Home-Made Parabolic Dishes for Microwave Applications

by S. Reithofer, DL 6 MH

The interest of radio amateurs in microwave technology has increased considerably in recent times. For this reason, the author is to describe a simple manner of constructing efficient parabolic dish antennas for the 10 GHz and 24 GHz bands.

It is true that horn radiators are simpler to construct, however, they become too large and unhandy when constructed for high antenna gains. This can be seen by comparison: A horn radiator for 10 GHz with approximately 25 dB gain has a length of approximately 60 cm and an aperture of 25 cm x 19 cm. In comparison, a parabolic dish of 30 cm diameter already exhibits a gain of 27 dB at this frequency and is considerably more favorable both in its dimensions, weight, and transportability than a horn radiator.

Manufacture of Parabolic Antennas

Of the many possibilities for manufacturing parabolic dishes, the author has found the following to be most favorable:

The main surface of the dish is made from a wire mesh grid which should be as fine as possible. It should not be more than 0.1 λ, and 0.05 λ would be better. This corresponds to a maximum of 3 mm for the 10 GHz band, and a maximum of 1.25 mm for the 24 GHz band. In the case of the author's prototype, a grid of 2.5 mm was used for 10 GHz, and 0.8 mm for 24 GHz. Such metal grids are readily available from hardware stores. The grid for 10 GHz should be welded at the crossover points; for 24 GHz, the author used a fine brass grid.

Construction of the Parabolic Form

The following equation is valid for construction of a parabolic:

$$y^2 = 4 \times f \times x$$

where y is the spacing of a point of the parabolic in the vertical plane from a central line, x is the spacing of each point from a vertical tangent in the horizontal plane and f the focal depth, or spacing of the focal point from the vertical tangent on the center line.

These magnitudes are given in the form of a drawing in **Figure 1**.

After transposing the parabolic equation, the following results:

$$x = \frac{y^2}{4 \times f}$$

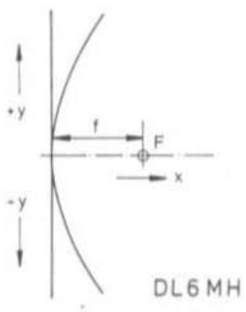

Fig. 1: The parabolic shape

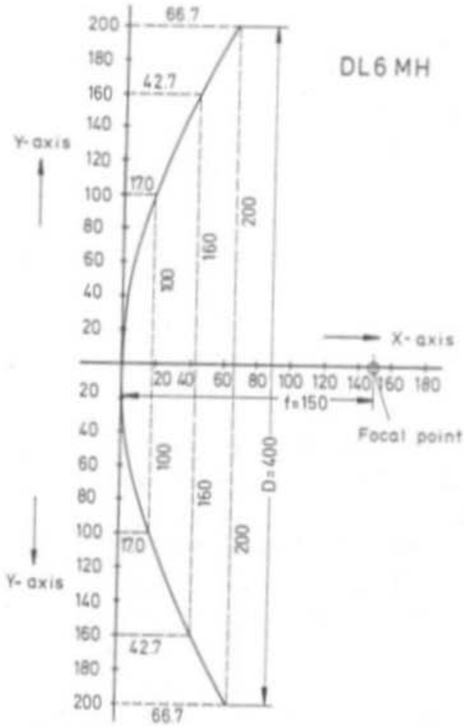

Fig. 2: Construction diagram of a parabolic dish of 40 cm diameter and a focal depth of 15 cm (f/D = 0.38)

For the given values of y, the following x-values result with f = 150 mm and D = 400 mm:

y mm	x mm
20	0.7
40	2.7
60	6.0
80	10.7
100	17.0
120	24.0
140	32.7
160	42.7
180	54.0
200	66.7

Several of these values are given in **Fig. 2.** For construction of the antenna, the above values are drawn to scale. This is followed by making a template. The required values for smaller or larger parabolic dishes can be calculated as required according to the above equation.

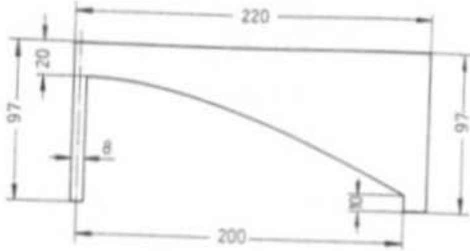

Fig. 3: Template for the plaster form of a dish as given in Figure 2

Construction of the Parabolic Template

The practical construction of the antenna is commenced by cutting a template in the shape of half of the parabolic form from metal plate. A metal plate of approximately 2 mm thickness is sufficient for constructing the 40 cm dish. In order to ensure that the template can be rotated around the central point, it is provided with a central pivot **(Figure 3)**. The dish is constructed on a large wooden board of approximately 50 cm x 50 cm. A tube of approximately 10 mm inner diameter is fixed in the center of this board with the aid of a wooden block or similar so that its top is mounted 77 mm from the surface of the board. The photograph given in **Figure 4** shows this phase of construction.

Fig. 4: Preparations for making the plaster form

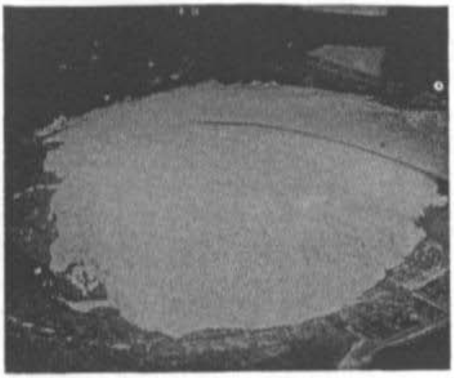

Fig. 5: Placing the plaster around the central hole

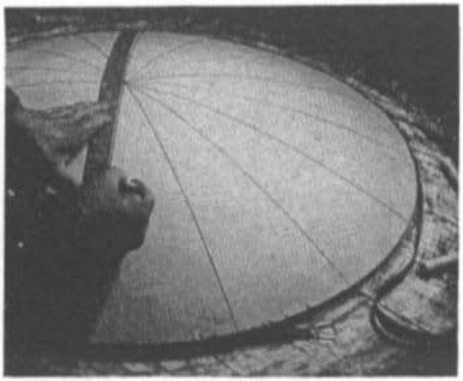

Fig. 7: The segments are now marked on the form

Manufacturing the Plaster Form

The plaster is now mixed with water and placed around the central tube. This can be mixed with sand for the central core to save the amount of plaster required. The plaster is now placed in roughly the required parabolic shape after which the template is placed in the central tube and scraped around the edge to remove excess amounts of the soft plaster.

In the case of the last layer, the plaster surface should be kept somewhat softer by adding water. In this manner it is possible to obtain a flat surface with the aid of the template. This stage of construction is shown in **Figure 6**. The form can be completely smoothed using a thick mixture of plaster and water and using a wide brush.

Fig. 6: Scraping off the excessive plaster using the template

The form is now allowed to harden for one or two days, after which it is divided to 10 or 12 segments with the aid of a fiber pen or pencil **(Figure 7)**.

Wire Grid Segments

The corresponding segments are now cut from a wire grid using shears, allowing approximately 10 mm extra for the outer edge. These segments are firstly formed to a rough parabolic shape on a hard surface using a light hammer.

After having formed the segments to the required shape, they are laid one after another on the plaster form and soldered firstly at three to five points using a large (approximately 150 W) soldering iron. Attention should be paid that the segments correspond to the shape of the form and are in direct contact with it. After completing the 360°, narrow, thin metal strips of approximately 8 to 10 mm in width (tin plate or brass) are placed into position in front of the soldered joints and cut so that they stop approximately 30 mm before the center of the dish. These metal strips are soldered continuously to the seams of the segments.

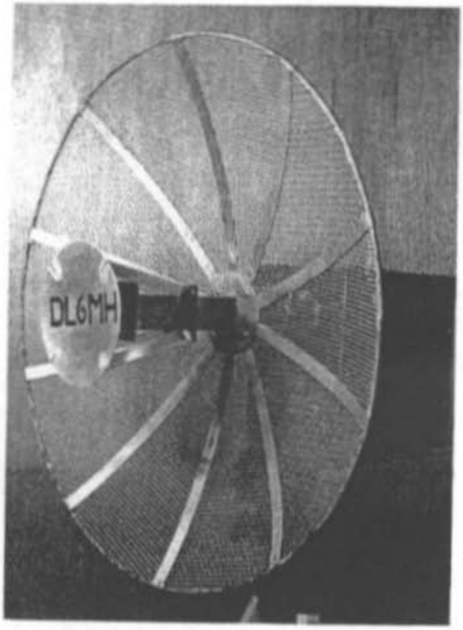

Fig. 8: The round plate for mounting the waveguide can be seen in the center of the completed 10 GHz antenna

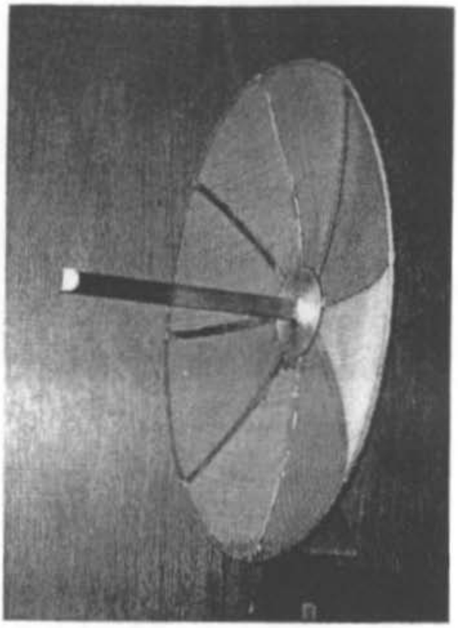

Fig. 10: An antenna for the 24 GHz band with radiator (D = 30 cm, f = 15 cm)

A ring of 4 mm diameter brass or copper wire is now placed around the edge of the plaster form and the excess grid at the edge of the dish is bent around this and soldered into place.

This will provide sufficient stability in the case of a parabolic dish of 40 cm in diameter.

In the case of larger dishes, vertical metal strips should be provided vertically on the rear of the dish for stability.

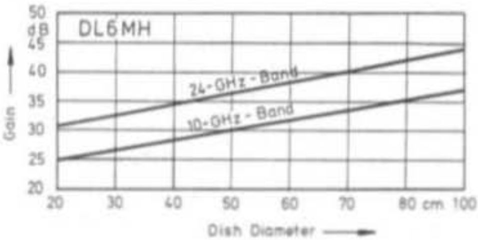

Fig. 9: Average antenna gain as a function of dish diameter

Waveguide Mount

The ends of the segments are cut at the center of the dish so that a hole of approximately 60 mm diameter is provided. An approximately 2 mm thick brass plate with a rectangular cutout for the waveguide is soldered into place above this hole. It is possible to provide such a metal plate at the front and back of the dish to provide improved stability, if required. The central plate of a 40 cm dish for mounting the waveguide can be seen in **Figure 8**.

Gain of Parabolic Antennas

The larger the diameter of the parabolic dish, the higher will be the gain and thus the narrower the beamwidth. The diagram given in **Figure 9** gives the approximate gain values that can be obtained in the 10 GHz and 24 GHz band.

Parabolic dish diameters of 30 to 40 cm have been found satisfactory for practical operation, especially during contests.

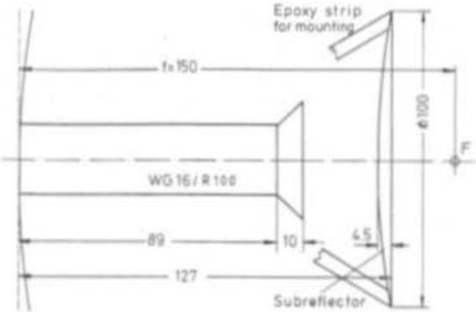

Fig. 11: A 10 GHz Cassegrain radiator for 40 cm parabolic dishes

Larger dishes have a very narrow beamwidth which means that it is very often difficult to set up the antenna to a required direction especially in the case of poor visibility. If the exact location of the station is known, it is possible with some experience for the antenna direction to be determined using a map and compass.

Radiators for Parabolic Dishes

The illumination and thus the overall efficiency of the antenna is mainly dependent on the radiator (sometimes called primary radiator or exciter). A very simple radiator was described in (1). The required cutout on the waveguide and the shape of the cap can be constructed without problems. The author has also used this type of radiator with success at 24 GHz. **Figure 10** shows a parabolic dish of 30 cm diameter which is equipped with this radiator.

A somewhat more extensive radiator is described in the VHF/UHF Manual published by the RSGB using a dipole and reflector for the 10 GHz band. It was described extensively (2) so that it is not necessary to go into it in detail here. The author has also tested such radiators successfully on the 10 GHz band.

If the parabolic dish is only to be used for transmitting, it is possible for the Gunn oscillator module to be mounted together with a short horn radiator of approximately 3 to 5 cm in length at the focal point of the dish. Suitable horn radiators were described in (3) and (4) together with their dimensions.

When using transceivers for the 10 GHz band such as the Microwave-Associates Gunn-Plexer that uses a varactor diode and a DC voltage for remote tuning, it is also possible for it to be installed in the focal point of the dish together with a small horn radiator. The mounting is usually made with three or four pieces of insulating material (strong strips of etched epoxy board material).

A somewhat more extensive method that can be easily achieved by radio amateurs, is the use of a Cassegrain system. In this

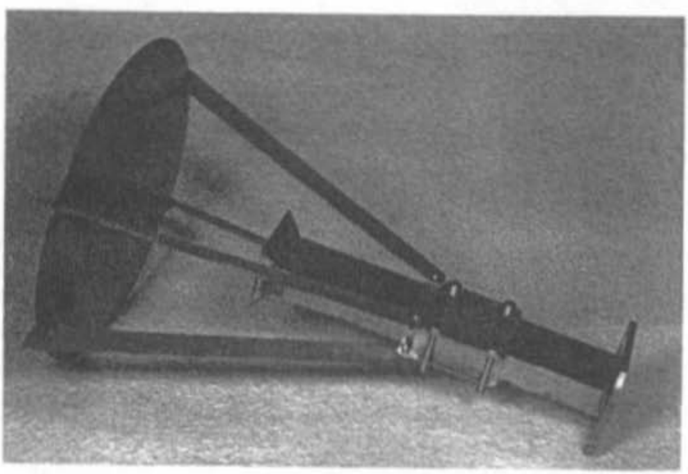

Fig. 12: Prototype of a Cassegrain radiator

case, the waveguide ends with a small horn which illuminates a round subreflector which reflects the energy efficiently to the main dish.

The construction of this Cassegrain system is described in detail in the VHF/UHF Manual published by the RSGB. A drawing with dimensions for the described 70 cm dish is given in **Figure 11**. The design given in **Figure 12** illuminates the dish well and possesses a very short depth.

The subreflector is made from soft brass or aluminium plate which has been hammered into shape on a metal plate. The required shape is given in the drawing. The subreflector is held into place using four strips of etched epoxy board material which are in turn mounted to the waveguide with the aid of a sliding bracket. The spacings such as the distance of the small horn from the center of the dish, and the spacing from the horn to the subreflector are not very critical and can be set using either an available measuring line for most favorable SWR, or according to the S-meter during operation.

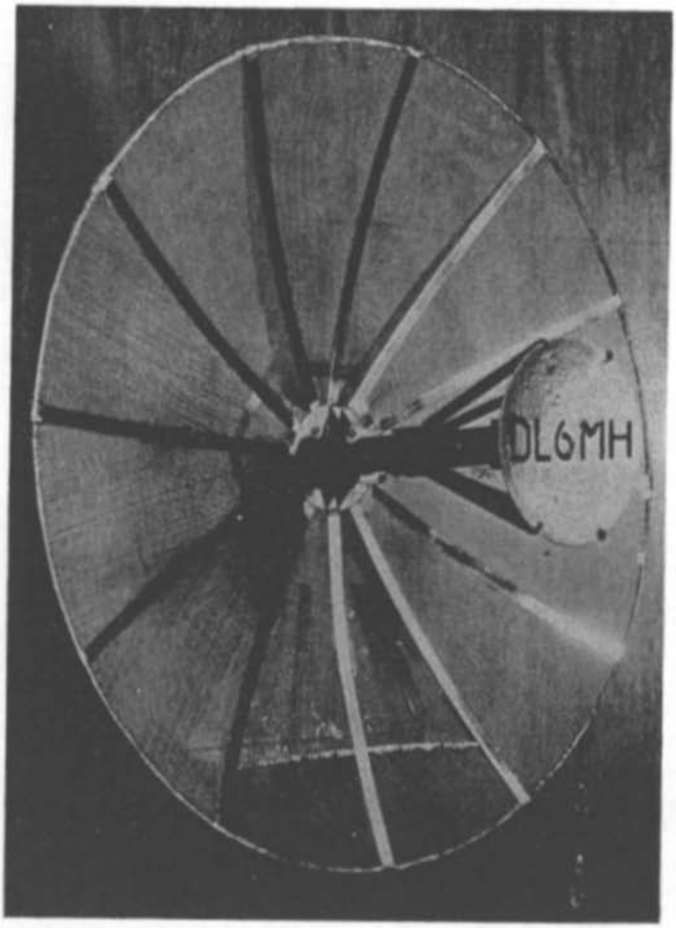

Fig. 13: Combined antenna for the 10 and 24 GHz band with Cassegrain radiator

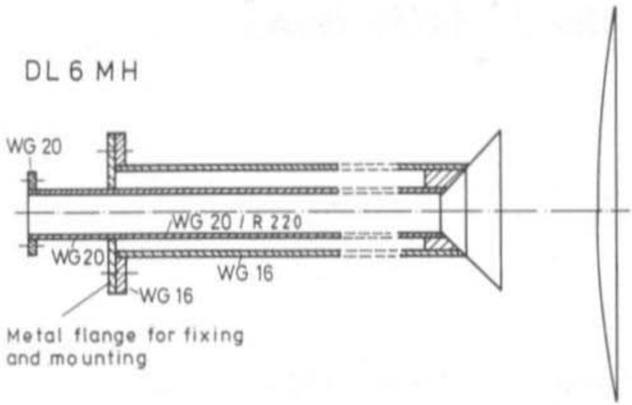

Fig. 14:
Combined radiator for either 10 or 24 GHz

Combined Radiator for 10 GHz and 24 GHz

In order to save using two completely different antennas, the author has developed an antenna that can be used on both bands. In order to ensure that the antenna is also efficient at the higher frequency of 24 GHz, a wire grid of 0.8 mm spacing was used. The diameter of the antenna shown in **Figure 13** amount to 60 cm. A Cassegrain radiator for 10 GHz is fixed in the center of the dish. For 24 GHz, a second waveguide for 24 GHz (WG 20) is inserted into the 10 GHz waveguide (WG 16).

A brass block is soldered into place at the end of the WG 20 waveguide whose external dimensions are such that it just slides into the WG 16 waveguide. The brass block has a rectangular hole with the outer dimensions of the WG 20 waveguide. This aperture is filed out in the form of a horn.

It will be seen in **Figure 14** that the small horn of the 10 GHz radiator forms the extension for the 24 GHz radiator. The rear end of the WG 20 waveguide is screwed to the WG 16 flange.

If the dish is to be used in the 10 GHz band, the 24 GHz waveguide is pulled out and the antenna connected to the 10 GHz station. Since 10 GHz signals are stronger over greater distances than at 24 GHz, and since the dish will possess larger beamwidths at the lower frequency, it is easier to find the required station by setting the antenna up at 10 GHz, after which the dish is fixed into position and the WG 20 waveguide for 24 GHz placed into the WG 16 waveguide. This means that it should be possible to make communications on 24 GHz without directional problems.

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