevent tolerance buildup.
5. The driven element length is not critical. The dimensions given here are not finalised so adjustments of "T" match, length of driven element and diameter of wire in the "T" match are suggested until I can obtain an optimum set of sizes for a 1.2:1 VSWR.

Figure 3–23: W1JR 28 Element 70cm Yagi



```
Boom:21' x 1" x .75" square .062" wall (std USA length)
Elements: 3/16" Dia. rod
```

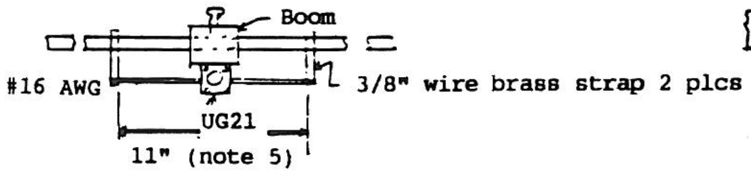
```
Element mtg.
```



```
4-40 screw/nut/lock washer
3/16" hole 56 plcs

Drill and tap
4-40 (28 plcs)
```

```
Feed: T Match 4:1 balun
```



```
Use 4:1 lambda/2 balun. I used 10" of 0.141 semi rigid coax 50
Ohm.
```

Table 3–4: Sizes W1JR 28 El. 70cm Yagi

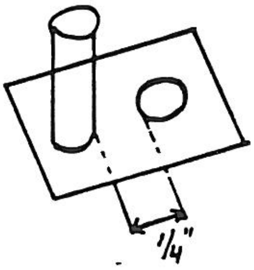
El.	Length	X-Pos	El.	Length	X-Pos	El.	Length	X-Pos
Ref	13.797	0.500	D9	11.475	69.124	D19	11.106	175.816
DE	13.500	6.557	D10	11.407	78.960	D20	11.079	186.744
D1	12.363	8.606	D11	11.366	89.206	D21	11.065	197.673
D2	12.226	13.524	D12	11.339	99.724	D22	11.038	208.602
D3	12.090	19.398	D13	11.284	110.380	D23	10.997	219.530
D4	11.935	26.229	D14	11.257	121.172	D24	10.983	230.459
D5	11.817	33.879	D15	11.216	132.101	D25	10.970	241.388
D6	11.694	42.076	D16	11.188	143.029	D26	10.942	252.316
D7	11.612	50.682	D17	11.161	153.958			
D8	11.543	59.698	D18	11.134	164.887			

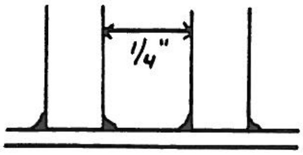
3.26 Dual Dipole Feed for 432 MHz

Ray May K5AZU - September 1983

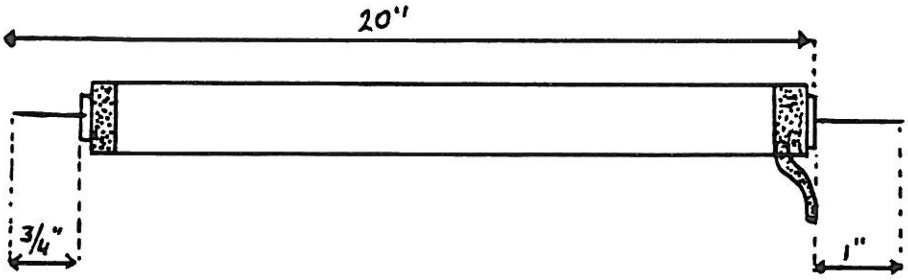
1. **Parts list:**
   - 4 pcs 1/2" Copper tubing 6 3/8" long 5/8 OD
   - 2 pcs 20" RG11 0.66 vf coax
   - 2 pcs Brass plates 2" x 3" 1/32 " thick

2. Drill 2 holes 5/8" dia. in brass plates and solder. The holes should be 1/4" apart. Use refergeration solder (stronger).



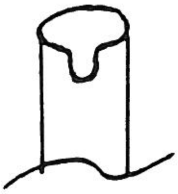


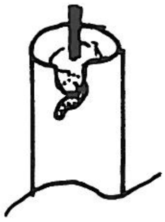
3. Cut 2 20" sections of RG11 (regular type) .66 vf and dress ends.

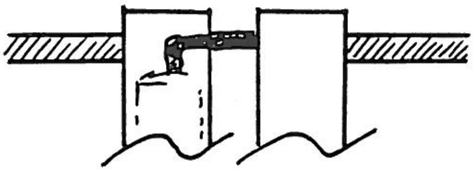


4. Solder elements to tubes. Push end with pigtail up from bottom of tube. Solder braid to tube first. Bend the 1 1/4" long centre conductor over and solder to the other tube.

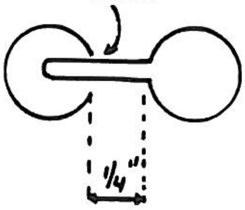
cut notch on one side only.



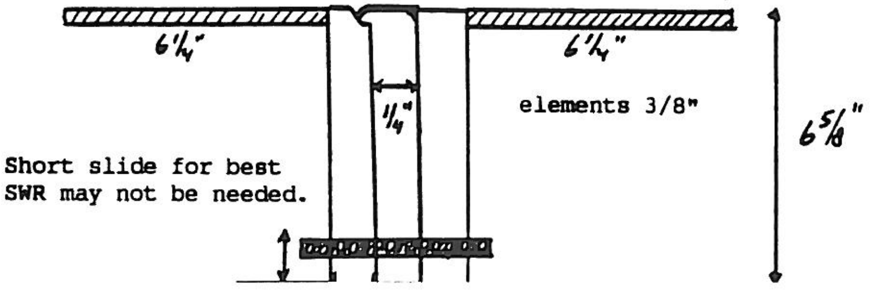


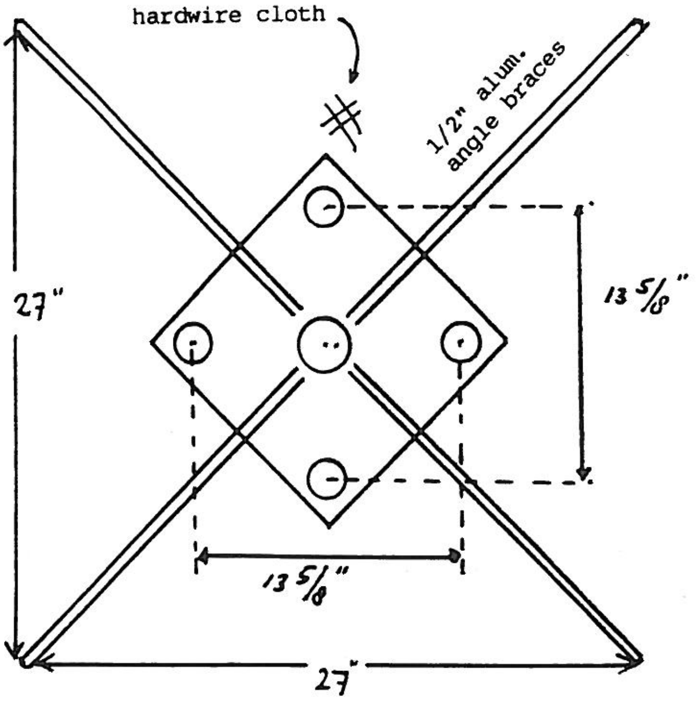


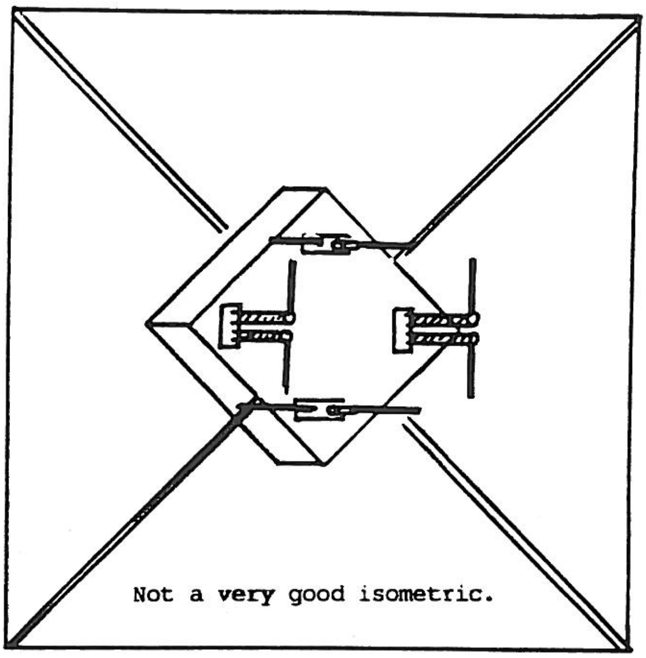
notch



5. Build back plane out of hard wire cloth and strengthen with angle aluminium. Solid plane can be a 14" x 14" x 3" chassis. Drill holes so that brass antenna plate fit flush. Mount two sets of antennas, 1 set for horizontal and the other for vertical. Bring 20" of coax RG11 together and lay in a short piece of RG8 to connect to the relay. (Switches horz. vert.) Solder braid and pull centre conductor together and solder. Seal with sealistor RTV. Water in connectors and coax is our chief problem, it causes SWR to go up.







6. The control circuit I am using, to switch between Horizontal and Vertical polarisation can be seen in Figure 3–24. K1 goes instantly ON and delayed OFF due to C2. K2 goes delayed ON via R2/C2 but falls OFF instantly.

3.27 DL9KR Long Yagi Mark II

Jan Bruinier DL9KR - October 1983

This design as several others is based on the proven director arrangement published by DL6WU. However, there are some modifications making this relatively short (6λ) antenna particularly useful for EME applications. Measurements at the Deutsche Bundespost antenna range showed a clean pattern involving a gain of 15.6 dBd minimum, 3 dB angle in the E-plane 24°, first side lobes down 17 dB, F/B ratio 25 dB. Impedance is 240 ohm and can be fine adjusted by slight modifications in driven element and first director length (not position). Data given are for an insulated boom, i.e. fibreglass or wood. The grid reflector is a 450 x 450 mm square consisting of 8 aluminium rods of 4 mm dia. The driven element is fabricated of 6 mm dia. copper tubing into which the "delta branches" of 3 mm dia. enamelled Cu wire are soldered. Directors are made of 2.5 mm Cu enamelled wire. This wire size is sufficient to withstand medium size birds but could be bent by "the big ones". Director lengths must be corrected if a different wire size is used.

Figure 3–24: K5AZU's Hor/Vert Polarisation control

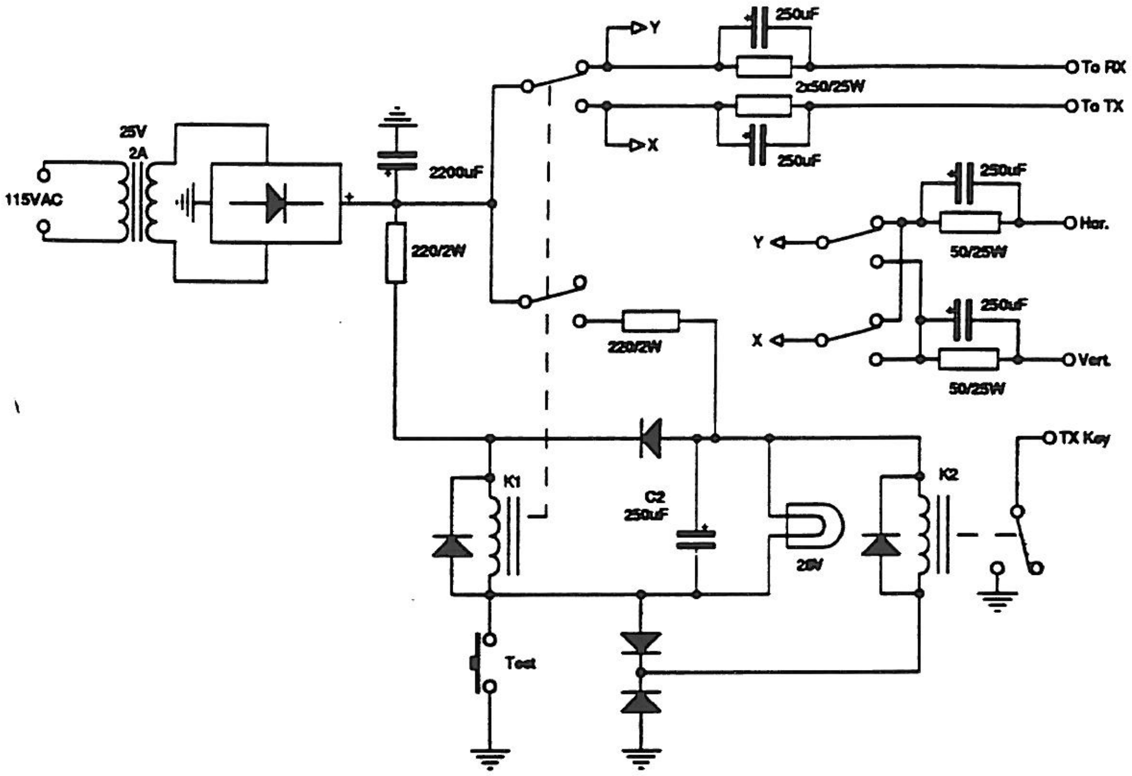


Table 3–5: Dimensions DL9KR Long Yagi Mark II

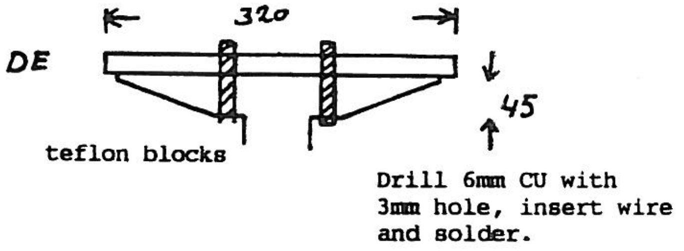
Spacing	mm	Length	mm	Spacing	mm	Length	mm
R-DE	125	R	450	D9-D10	262	D9	287
DE-D1	148	DE	330	D10-D11	262	D10	286
D1-D2	184	D1	302	D11-D12	272	D11	285
D2-D3	195	D2	302	D12-D13	282	D12	283
D3-D4	195	D3	300	D13-D14	282	D13	282
D4-D5	195	D4	297	D14-D15	282	D14	281
D5-D6	236	D5	295	D14-D15	282	D14	281
D6-D7	232	D6	293	D15-D16	282	D15	279
D7-D8	243	D7	291	D16-D17	282	D16	278
D8-D9	252	D8	289			D17	277

The boom length can be increased. In this case cut D15, D16 and D17 to 280 ,279 and 278 mm respectively and decrease subsequent director lengths by 1 mm, maintaining a spacing of 282 mm between the directors.

Note: Changes versus the original DL6WU design:

- Omitting the first close spaced director.
- Use of delta feed (W1HDQ).
- Different spacing of D6.
- Use of a grid type reflector.
- Slightly shorter first 3 directors (D15, D16 & D17).
- Spacings designed for 432 vs. 435 MHz (DL6WU).
- DE design allows "opening" of open wire line directly into "delta branches".

Figure 3–25: DL9KR Long Yagi Mark II Details



3.28 Open Wire Feedline

Jan Bruinier DL9KR - October 1983

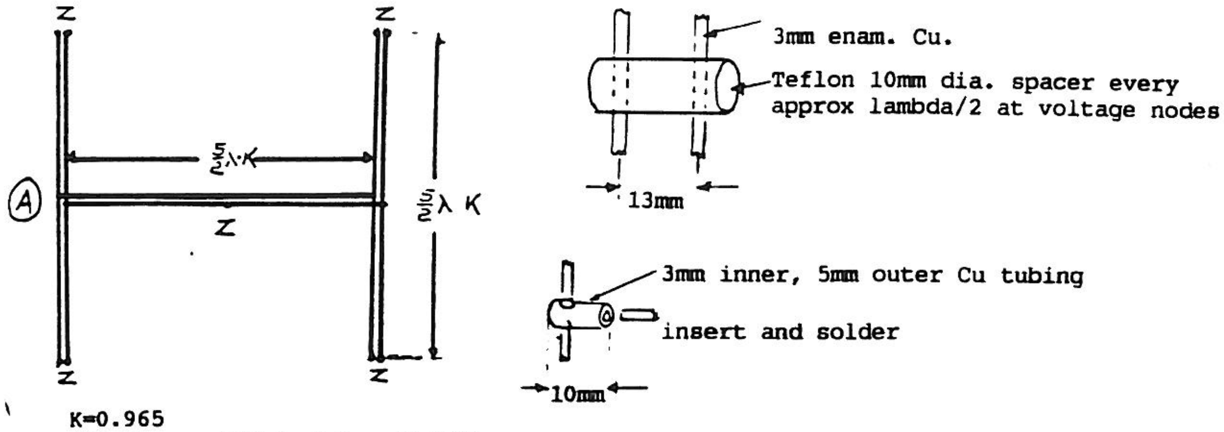
The here described phasing and feeding harness is designed for high gain (15-17 dB) long Yagis enabling the user to transform the impedance of 4 antennas into the same impedance at the centre feed point, independent of open wire line impedance. K-factor will vary between approx 0.96 and 0.97 depending on line construction, i.e. number of spacers (and dia.) per length unit. Do not exceed a centre to centre spacing of 0.02λ. Lines must be run as straight as possible. Use Teflon supports at a minimum of places indicated by design of array. Do not use fishing line for additional support. Avoid oblique angles. Lines must be spaced from other parts at least 0.1λ.

3.29 N9AB's Quagi Array

Andrew Bachler N9AB - December 1983

The individual original Quagis were identical to the ones published in QST except for the addition of a home-brew 1/4 wave sleeve balun. Since the array was first installed, Andy has added 3 additional directors and a second reflector. The director lengths continue with the same taper. Spacing is about 10 inches. The second reflector is the same as the first and spaced 13 inches behind it. Each director is made from 1/8" welding rod. The driven elements and reflectors are made of insulated solid wire. The boom material is 1.25 to 1.5 inch diameter 12 foot long bamboo poles, wrapped their entire length with plastic tape for weather proofing. Fibreglass rod is used to extend the booms for the added elements.

Figure 3–26: Open Wire Feedline



K=0.965
432 Mhz.: 5/2 Lambda x K=1674mm

Boom supports are not needed since each antenna is very sturdy (and heavy - about 7 pounds -). Spacing is 5 Feet, but 5.5 or 6 Feet may be better if you plan to use more than 19 elements. Each antenna is fed with a 50 ohm 10 ft section of a 1/2 inch hardline connected to an "RIW-Products" eight port power divider. Additional hard line connects the 2 eight port dividers to a single 2 port divider. Andy reports he can hear his own echoes with as little as 25 W and estimates that each antenna including boom-to-mast clamp and copper pipe balun cost about $5,- to build.

3.30 70 CM Flat Dish Feed

Jan Bruinier DL9KR - March 1984

The design principle of this flat dish feet is a "Bi Square" (as known from HF) in front of a reflector plane. The advantages are: low losses, a low Q and a perfect match is possible. However there is the necessity for an adjustable capacitor based on the different impedances of coax versus quarter wave open line. The dimension "D" is approximately 100mm. At DJ8QL when this feed was used in conjunction with an IMU-horn, no beam slewing was observed. Sunnoise maxima for 70 and 23 cm occurred at exactly the same dish position. The IMU-horn extended 60 mm beyond the reflector plate. Exact gain and pattern data will be provided at a later date.

3.31 LX1DB Multi Band Feed

Willy Bauer LX1DB - June 1984

On 432 and 1296 MHz Willy uses a conventional IMU dual mode horn surrounded by orthogonal dual dipole feeds (as proposed by K3BPP) which are recessed approximately a quarter wavelength (50 mm) as first suggested by VE7BBG. To add 2320 capability he vertically off-set a 2320 version of the IMU horn by 3.5° (280 mm) which was mounted on an extension of the 432 MHz feed's reflector. This arrangement gave fine results on 432 (17.5 dB Sunnoise) and 1296 (19 dB) but degraded performance on 2320 (13 dB). Willy then rearranged the feed to have the 2320 horn at the dish's phase centre with the 432 array surrounding it and the 1296 horn off-set by 240 mm as shown in the following diagrams. This increased the 2320 Sunnoise to 16.5 dB while the 432 and 1296 Sunnoise remained unchanged. This is the configuration Willy now is using and he is very pleased with its performance.

Figure 3–27: 70cm Flat Dish Feed

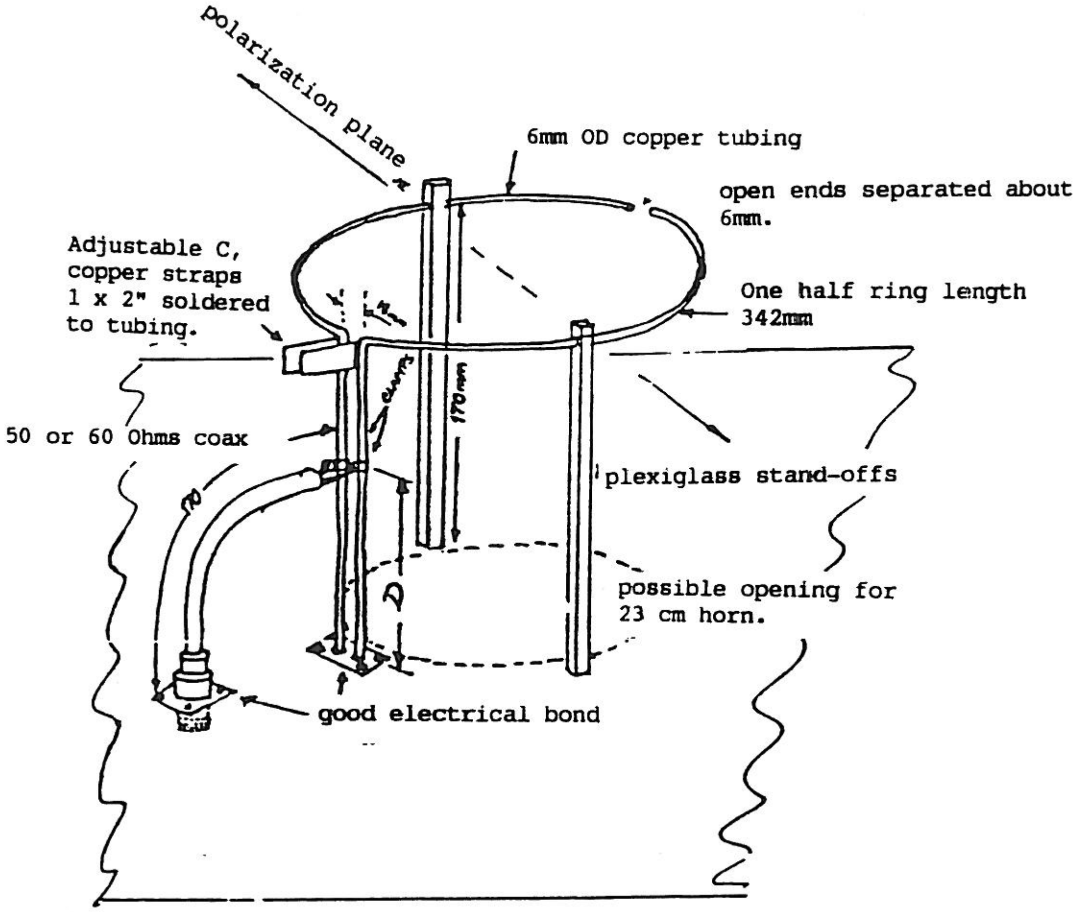
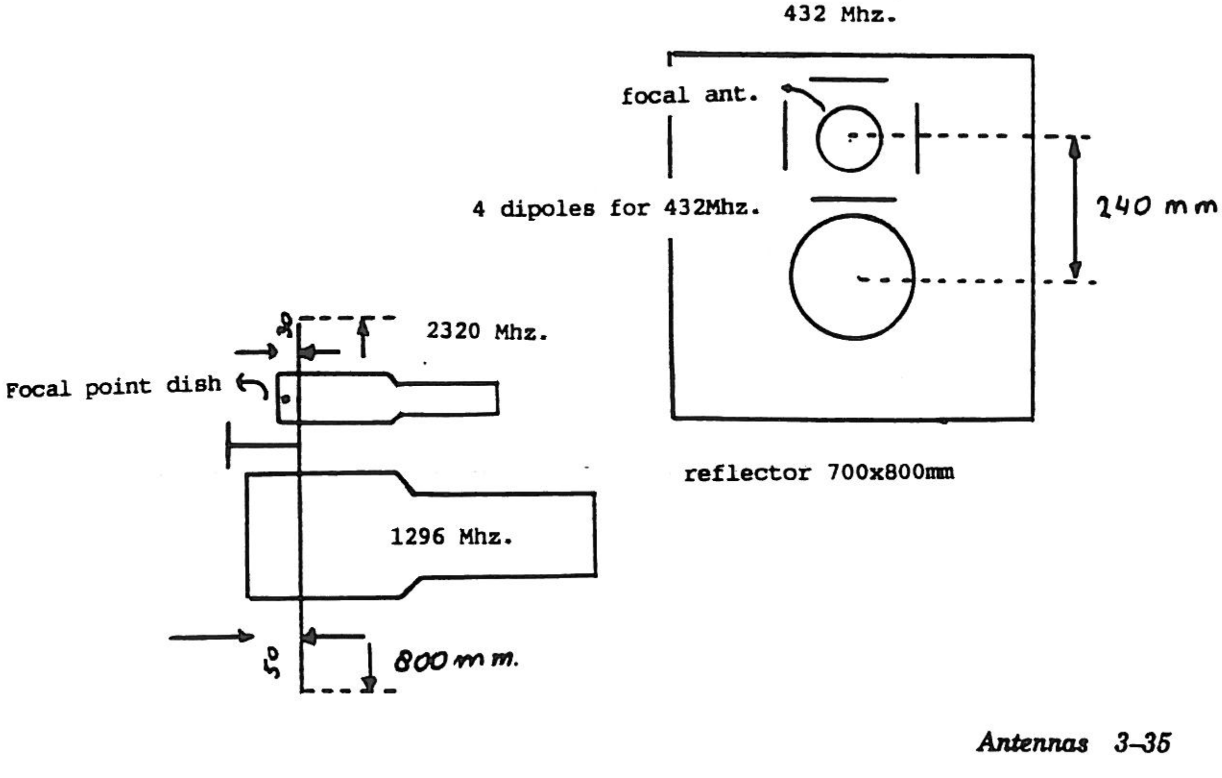


Figure 3–28: LX1DB Multi Band Dish Feed



3.32 Beam Pattern Characteristics of Different Feeds

Barry Malowanchuck VE4MA - July 1984

Barry made up a comparison of the beam pattern characteristics between a number of feeds which have been published upto now in the Newsletter and other references suitable for 1296. The competitors shown in Figure 3–29 are:

- The W2IMU Dual Mode horn.
- DL7YC's feed horn.
- WA9HUV design, published in Hamradio May 1982.
- The beam forming ring dipole disk feed (Kildal and Skettemyr).

3.33 Dipole Disk Antenna with Beam Forming Ring

Per-Simon Kildal & Sven A. Skettemyr IEEE - November 1984

Abstract - A method of improving the radiation characteristics of a dipole disk antenna by using a beam forming ring (BFR) is suggested. The radiation patterns of the dipole-disk antenna are calculated by the moment methods (MM) and the uniform geometrical theory of diffraction (UTD) and are compared with experimental results.

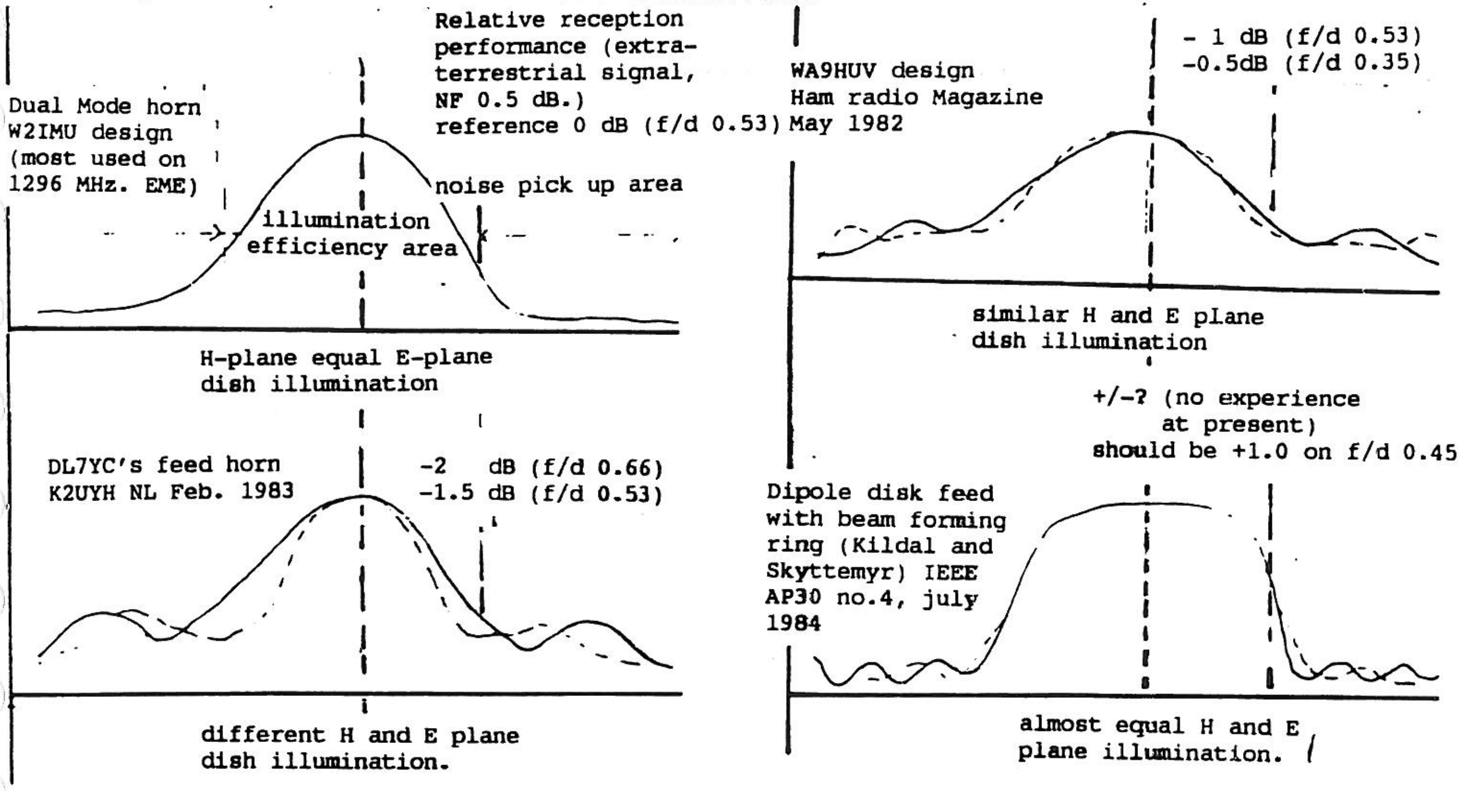
3.33.1 Introduction

The dipole disk antenna [1,p245], which consists of a halfwave dipole over a circular plane reflector, is widely used as a feed for paraboloidal reflector antennas at VHF and UHF. This is because it is convenient to feed and support it by means of a stiff coaxial cable lined along the axis of the paraboloid (Figure 3–30). This simple centre support offers minimum blockage when compared to the three or four legged supports. However the broad H-plane pattern of the dipole disk feed results in low aperture efficiency and low front to back ratio of the paraboloid.

A method of improving the radiation characteristics of the dipole disk antenna is described in this paper. The method consists in incorporating a circular conducting beam forming ring (BFR) over the dipole in a plane parallel to the disk. The BFR compresses the H-plane pattern of the dipole disk feed whereas it has no significant effect on the E-plane pattern. The ring can be supported by means of dielectric rods. The antenna, when used as a feed for paraboloidal reflectors, exhibits near identical principal plane aperture illumination, reduced H-plane spillover lobes, and increased aperture efficiency.

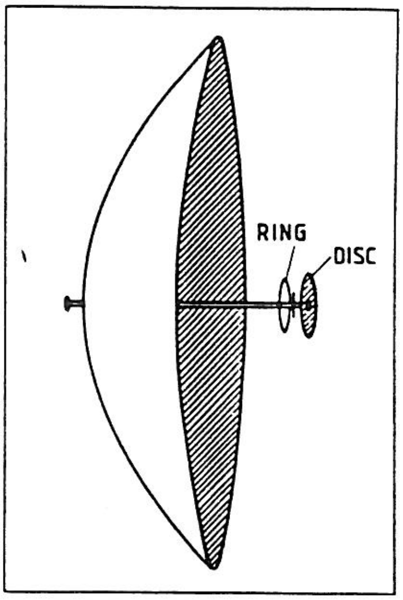
Beam-forming by means of a ring is an extension of an idea which was used to form the beam pattern of a linear array of crossed dipoles, which feed a large parabolic cylinder antenna [2], [3]. The beam pattern of the dipole-disk feed can also be formed in other ways, for instance, by using a corner reflector instead of a disk. However a disk with BFR has the advantage of circular symmetry so that the beam forming properties are retained if the dipole is rotated about the symmetry axis. Therefore if two orthogonal crossed dipoles are used instead of one dipole, the beam pattern of each dipole is formed symmetrically by means of the same BFR. Thus the beam forming ring can be used for two orthogonal linear polarisations, and for circular or elliptical polarisation if the two orthogonal dipoles are properly combined. The symmetrical beam pattern can also be retained forboth linear polarisations if the two orthogonal crossed dipoles operate on different frequencies. However then the ring must be elliptical rather than circular, and the optimum axis of the elipse in the H-plane of one dipole must correspond to

Figure 3–29: Pattern Characteristics of Different Feeds



the optimum radius of the circular ring, which should have been used if only one dipole was present. A similar technique which has been used to obtain axially symmetric beam patterns is to place the dipole in a cavity [4].

Figure 3–30: Dipole-disk antenna with ring used as feed in paraboloidal reflector



3.33.2 Beam Pattern Analysis

The radiation patterns of the dipole-disk antenna, with and without the BFR, are calculated by means of the method of moments (MM) [5] and the uniform geometrical theory of diffraction UTD [6]. A simplified approach has been used. The current distribution on the dipole is assumed to be sinusoidal, which is very close to the actual current distribution on resonant halfwave dipoles, even when other scattering objects are close to the dipole.

The current distribution on the ring is found by means of MM, by assuming an infinite ground plane. The ring is considered as a thin wire antenna [5,p.62]. It is divided into subsections, over which the current distribution is taken to be constant, i.e., pulse basis functions. The solution is tested at the centre of each pulse, i.e., point matching. The ground plane effect is included by means of image theory. The current distribution is then found when the ring is excited by the radiation from the sinusoidal current distribution on the dipole source. When the radiation field from the current distribution is calculated, the finite size of the disk is included by means of UTD. However the current distribution on the ring is still assumed to be the same as calculated for the infinite disk. This is off course an approximation, which may only be valid for large diameters of the disk.

The numerical UTD analysis is further simplified. The sources for the fields, which are reflected and diffracted by the disk, are the current on the ring and on the dipole. They are distributed sources, but in this simplified analysis they are assumed to be two point sources, radiating with their far fields from the centre of the ring and from the centre of the dipole. Both these centres lie on the symmetry axis of the disk, so that the diffraction analysis gives only two diffracted rays between each source point and field point. Even though the rim of the disk is not in the far field of the radiation from the ring, the analysis gives good results. The accuracy is higher for large disk diameters.

The diffracted rays have a caustic when the field point is on or close to the axis of the feed. The fields in the caustic region are calculated by using the equivalent edge current technique. The ring current approach is used for field points between the axis and 55° off axis.

3.33.3 Comparison with Measurements

The beam patterns of a dipole disk antenna with and without ring, were measured. In order to measure the beam patterns it was necessary to arrange the antenna with a coaxial input on the rear side of the disk, instead of the center-feed coaxial line which is used when the feed is mounted in a paraboloid.

The measured and computed beam patterns are shown in Figure 3–31 and Figure 3–32 together with the dimensions of the feed. It can be seen from above figures that the H-plane pattern is compressed by the BFR and made almost identical to the E-plane pattern in the mainlobe region. The measured and computed beam patterns agree well in the mainlobe region. However there is a discrepancy between the two in the sidelobe region. This mainly caused by measurement errors due to reflections from objects in the antenna measurement facility. Repeated measurements with slightly different antenna positions gave different sidelobe patterns, typical of reflections.

3.33.4 Optimisation of Dipole-Disk Parameters

The aperture efficiency η^f, including spillover, polarisation loss, aperture illumination, and phase error loss was used to optimise the geometrical parameters of the dipole-disk antenna with ring.

The heights of the dipole and the ring over the disk and diameter of the ring were optimised when the diameter of the disk was assumed to be infinite. This was done in order to eliminate edge diffraction from the disk when optimising these parameters. The optimum dimensions were definite the dimension which gave the maximum aperture efficiency η^f. Note that η^f does not include blockage, so that it could be maximised even if the diameter of the disk is assumed to be infinite. The diameter of the disk was than reduced in order to find how small diameter could be tolerated before the aperture efficiency was significantly reduced due to edge diffraction. The optimum feed dimensions are:

height of dipole over disk	0.3 λ ($\pm$ 0.05λ)
height of ring over disk	0.5 λ ($\pm$ 0.05λ)
diameter of ring	1.2 λ ($\pm$ 0.10λ)
diameter of disk	2.0 λ (+ ∞)
thickness of ring	0.035 λ ($\pm$ 0.01λ)

As indicated, the feed dimensions are not critical with the tolerances in the parenthesis. The diameter of the disk should be as small as possible in order to reduce blockage loss.

3.33.5 Performance Characteristics

The different parameters which characterise the feed pattern are calculated. They are discussed below for a dipole disk antenna with ring and are compared with the corresponding parameters when the BFR is not used. The characteristic parameters are functions of the subtended halfangle ψ_0 of the paraboloid but are independent of the actual size of the paraboloid in terms of wavelengths. ψ_0 is related to the focal length F and diameter D as $f/D = [4\tan(\psi_0/2)]^{-1}$ The dimensions and positions of the dipole and the ring are given in Section 3.33.4.

Figure 3–31: **Beam patterns for a dipole-disk antenna without ring**

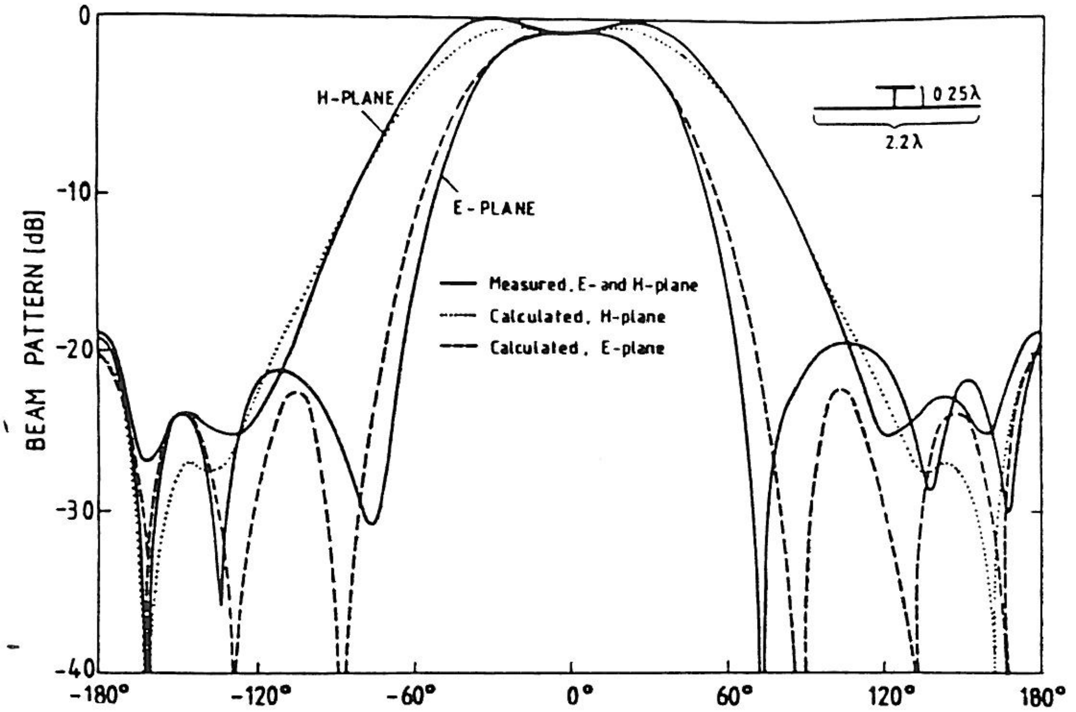
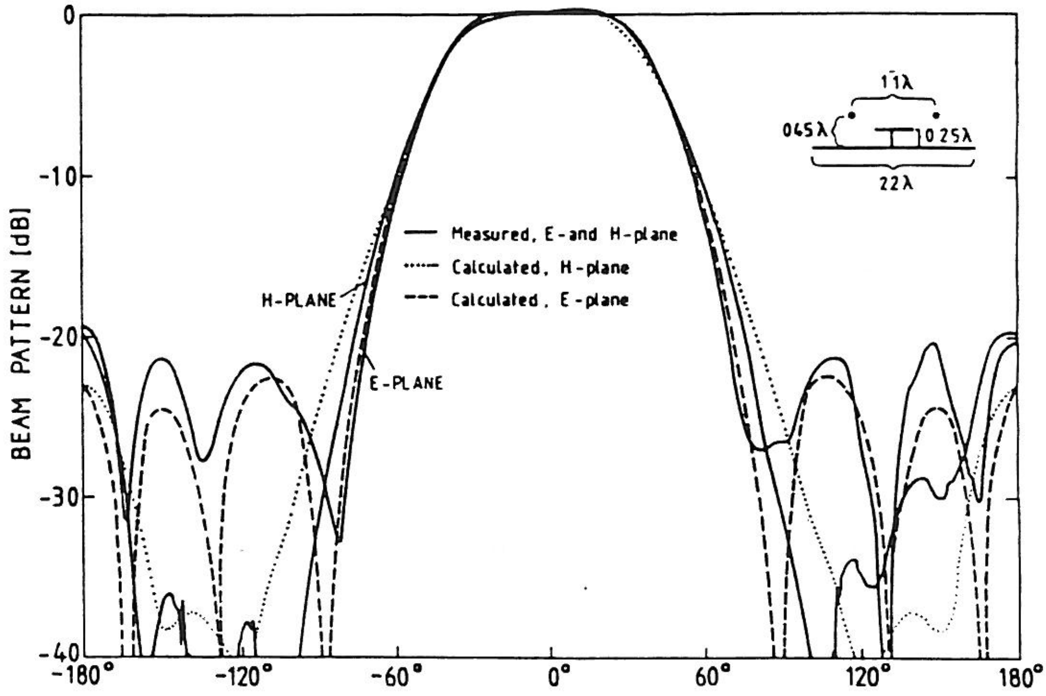


Figure 3–32: **Beam patterns for a dipole-disk antenna with ring**



3.33.5.1 Aperture Efficiency

The overall efficiency NF as given by [7, eq.(4.242-2)], including spillover, polarisation loss, aperture illumination, and phase error loss, is calculated. It is shown in Figure 3–33 as a function of the subtended half angle ψ_0 of the paraboloid with the diameter of the disk as a parameter.

Figure 3–33 shows that η^f for a dipole-disk with ring has a maximum for $50° < \psi_0 < 55°$, slightly dependent of the ring disk diameter. For a dipole-disk without ring the maximum η^f is obtained for a deeper paraboloid $62° < \psi_0 < 67°$. The maximum value of η^f is considerably improved with the beam-forming ring. For a practical disk-diameter of 2.0λ the improvement is from η^f=0.73 for ψ_0=62° to η^f=0.84 for ψ_0=52°. Thus the improvement in maximum aperture efficiency is up to 15 percent when a beam forming ring is used. Figure 3–33 also shows that the aperture efficiency decreases as the disk diameter is decreased, but the decrement is less for the dipole-disk with ring than the one without ring. For a dipole-disk with ring the reduction in NF is insignificant for disk diameters down to 2λ.

Figure 3–33: Aperture efficiency

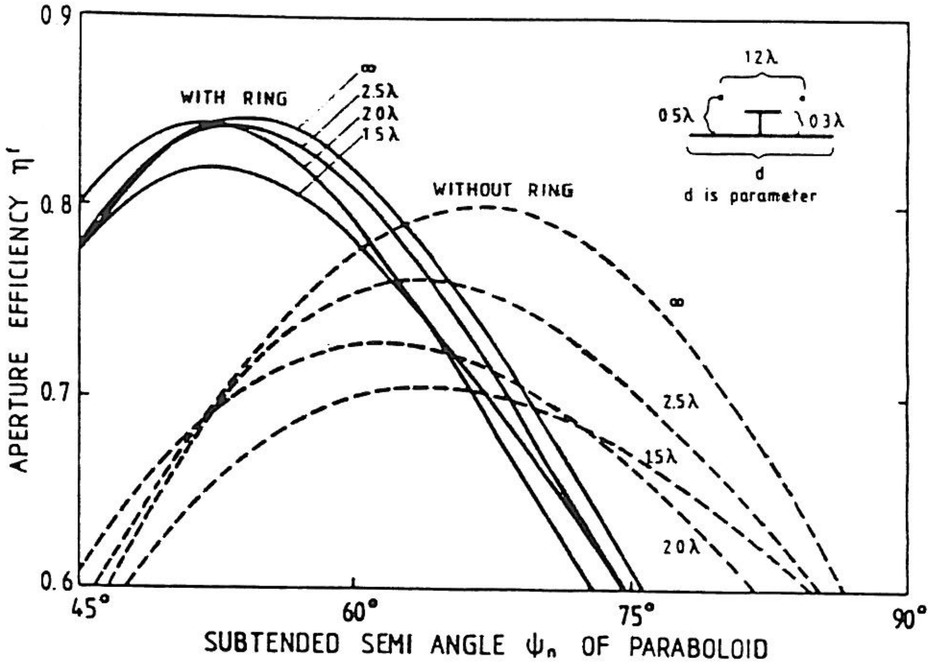
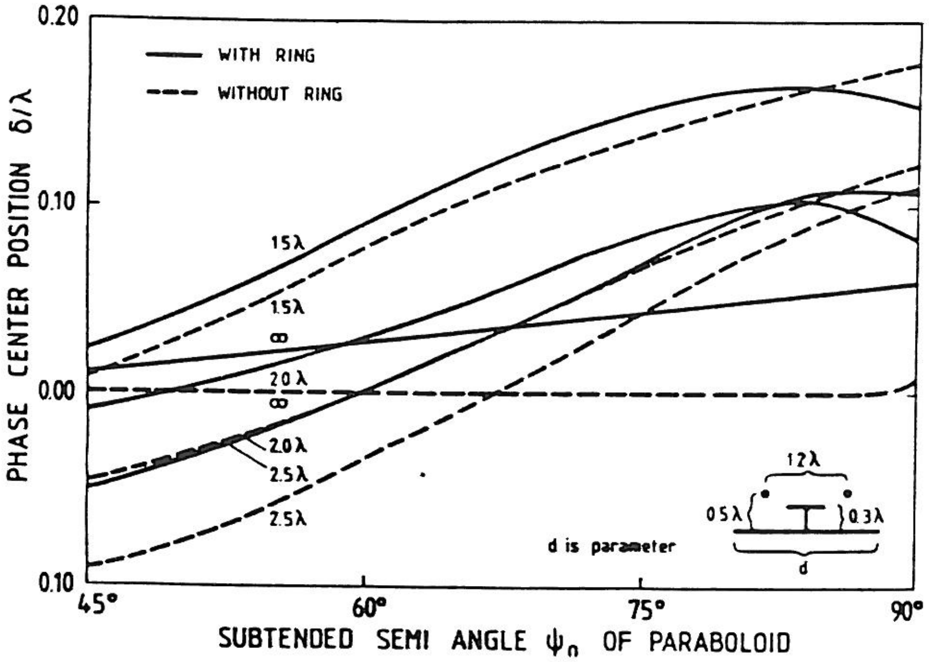


Figure 3–34: Phase centre position



3.33.5.2 Phase Centre

The aperture efficiency η^f in Figure 3–33 is given when the phase centre of the feed coincide with the focal point of the paraboloid. The phase centre position δ is calculated as explained in [8, appendix 5], where by a proper use of the method proposed in [7,sec. 4.25], a combined phase centre for E-and H- plane is obtained as the phase reference point which maximises the aperture efficiency. δ is shown in Figure 3–34 for dipole disk antennas with and without ring. It is measured from the centre of the disk and is positive in the direction of the dipole. With finite disk diameters the phase centres is closer to the dipole when the subtended half angle ψ_0 of the paraboloid is large, and near the disk for small ψ_0. The corresponding phase efficiency No, due to defocusing, is close to unity when the phase centres coincides with the focal point. It decreases slightly with increasing ψ_0 but is always higher than 0.98 for $\psi_0 < 90°$. If the phase centre and the focal point do not coincide, the defocusing efficiency is reduced. It follows approximately [9]

$$\eta^{\phi} \approx 1 - \frac{1}{12}(2k\Delta \sin^2 \frac{\psi_0}{2})^2$$

where Δ is the spacing between the phase centre and the focal point. A tolerance on the phase centre position can then be defined by $\eta^{\phi} > 0.99$, which gives

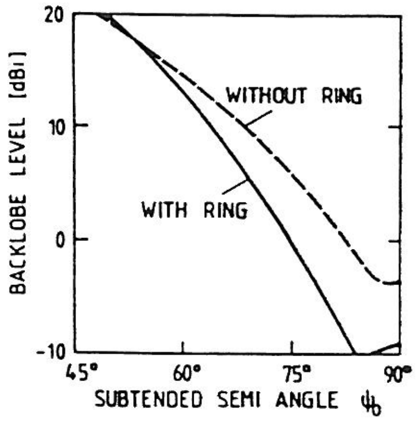
$\Delta < \pm 0.17\ \lambda$ for $\psi_0 = 50°$
$\Delta < \pm 0.12\ \lambda$ for $\psi_0 = 60°$
$\Delta < \pm 0.09\ \lambda$ for $\psi_0 = 70°$

Thus the feed can be displaced this distance Δ from the focal point without significant defocusing loss.

3.33.5.3 Backlobe Radiation of Paraboloid

The backlobe radiation from the paraboloid is caused by diffraction from the rim of the paraboloid. A simple formula for it can be derived from Keller's geometrical theory of diffraction [10, p. 177] and the concept of equivalent edge currents. It turns out to be independent of the size of the paraboloid in terms of wavelengths and therefore acterizes the feed pattern. It is shown in Figure 3–35 as a function of ψ. For $\psi > 55°$. the backlobe of the paraboloid is reduced when the beam forming ring is used.

Figure 3–35: Backlobe level



3.33.5.4 Spillover Lobe

Spillover lobes are the contribution from the direct radiation to the secondary beam pattern of the paraboloid. The highest spillover lobe is the level of the feed pattern in the direction of the edge of the paraboloid. For a feed with ring the level is considerably reduced and has become equal in E-and H-plane.

3.33.5.5 Subefficiencies

The contributions to the aperture efficiency from spillover, polarisation loss, aperture illumination, and phase patterns are calculated as explained in [8, appendix 5]. The different subefficiencies are given in Table 3–6, in which the dipole disk antenna, with and without ring are compared. The polarisation efficiency NP, which is the power in the nominally linearly polarised aperture field relative to the total power in the aperture field, is seen to increase when the ring is used. The spillover efficiency also increases.

3.33.5.6 Frequency dependence

The frequency dependence of the aperture efficiency is shown in Figure 3–36. The feed dimensions are as given in Section 3.33.4. The subtended semi-angle of the paraboloid is the one which maximises the aperture efficiency. ψ_0=61° for the feed without ring, and ψ_0=52° for the feed with ring. The aperture efficiency is more sensitive to frequency for an improved feed with ring than for a feed without ring.

Figure 3–36: Frequency dependence of aperturre efficiency

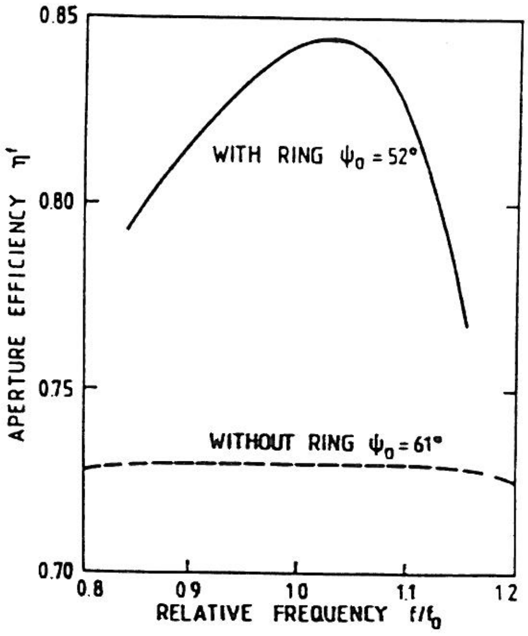


Table 3–6: Comparison of performance characteristics of directivity_optimized paraboloids (A), and of paraboloid with ψ_0=72°, which corresponds to 20dB taper in E-plane(B)

	A		B	
	Feed Without Ring	Feed With Ring	Feed Without Ring	Feed With Ring
Subtended half angle ψ_0	63°	54°	72°	72°
Gain of feed G^f	6.4 dBi	7.5 dBi	6.4 dBi	7.5 dBi
Aperture taper E-plane	13 dB	6.6 dB	20.5 dB	20.7 dB
H-plane	3.9 dB	8.1 dB	6.0 dB	21.8 dB
Spillover lobes E-plane $A_1(\psi_0)$	−6.6 dBi	0.9 dB	−14.1 dB	−13.2 dB
H-plane $C_1(\psi_0)$	2.5 dBi	−0.6 dBi	0.4 dBi	−14.3 dBi
Backlobe of paraboloid G^b	13.3 dBi	17.6 dBi	7.6 dBi	3.2 dBi
Subefficiencies:				
Spillover efficiencies η^s	0.856	0.940	0.915	0.989
Polarization efficiencies η^p	0.983	1.000	0.975	1.000
Illumination efficiencies η^t	0.868	0.898	0.775	0.626
Phase efficiencies η^ϕ	0.999	0.997	0.996	0.989
Aperture efficiency η^f	0.729	0.841	0.688	0.612

3.33.6 Conclusion

The commonly used dipole-disk feed for paraboloidal reflector antennas is improved by means of a beam forming ring over the dipole. The performance characteristics of the dipole-disk, with and without the ring are compared in Table 3–6. The dimension of the feed is given in Section 3.33.4. The aperture efficiency of the paraboloid has a maximum for a subtended half-angle $\psi_0 \approx 63°$ when a dipole disk feed without ring is used. With ring the maximum NF occurs for a more shallow reflector ($\psi_0 \approx 54°$) These two cases are compared in Table 3–6 (Columns A). Note that the maximum available aperture efficiency is improved by 15 percent by means of the beam forming ring. This corresponds to a directivity improvement of 0.6 dB. The main contributions to the aperture efficiency loss are the spillover and illumination efficiency. The spillover loss is reduced from 14 to 6 percent, so that the equivalent noise temperature of the paraboloid is considerably reduced. The cross polarisation is also improved. The relative total polarisation [i.e., $10log(1-\eta^P)$], is reduced from -18 dB to -37 dB.

The aperture illumination tapers are nearly equal in the E- and H-planes for the feed with the ring (approximately 7 dB).The principal plane tapers differ by 10dB for the feed without the ring. The backlobe of the paraboloid is higher with the ring. The directivity-optimised paraboloids in Table 3–6 have high backlobe levels, low aperture taper, and much spillover. Therefore they are not applicable under circumstances where interference is a problem, or where low sidelobes or low noise temperatures are wanted. If the subtended angle is increased to ψ_0=72°, these disadvantages are reduced at the expense of the aperture efficiency. ψ_0=72° gives 20dB E-plane taper for both feeds. The performance characteristics are compared in Table 3–6 (Columns B). The aperture taper in H-plane is improved from 6 to 22 dB by means of the ring. The backlobe levels are now much lower than for the directivity-optimised paraboloids, and 4.4 dB lower with ring than without. The spillover lobes in H-plane are reduced with 14 dB when using the ring. The spillover power is also considerably lower with ring feed (only 1 percent compared with 8 percent without ring).

3.33.7 Acknowledgement

The authors wish to acknowledge the benefit of several discussions with their colleagues at the Electronics Research Laboratory (ELAB) and the division of telecommunications, both at the Norwegian Institute of Technology. The authors are especially thankful to Jon Anders, Odd Helge Longva for their comments and advice. K. Sudhakar Rao, who has a research scholarship for carefully editing the manuscript.

3.33.8 References

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3.34 Apparent Azimuth Beamwidth

Peter Riml OE9PMJ - December 1984

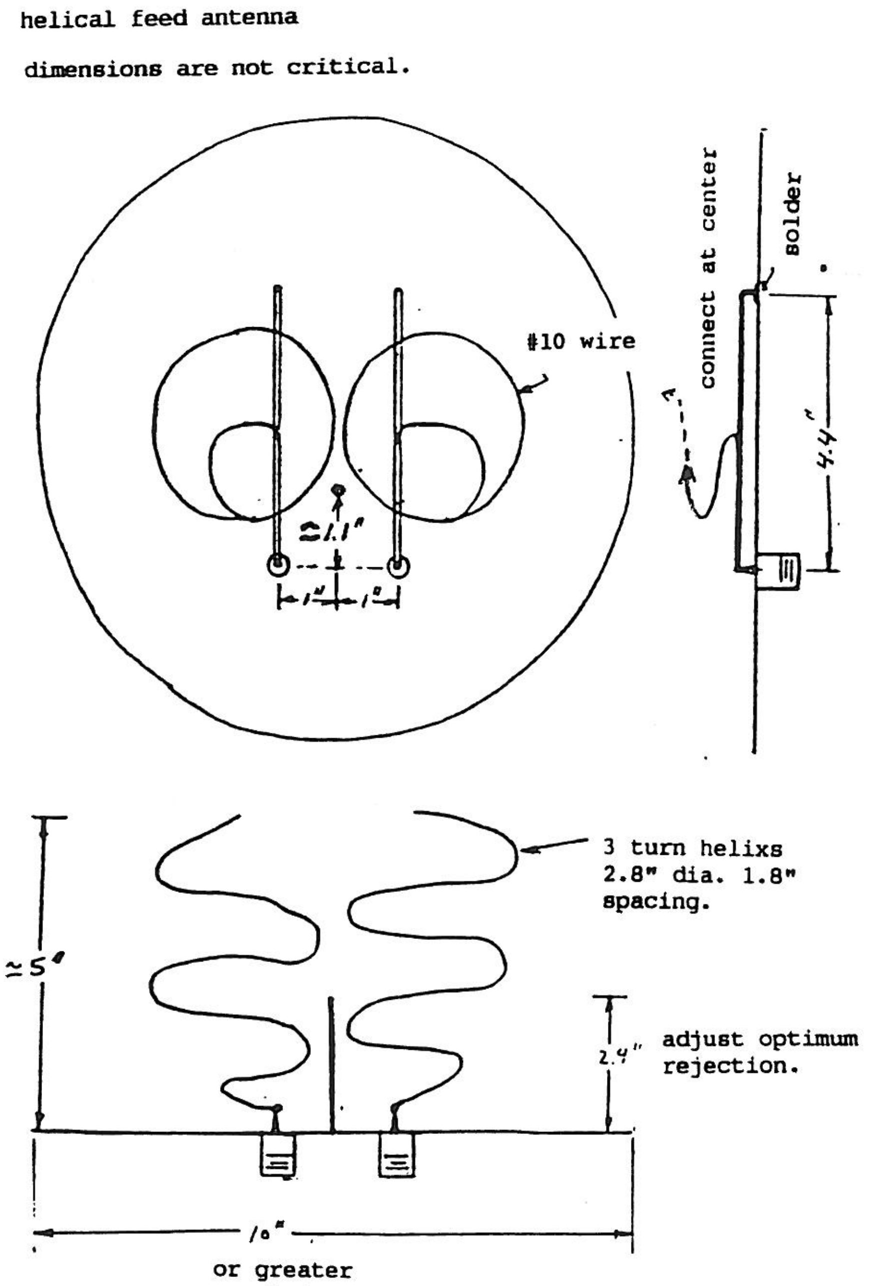
Peter OE9PMJ points out an error in K2UYH's response to KU4F's observation of a non-symmetrical beam pattern. Peter correctly explains that when looking at an elevated signal with an El-Az mounted antenna, the antenna's actual horizontal beam width will always be smaller than the corresponding azimuth angle (of rotation.) This is because of the solid geometry involved. A rotation on the horizon does not translate into an equal "orthonogal" rotation at an elevated angle. For an El-Az mount, the true vertical beamwidth of an antenna is always equal to the corresponding change in elevation angle, but the true horizontal antenna beam width hbw is equal the change in azimuth angle caz times the Cosine of the elevation angle, i.e. $hbw = caz\cos(El)$. Consider the case of measurement of a symmetrical antenna's 3 dB beam width using the sun as a source when it is at an elevation of 69°. An 8° 3 dB beamwidth is measured in elevation, while a 22° beamwidth is indicated by the azimuth readout. The true horizontal beam width is $22 * \cos 69$ or 8°. This is why, when the moon is at high elevation, it is possible to rotate your antenna a considerably larger distance in azimuth without signal levels being effected than when the moon is near the horizon or at a lower elevation. The mystery of the non-symmetrical antenna is thus solved.

3.35 Simple Circular Feed Antenna for 1296 MHz

Allen Katz K2UYH - December 1984

This month I have also provided details of a simple circular feed antenna, I have been experimenting with, see Figure 3–37. This feed consists of two 3 turn helical antennas mounted close to each other on the same ground plane. One helix is wound left-hand circular for transmit and the other right-hand circular for receive. (Remember that the polarisation sense of a circular feed antenna is reversed by the reflector.) A vertical post between the two helicals is used to minimise interaction between the 2 antennas. By varying this post's height and position, the transmit signal can be nulled at the receive port by greater than 15 dB and vice verse. A quarter wave "microstrip" like transformer/stub combination is used for matching and to limit the antenna's bandwidth. (i.e. to reject strong out band signals.)

Figure 3–37: Simple Circular Feed Antenna for 1296 MHz



3.36 2304 MHz Circular Polarised Feed

Bill Byrd WA4HGN - January 1985

This month we have details of a circular feed for 2304 which is believed to have originated with K6YFK. Bill WA4HGN had planned to put up on 2300 just before his death. It certainly appears simple, but I must confess I am unfamiliar with the principle upon which it is based. I cannot say if this design can be scaled to 1296 or even how well it works. The design is supposed to be optimum for about 0.375 f/D dish which is a little deeper than the dish most of us use but almost ideal for the typical TVRO dish.

Comments in the February EME-Newsletter by Dick Turrin W2IMU. Dick writes that the principle of operation of the circular feed described in last month's NL is quite simple and makes use of the fact that when a travelling wave passes through a region inside a waveguide where there is some dielectric material, it will slow down. If the dielectric material is lined up with only a horizontally polarised wave, it will slow that wave down, but not a vertically polarised wave (to which, it is not aligned). In the case the feed under discussion, when one of the probes is driven with RF, the component of its electrical field parallel with the dielectric slab under goes delays, while the component orthogonal to the slab experiences little delay. (Note that the slab is placed at 45° to the probes). If everything is right, when these components arrive at the end of the guide they will be 90° out of phase and produce circular polarisation. One probe produces RCP and the other LCP since the opposite component is delayed.

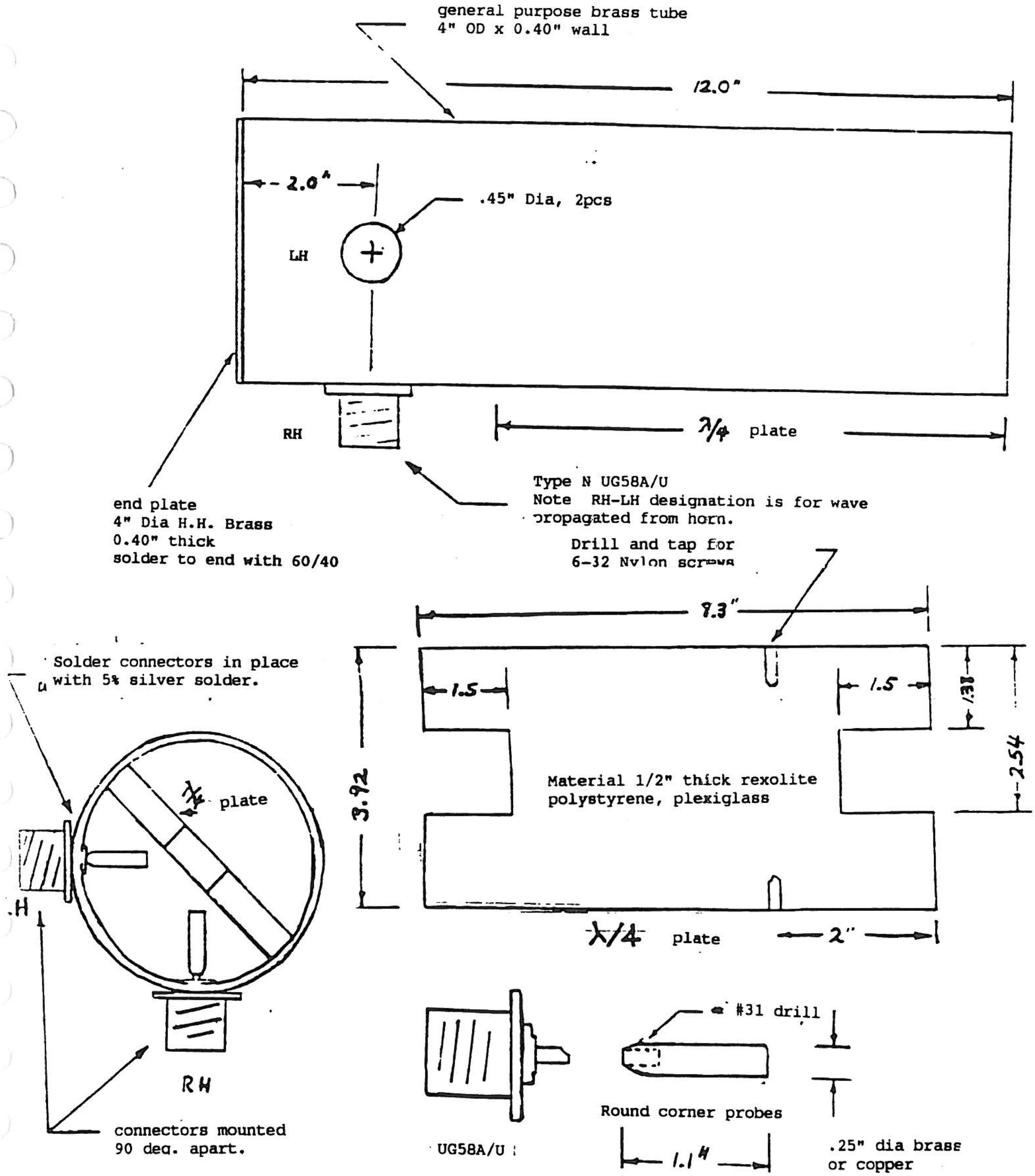
There are however, a number of unanswered technical questions. The notch cut into each end of the rexolite slab is an attempt to provide an impedance match in and out of the dielectric material. When you place a dielectric material into a guide you alter its wave impedance and introduce higher order modes. It is very questionable to place the radiating aperture right at the end of the phase shifter. Good practice is to place at least one half wavelength of guide on either sides of the phase shifter to kill the higher order modes. Dick is concerned that some of these higher modes could mess up the radiation pattern of the horn. (The only way to know how badly the pattern is distorted, is to measure the horns pattern.) Dick is also concerned with the unsymmetric probes used with this horn. Such probe placement also tends to stir up higher order modes and cause too much cross-talk between the probes. The IMU dual mode horn employs a similar arrangement, but uses a post on the back wall to kill this coupling. A more serious problem is that the guide cut-off for the TM01 mode is very close to the operating wavelength! This means that if an TM01 is stirred up by the probes, it will be propagated by the guide and affect the pattern. Overall, Dick says not to expect too much from the performance of this horn and strongly recommends that you measure it before you try to use it.

3.37 Offset Feed for 144, 432 & 1296 MHz

Allen Katz K2UYH - April 1985

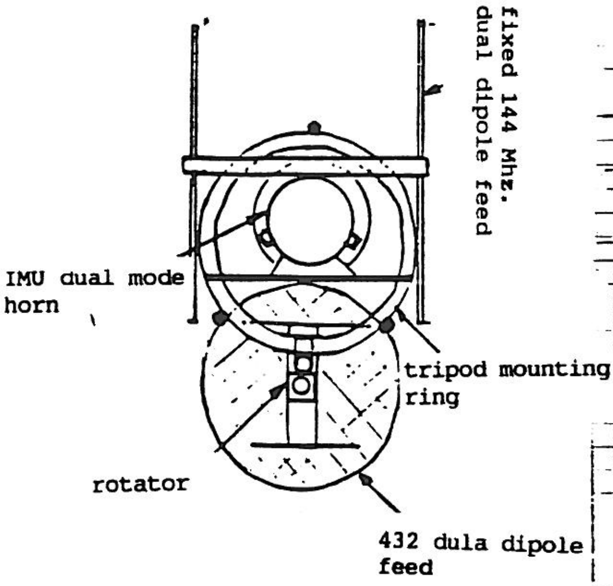
For sometime I have been trying to find a good solution to the dual band feed puzzle. The combination IMU/BPP feed appears a good compromise, but I have always liked the idea of being able to fully rotate my 432 MHz polarisation, but the BPP arrangement only allows vertical or horizontal polarisation and nothing in between. I had originally considered offsetting my 1296 feed, but decided the loss in performance was too great. Recently I reviewed the numbers involving feed offset (see the following curve from Silver) and realised that if I offset the 432 feed the gain degration would be negligible. According to the data, I could offset my 432 feed almost 6 feet before more than 1 dB is lost. I moved the 432 feed rotator to the bottom of the ring feed (see diagram) and placed the 1296 IMU feed almost at the centre of the dish but offset slightly up. With this arrangement the 432 beam is squinted 6° up and the 1296 beam about 1.5° down, this means I must substract 6° from the moons elevation when operating on 432 and add 1.5° when on 1296. There is no change in the azimuth setting. The system appears to work exactly as predicted. One disadvantage is that I can no longer measure cold sky to Groundnoise on 432 as I cannot tilt far enough into the ground to get an accurate reading. In fact I

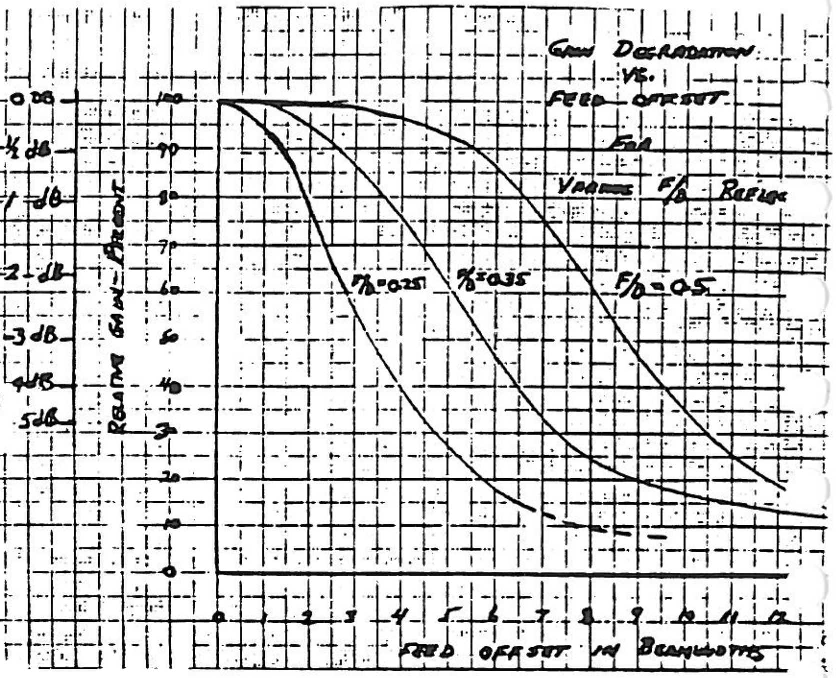
Figure 3–38: 2304 MHz Circular Polarised Feed



now just make the horizon, but this seems a small price to pay for the convenience of 2 feeds. Actually I have 3 feeds as I also have a fixed dual dipole feed for 2 meters mounted across the feed ring.

Figure 3–39: Offset Feed for 144, 432 & 1296 MHz





3.38 Chaparral Feed for 1296MHz

Dick Turrin W2IMU - September 1985

A version of scalar feed, called the Chaparral feed, is very popular in TVRO designs. It features low side and rear radiation by employing a multiple choke collar surrounding an open end circular waveguide radiating aperture. One such design by M/A-COM with three slots is shown in Figure 3–40 with dimensions normalised to a free space wavelength. The originator claims that this feed can accommodate a reflector with f/D ranging from 0.30 to 0.44 by simply moving the collar by 0.25 wavelength front to back. For EME operation, this means we can have our cake and eat it too! Maximum gain for transmitting and optimum G/T for receiving.

This note suggests using heavy fingerstock where the collar meets the waveguide outer surface to permit physical movement of the collar without loosing electrical integrity. Use any means you can to obtain the linear movement; rack-and-pinion, lead screws, cable and pulleys or even small hydraulic jacks. The movement does not have to be fast because of the nature of EME communications.

The fingerstock can be weatherproofed on the aperture side with a loose fitted plastic film (radome) and at the rear with a close fitting gasket and guide collar arrangement. Choose an f/D for the reflector of 0.35 which requires that the collar be moved away from the guide aperture by 0.25 wavelengths for transmitting and then moved just to flush with the end of the guide for receiving. Because the feed blockage is larger than usual, this feed should be used with a reflector diameter greater than 20 wavelengths.

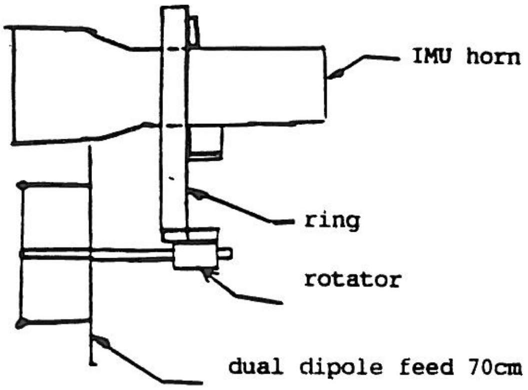
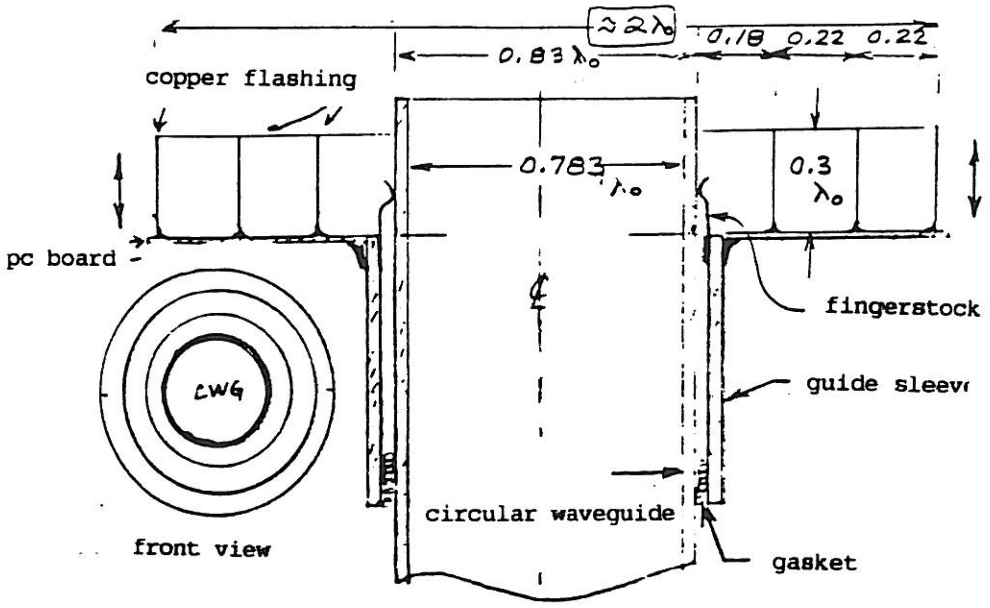


Figure 3–40: Chaparral Feed for 1296MHz



3.39 A Small Dipole Fed Resonant Reflector Antenna with High Efficiency, Low Cross Polarisation and Low Sidelobes

Per Simon Kildal Senior member IEEE - August 1986

3.39.1 Abstract

The computer aided optimisation of a small 5 wavelength diameter reflector antenna with a centre supported dipole disk feed is described. The primary radiation is controlled by using a patented beam-forming ring to give low cross-polarisation and low sidelobes due to spillover. The efficiency is maximised by controlling and taking advantage of the multiple reflections between the feed and the reflector. This has inspired the name "resonant reflector antenna". The gain from the feed reflector resonances is so large that it compensates almost completely for the about 1 dB loss due to centre blockage of the aperture.

3.39.2 Introduction

Small dipole fed reflector antennas are quite popular in L-band e.g. in ship earth stations for the INMARSAT satellite communication system. However, if the reflector diameter is less than typically seven wavelengths, such antennas are very difficult to design with high aperture efficiency, low sidelobes and low cross polarisation. The former is important in order to reduce the physical sizes of the antennas. The reasons for these difficulties are: severe blockage of the aperture caused by the feed, interference from the backlobe of the feed, and multiple reflections between the feed and the reflector. This paper describes a reflector antenna which has been designed by computer aided control of all these different effects contributing to the aperture efficiency. In particular, the spacing between the feed and the reflector is successful tuned to resonance. The resulting resonant reflector antenna (Figure 3–41) has very high performance. The theory behind the design is also given (Section 3.39.3).

Figure 3–41: The Resonant Reflector Antenna with dipole disk feed and beam-forming ring

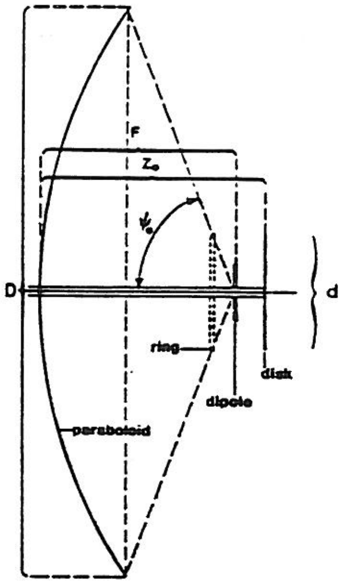


Fig. 1. The resonant reflector antenna with dipole disk feed and beam-forming ring.

The starting point of the optimisation is a parabolic reflector fed by a dipole-disk feed, i.e., a dipole over a plane circular disk. [1, p. 245]. Using this feed antenna is advantageous as it can be fed and supported by means of a stiff coaxial line along the axis of the paraboloid, thereby avoiding blockage from support struds across the aperture. However, the dipole disk antenna has a much broader radiation pattern in the H-plane than in the E-plane, causing low efficiency and high cross polar sidelobes. This is improved by means of a conducting circular beam forming ring, which compresses the H-plane pattern to be equal to that in the E-plane [2]. The moment method computer program in [3] is used to calculate and optimise the geometry of the feed. This is done by trying to maximise the feed efficiency and its subefficiencies [4], and by trying to minimise the cross-polar sidelobes (Section 3.39.4). Afterwards, the radiation pattern of the complete reflector antenna with the feed is calculated and optimised, also by means of the moment method computer program. The moment method requires a long computation time, but is still possible to use because the reflector has only a five wavelength diameter. During this computation the feed is located with its phase centre coinciding with the focal point of the reflector; the phase centre being calculated by the method purposed in [5] and [6]. The radiation patterns and the corresponding aperture efficiency are calculated for different reflector sizes, showing resonances every time the spacing between the reflector and the disk is a multiple number of half wavelengths (Section 3.39.5). The final reflector geometry is chosen from the results of these computations.

Resonances between a disk and a reflector are also the main reason for the high efficiency of the backfire antenna [7]. the resonant reflector antenna is related both to the backfire antenna and to the reflector antenna, as it takes advantages of both the feed reflector resonances and the reflector focusing. The results of measurements on a practical model of the resonant reflector antenna are presented, when excited for both linear and circular polarisation

3.39.3 Factorisation of the aperture efficiency

Let us assume that the feed antenna is linearly polarised with the dipole parallel to the Y-axis. Then the radiation field of the feed in a point $\vec{R}$ can be written approximately as

$$\vec{E}(\vec{r}) = \frac{1}{r}e^{-jkr}[A(\theta)\sin\varphi\vec{a}_\theta + C(\theta)\cos\varphi\vec{a}_\varphi] \qquad (3–1)$$

where $k = 2\pi/\lambda$ is the wavenumber, θ is the polar angle, φ is the azimuth angle, and where $\vec{a_\theta}$ and $\vec{a_\varphi}$ are unit vectors in the directions of increasing θ and φ, respectively. $A(\theta)$ is the E-plane pattern, and $C(\theta)$ is the H-plane pattern. The approximation leading to (3–1) implies that radiation into higher order azimuthal modes is neglected. These modes are described by $\sin\eta\varphi$ and $\cos\eta\varphi$ variations of the two field components for $\eta = 2, 3, \ldots$. They will normally be present in dipole feeds, because the dipole itself is not circular symmetric about the Z-axis. However, if the remaining feed geometry (i.e., in our case the disk and the ring) has circular symmetry, we have experienced that higher order modes can be neglected. Let us now assume that the feed described by (3–1) is ideally excited for circular polarisation, this means that another dipole is added to the feed, with the same location as the original one but orthogonal to it (i.e., parallel with the x-axis), and that this dipole is excited equally strong and exactly in phase quadrature with the original dipole. Then the copolar circular polarised radiation pattern $CO(\theta)$ of the feed is the mean of the E- and H-plane pattern, and the cross polar radiation pattern $XP(\theta)$ is half the difference between the two, according to [4, sec 3]. Thus,

$$CO(\theta) = [A(\theta + C(\theta)]/2 \qquad (3–2)$$

$$XP(\theta) = [A(\theta - C(\theta)]/2 \qquad (3–3)$$

These are also the co- and cross-polar radiation patterns measured for the linearly polarised feed in the 45° plane. We know that $XP(\theta) = 0$. To be able to maximise the aperture efficiency of an antenna, it is important to understand the different contributions to it. In our case there is no blockage due to support struts across the aperture. We can then write the apperture efficiency as:

$$\eta_\alpha = \eta_f \left|1 + \Delta_{cb} + \Delta_{f_s} + \Delta_l\right|^2 \qquad (3–4)$$

where η_f is the feed efficiency, Δ_{cb} is the contribution from centre blockage, Δ_{f_s} is the contribution due to multiple reflections between the feed and the reflector, and Δ_l is the contribution from the backlobe of the feed. The feed efficiency η_f depends on the shape of the radiation of the feed and on the subtended half-angle ψ_o of the paraboloid. It is defined in [1] and [10]. It also can be expressed as [4, eq(22.)]

$$\eta_f = 2\cot^2(\psi_o/2)\frac{\left|\int_0^{\psi_o} CO(\theta)\tan(\theta/2)d\theta\right|^2}{\int_0^{\pi}[|CO(\theta)|^2 + |XP(\theta)|^2]\sin\theta\; d\theta} \qquad (3–5)$$

Provided the phase reference point $CO(\theta)$ coincides with the focal point of the reflector. η_f can be factorized into a number of subefficiencies, characterising losses due to spillover, cross polarisation, nonuniform aperture illumination, and phase errors [4]. It can also be used to define a phase centre for the feed, as the feed location which minimises the phase error losses [5], [6]. The blockage term delta Δ_{cb} is negative and proportional to the aperture area blocked by the feed, i.e. the area of the disk. It can be written approximately as

$$\Delta_{cb} = -C_b(d/D)^2 \qquad (3–6)$$

where d is the diameter of the disk and D is the diameter of the reflector, and where the blockage parameter C_b is [8, eq.(24)]

$$C_b = \frac{CO(0)\ \tan^2(\psi_0/2)}{\int_0^{\psi_o} CO(\theta)\ \tan(\theta/2)d\theta} \qquad (3–7)$$

The backlobe term Δ_l can be expressed as [9, eq. (6.35)]

$$\Delta_l = -\frac{1}{2kF}\frac{XP(\pi)e^{j(2kF+\pi/2)}}{\int_0^{\psi_0} CO(\theta)\ \tan(\theta/2)\ d\theta} \tag{3–8}$$

Where F is the focal length of the paraboloid. The phase term $\pi/2$ comes from the radiation integral over the reflector aperture. The multiple reflection term Δ_{fs} is very difficult to calculate, as, according to [9], we need to know the field scattered from the feed when it is illuminated by a plane wave. This effort is therefore also often referred to as feed scattering [10, sec. 3.4]. However, it is very easy to see that the following proportionality relation must be valid [9, eq. (6.24)]

$$\Delta_{fs} \propto e^{-j2kF} \tag{3–9}$$

We see from (3–8) and (3–9) that Δ_l and Δ_{fs} depend strongly on the focal length through the phase terms $2kF$ and $-2kF$, respectively. The idea behind the resonant reflector antenna is to choose the focal length in such a way that Δ_l and Δ_{fs} become real and positive in order to make up for the losses due to the negative blockage term Δ_{cb}.

Figure 3–42: Feed efficiency of dipole disk with ring

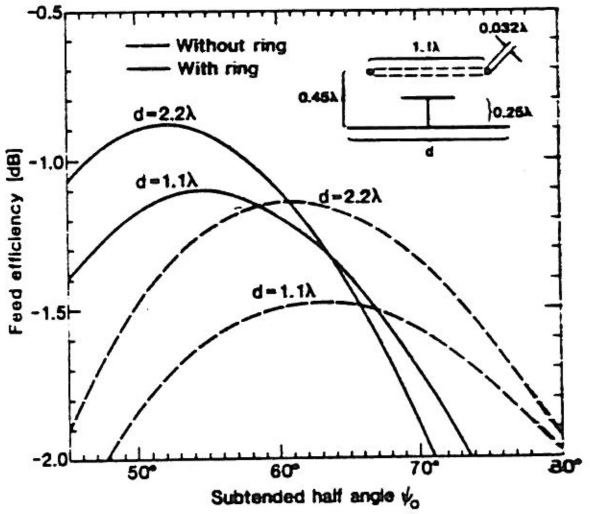


Fig. 2. Feed efficiency of dipole-disk with ring as function of subtended half-angle Y0 of paraboloid.

3.39.4 Optimisation of Feed Pattern

The feed is a half wave dipole located about a quarter of a wavelength above a plane circular disk. A beam forming ring over the dipole is used to improve the radiation characteristics, as explained in [2]. The radiation pattern of the dipole disk antenna is in [2] calculated by using the uniform geometrical theory of diffraction [11] in an approximate way. These calculations are here improved by using the moment method computer program ROT2 [3]. The feed is modelled without taking the centre support line into consideration. The feed efficiency is evaluated from the calculated patterns by using (3–5). The results without and with the ring (for the optimum position of it) are shown in Figure 3–42. We see that higher efficiencies are available with the ring than without the ring, but the optimum subtended angle of the paraboloid is smaller. Furthermore, the level of the first cross-polar sidelobe in the feed pattern $XP(\theta)$ is strongly reduced by using the ring Figure 3–43. The radiation patterns themselves do not differ significantly from those given in [2], and are therefore not shown here. However, we may repeat that the main advantage with the ring is that the sidelobe outside $\theta=\psi_0$ is strongly reduced in the H-plane, thereby reducing the spillover lobes in the radiation pattern of the complete reflector antenna. It is important to reduce the diameter of the disk as much as possible in order to minimise loss due to centre blockage, see [6]. However, the feed efficiency decreases for small disk diameters.

Figure 3–43: Level of first cross-polar sidelobe

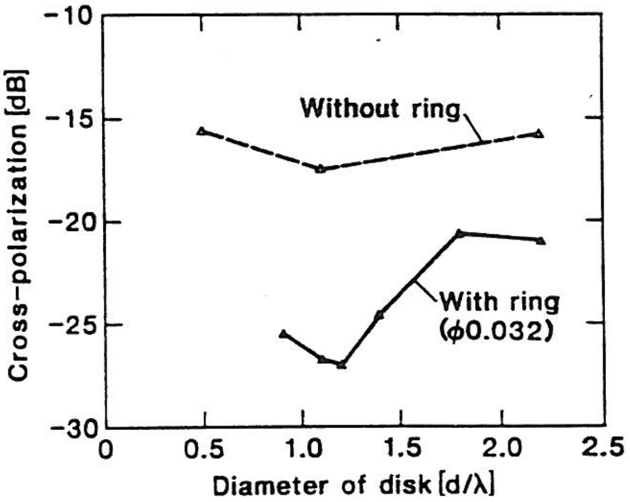


Fig. 3. Level of first cross-polar sidelobe in 45 deg. of radiation pattern of feed.

A disk diameter of $d = 1.1\lambda$ was found to be a good compromise, for which the cross polarisation in Figure 3–43 also has a minimum. The phase centre of the feed is calculated by the method of [5] and [6]. The results are plotted in Figure 3–44. We see that the phase centre varies rapidly with the diameter of the disk. For $d = 1.1\lambda$ it is located 0.25λ above the disk, in the position of the dipole. We are interested in having a good compromise between low sidelobes and high efficiency. Therefore, a subtended angle of $\psi_0=60°$ is chosen for the further optimizations in Section 3.39.6, even though the maximum feed efficiency occurs for $\psi_0=53°$ (Figure 3–42). The different subfactors of the feed efficiency for this ψ_0 is shown in Figure 3–45. We see that the spillover loss is reduced by nearly 0.5 dB by using the ring.

Figure 3–44: Location of co-polar phase centre

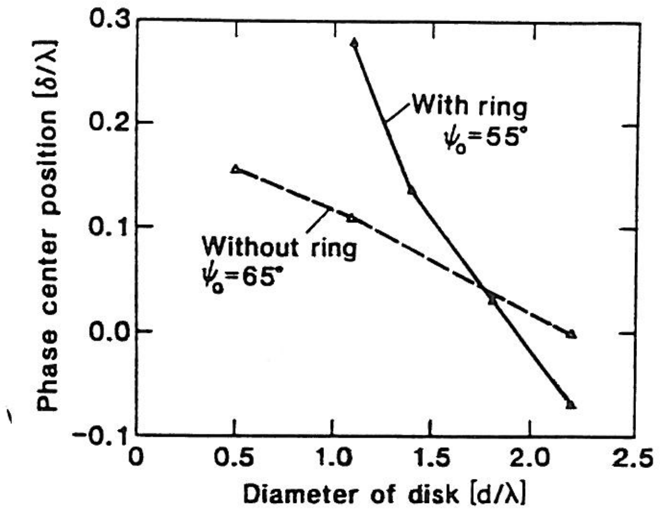


Fig. 4. Location of copolar phase center of radiation pattern of disk and g is positiv on the dipole side of the disk.

Figure 3–45: Subfactors of feed efficiency with and without ring

TABLE I
SUBFACTORS OF FEED EFFICIENCY FOR DIPOLE-DISK ANTENNA WITH AND WITHOUT RING ($d = 1.1\ \lambda$, $\psi_0 = 60°$)

	without ring	with ring
Spillover η_{sp}	- 0.89 dB	- 0.43 dB
Polarization η_{pol}	- 0.08 dB	- 0.02 dB
Illumination η_{ill}	- 0.52 dB	- 0.73 dB
Phase η_{e}	- 0.00 dB	- 0.00 dB
Feed efficiency $\eta_f=\eta_{sp}\eta_{pol}\eta_{ill}\eta_e$	- 1.49 dB	- 1.18 dB

3.39.5 Optimisation of Feed Location

In this section the directive gain of the complete antenna with the paraboloidal reflector and feed is calculated by the ROT2 program. The centre support for the feed is not modelled in the calculations. The calculations are repeated for different reflector sizes, but always with the feed located in such a way that its phase centre coincides with the focal point of the paraboloid. This means that the spacing Z_0 between the apex of the paraboloid and the disk is $Z_0 = F + 0.25\lambda$, where F is the focal length of the paraboloid. ψ_0=60° is constant in all calculations. The aperture efficiency of the reflector is evaluated from the calculated directivity. This is presented in Figure 3–46 as a function of the disk reflector spacing Z_0. For comparison we have also plotted the feed efficiency η_f in (3–5), the feed efficiency plus the centre blockage loss (i.e., (3–4) with $\Delta_{fs} = \Delta_l = 0$ and Δ_{cb} given by (3–6)), and the previous one which included also the backlobe interference represented by Δ_l in (3–8).

We see that the efficiency as calculated by using the moment method on the complete antenna has resonant peaks each time Z_0 is a multiple number of half wavelengths. We also see that these resonances cannot be explained by the backlobe interference alone. They must therefore be caused by multiple reflections between the feed and the reflector, i.e. the term Δ_{fs}, in (3–4). The loss due to centre blockage is very high for reflector diameters between 4λ and 5λ, (corresponding to Z_0 between 2λ and 2.5λ in our case). However this loss is seen to be almost entirely compensated for by the gain due to the reflector resonances within a narrow frequency band around the resonance peak at $Z_0 = 2.1\lambda$. We can associate this peak with a resonant reflector antenna, as the high efficiency is obtained both from the focussing properties of the reflector and from the feed reflector resonances. The efficiency peak occurring at $Z_0 = 1.6\lambda$ is almost entirely a resonance phenomenon, making the antenna very similar to a backfire antenna.

3.39.6 A Practical Design

This section describes a resonant reflector antenna designed to satisfy the requirements for INMARSAT ship earth stations. For this application there are two slightly separated frequency bands with centre frequencies 1.54 GHz and 1.64 GHz and with bandwidths of about 10 MHz. The total relative bandwidth from 1.535 to 1.645 GHz is about 7 percent, which is sufficiently narrow to fit within the -0.3 dB points of the resonance peak at $Z_0 = 2.1\lambda$ in Figure 3–46. It was chosen to move the 1.64 GHz frequency band slightly closer to the peak than the 1.54 GHz band, in order to optimise the performance at 1.64 GHz.

The antenna is designed from the results of the numerical optimisation. In addition, the reflector diameter is increased slightly from 4.3λ to 5.5λ at 1.64 GHz, without changing the feed reflector spacing zo, in order to increase the directivity from 21.1 dBi to 22.8 dBi at 1.64 GHz. This is advantageous for the INMARSAT application even though the computed aperture efficiency decreases from -1.5 dB to -1.8 dB at 1.64 GHz. When $Z_0 = 2.1\lambda$ and $D = 5.5\lambda$ we get ψ_0=73° for the subtended half-angle of the paraboloidal reflector. This value of ψ_0 gives a feed efficiency of -1.95 dB, according to the results in Figure 3–42. The centre blockage efficiency $|1 + \Delta_{cb}|^2$ when evaluated from (3–6) and (3–7) becomes -0.95 dB. This loss is larger than the 0.7 blockage loss seen in Figure 3–46 for $D = 5.5\lambda$ and ψ_0=60°. The reason is that the blockage parameter Cb is larger when ψ_0=73°, due to the larger aperture taper. Feed efficiency and blockage give together an efficiency of -2.9 dB for ψ_0=73° and $D = 5.5\lambda$. The overall efficiency computed by the moment method is -1.8 dB. Therefore, the gain from the feed reflector resonances is in this case with an increased reflector about 1.1 dB, which is slightly more than for the smaller 4.3λ reflector. We see from Figure 3–46 that with the larger reflector diameter it is possible to use the resonance peak at $Z_0 = 2.6\lambda$ to get nearly the same overall antenna efficiency, but $Z_0 = 2.1\lambda$ is better in our case because the axial length of the antenna becomes smaller and thereby makes it possible to enclose the antenna in a smaller radome.

Figure 3–46: Aperture efficiencies by different methods

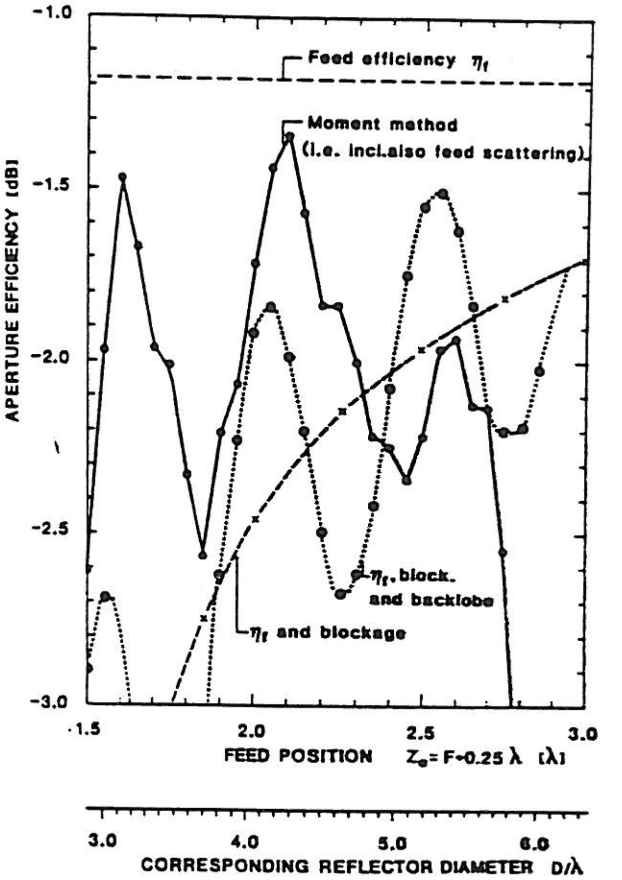


Fig. 5. Aperture efficiencies of reflector antenna calculated by different methods for Y0 = 60 deg.

Figure 3–47: Co- and cross-polar radiation patterns

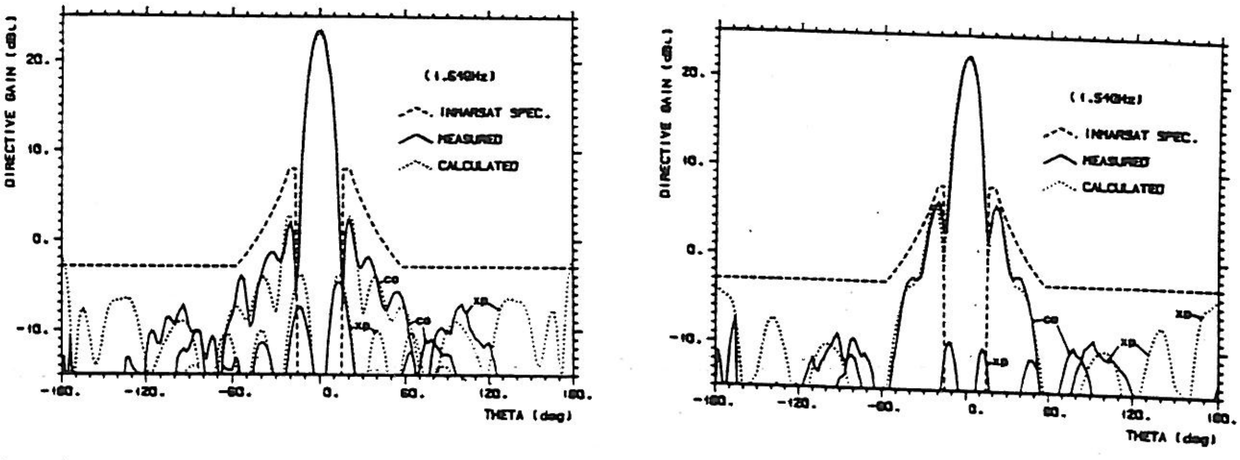


Fig. 6. Co- and cross-polar radiation patterns in 45 deg. plane of resonant reflector antenna. A. 1.64 Ghz. B. 1.54 Ghz.

A linearly polarised model has been built, with the dipole fed through a conventional balun located inside the centre support tube. The ring is supported by four dielectric rods to the disk. The measured copolar and cross-polar radiation patterns in the 45° plane are shown in Figure 3–47. The agreement with the computed patterns is very good within the mainlobe and the first sidelobes, in spite of the fact that the centre support tube is not included in the calculations. The agreement is not so good for the backlobes, mainly due to the limited accuracy of the computer program ROT2. We also see that the measured sidelobe levels are well below INMARSAT's specifications. In addition, the cross-polar are less than -27 dB below the main beam maximum, which is quite good for such a small antenna with a dipole feed. A circular polarised model has been built by using two orthogonal feed dipoles. These dipoles are fed in quadrature by a 3 dB power divider and a 90° delay line, both located within the centre support tube. The overall performance of the circular polarised model is also very high. The voltage standing wave ratio of the dipoles have been tuned by conventional techniques to be less than 1.35 dB at 1.54 GHz and less than 1.20 at 1.64 GHz The results as measured directly on the dipoles, with the power divider disconnected, is shown in Figure 3–48. The axial ratio is typically 0.4 dB in both bands. The power gain of the antenna was measured. A breakdown of the different losses is shown in Figure 3–49, showing aperture efficiencies at 1.54 GHz and 1.64 GHz of 63 and 66 percent, respectively. These values differ less than 0.2 dB from the results computed with the moment method program. The measurement accuracy is estimated to about ± 0.2 dB. The efficiencies would have been even higher with a smaller reflector diameter, as the maximum efficiency occurs for a diameter of $D = 4.3\lambda$

Figure 3–48: **Input VSWR of the dipoles**

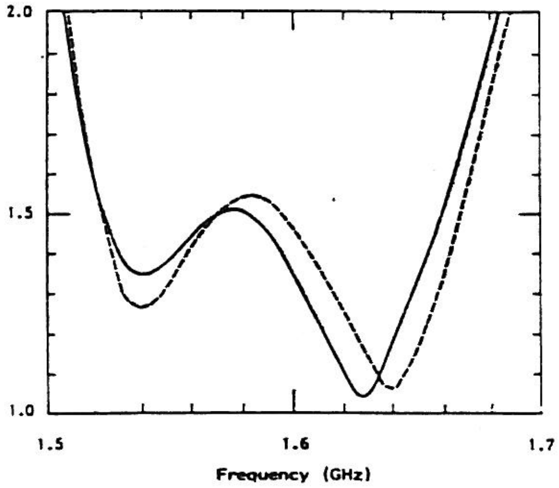


Fig. 7. Input VSWR on each of the two orthonogal dipoles in the resonant reflector antenna.

Figure 3-49: Practical results

TABLE II
MEASURED GAINS AND MEASURED LOSSES OF PRACTICAL CIRCULARLY POLARIZED DESIGN

	1.54 GHz	1.64 GHz
Measured power gain	21.59 dBi	22.37 dBi
Insertion loss, power divider	0.16 dB	0.21 dB
Insertion loss, dipoles	0.10 dB	0.02 dB
Axial ratio loss	0.00 dB	0.00 dB
Insertion loss in cable	0.30 dB	0.30 dB
Resulting directivity	22.15 dBi	22.90 dBi
Corresponding aperture efficiency	- 2.0 dB 63%	- 1.8 dB 66%
Computed directivity	22.1 dBi	22.8 dBi

3.39.7 Conclusion

A resonant reflector antenna has been described. This consists of a dipole disk feed and a paraboloidal reflector with a diameter of about 4 to 6 wavelengths. The spillover sidelobes have been reduced by using a patented ring over the dipole [12]. The spacing between the feed and the reflector has been controlled in order to take advantage of the backlobe of the feed and of the multiple reflections between the feed and the reflector. The gain from these feed reflector resonances is so large that it compensates almost completely for the about 1 dB loss due to centre blockage of the aperture. Aperture efficiencies above 70 percent are available within a relative frequency band of approximately 5 percent. The resonant reflector antenna shows also very good sidelobe and crosspolarisation performance. The far-out sidelobes are more than 30 dB below the main beam maximum, and the first cross-polar sidelobe is more than 27 dB below the main beam maximum.

This paper has shown that it is possible to design small reflector antennas with much higher efficiency then should be expected from conventional design rules. This has been shown by a thorough and systematic computer aided step-by-step optimisation, based on simple analytical models of how reflector antennas work.

3.39.8 Acknowledgement

The author acknowledges the collaboration with the engineers at A/S Elektrisk Bureau during the development of the resonant reflector antenna for their INMARSAT ship earth station SATURN. I am grateful to Erling Ellingsen for doing the measurements on the antenna models and for designing the power divider. Furthermore, I am grateful to the Norwegian Council for Scientific and Industrial Research (NTNF) for providing the basic financial support for the development of the reflector antenna field at the Electronics Research Laboratory (ELAB) at the Norwegian Institute of Technology (NTH).

3.39.9 References

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3.40 Circular Loop Dish Feed For 432 MHz

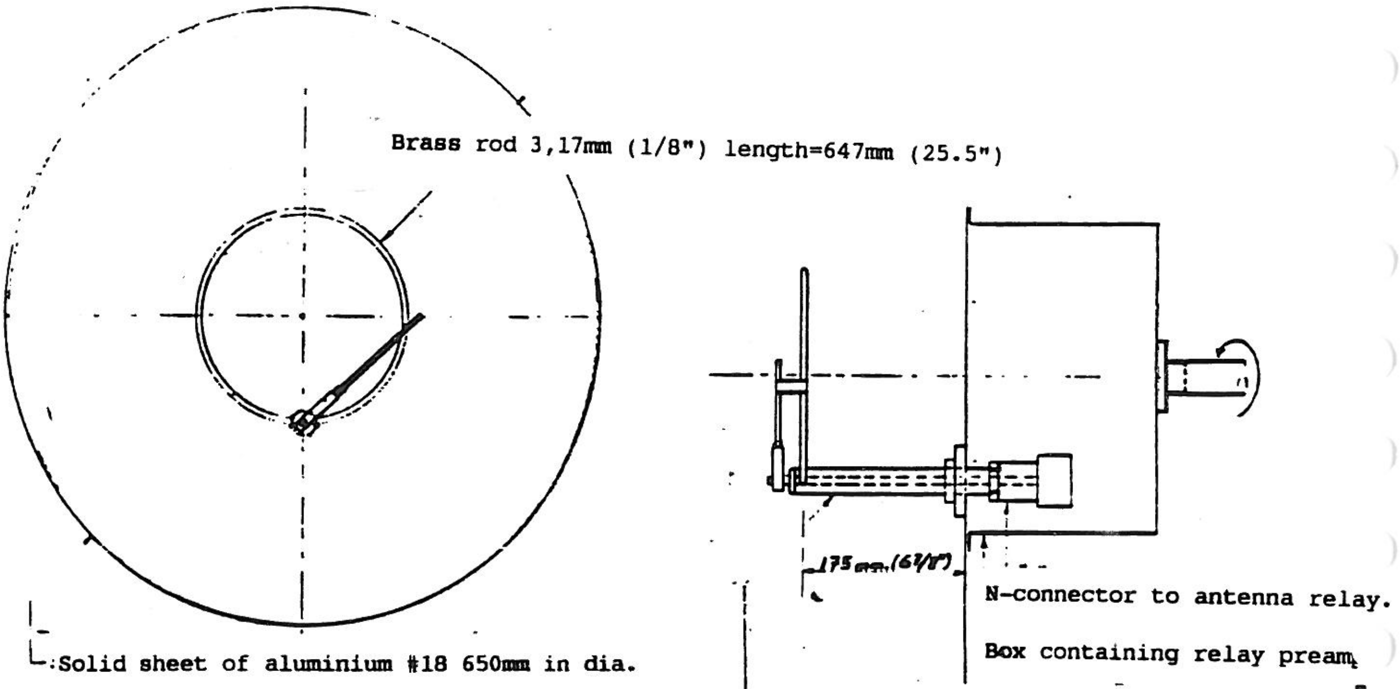
Max Bianchi XE1XA - September 1986

Resonant one wavelength round loop, spaced one quarter wavelength from a one wavelength in diameter solid round reflector.

3.40.1 Characteristics

Lightweight, easy to construct. SWR can be adjusted with the gamma match to virtually 1:1 over a wide bandwidth to cover EME and satellites mode L and B. Beamwidth has been measured: 58° at -3 dB and 112° at -10 dB on both E and H plane, thus making it suitable for feeding a dish with f/D = 0.45. Polarisation is easy to rotate since the circular reflector has less turning radius than the square one used on the dual dipole feed. Thus making it easier to clear the supports. On my dish (5m, f/D = 0.45) this feed will match or out perform the dual dipole feed and others I tested both in Sunnoise and Cold Sky to ground ratio. Antenna noise temperature with this feed has been measured with hot/cold method to be less than 53°K at 432 MHz. Do not reduce the reflector diameter: It will reduce the G/T ratio of the system.

Figure 3–50: 432MHz Circular Loop Dish Feed



Brass rod 3,17mm (1/8") length=647mm (25.5")

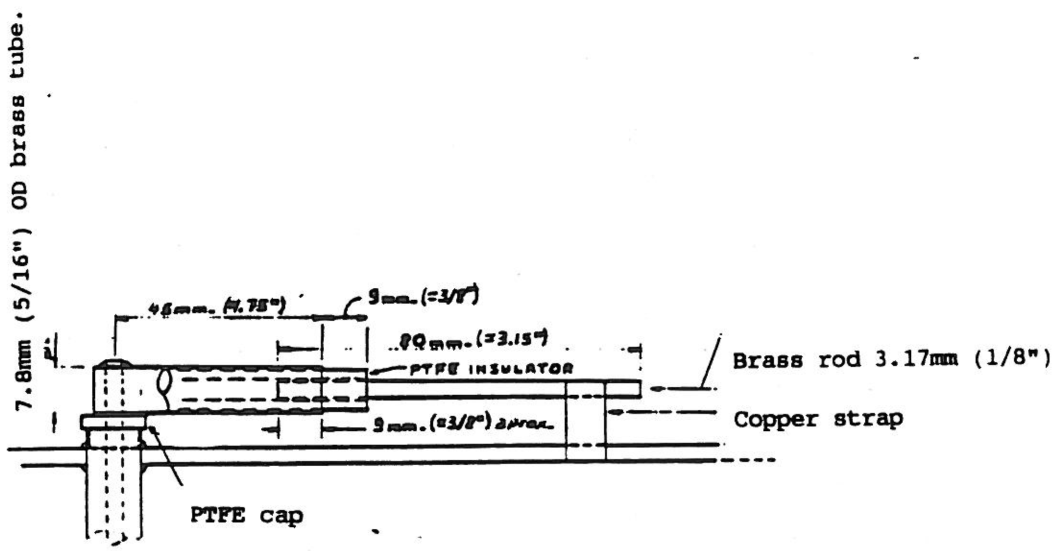
Solid sheet of aluminium #18 650mm in dia.

N–connector to antenna relay.

Box containing relay pream.

Coax air dielectric line 50 Ohms inner conductor 4.7mm (3/16") OD copper, outer conductor 12.7mm (1/2") OD brass tube, thin wall.

Figure 3–51: Gamma Match 432 MHz Circular Dish Feed



Brass rod 3.17mm (1/8")

Copper strap

PTFE cap

Gamma match detail. The matching point is found close to 1/4 of the loop circumference. Adjust with low power to best SWR. Than solder the shorting strap.

3.41 W1EJ/K1FO 24' 432 MHz Yagi

Steve Powlishen K1FO - October 1986

Gain of this Yagi is 18.0 dBd at 434 MHz. The VSWR is 1:1.18 at 432.12 MHz. The dimensions given are for 3/16" elements which are insulated mounted through a round boom. All dimensions in Table 3–7 are in inches. Use the boom support as per 32 element Yagi. Reflector up to director 9 and director 26 up to director 31 are passing through a 1" round boom. Director 10 up to director 15 and director 21 up to director 25 are passing through a 1 1/8" round boom. Director 16 up to director 21 are passing through a 1 1/4" round boom.

Table 3–7: Sizes W1EJ/K1FO 24' 432 MHz Yagi

El.	X-Pos	Length	El.	X-Pos	Length	El.	X-Pos	Length
Ref	0	13.6875	D10	64.625	11.46875	D21	177.9375	11.0625
DE	4.09375	13.3750	D11	73.9375	11.40625	D22	188.9025	11.03125
D1	5.75	12.75	D12	83.53125	11.34375	D23	199.9375	11.0
D2	8.8125	12.3125	D13	93.4375	11.3125	D24	211.03125	10.96875
D3	13.0625	12.125	D14	103.5	11.28125	D25	222.125	10.96875
D4	18.375	11.9375	D15	113.75	11.21875	D26	233.25	10.9375
D5	24.5	11.8125	D16	124.1875	11.21875	D27	244.4375	10.90625
D6	31.4375	11.6875	D17	134.75	11.1875	D28	255.625	10.875
D7	38.9375	11.625	D18	145.375	11.1875	D29	266.875	10.84375
D8	47.0625	11.5625	D19	156.1875	11.125	D30	278.125	10.84375
D9	55.6875	11.5	D20	167.0	11.09375	D31	289.375	10.8125

Figure 3–52: W1EJ/K1FO 24' 432 MHz Yagi driven element

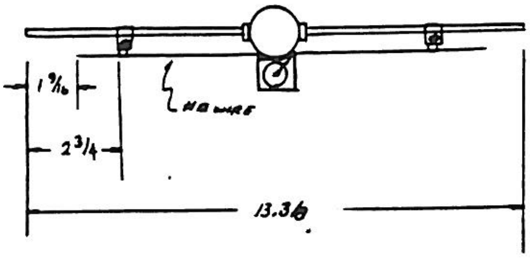
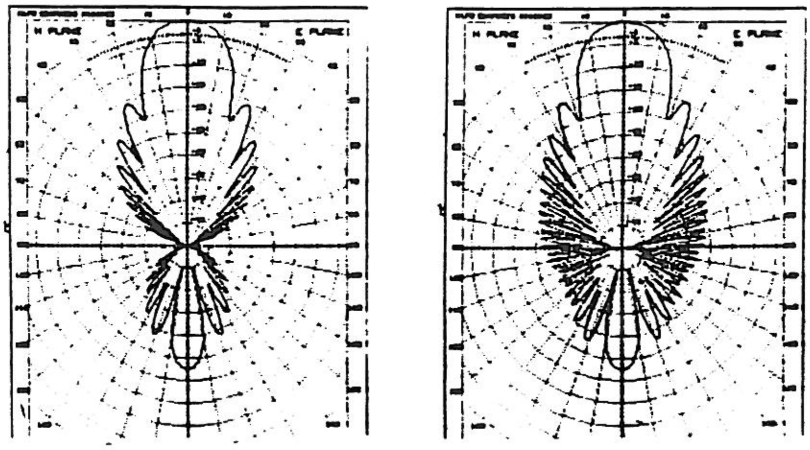


Figure 3–53: W1EJ/K1FO 24' 432 MHz Yagi performance



3.42 Antenna Polarisation Controller

Yoshiro Mataka JA4BLC - November 1986

The polarisation controller shown in Figure 3–54 is designed to work with KENPRO KR500 rotators, but it should be easy adaptable for other rotators. This controller allows polarisation angle to be set independently for transmit and receive while it automatically resets the polarisation to the appropriate positions.

3.43 Elevation Drive System

Scott Mathewson WA3FFC - December 1986

This elevation drive is using a 4:1 gear reduction and gives therefore 4 times the accuracy on the readout 2.5° with the normal control box. The strength is as strong as you build the bearings and plate, but I am certain that it is stronger than most commercial systems available today. If the torque is a problem, just gang more rotators. See Figure 3–55 for construction details.

Figure 3–54: JA4BLC Polarisation Controller

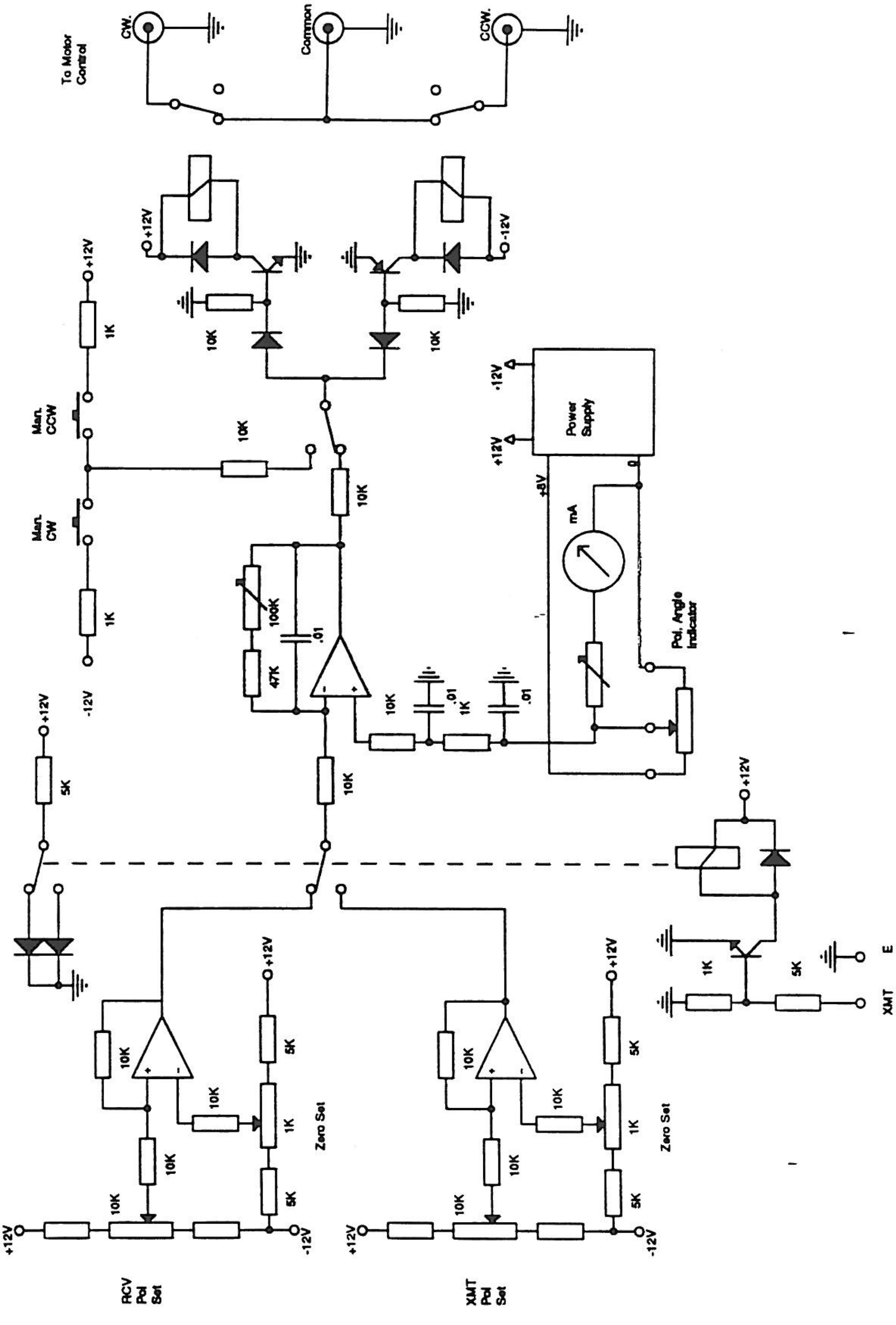
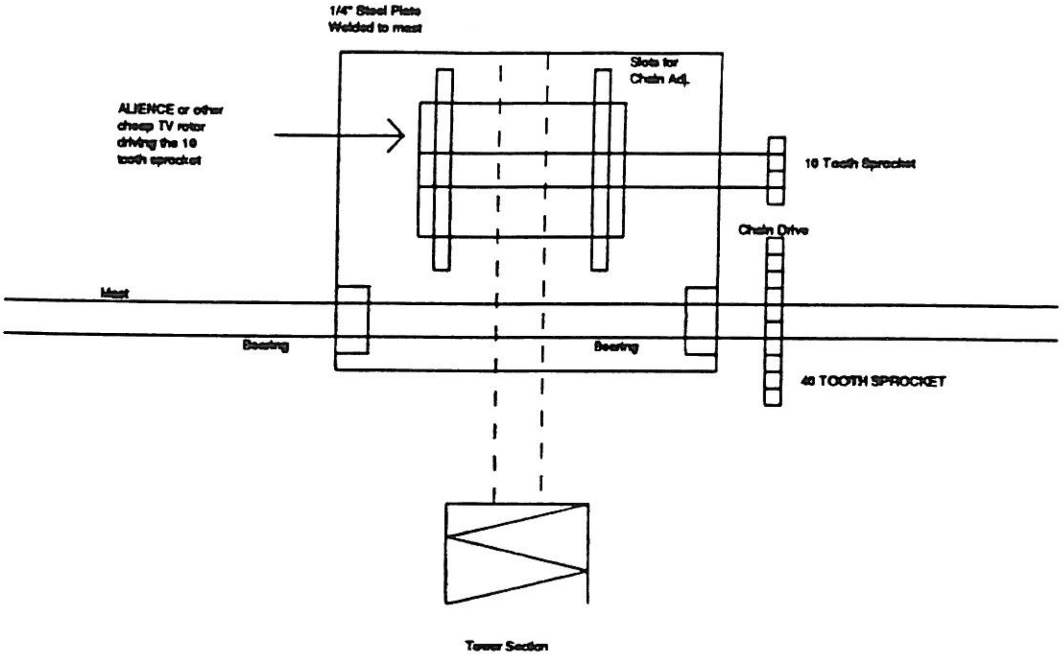


Figure 3–55: WA3FFC Elevation Drive



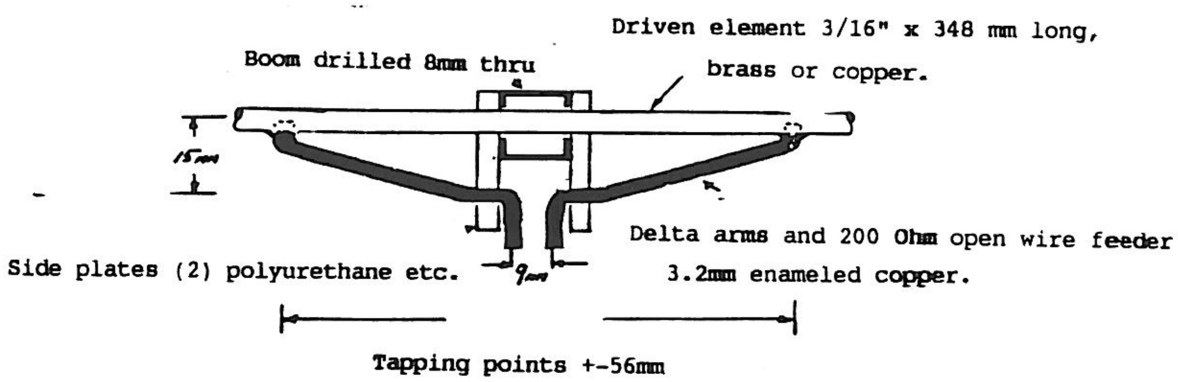
3.44 Delta Match and Open-Wire Feed For 21 El. Tonna Yagis

Ian White G3SEK - January 1987

3.44.1 Delta match

Figure 3–56 shows the dimension of a 200 ohm delta match for 21 El. Tonnas. This modification applies only to the older version without a sleeve balun. The folded driven element is replaced by a single rod passing through the boom on insulating side plates. Elements length and tapping point must be accurate for a good 200 ohm match, but the exact shape of the delta section is not important. Gain with the new driven element is as least as good as before. On a crude test range, I actually measured a small but consistent improvement in gain.

Figure 3–56: Delta Match



If you are converting more than one antenna, it is worth the time to make a few simple jigs. A few nails in a board will help you bend all the half-delta sections to the same shape. To drill pilot holes in the boom, make a jig with a pin to locate the existing dipole fixing hole as shown in Figure 3–57. The same jig can be used to pilot drill the plastic side pieces.

3.44.2 Open wire feed system

The open wire feed system follows DL9KR's recommendations. Make the feeder from thick hard-drawn enamelled wire so that it is semi rigid. Use only straight runs, with a minimum number of PTFE spacers. Joints can be made using small pieces of brass tube. T-joints must be at right angles. To get straight, stiff pieces of wire, it is best to buy soft copper and hard draw it yourself. Long term weather resistance can be a problem with some kinds of enamelled wire, while others are perfectly OK. N4GJV's is still OK after 3 years, and my first set lasted over 2 years. Polyurethane "self fluxing" enamel has very poor resistance to sunlight and weather, though it's good as an Aerosol spray for protecting solder joints because you can solder through it to make repairs.

With 3.2 mm wire at 9mm spacing, the impedance is close to 200 ohm, so any length can be used to join two vertically stacked antennas. Groups of 2 Yagis are joined by full wave horizontal sections of line, giving a feed impedance of 50 ohm (balanced) for each group of 4 Yagis, as shown in Figure 3–58. The 2

Figure 3–57: Jig for drilling boom and side plates

Fig. 2 Jig for drilling boom and side plates.

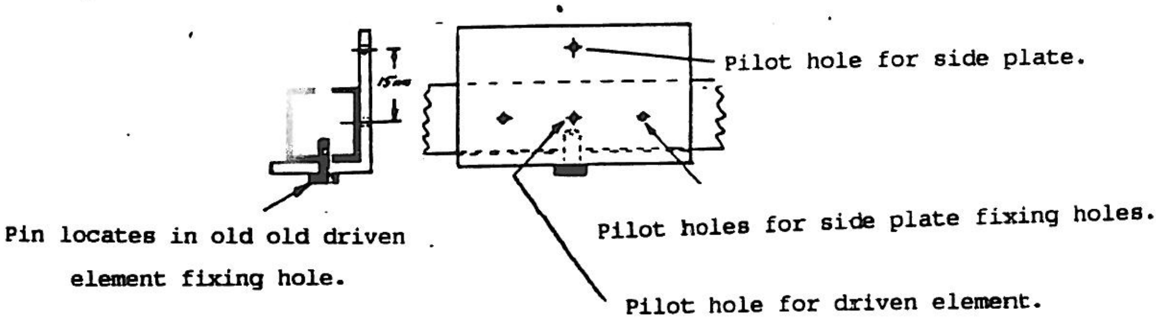
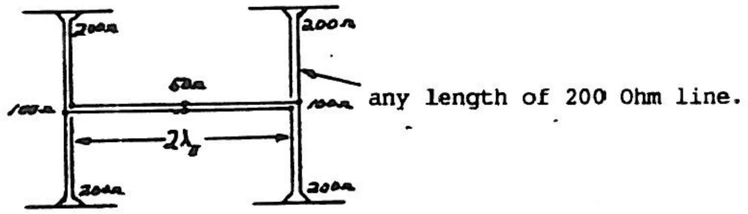


Figure 3–58: Open Wire Array Matching

Fig. 3 Array matching



halves of the array are joined by 1/2 " Heliax, with sleeve baluns. No 50 ohm matching adjustments were required in my system (VSWR < 1.2:1), though I did optimise the Preamp in position at the antenna.

For success with open wire feeder at UHF, follow all of DL9KR's recommendations, plus one more: keep the VSWR low! If you try to use open wire at high VSWR , you create very high impedances at some points along the feeder, and these will be vulnerable to raindrops etc. collecting and changing the VSWR. The VSWR on my system is mostly 1:1 and is nowhere greater than 2:1 , so even when the open wire is dripping wet the VSWR hardly changes. My all coax system had 21 places where water could get in, and I could never be sure it was dry inside. With open wire, completely exposed to the weather, I know where the water is and it is no problem!

3.45 K1FO 22 El. 432 MHz Yagi

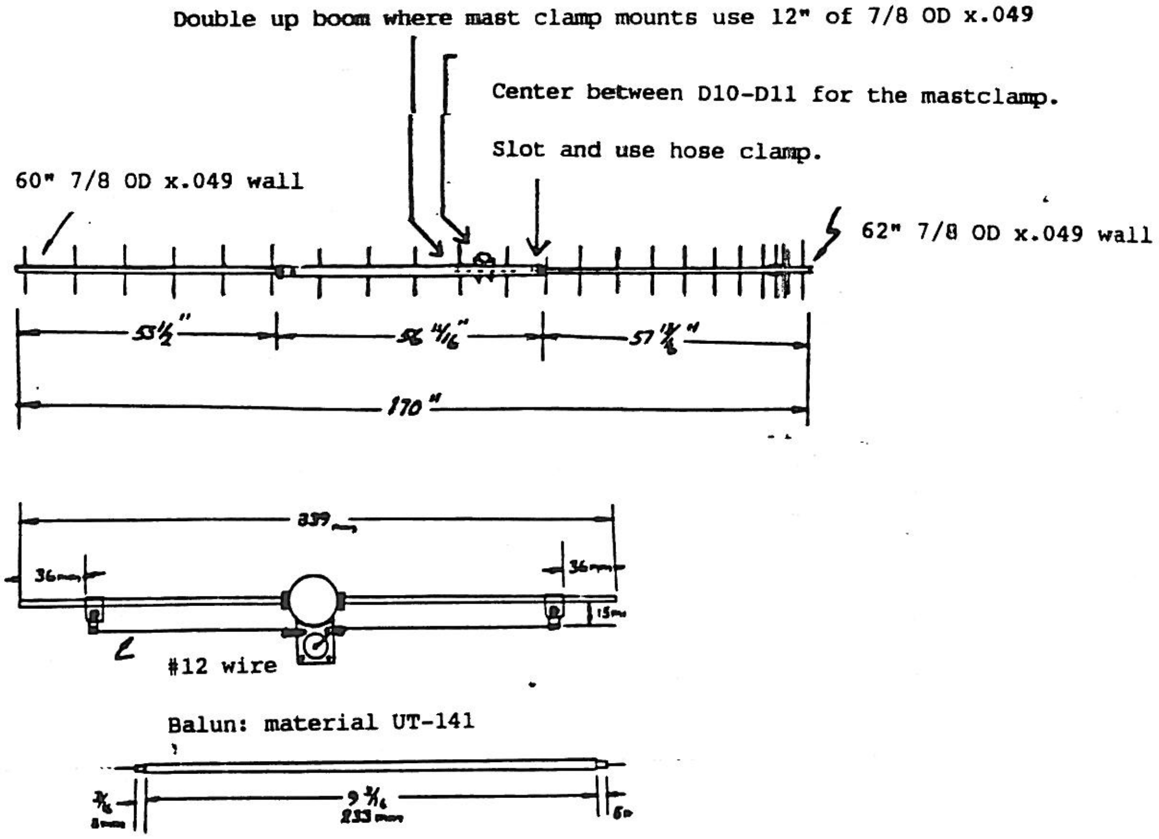
Steve Powlishen K1FO - February 1987

The gain of this Yagi at 432 MHz is 15.7 dB or +0.8 dB over the RIW19 Yagi. It measured +1.0 dB over the RIW19 Yagi at the NEVHF Conference in 1986. The design is based upon a computer generated geometry by W1EJ. All dimensions in Table 3–8 are millimetres. The VSWR at 432.110 is 1.13:1 Dry and 1.55:1 Wet. The E-Plane -3 dB is at 23°, and the H-Plane -3 dB is at 24°. For use of this Yagi at 439 MHz all elements should be shortened by 5 mm.

Table 3–8: Sizes K1FO 22 El. 432 MHz Yagi

El.	X-Pos	Length	Boom	El.	X-Pos	Length	Boom
REF	30	346	I	D10	1672	288	I I I
DE	134	339	I	D11	1909	286	I I I
D1	176	322	I	D12	2152	285	I I I
D2	254	311	I	D13	2403	284	I I I
D3	362	305	I	D14	2659	283	I I I
D4	496	301	I	D15	2920	281	I
D5	652	297	I	D16	3184	280	I
D6	828	295	I	D17	3452	279	I
D7	1020	293	I	D18	3723	278	I
D8	1226	291	I	D19	3997	277	I
D9	1444	289	I	D20	4272	276	I

Figure 3–59: K1FO 22 El. Yagi construction



Double up boom where mast clamp mounts use 12" of 7/8 OD x.049

Center between D10-D11 for the mastclamp.

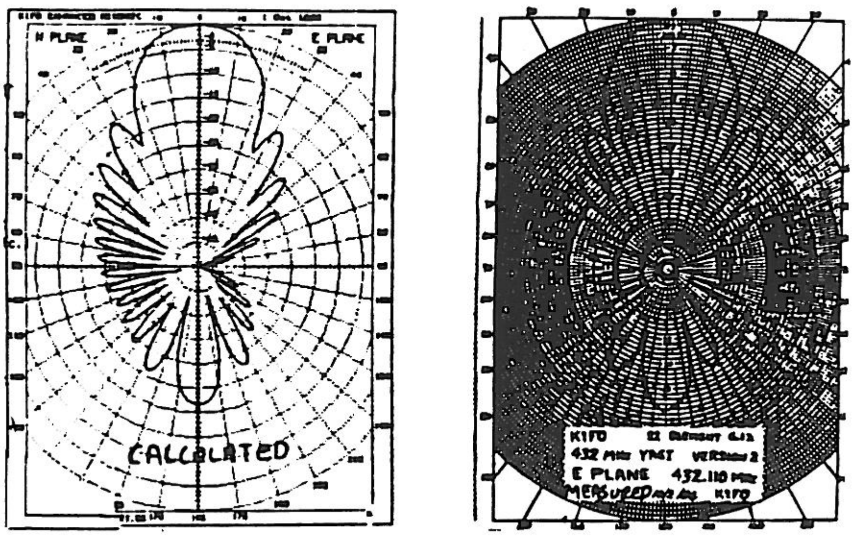
Slot and use hose clamp.

60" 7/8 OD x.049 wall

62" 7/8 OD x.049 wall

Balun: material UT-141

Figure 3–60: K1FO 22 El. Yagi performance



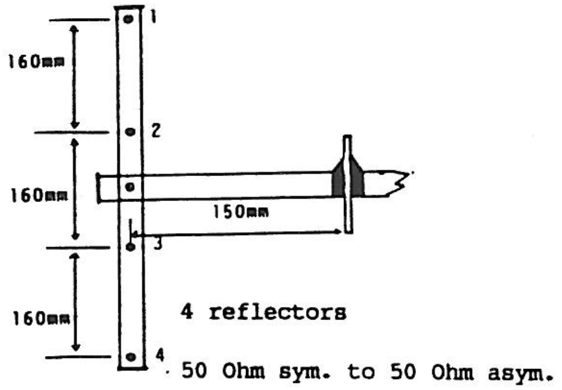
3.46 Modified 21 El. F9FT Yagis

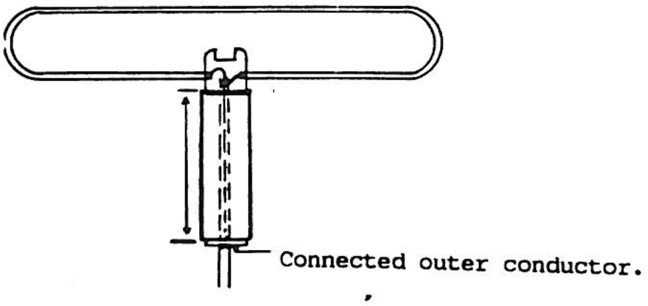
Heinz Januscheit DK1PZ - April 1987

Here is a modification for 21 element F9FT's used by DK1PZ and some others. PA3DZL uses 8 of these Yagis. The reflector elements are made of 4mm diameter solid aluminium and are 360mm long. The distance between the dipole and the reflector is not critical for the SWR. The coax is soldered to the dipole and NOT connected to the tube.

Figure 3–61: 21 El. F9FT Modifications

The reflectors are 360mm long.



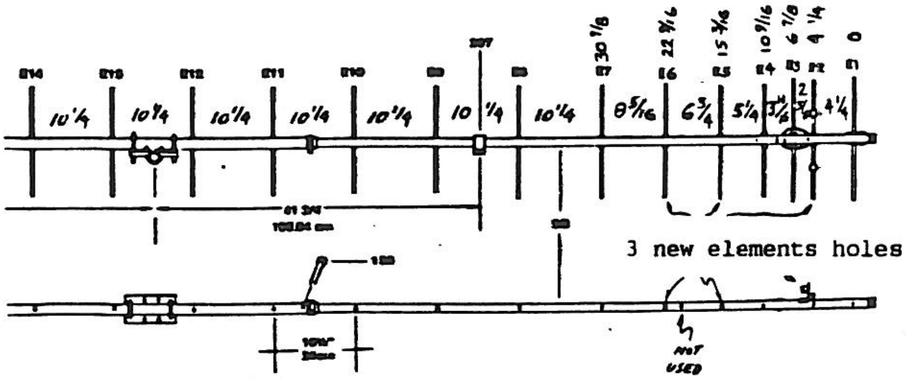


3.47 Modifications to the CC424B

Steve Powlishen K1FO - April 1987

Gain with these modifications: 16.4 dBd at 432 MHz which is 0.5 dB more than the stock 424B. VSWR is 1.13:1 with dry conditions and 1.9:1 with wet conditions. The sidelobes are -7 dB compared to the stock 424B. The balun must be shorted by 1.00". Do not use black rectangular spacer insulators. Chamfer all element ends approximately 1/32".

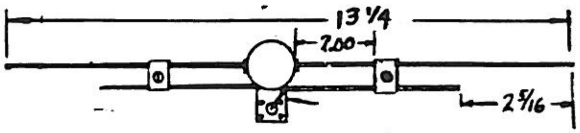
Figure 3–62: **Modified CC424B**



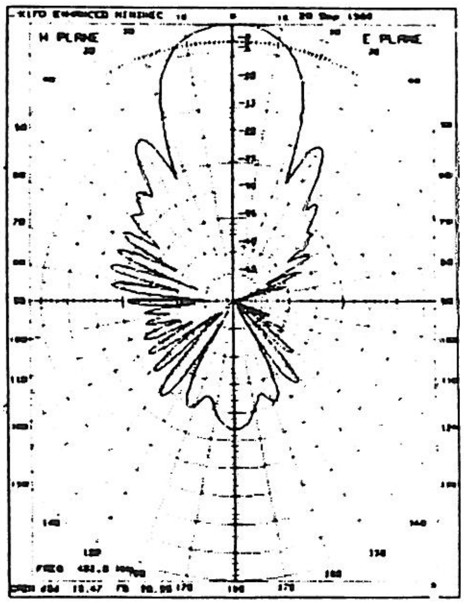
424B

Drill new hole for N-connector bracket. 2 5/8" to rear of original for balun clamp located as required.

Version D 424B-D2424
2 aditional reflectors (424B-24)



Important for proper match:
Replace #16 wire with #12 wire.



Gain 16.4 dbd at 432Mhz.
(+ 0.5 db. /stock 424B)

3.48 Scalar Horn Feeds for 23 & 13cm

Barry Malowanchuck VE4MA - August 1987

3.48.1 Construction

Two models were constructed, one for 23cm and another for 13cm. The 23cm unit uses a quadrature hybrid and orthogonal monopoles to generate circular polarisation. This approach is popular in Europe and described by OE9PMJ in a past Newsletter. The 23cm feed is shown in Figure 3–63. This unit is constructed out of sheet aluminium and is very light inspite of its size. The unit was fabricated of aluminium air duct material and used techniques familiar to sheet metal workers. The 7" diameter feedhorn was first constructed from a piece of 7" air duct. It was rerolled in a sheet metal shop inside out and the formed seam re-used and reinforced by rivets (with the heads inside). The horn was sealed at one end using a standard end-cap for 7" air duct. The 2 monopoles are made of #14 wire soldered to UG58a connectors. The resultant VSWR was much less than 1.2:1.

The 16.5" scalar ring was constructed again by a sheet metal shop. It was really built as an abrupt transition between 7" and 16.5" air duct. The unit was built so that the scalar ring could be telescoped along the 7" duct. Hose clamps provide enough pressure to secure the scalar ring and 7" cap to the waveguide. The transition from the 16.5" disk to the 7" sleeve and the 16.5" could be made with tabs bent over and riveted on the unit build, the 16.5" transition was produced by making a rolled edge. The open edge was folded back on itself for strength.

The 13cm model used a W2IMU type linear polarizer to generate circular polarisation. The waveguide was created out of 4" coffee cans to which #10-32 nuts were soldered for the polarizer. A notable feature on the end of the waveguide short is the nulling post. This is a variation of the post as described by W2IMU, in that the length of the post is made variable at a fixed location. The brass screw provided very good control of the nul between the left hand and right hand polarisation ports. A similar function is provided on the OE9PMJ 23cm coupler by the tuning screws midway the TX RX and the A B ports. Only these two tuning screws were found necessary as the isolation and balance between ports was excellent. The dimensions of the 13cm feedhorn are given in Figure 3–64.

The scalar ring was constructed using a piece of epoxy glass printed circuit board and a strip of tin plate soldered to it. A sliding joint for the 4" waveguide was created with another piece of tin which had tabs cut out and bent along one edge. This edge was soldered to the circuit board as well. A hose clamp provided sufficient pressure to hold it tight.

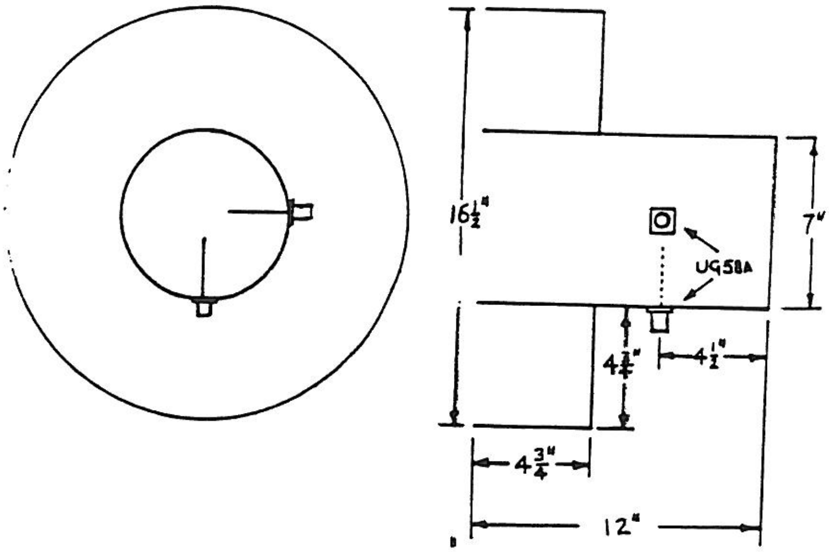
A word of caution to builders of the OE9PMJ coupler is required. You may find the 2mm thickness of the centre plate difficult to obtain. By using the impedance ratios, the width of the 35 ohm and 50 ohm sections can be modified to suit the thickness of the centre conductor material.

3.48.2 Feedhorn Test Results

The 23cm feedhorn was evaluated in front of a 2.6m (8.5 ft) dish with an f/D of 0.42. The 7" feedhorn without scalar ring provide an impressive 2 dB improvement in Sunnoise over a dual dipole feed, which like the W2IMU feed is optimum for f/D's of 0.5 to 0.6. When the scalar ring was added, a further 0.5 to 0.75 dB improvement was noted. The Sunnoise measured (May 1987) was 10.25 dB with the Cold Sky to horizon being 5.5 to 6 dB.

The 13cm feedhorn with an MGF1412 Preamp produces 9.75 dB of Sunnoise. No comparisons were made with other feeds on this dish, however some very revealing pattern measurements were done in the fall of 1986. Figure 5 shows the measured pattern along with that of a 4" feed without the scalar

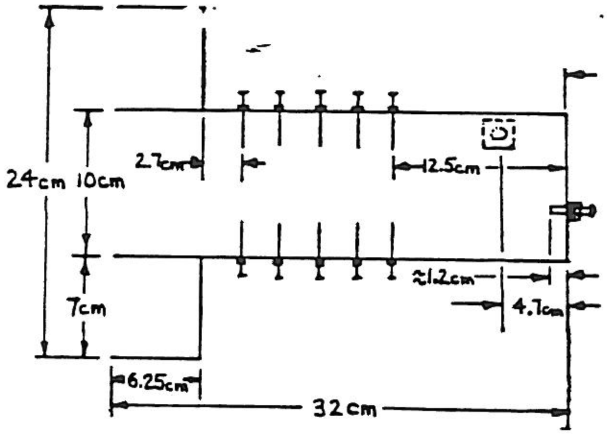
Figure 3–63: VE4MA 23cm Feedhorn



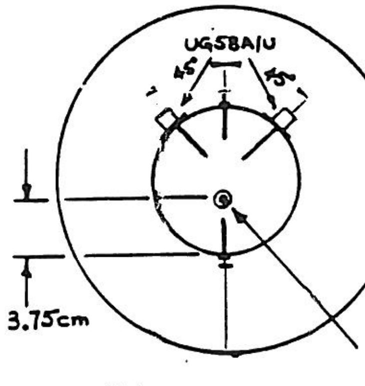
Probes are # 14 wire total length
of probe 2.4" Illumination optimum
for f/d 0.4 VSWR < 1.2:1

Figure 3–64: VE4MA 13cm Feedhorn

Screw spacing 2.7cm
Screws penetrate 2.4cm inside can.



#10-32 brass screws nuts soldered to can.



1/4" brass screw (nulling post)
nut soldered to can.

Probes are 3.15cm inside can(#14 wire)
VSWR measured 1.06 (30db return loss)
isolation approx. 30db.

ring. The ring has the affect of equalising the E and H plane patterns but also broadens out the main lobe. The main lobe puts more power out closer to the edge of the dish resulting in the illumination efficiency increase. If the number of scalar rings could be increased we could find that the pattern would improve even more, although the size would be prohibitive and in the case of small dishes (less than 10 wavelengths across), the blockage of the feedhorn would become excessive. The sidelobes of the dish would rise significantly and destroy the benefits of the new feed.

The feedhorn designs presented would appear to be optimum for an f/D of 0.4 which is very common for commercial and TVRO type dishes. Based on the beam width required for dishes with f/D's close to 0.3, it seems unlikely that any prime focus feedhorn will be able to provide efficient illumination. These reflectors should be avoided for amateur use unless its very large or the price is very reasonable.

3.49 Digital Antenna Readout System

Yoshiro Mataka JA4BLC - August 1987

Figure 3–65 shows Yoshiro's digital readout system in detail. The incremental rotary encoder (720 pulses/rev) and pulse multiplier discriminator give a 0.125° resolution. A 4 bit up/down counter (3 x 74LS193) counts a maximum of 4096 pulses. This 12 bit data is transformed to 4 digit BCD data by a 32 K ROM lookup table and from there it is transformed into latches and the LED angle display. A Z-pulse calibrates the system to a preset angle. Yoshiro is using 180° for this purpose. His dish's rest position is at 183° and he turns the dish 3-4° to the east each time the system is turned on to calibrate. This same arrangement may also be used for elevation. He suggests modifying the ROM lookup table to include negative angles. The whole unit should cost about $150,- including the rotary encoder. Yoshiro is working to interface this system to his personal computer for auto tracking.

3.50 Improving the KLM 432-30LBX

Steve Powlishen K1FO - September 1987

This modification is optimised for the 32 element version, but also usable for the 29, 30 and 31 element versions. Details of the mechanical changes of the driven element for the KLM 432-30LBX can be found in Figure 3–66.

3.51 Dual Dipole Feed for 432 MHz

Russ Miller N7ART - July 1988

Figure 3–67 shows the construction details of N7ART's Dual Dipole Feed for 432 MHz. It consists of a pair of dipoles mounted 6.5625 inch above a solid backplane reflector. The conversion from balanced to unbalanced is done by a bazooka, wherein a quarter-wave line section shorted at the solid backplane is formed by connecting an additional piece of tubing. Fine tuning of the VSWR is done by changing the length of the dipoles. The two dipoles are connected together by a Power Divider & Matching Transformer also shown in Figure 3–67.

Figure 3–65: JA4BLC Digital Readout System

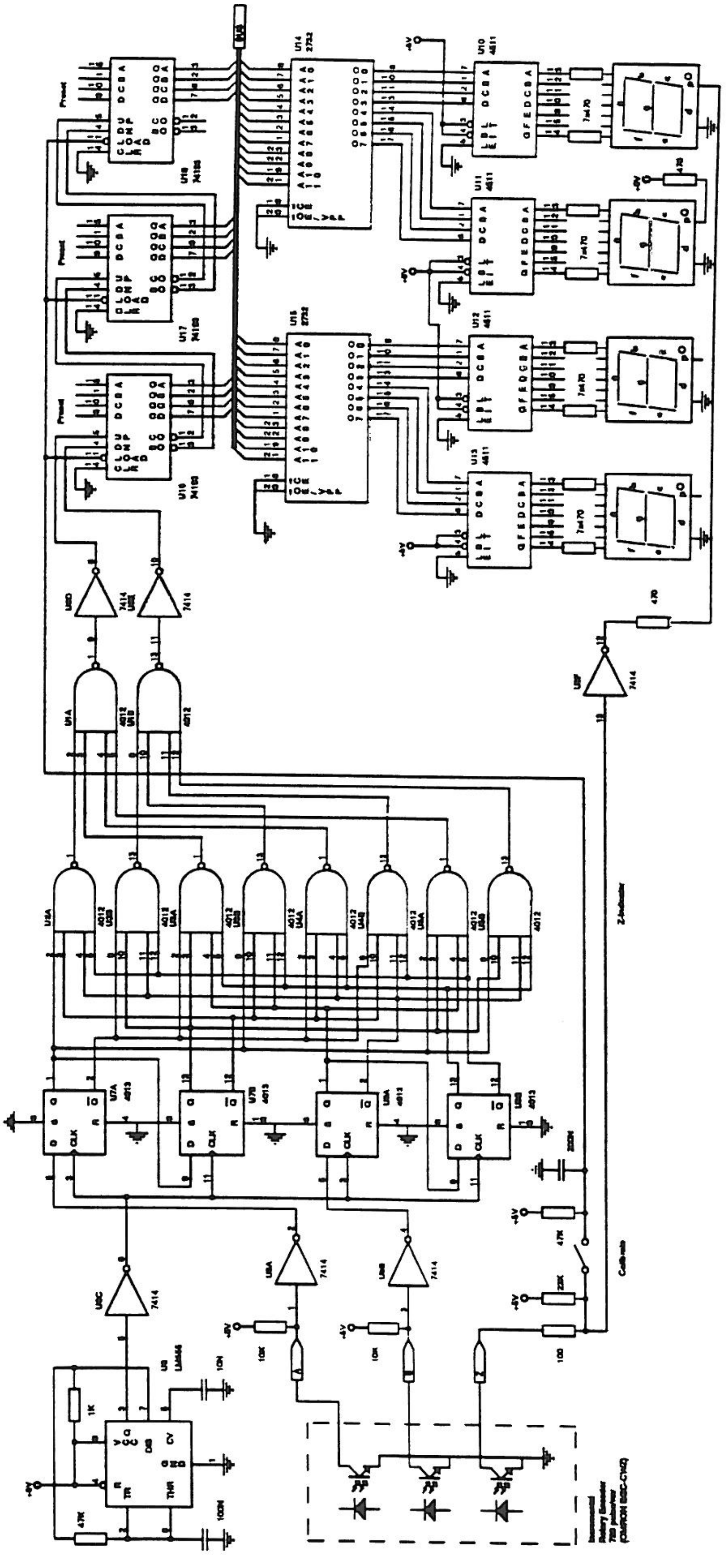
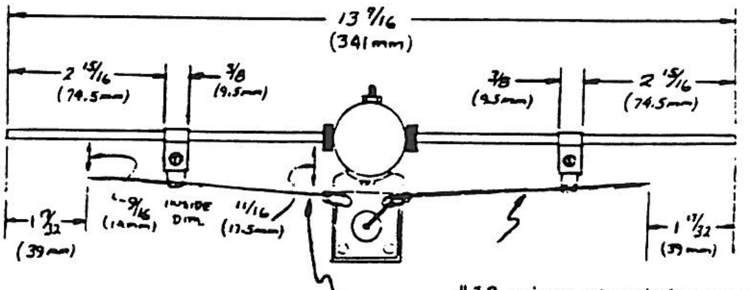


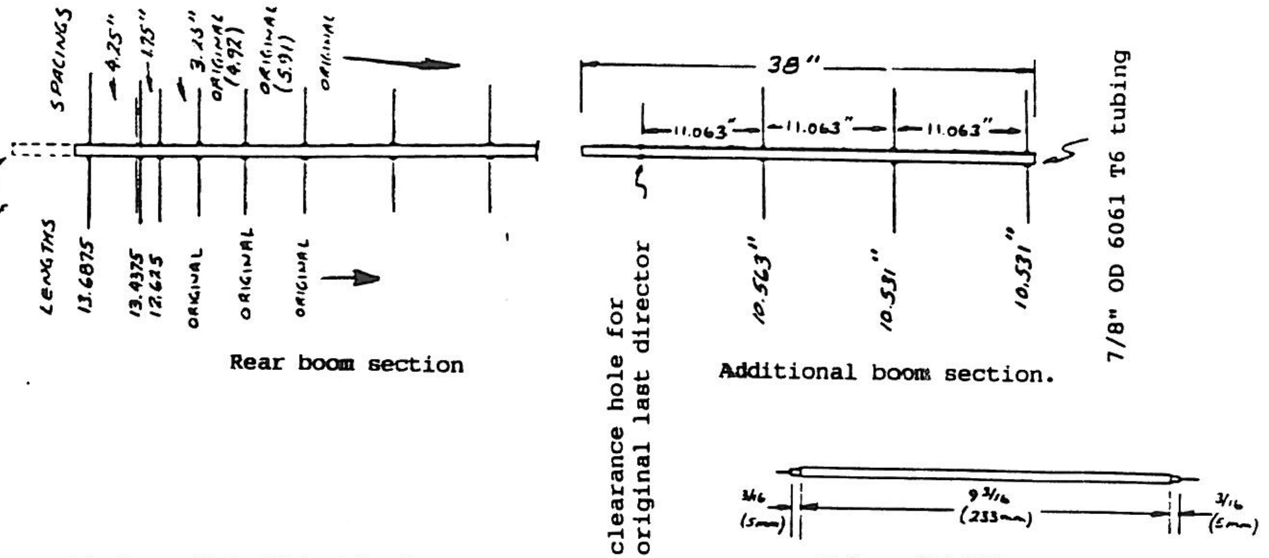
Figure 3–66: Modifications to the KLM 432-30LBX



#12 wire 4 13/16" long (122mm)

#12 wire straight portion 4 13/16" long (122mm) additional length connects to N connector center pin

Note: T-wires are not parallel to driven element.



Rear boom section

Additional boom section.

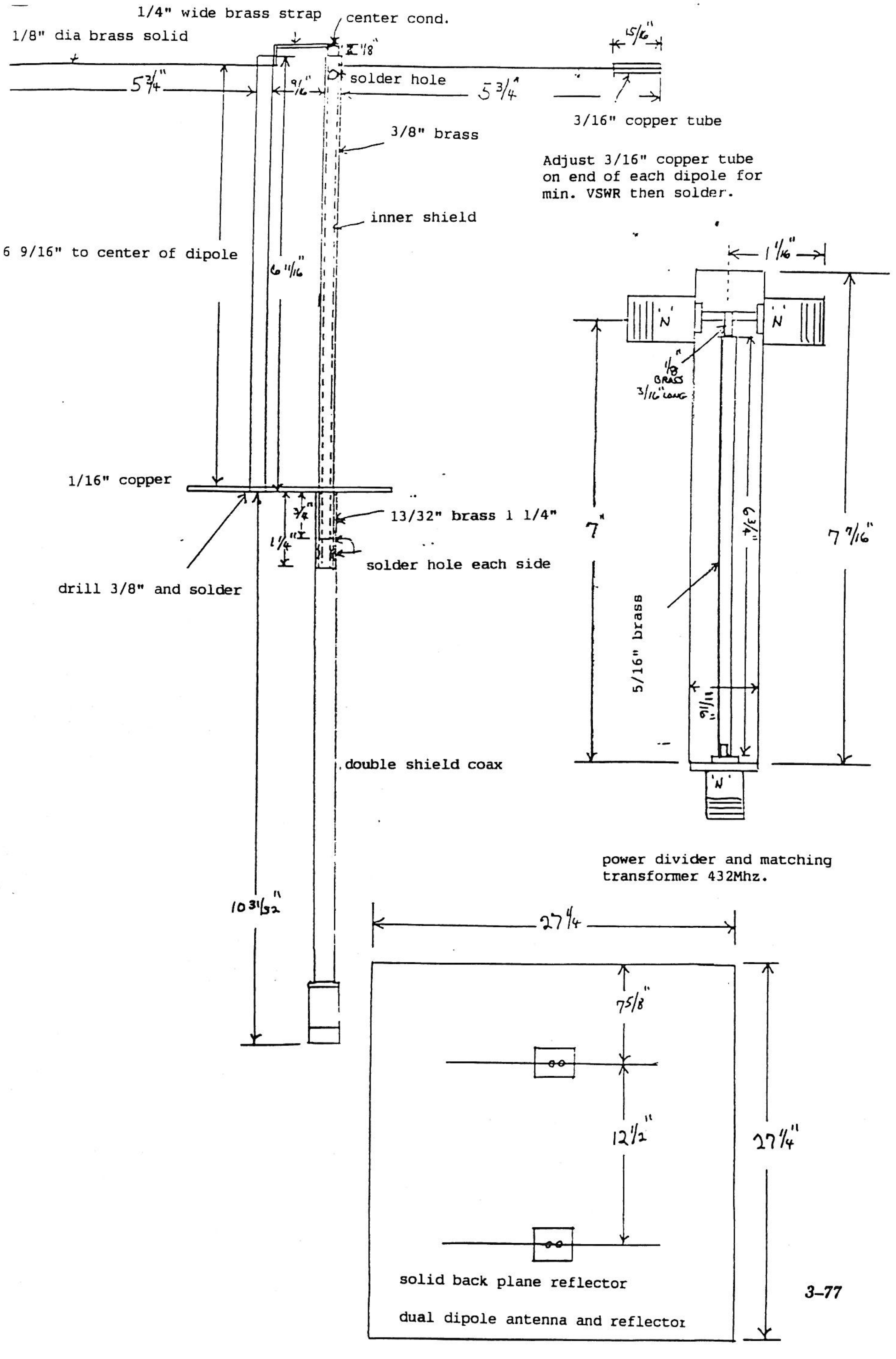
Balun: UT 141 coax

3.52 Low Noise 432 MHz Yagi

Peter Beyer PA3AEF - July 1988

This yagi is designed according to the recipe of DL6WU. It's frequency is centred at 432.000 MHz. Due to space restrictions, (9 stock building 120 ft high) the goal was a compact design withstanding the high winds at this height. With these short yagi's PA3AEF was able to mount 8 of these on top of the building. Although being very short (5.7λ) the antenna's noise performance is quite well. NECII computer analysis showed for the total array of 8 a noise temperature of 26°K at 30° Elevation. The gain for a single yagi was calculated at 17.33 dBi while being 26.12 dBi for the array.

The yagi is using an extended reflector with 4 reflectors spaced 138mm vertical. The elements are isolated, mounted 5mm above a 20x20mm metal boom, using 5mm aluminium rods. The dipole is folded. Optimum stacking space is 1.54m in the E-plane and 1.4m in the H-plane. Table 3–9 shows the dimensions and Figure 3–68 the computer analysis.



Adjust 3/16" copper tube on end of each dipole for min. VSWR then solder.

power divider and matching transformer 432Mhz.

solid back plane reflector

dual dipole antenna and reflector

Table 3–9: Dimensions PA3AEF 22 El. 432 MHz Yagi

Element	**Position**	**Length**	**Element**	**Position**	**Length**
RE-DE	135mm	350mm	D9 -D10	250mm	279mm
DE-D1	52mm	325mm	D10-D11	260mm	277mm
D1-D2	125mm	303mm	D11-D12	270mm	276mm
D2-D3	149mm	299mm	D12-D13	277mm	275mm
D3-D4	174mm	295mm	D13-D14	277mm	274mm
D4-D5	194mm	292mm	D14-D15	277mm	272mm
D5-D6	208mm	289mm	D15-D16	277mm	271mm
D6-D7	218mm	286mm	D16-D17	277mm	270mm
D7-D8	229mm	283mm	D17		269mm
D8-D9	239mm	281mm			

3.53 Array With Polarisation Control

John Stefl WA9FWD - February 1989

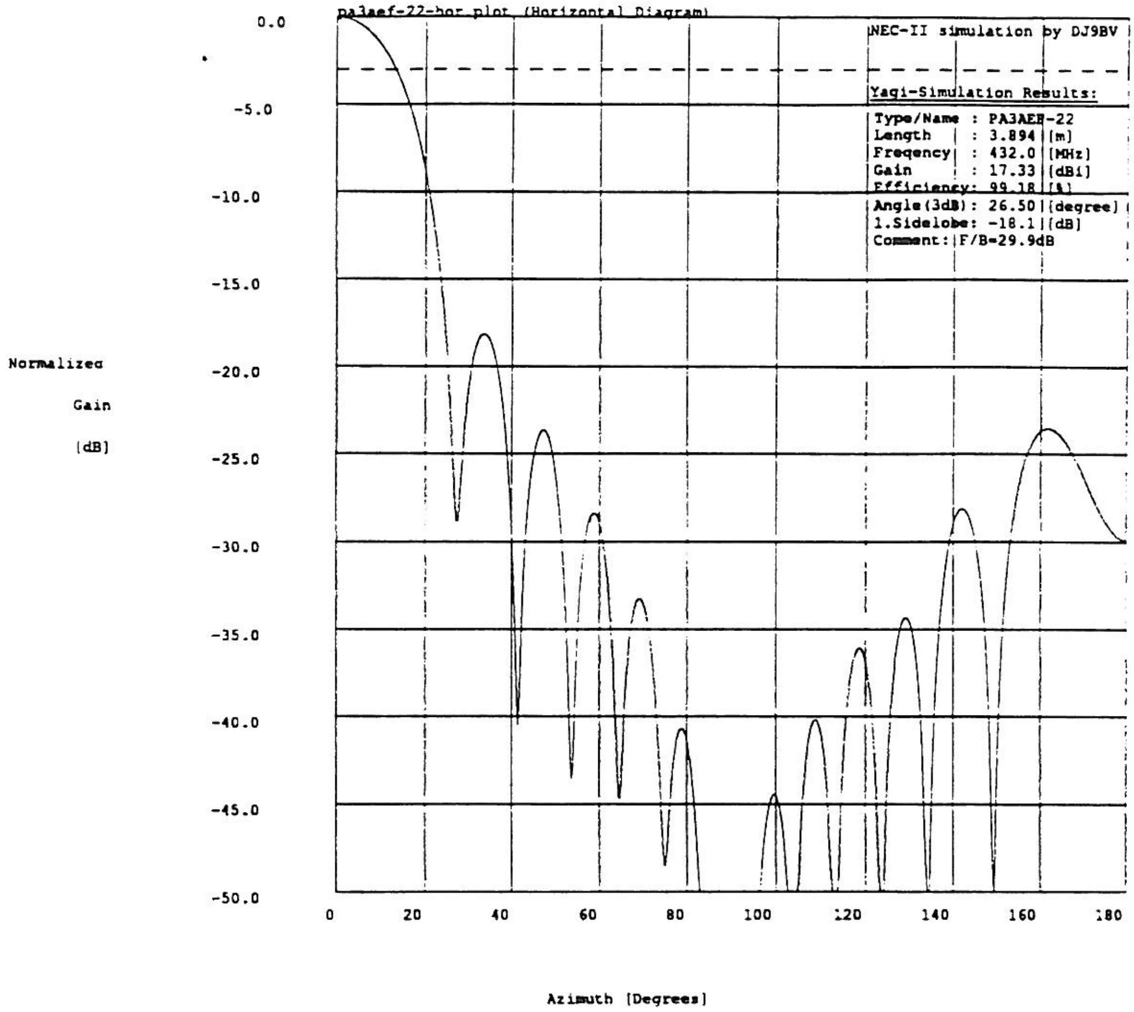
Figure 3–69 and Figure 3–70 shows WA9FWD's solution for polarisation control on a Yagi array system. The azimuth rotator used by WA9FWD is a Daiwa MR750PE with 4 motors 30 rating. A HAM IV is used for polarisation control. The elevation driver is made of a Saginaw dish drive with 18" travel. The elevation hinges are 4 pieces of 4-1/2" x 4-1/2" solid brass ball bearing door hinges. Everything is mounted on a self supporting Rohn HDBX40 40' tower. The weight of the antenna assembly without the phasing lines is about 45 lbs, while the weight of the mount and the rotators is almost 300 lbs.

3.54 Modified VE4MA 1296 MHz Feedhorn

Tom Ellis WB0QMN - March 1989

This modification presented by WB0QMN makes the 1296 MHz feedhorn by VE4MA suitable for 0.33 - 0.36 f/D dishes. The probes are made of 2.1" long 1/8" brass rods. (Figure 3–71) The tuning stubs (3 & 4) are 1/8" fine thread rods and nuts. The horn is used with a quadrature coupler for circular polarisation.

Figure 3–68: PA3AEF Yagi Performance



3.55 Feedhorns for 23 and 13 cm

Barry Malowanchuck VE4MA - August 1989

Barry expands on his earlier work with scalar horns and gives optimum dimensions for different f/D ratios. He also discusses the dual dipole feed and has discovered, contrary to earlier reports, that changing the size of the reflector has little affect of the dipole feeds pattern - if anything, it increases the side lobes. He found that he could alter the pattern by changing the dipole reflector (d/r) spacing and presents information on optimum spacing for receive and transmit for different f/D ratios. KU4F has put these ideas into practice by using different sets of dipoles for receive and transmit. with different d/r spacings. The TX dipoles' d/r spacing are optimumly positioned for transmit while RX dipoles' d/r spacing are optimumly positioned for receive. (Thornton must rotate his feed between RX and TX when the ideal receive and transmit polarisations are in alignment- the reverse of the case for most systems.) It is also possible that the d/r spacing could be moved mechanically between TX and RX. This idea applies to the scalar horn which also has a different optimum ring position for RX and TX. It would be interesting to work out the dB difference between 2 positions this is something Barry has not yet done.

Figure 3–69: Elevation and Polarisation Drives

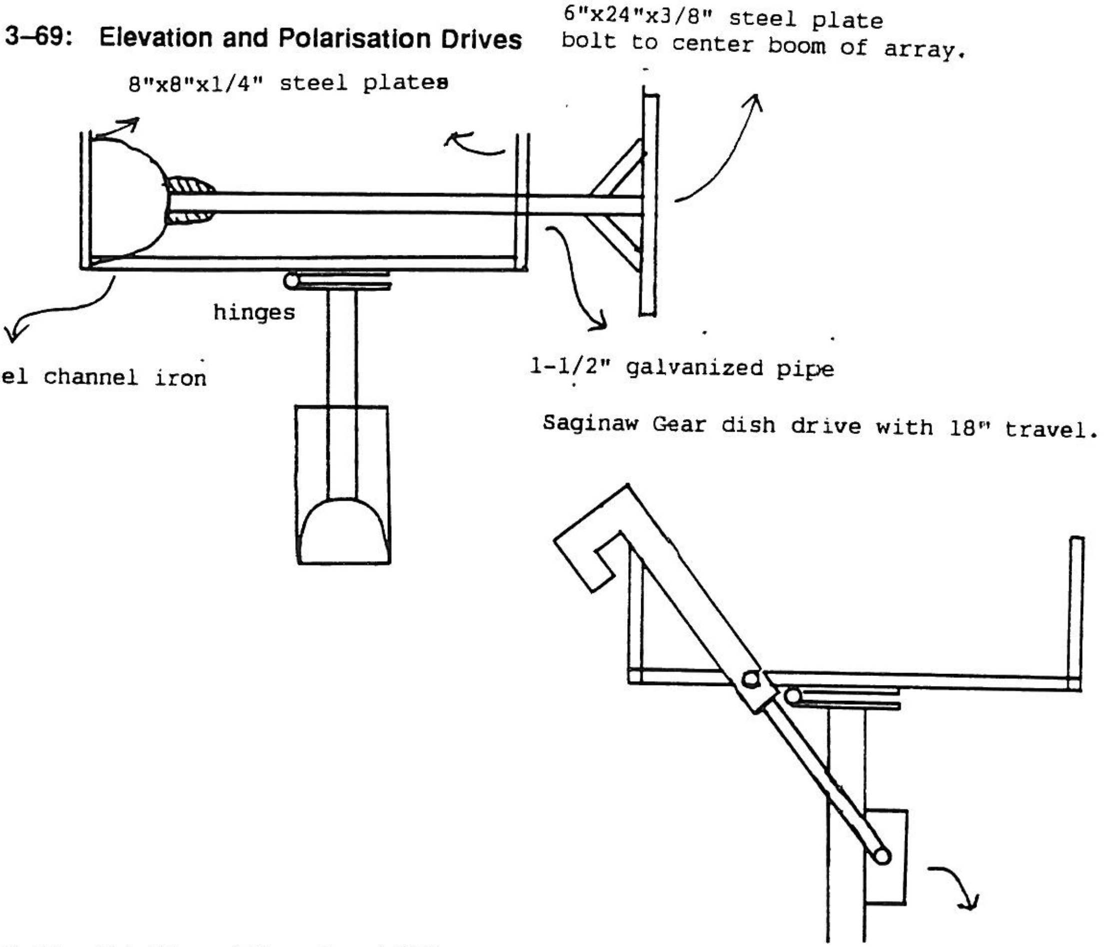


Figure 3–70: Top View of Mount and H-Frame

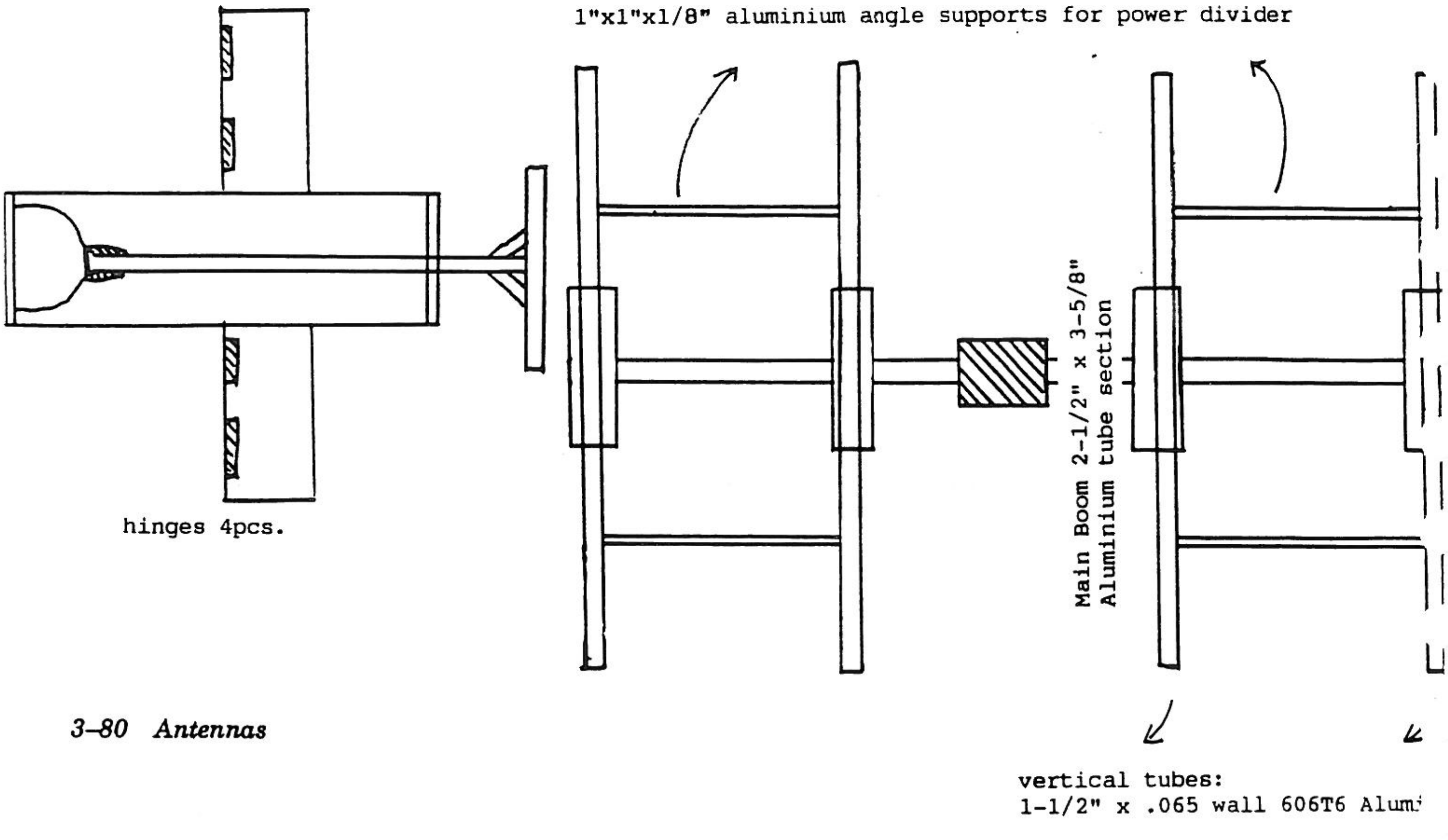
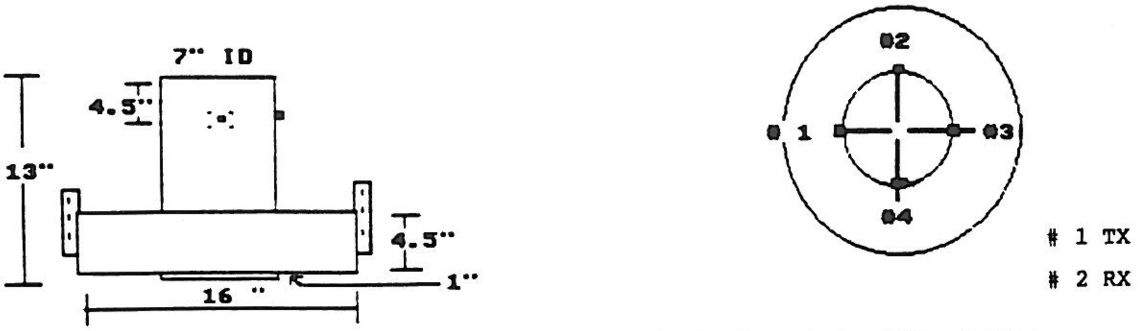
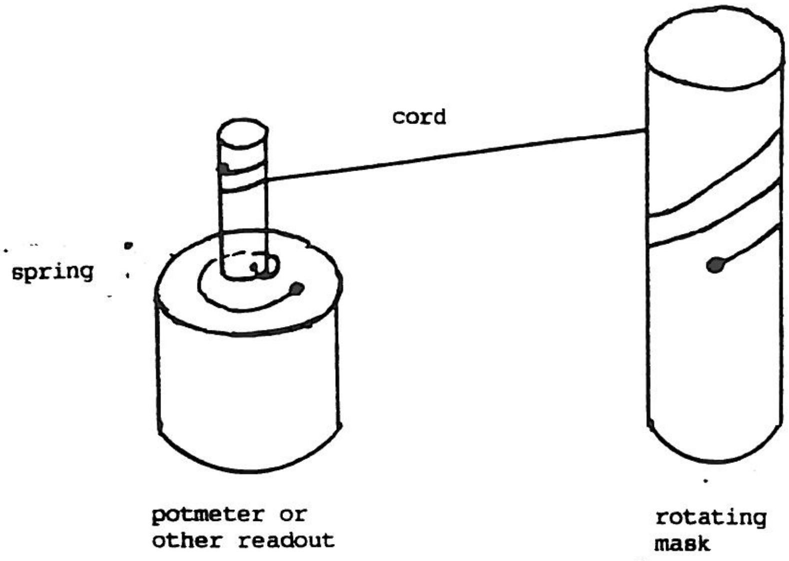


Figure 3–71: Modified VE4MA 1296 MHz Feedhorn



Probe length is 2.1", 1/8" brass rod # 3,4
Tuning stubs 1/8" fine thread rod and nuts.
Use with quadrature coupler for circular polarisation.

Figure 3–72: The Spirolator



3.56 The Spirolator

Ed Gray W0SD - August 1989

Connecting a pot (or other read out) to a rotating mask can be a problem without significantly mechanical effort. Pulleys and belts tend to slip. Ed suggests loading a pot (or other rotary readout) with a spring so that it always returns to one end of its rotation. Attach a cord to the pot and wrap it several times around the pot's shaft. Than wrap and secure the other end of the cord around the mask, when the mask is at the corresponding end of its rotation. When the mask rotates, it will wind the cord around itself and at the same time cause the pot to rotate against the spring. Since both ends are secured, there is no chance for slippage.

3.57 Circular Polarisation Standard

Allen Katz K2UYH - November 1989

The I.A.R.U. has decided that the standard currently in use on 1296 MHz is also the one on use on 2.3 GHz. The diagram below shows the correct polarisation connections to an W2IMU horn. Remember the circular sense produced by the feed is reversed by the reflector. Thus for right hand circular on transmit, you connect the transmitter to the left circular port of the horn. In any case if you connect your feed as shown in Figure 3–73, it should produce the correct sense.

Figure 3–73: Circular Polarisation Standard