PARABOLIC ANTENNAS AND THEIR FEEDS

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Dish antennas and their feeds are a mystery to the majority of Hams who have not spent a lot of time paging through the few articles that have been published over the years. Most of these articles are geared to the "learned souls" who by employment, or sheer intelligence, have a good grasp on the theory. I will try to simplify the subject.

What is needed is motivation. You build a 5.7 GHz transverter, now you find out the problems of feedlines and antennas, what to do ??? Assuming you have surmounted the feedline problem, lets go into the antenna. There are some basics to understand:

(1) **Parabolic or dish antennas are NOT frequency dependant.** That is any dish will work to some degree at any frequency. The basic determining factor is, how many wavelengths in diameter is your dish? The more wavelengths the more gain. For instance, an 8ft dia dish has about 28 dB of gain at 1296MHz, the same dish has 45 dB of gain at 10368 MHz.

(2) **Dish antennas are NOT all the same shape**. Some are very shallow, some are very deep. They all work. Your problem is to determine what you have and to select the proper feed for that particular dish.

(3) **Wind loading**. This is the one area that you have to watch. There isn't a yagi made that can match a dish for windloading. This is the area that will force you to do some trade-offs. Keep in mind that at 80 mph every square ft. of antenna that you have up exhibits about 16 lbs. of force on its mounting structure. ie (3ft dia dish = 113lbs windload)

(4) **Condition.** Does your dish have any damage? The higher in frequency you go the more accurate the surface must be. A few dings here and there are nothing to worry about. The things to be aware of are the size of the dent or imperfection and how many there are. Without going into the math, if you have a 4ft dish that has some dime sized dents in it don't worry. But if that same dish was dropped and is twisted out of shape a couple of inches, try to beat it back into shape or better yet find a better one

(5) **Beamwidth.** Dish antennas are just like flashlights; they focus the energy to a narrow beam. Lets take the same 8ft dish at 1296 MHz, its beamwidth is 6 degrees. The same dish at 10368 MHz has a beamwidth of about .8 degrees. Pointing can be a problem.

(6) **Dish size** If you Double the size of a dish your gain increases by 6 dB. and vice-versa. Remember 6 dB is 1 "S" unit. This is one decision that you have make, because windloading, rotator apparatus, and mounting structure come into consideration.

(7) **Solid versus Mesh Dishes**. Mesh dishes, (like TVRO), have less windloading. They are also lighter. The holes must be less than 1/10 of a wavelength in diameter, at the highest operating frequency.

FEEDS

Feeds are the most difficult and important part of any dish antenna system. You can't just bolt a horn on the front of a dish reflector and get satisfactory performance. They have to match each other. Ideally the feed should illuminate the dish 10 dB down at the edge from what it is at the center. You don't want to under illuminate a dish. Why have a 6ft. reflector when a 4ft. on would do. You are just wasting aluminium. Conversly, you don't want to over illuminate. You are wasting RF over the edges. Feeds by design have a specific beamwidth, this is what must be taken into consideration when choosing your feed for your dish in question. Other considerations are difficulty of construction, testing etc. Some feeds get pretty wild for a guy with just hand tools.

To determine the type of feed for your particlar dish you must know two factors. The focal point, (focal length), represented by the letter "f", and the f /D ratio. With this information you can select the proper feed for the dish in question. The proceedure is simple:

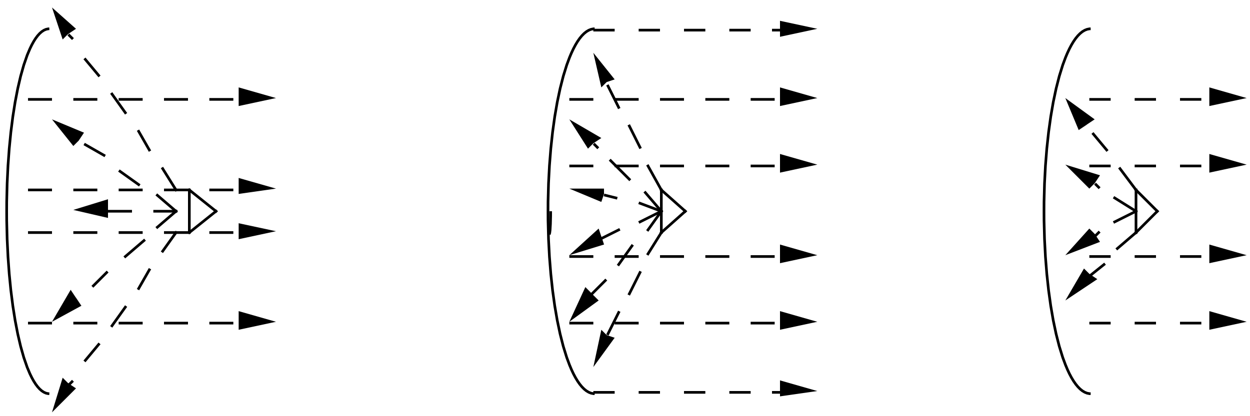
(1) Measure diameter of dish ("D")

(2) Measure the depth of the dish, from rim down to center. ("c")

(3) Calculate the “ f” by using the equation, D^2 /16c.

(4) Calculate the f/D ratio by dividing the diameter of the dish into the focal point distance. The answer should fall between .25 and .55 for any reflector normally found at a fleamarket.

After doing some number crunching you will realize that a f/D of .5 is a rather flat dish an an f/D of .25 is a deep dish. If you have a deep dish you will need a broad beamwidth feed to illuminate it properly. On the other hand if you used that feed on a dish that had a f/D of .5, you would over illuminate it, because the focal point is so far out in front of the dish. The feed has to be placed at the focal point, wherever it is, to illuminate the dish properly



Over Illuminate **Proper Illumination** **Under Illuminate**

Most of the dishes that are available seem to be the deep type in the .25 to .35 f/D range. These are not, unfortunately, suitable for the easy coffee can feeds that you see in most articles. If you do come across a dish that has a f/D of .45 to .5, one of those feeds will work just fine. Make sure whatever feed you decide on, that you mount it dead center in the dish, at the focal point. (The feed and the dish both have focal points, the feed should be mounted so that the two focal points are coincidental.) Make sure your polarization is correct. In a monopole type feed the monopole element will be horizontal for horizontal polarization. For a waveguide type feed the long dimension of the guide will be vertical for horizontal polarization.

Another consideration, more than one feed mounted on the same dish. This takes some thought. The obvious advantage of this set-up is one dish and possibly one feedline with a coax switch resulting in less wind loading than having more than one dish mounted on your tower.

Disadvantage; skewing of your signal. You can’t mount two or more feeds at the exact focal point at the same time. You will peak up on one band for a contact, then go to the next band for another contact and he may or may not be there. You will have to change your azimuth to peak him again. This is fine once you find out how much your heading has to move from one band to the next. Don’t stack feeds vertically, unless your dish has an elevation control.

Radomes. After you make your feed, mount it, etc, think about weatherproofing and keeping the critters out. I have used PVC pipe on feeds as high in frequency as 10368 MHz. Tests were performed at a local antenna range with no loss in signal. This opened a whole new source of material to me, because of the fittings, tubing, glue, etc. that are readily available at local home improvement centers.

After stumbling around for the past few years I have narrowed the possible choices of feeds for any given dish f/D to three. They are the simple Splasher for deep dishes (f/D of .25 to .35), Scaler for dishes with f/D of .3 to .45, and Pyramidal horns for .45 and up. Up to now the scaler has proved to be by far the best, although the most difficult to construct. The splasher and pyramidal horn feeds can be made with simple hand tools, athough care must be taken in measuring when constructing any feed. I suggest the bare minimum requirement would be a pair of dial calipers.

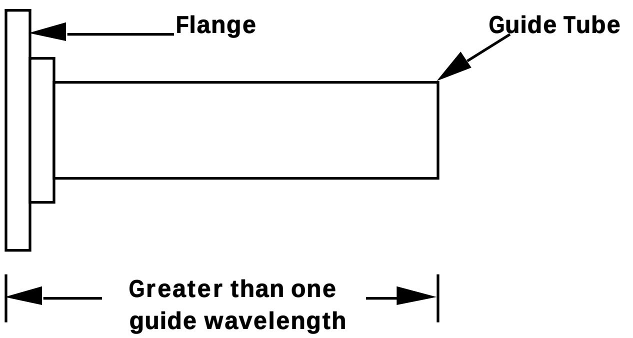
FEED CONSTRUCTION

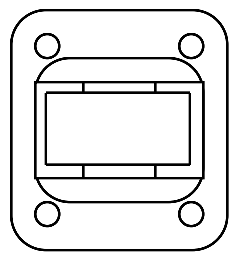
SPLASHER FEED

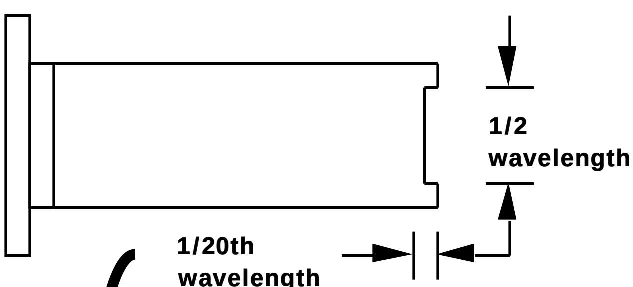
This feed is probably the least difficult to build. For materials, all that is needed is a short length of wave guide good at the frequency of interest. The wave guide must be more than one guide wavelength long and have a flange at one end.

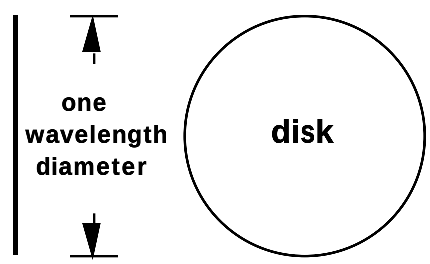
A transition from “N” connector to your short length of guide material. These can be obtained at modest cost at fleamarkets. A small piece of brass sheet stock. Thats it.

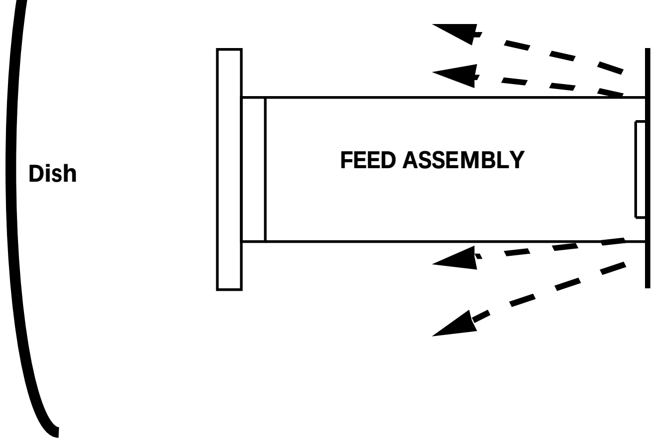
(1) Square off the end of the guide tube without the flange. Ensure there is a good finish with no burrs.
(2) Cut a circle out of the sheet brass one (1) wavelength in diameter.
(3) Mill or file a notch 1/2 wavelength long, 1/20 of a wavelength deep on the end of the guide that you squared up, centered on each long side.
(4) Solder the disk that you made one wavelength in diameter on the end of the guide tube that you filed the notches in. If all is well, you will have a rectangular tube with a disk on one end, the two small slots will be visible just behind the disk. Be carefull not to get a blob of solder inside the tube, solder blobs kill RF.
(5) Bolt on the transition and your ready to go.
(6) Mount the feed so the slots are at the focal point of the dish.
(7) Polarization, I might mention at this time you must mount this and any feed mentioned in this article so that it is in HORIZONTAL polarization. This is easy to identify if you are using a rectangular waveguide feed. The long dimension of the guide tube will be vertical. With circular waveguide the probe, or monopole of the feed will enter the tube from the side. This is an easy mistake to make but when you consider the attenuation of a crosspolarized signal its catastrophic.











Pyramidal Horn

Note: The materials for this feed are the same as the splasher.

(1) Square off the end of the guide tube without the flange. Make sure there are no burrs.
(2) You now have to calculate the shape of the horn, which depends on the f/D of the dish and the wavelength of the frequency intended. Assume an 8ft dish that measures 12 inches deep in the center. f=D2/16c, That is 96inches squared which is 9216 inches, divided by 16c which is 192 inches. The answer is 48 inches, the focal point. The f/D ratio is 48 divided by 96 = .5 The f/D ratio of this dish is .5. With this info and the wavelength of your frequency of operation, you are all set to go.

FIG. 1

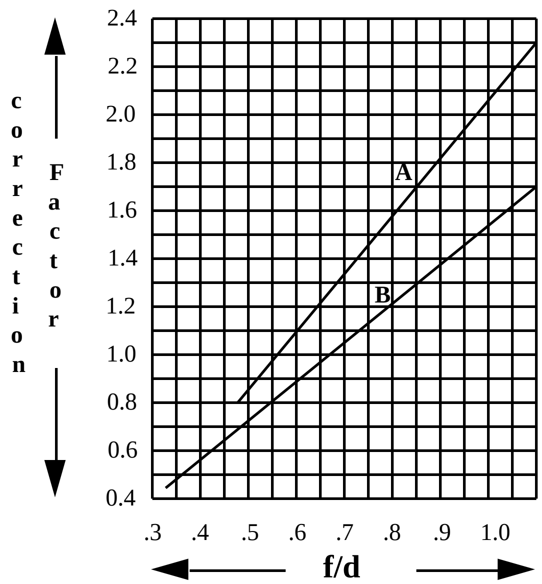


FIG. 2

WAVELENGTH
For popular bands

1,296 mhz = 9.108 inches

2,304 mhz = 5.124 inches

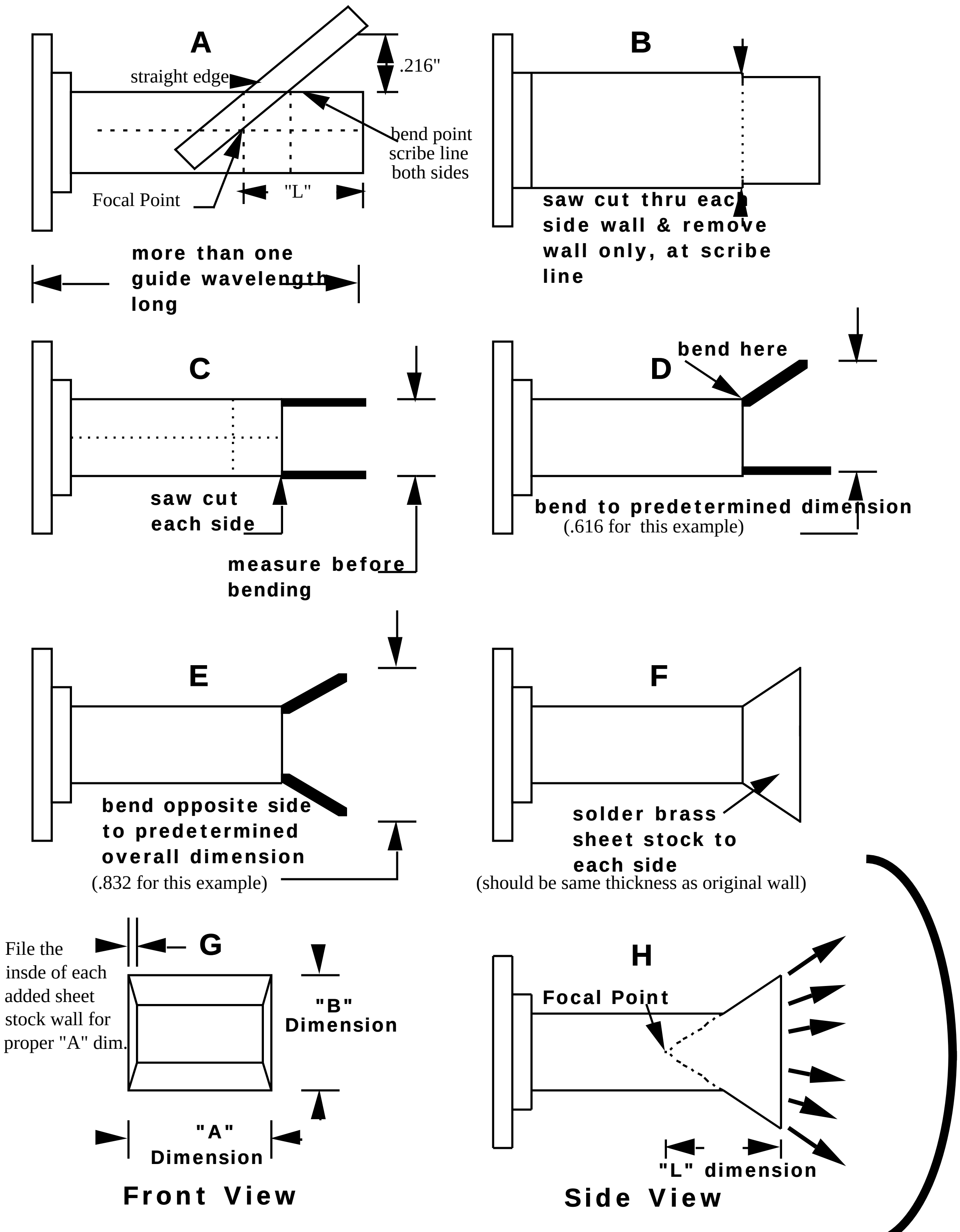
3,456 mhz = 3.420 inches

5.760 mhz = 2.052 inches

10,368 mhz = 1.140 inches

Note: A guide wavelength is longer than a free space wavelength. It is calculated using the cut-off freq. of the guide tube being used. 10.368 GHz in WG90 = 1.469

From the chart in FIG.1 determine the multiplying factor for the “A” and “B”, the **inside** dimensions of your horn at the open end. From the chart in FIG 2 determine the wavelength of the band you are working with. Assume we are working at 10368 MHz, the wave length is 1.140 inches. From the example above we know we have a f/D of .500. The multiplying factor for the “B” dimension is .73. Therefore the “B” dimension is 1.140 X .73 or .832 inches. “A” is calculated the same way. The multiplying factor is .88 X 1.140 = 1.003 inches for the “A” dimension. The focal point “L” of the horn is calculated as “A” squared divided by the wavelength. 1.003 squared = 1.006 divided by 1.140 which is .874 inches.
(3) The dimension for B is .832 inches. We are using WG 90 which measures .400 across the short dimension. Subtract .400 from .832 = .432 in. Now divide that by 2. That is .216 in. This is the amount that each side has to be bent to form the horn . To allow us to accurately make this bend just add the .400 (short dimension of tube) to .216 which is .616. This gives us the predetermined dimension in Fig “D”. The second side is easy, measure from the first side and bend to the finish dimension .832 as in Fig E. Remember all dimensions are on the inside of the horn.
(4) To layout the bend point illustrated in Fig A, determine the “L” dimension. Carefully measure from the end of the tube and scribe a line across the short dimension. Then scribe a line down the length of the tube in the middle. Where these two lines intersect is the focal point. Hold a straight-edge on that point and rotate it so its .216 inches from the end of the tube. The point where the straight edge leaves the tube is the bend point. Do this for both sides. Use a fine tooth hobby saw to make the cuts on each side of the guide tube illustrated in figs B & C. File any rough edges.
(5) Cut two pieces of hobby brass to form the “new” sides of your guide tube and solder them in place as in fig F.
(6) For dimension “A” , we are using WG90 it’s .900 already, our horn dimension calls for 1.003, just file as much as practical from each piece of hobby brass, on the inside.



NOTE: This feed should be mounted on the dish so that the focal point of the feed is at the focal point of the dish.

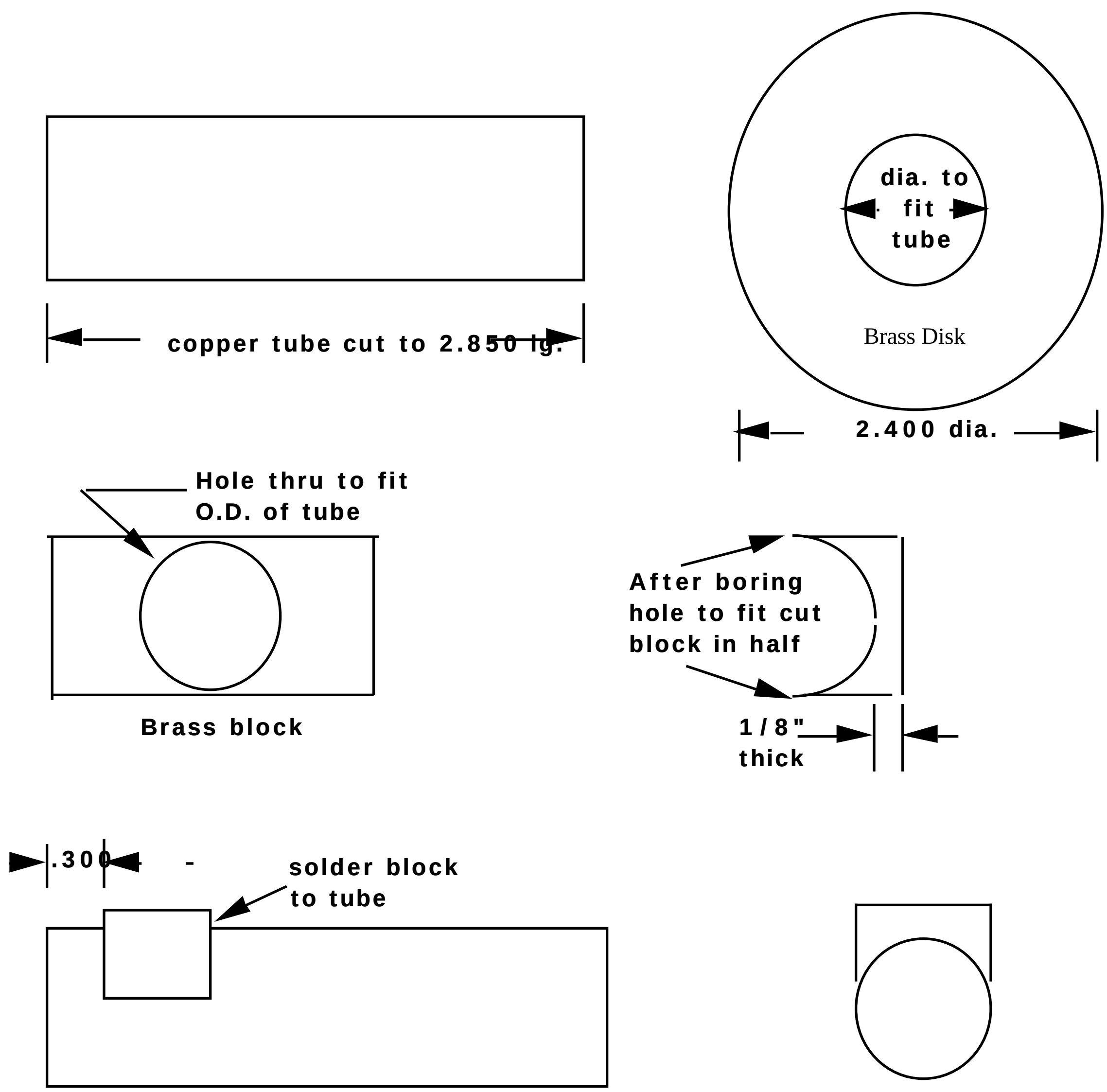
To calculate "L" (the focal point) Square the dimension "A" then divide by the wavelength.

SCALER HORN

This feed horn is probably the most difficult one to construct. I have a milling machine and a lathe at my disposal which have proved invaluable. You may be able to enlist the aid of a local shop for this project. I have made this type of horn for 5750 MHz and 10368 MHz. I took my time and the results were worth it. The 10 GHz feed had better than 26dB of return loss. I will describe the 10GHz feed

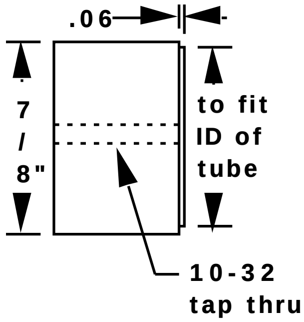
Materials needed:

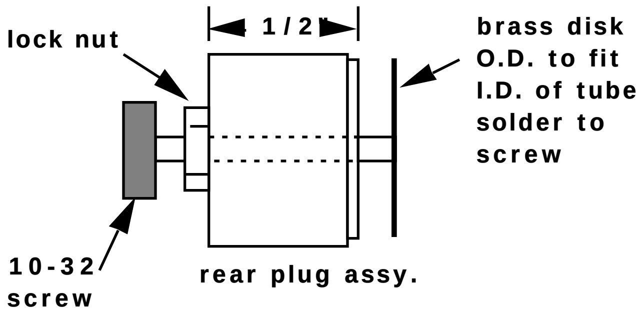
(1) short pc. copper tubing about 3 inches long, 7/8 dia, .030 wall thickness.
(1) pc. brass 2 1/2 in. in diameter 1/8 thick
(1) pc. brass 7/8 wide X 5/8 X 1 1/8 long
(1) pc. brass 7/8 dia. X 1 in. long
(1) brass 10-32 machine screw 1 in. long
(1) pc. hobby brass .800 dia X .050 thick.
(1) chassis type "N" connector
(2) pcs. 1/2 X .015 X 12 in. hobby brass.

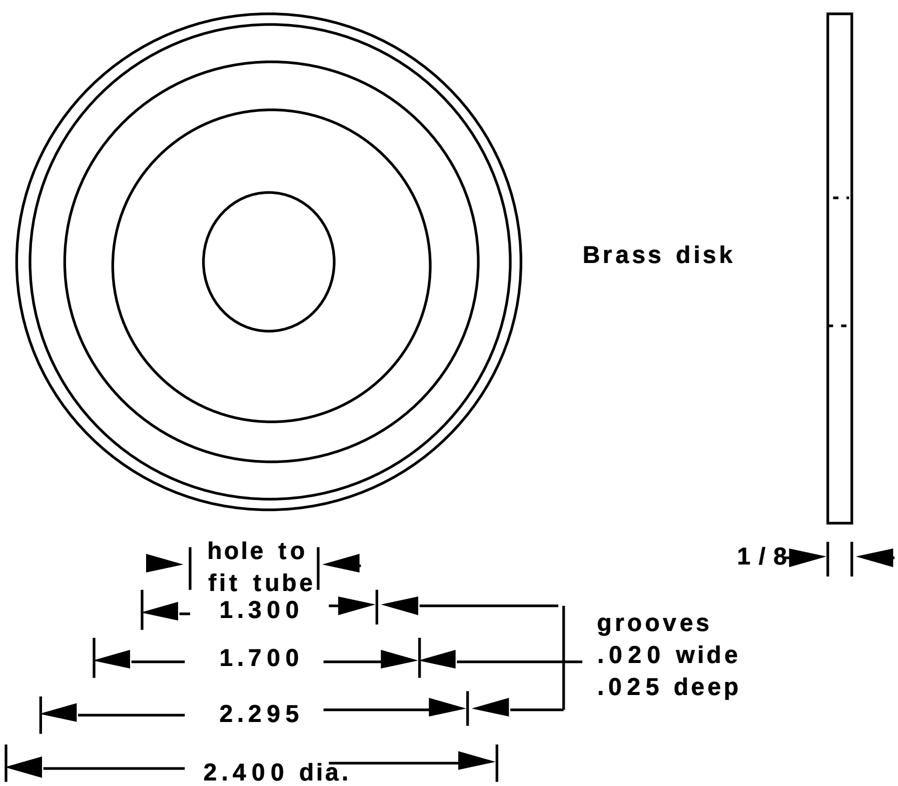


Construction:

Face off each end of the copper tube. The length is not too important just so it's over (1) guide wavelength. Square up the brass block to 7/8 " wide by 5/8" thick. Mill one end square. Drill and bore the tube hole to a size that allows the tube to slip thru. Locate this hole from one end to allow about a 1/8” wall thickness. Saw the block in half as per sketch above. Solder to tube in location shown.







Turn the 2 1/2 dia. by 1/8 thick disk to 2.400 in dia. and drill and bore the center hole to a size that allows you to push the tube thru with some effort. Machine the grooves to dimensions shown (this is the tricky part).

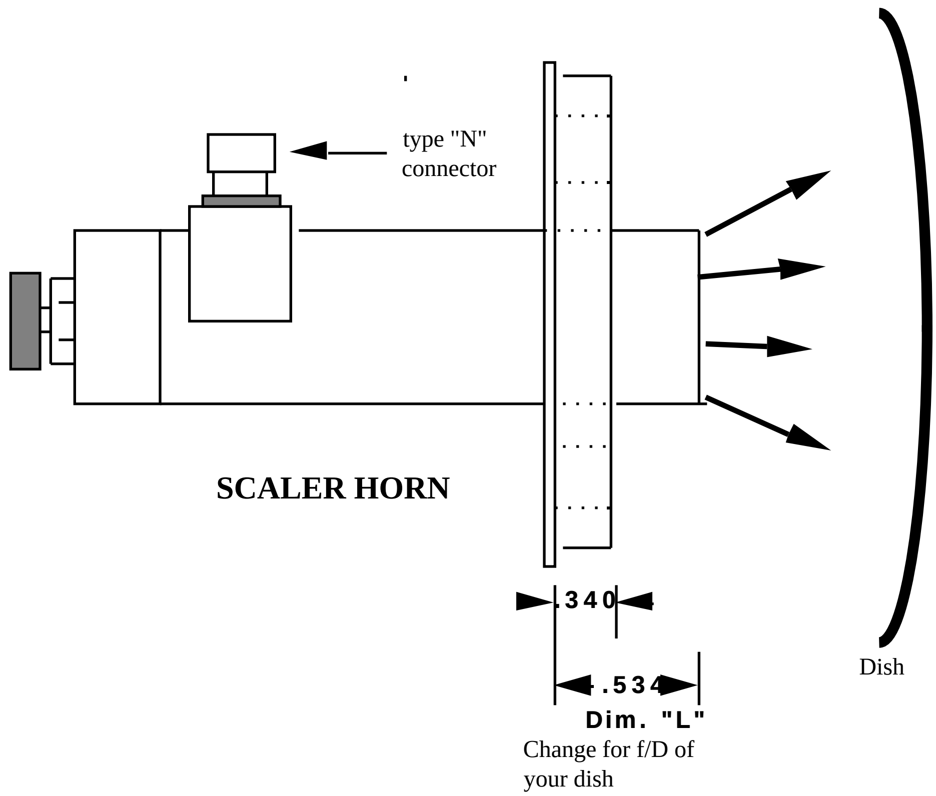
Locate the brass (1/2 by .015) and cut to the proper length for each of the 3 grooves. You can get close by calculating the circumference for each groove, and cutting a little long. Pre form each ring of brass so it is close to the right dia. Using a soft hammer tap each ring in it’s groove and file the length for a final fit. When your satisfied, clean the ring and brass and solder the assy. together. When it cools down return to lathe and face the strips to the proper length. This last operation is not as scary as it sounds, just take your time. Remove all burrs.

The end cap is much easier. Turn the O.D. to the same dia. as the tube, then turn a step to the same dia. as the I.D. of the tube as per sketch. Drill and tap a 10-32 hole thru the length. Thread a long brass machine screw and lock nut thru the cap and solder the .050 thick disk to the end of the screw as shown. The .050 disk must fit the I.D. of the tube freely, make sure before soldering. I drilled a small hole in the center of the disk when I turned the O.D. and in turn turned a small stud on the end of the 10-32 screw so as to keep the disk concentric with the screw, when soldering. This completes the end cap

Lets return to the tube assy. Drill a hole in the brass block for the center pin of the chassis type “N” connector, .600 from the end of the tube, and on the center line of the tube. Solder a pc. of 1/8 dia. wire to the center pin of the connector. Adjust the length of this pin so that it projects into the tube .260in. file a radius on the end of the wire after obtaining the proper length.

Clean the tube, the end cap, and the “N” connector and solder the assy. together. Slide on the brass disk and your ready for testing.

Apply RF and check your return loss. Adjust the 10-32 screw for the best match and snug up the lock nut.



This feed was designed for a reflector with a f/D of .375, The “L” dimension determines the beamwidth of the feed, if you have a dish with a different f/D “L” wiil have to change.

To calculate the “L” dimension for your scaler horn you must determine the f/D of your dish. Find the correction factor for that f/D. from the chart below. Multiply that correction factor by the wavelength that your using.

EXAMPLES OF DIFFERENT “L” DIMENSIONS FOR VARIOUS DISH f/D RATIOS

f/D	Correction		Wavelength	=	“L”
0.30	0.55	X	1.140	=	.627
0.35	0.51	X	1.140	=	.581
0.40	0.43	X	1.140	=	.490
0.45	0.30	X	1.140	=	.342

This feed can be made for any freq. I chose 10 GHz for this discription, I have made 5.7 GHz feeds that performed just as well. For detailed Info as far as the math involved I suggest the excellent article by Dick Turrin, W2IMU in the ARRL UHF / MICROWAVE EXPERIMENTERS MANUAL

Performance:

Over the past several years I have been playing around with Dish antennas and experimenting with several feeds. It is surprising what you can get away with, and still come up “smelling like a rose”. When you take your time, do a little reading and make some tests, it’s almost scary how good this stuff works. I still rember the contact with KD5RO from Camelback Mt. in Pa. to Rochester NY. one summer contest a few years ago. We had just worked him on 432, he knew we had 3456 and suggested I give him a call. I had 5mw out of the transverter and about 10ft. of feed line. We made the contact with little or no trouble. This type of thing has repeated itself over the past few years several times, with different bands, feeds, and reflectors. Just keep the basics in mind, and you will be amazed at what can be accomplished.

References:

1. R.S.G.B. VHF UHF MANUAL
2. ARRL HANDBOOK
3. MICROWAVE DEVICES AND CIRCUITS by Samuel Y. Liao
4. ARRL UHF / MICROWAVE EXPERIMENTERS MANUAL