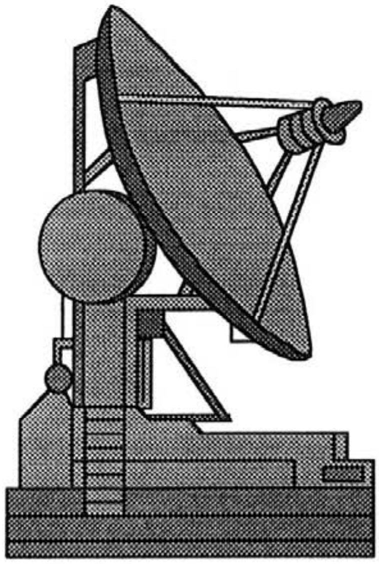
HYPER



BULLETIN D'INFORMATIONS
DES RADIOAMATEURS ACTIFS
EN HYPERFREQUENCES

NUMERO SPECIAL

ANTENNES HYPERFREQUENCES

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Pour " s'abonner " à HYPER :

Envoyer des enveloppes self-adressées et timbrées à 4,20 FF .

PRESENTATION

Une question revient souvent lors de discussions , sur les équipements hyper :

Quelle antenne ou quelle source pour telle ou telle parabole ?

Il est vrai que , grâce aux travaux de DB6NT , G3WDG ou bien d'autres , la réalisation de transverters performants est maintenant simplifiée .

Mais il reste à trouver une bonne antenne , gage de réussite .

Des modèles commerciaux existent mais restent assez chers . Le plus simple est donc de se lancer un peu dans la mécanique (parfois trés peu d'ailleurs) .

C'est pourquoi nous avons préparé cette compilation de tous les articles que nous avons pu trouver à ce sujet .

Ces documents sont extraits des ouvrages ou revues suivantes :

- Toute l'electronique
- VHF-UHF Manual
- The Gunnplexer cookbook
- DARC 10 Ghz SSB TRVT
- Feedpoint
- Hurk Infos
- VHF antennes
- Megahertz Magazine
- UHF VHF Manuel
- Praxis der Mikrowellen antennen
- VHF Communications
- Microwaves Newsletter
- Proceedings Weinheim
- Proceedings Munich
- Proceedings CJ
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SOMMAIRE

Mes remerciements aux Oms m'ayant fait parvenir des articles ou des photocopies d'ouvrages ou de revues :

F5JWF
F1EIT
F1JGP
F1NWZ
F5EFD
F1BJD
F1JEB
G3PHO

ANTENNES HYPER :

GENERALITES

Les antennes hyperfréquences

Une antenne est un composant utilisé pour émettre une radiation dans un milieu (air par exemple). L'application la plus répandue est l'utilisation d'une antenne « émettrice » en regard d'une antenne « réceptrice » permettant ainsi une transmission.

A part quelques cas particuliers (émetteurs ou récepteurs mobiles) il est plus intéressant d'utiliser, pour des faibles distances et des basses fréquences, des lignes de transmissions (câble, guides d'ondes, etc.) tandis que l'utilisation d'antennes semble réservée aux longues distances et hautes fréquences.

Le type de l'antenne sera choisi en fonction de son application, le critère le plus déterminant dans ce choix étant le gain et le diagramme de rayonnement de cette antenne.

Les antennes cornet

Prenons le cas d'une émission hyperfréquence par guide d'onde ouvert.
Nous remarquons les deux faits suivants :
— la ligne est désadaptée (le TOS présenté par l'air face au guide étant de l'ordre de 2) ;
— la transmission est omnidirectionnelle.
Pour palier ces deux inconvénients une antenne cornet permet, par exemple, une meilleure adaptation et une meilleure concentration de l'énergie émise.

Principe

Afin de concentrer une énergie émise, nous venons de voir que l'utilisation d'une antenne était nécessaire. Le diagramme de rayonnement d'une antenne émettrice représente la répartition du champ électrique (ou plus souvent la puissance reçue à une distance constante de l'émetteur) en fonction de la direction de cette antenne par rapport à un récepteur (angle de rayonnement).
Si l'antenne est utilisée comme réceptrice, le diagramme de rayonnement sera le même, mais représentera alors la sensibilité de réception dans diverses directions par rapport à un emetteur fixe.
L'utilisation de coordonnées polaires permet de tracer directement la courbe puissance (dB) en fonction de l'angle d'émission.

Le diagramme de rayonnement est bien entendu à trois dimensions mais, pour des raisons pratiques, il est représenté à deux dimensions et ceci dans un ou plusieurs plans sont différents.
Par exemple pour une antenne cornet, les deux plans considérés sont les plans E et H (fig. 1). Les diagrammes de rayonnement relevés pour dans ces deux plans différents.
Un diagramme de rayonnement est constitué d'un lobe principal et de lobes secondaires (fig. 2). La puissance est concentrée dans le lobe principal et l'on s'efforce en général d'avoir le minimum de puissance dans les lobes secondaires et arrières.
L'angle d'ouverture θ à 3 dB est l'angle directement correspondant à une perte en puissance de 3 dB (par rapport à la puissance nominale).
Le gain G est la puissance maximale du lobe principal comparée à la puissance équivalente d'une source excitant une antenne omnidirectionnelle ou isotropique.
Ce gain prend en compte les pertes propres de l'antenne.
A la sortie d'une antenne, le champ émis est composé de :
— le champ d'induction (proche) ;
— le champ de radiation (éloigné).
Les mesures d'antennes, afin de ne pas être perturbées par le champ d'induction, doivent être effectuées dans le champ de radiation.
On définit comme R la distance entre antennes où le champ de radiation prend naissance. La différence de phase de l'onde reçue est alors inférieure à $\lambda_0 \times 16$ entre le bord et le centre de l'antenne réceptive.

Calculs pratiques

Considérons la figure 3.
$\Delta R = R' - R$
$\Delta R \leq \frac{\lambda_0}{16}$ en négligeant ΔR^2 et en utilisant le théorème Pythagore.
Nous exprimons alors R = distance minimale pour être dans le champ de radiation
$R \geq \frac{2D^2}{\lambda_0}$
La puissance reçue P_R à l'antenne réceptrice est :
— proportionnelle à la puissance émise P_T, au gain G_T de l'antenne émettrice, à la surface équivalente A_{ER} de l'antenne réceptrice ;
— et inversement proportionnelle au carré de la distance séparant les deux antennes :
$P_R = P_R \times G_T \times \frac{A_{ER}}{4 \pi R^2}$
La surface équivalente d'une antenne est donnée par la formule :

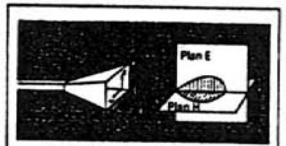


Fig. 1 : Définition des plans E et H

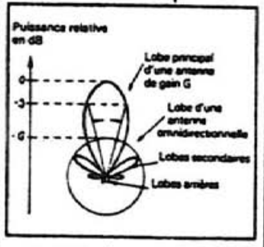


Fig. 2 : Diagramme de rayonnement

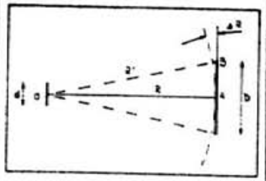


Fig. 3 : Distance minimum entre antennes

$A_E = \frac{G \cdot \lambda_0^2}{4\pi}$ soit $A_{ER} = \frac{G_R \lambda_0^2}{4\pi}$
On a alors :
$P_R = \left(\frac{\lambda_0}{4 \pi R}\right)^2 P_T G_R G_T$
Si les deux antennes sont identiques :
$G_T = G_R = G$
$G^2 = \frac{P_R}{P_T} \left\{\frac{(4 \pi R)}{\lambda_0}\right\}^2$

Seul le rapport $\frac{P_R}{P_T}$ est à connaître.
Si l'on utilise un détecteur, dans son régime quadratique, ce rapport est aisément mesurable.
La formule (1) exprimée en dB devient :
$G_{dB} = \frac{1}{2}[P_R - P_T]_{dB} + \left\{\frac{4 \pi R}{\lambda_0}\right\}$

Technique des mesures

Pour toutes les mesures d'antennes, certaines précautions sont à prendre.
1) Eviter les réflexions sur des obstacles proches.
2) Séparer les deux antennes d'une distance minimale
$R = \frac{2D^2}{\lambda_0}$
3) Eviter la réflexion du sol : positionner les antennes à une hauteur minimum h telle que :
$h = \frac{D^2}{d}$
D = dimension la plus large de l'antenne réceptrice
d = dimension la plus large de l'antenne émettrice.

Calcul d'erreurs

Nous avons vu que le gain s'exprimait comme suit :
$G_E G_R = \frac{P_R}{P_T}\left(\frac{4 \pi R}{\lambda_0}\right)^2$

en passant en logarithmes et en exprimant les erreurs en valeurs relatives nous obtenons :

$$\frac{\Delta G_E}{G_E} + \frac{\Delta G_R}{G_R} = \frac{\Delta R}{R} + \frac{\Delta \lambda_0}{\lambda_0} + \frac{\Delta(P_R/P_T)}{P_R/P_T}$$

Si : R = 1,5 m $\frac{\Delta R}{R} = 0{,}04$ dB
Cette valeur décroît si R croît.

$\frac{\Delta \lambda_0}{\lambda_0} = 0{,}0013$ dB.

Cette valeur peut donc être négligée.
$\frac{\Delta(P_R/P_T)}{P_R/P_T}$ est de l'ordre de 0,5 dB, relativement importante. Cette valeur de plus s'additionne aux erreurs dues à la mesure (réflexion... etc.).
La dernière source d'erreur est enfin la désadaptation du système et entraîne une erreur de l'ordre de 0,2 dB.

Les antennes paraboliques et les antennes à fentes

Spécifiques des hyperfréquences, les antennes paraboliques et les antennes à fentes ont des domaines d'application différents. Leurs principales caractéristiques sont étudiées ci-après.

Les antennes paraboliques

Les antennes paraboliques sont constituées d'une source primaire et d'un réflecteur. L'illumination du réflecteur par la source primaire peut être soit directe soit indirecte. Dans ce dernier cas un sous réflecteur est nécessaire.
L'antenne SL 19700 est du premier type.
La géométrie de l'antenne (fig. 4) est donnée :
— en coordonnées rectangulaires :
$y^2 = 4fx = 4Dx(f/D)$,
avec $f = D^2/16c$;
— en coordonnées sphériques,
$\rho = \frac{2f}{1 + \cos \psi}$
La propriété de base des antennes paraboliques est de transformer l'onde sphérique issue d'une source située à distance focale F en onde plane (plan A' A"). Réciproquement, toute énergie reçue dans le plan A' A" est focalisée au point F.
L'analogie avec un miroir optique nous permet de dire que la distance de F au plan A' A" est constante soit :
$FOA = FP_1 = FP_0A_0 = f + c =$ constante.

Ainsi différents rayons émis de F sont en phase dans tout le plan A'A" (plan d'ouverture).
Une portion de l'énergie émise par la source primaire est cependant rayonnée à l'extérieur de la parabole ; ceci est appelé le phénomène de débordement « spill-over ».
Les antennes paraboliques sont les plus utilisées en hyperfréquences. En effet elles peuvent être utilisées à n'importe quelle fréquence et théoriquement à fréquence donnée, leur gain peut être choisi en fonction de la formule :
$G = 4 \pi A_E/\lambda_0^2$.
A_E = surface effective (surface d'ouverture).
Si l'on double le diamètre du réflecteur, A_E est multiplié par 4, il s'en suit donc une augmentation de gain de 6 dB.
D'autre part, si l'on augmente le diamètre du réflecteur, le faisceau émis sera plus large.
Nous avons vu que la source primaire émettait une énergie hors du réflecteur.
Lorsque le diamètre de cette source primaire est inférieur à 0,3 D, (D diamètre du réflecteur), la perte de gain peut être estimée inférieure à 1 dB.

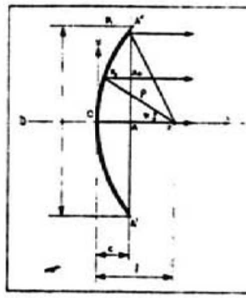


Fig. 4 : Géométrie d'une antenne parabolique

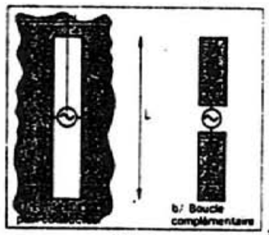


Fig. 5

Les antennes à fentes

Les antennes à fentes sont très utilisées pour la mesure de vitesse de véhicules se déplaçant très rapidement. Il est en effet nécessaire de réduire au minimum la résistance de l'air, donc d'utiliser au maximum des ouvertures d'antennes faibles.
Considérons (fig. 5) une ligne de transmissions constituée de deux demi-plans court-circuités et alimentés par une source de courant. Le champ électrique varie dans la direction de la transmission et est couplé aux fentes.
Si nous prenons comme hypothèse que les plans de conduction sont infinis, le principe de *Babinet* nous montre que la distribution du champ électrique (courant magnétique) dans les fentes est identique à la distribution d'un champ électrique dans une boucle (fil électrique de faible section).
Si la longueur L de la fente est égale à λ/2 (λ = longueur d'onde dans le guide) la radiation est alors identique à celle créée par un fil de longueur λ/2.
La figure 6 montre les différentes possibilités pour créer des fentes « ac-

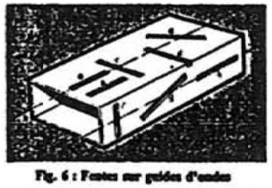


Fig. 6 : Fentes sur guides d'ondes

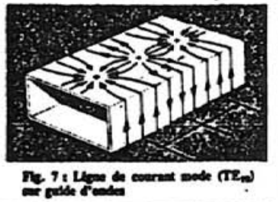


Fig. 7 : Ligne de courant mode (TE_{10}) sur guide d'ondes

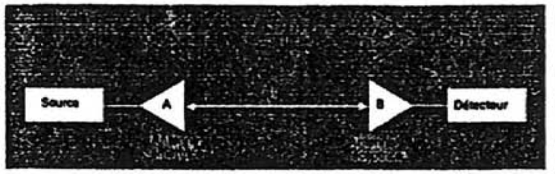


Fig. 8 : Principe de mesure. Méthode des 3 antennes.

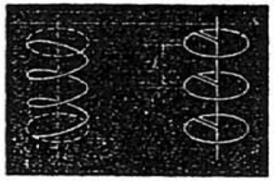


Fig. 9 : Antenne hélice

Fig. 10 : Décomposition d'une onde z'oz dans le plan xoy.

tives » dans un guide d'ondes. Il suffit de couper les lignes de courant (figure 7). Les fentes a et f de la figure 6 ne rayonneront donc pas.
Les fentes sont en général du type cavité, afin de concentrer le champ dans un seul plan. Afin d'obtenir une antenne à faisceau étroit, il est courant de percer plusieurs fentes. Celles-ci sont disposées tous les λ/2 par rapport à l'axe de symétrie du guide afin de respecter la cohérence de phase.

Calcul du gain

Lorsque l'on ne dispose pas de deux antennes identiques, il est possible de calculer le gain d'antennes de technologie différente grâce à la méthode dite des trois antennes.
La figure 8 montre le principe de mesure.
Si nous commençons par utiliser les antennes A et B puis A et C et finalement B et C, nous disposons de trois équations à trois inconnues (à condition de garder R et λ constants.
R = distance entre ouvertures.
λ = longueur d'onde d'émission

$$G_A G_B = \left\{\frac{4\pi R}{\lambda_O}\right\}^2 \left.\frac{P_R}{P_T}\right|_1 \qquad 1)$$

$$G_A G_C = \left\{\frac{4\pi R}{\lambda_O}\right\}^2 \left.\frac{P_R}{P_T}\right|_2 \qquad 2)$$

$$G_B G_C = \left\{\frac{4\pi R}{\lambda_O}\right\}^2 \left.\frac{P_R}{P_T}\right|_3 \qquad 3)$$

soit $(= K4\pi R/\lambda_O)^2$

En divisant membre à membre (1) et (3) nous obtenons :

$$\frac{G_A}{G_C} = \frac{\left.\frac{P_R}{P_T}\right|_1}{\left.\frac{P_R}{P_T}\right|_3} \quad \text{soit } G_C = G_A \frac{\left.\frac{P_R}{P_T}\right|_3}{\left.\frac{P_R}{P_T}\right|_1}$$

En remplaçant G_C par sa valeur dans (2) nous avons :

$$G_A^2 = K \cdot \left.\frac{P_R}{P_T}\right|_1 \cdot \left.\frac{P_R}{P_T}\right|_2 \cdot \left.\frac{P_T}{P_R}\right|_3$$

Soit, en décibels :

$$G_A = \frac{1}{2}\left(K + \left.\frac{P_R}{P_T}\right|_1 + \left.\frac{P_R}{P_T}\right|_2 + \left.\frac{P_R}{P_T}\right|_3\right)$$

La connaissance de G_A nous permet d'en déduire G_B et G_C.
Il est donc possible de calculer le gain de trois antennes différentes sans connaître a priori le gain de l'une d'entre elles. Seul le rapport des puissances transmises et réfléchies est à mesurer.

Les antennes hélice

Les antennes hélice sont certainement les antennes les plus simples à réaliser et à utiliser lorsque l'on désire avoir une polarisation circulaire.
En effet ce type d'antenne conserve à la fois son impédance et ses propriétés de radiation pour une gamme très étendue de fréquences.

Modes de radiation
Une antenne hélice a deux modes principaux de radiation : le mode transversal et le mode axial. L'intensité maximale du champ électrique est alors respectivement perpendiculaire ou parallèle à l'axe de l'hélice.
Le premier mode a lieu lorsque la dimension de l'hélice est faible comparée à la longueur d'ondes ; le second apparaît lorsque la longueur d'un tour de l'hélice est du même ordre de dimension que la longueur d'ondes.
Une antenne hélice ne doit pas être considérée comme un type spécial d'antenne mais comme un cas particulier des antennes brins ou à boucles (fig. 9).
La polarisation circulaire est basée sur deux critères : les champs traversés doivent être d'intensité égale et en quadrature.
L'axe de l'hélice (*l*) rayonne comme un dipole électrique tandis que la surface (A) équivalente à un tour (perpendiculaire à l'axe) rayonne comme un dipole magnétique.
Chacune de ces radiations est proportionnelle au moment du dipole.
Si un courant alternatif d'amplitude I et de pulsation ω traverse un conducteur de faible longueur *l*, le moment électrique est alors ;

$$l\int I dt = \frac{Il}{j\omega}$$

Ce même courant traversant une boucle de surface A dans un milieu de perméabilité μ crée un moment magnétique μ IA.
À une distance R, les champs de radiation résultant de ces deux dipoles sont proportionnels aux moments des dipoles d'origine.
Parallèlement à l'axe des dipoles, le rapport des flux est alors :

$$\frac{j\omega\mu H_m}{j\omega\epsilon E_e} = \frac{IA\mu}{Il/j\omega}$$

Si nous appelons H_e et E_m les intensités magnétiques et électriques issues des dipoles électriques nous avons :

$$\frac{E_e}{H_e} = \frac{H_m}{E_m} = \sqrt{\frac{\mu}{\epsilon}} = Z.$$

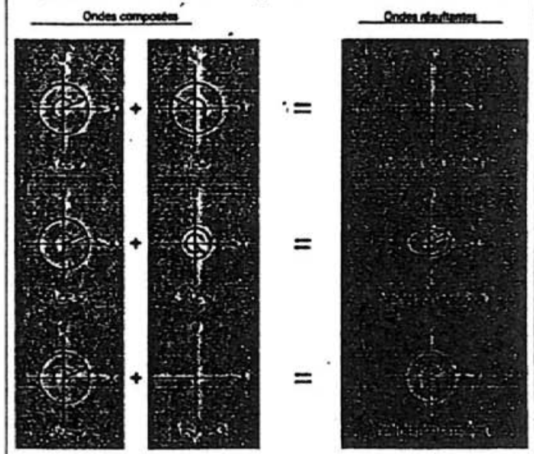


Fig. 11 : Une onde elliptique résultant de deux ondes polarisées circulairement.

donc $\frac{E_m}{E_e} = \frac{H_m}{H_e} = Z\frac{H_m}{E_e} = \frac{j\omega\mu A}{Zl}$

Les champs E_m et E_e puis H_m et H_e sont donc en quadrature.
La condition d'égalité en intensité est vérifiée si

$$A = \frac{l}{\omega\sqrt{\mu\epsilon}}$$

Théorie de la polarisation

Soit une onde A(t) propagée selon l'axe z'oz (fig. 10). Cette onde peut se décomposer en deux vecteurs orthogonaux :
A(t) = Ax (t) + Ay (t).
Si nous considérons une onde sinusoïdale de pulsation ω = 2πf nous avons :
$A(t) = A_x \cos\omega t + A_y \cos(\omega t + \delta)$,
Ax(t) étant maximale lorsque t = 0 et δ représentant l'angle de phase entre Ax et Ay. Dans le plan xoy le vecteur A(t) varie en fonction du temps, l'extrémité de A(t) décrit donc une ellipse appelée ellipse de polarisation.

Nota :
— Si Ax = 0 ou Ay = 0
ou δ = 0 ou δ = 180°
A(t) sera en polarisation rectiligne.
— Si Ax = Ay et δ = 90° ou δ = 270°
A(t) sera en polarisation circulaire.
Si δ est dans le troisième ou quatrième quadrant, A(t) tourne de x'ox vers y'oy, l'onde est alors dite « de pas à droite » (sens inverse des aiguilles d'une montre) dans le cas inverse l'onde est dite « de pas à gauche ».

La polarisation elliptique peut aussi être considérée comme la somme de deux ondes de polarisation circulaire (fig. 11).
Nous avons envisagé la polarisation d'une onde quelconque A en fonction des paramètres qui lui sont liés. En général, la polarisation est exprimée en fonction du vecteur champ électrique dirigé dans le sens où la radiation est la plus forte.
Ainsi un dipole placé verticalement (par rapport au sol) créera une polarisation verticale.
Comment une antenne cornet PM 7320 X/01 rayonne-t-elle ?
En théorie, il est impossible de recevoir un signal émis en polarisation horizontale par une antenne polarisée verticalement. Cependant, les imperfections des antennes ainsi que les réflexions diverses permettent une détection.
Les réflexions entraînent des glissements de fréquences ; la réflexion sur un réflecteur (miroir) crée un glissement (déphasage) de 180°.
Il s'ensuit donc qu'une onde « de pas à droite », après réflexion sur un réflecteur, devient une onde « de pas à gauche ».
Pour mesurer le gain d'une antenne non linéaire, il suffit de mesurer les gains respectifs décomposés dans deux directions orthogonales et d'en faire la somme. ■

Bibliographie : Philips, Sivers Lab, Expériences de base en Hyperfréquences.

Les paraboles

Parabolic dishes

Antennas based on paraboloidal reflectors are the most important type for the microwave bands. Their main advantages are that in principle they can be made to have as large a gain as is required, they can operate at any frequency and they should require little setting up. Disadvantages are that they are not the easiest things to make accurately, which limits the frequency at which a given dish can be used, and large dishes are difficult to mount, and may have a high windage.

The basic property of a perfect paraboloidal reflector is that it converts a spherical wave emanating from a point source placed at the focus into a plane wave, ie the image of the source is focused at an infinite distance from the dish. Conversely, all the energy received by the dish from a distant source is reflected to a single point at the focus of the dish.

The geometry of the paraboloid

A paraboloid is generated by rotating a parabola about a line joining its origin and focus. Two methods for constructing a parabola are given below:

By calculation

Convenient forms of the equations of a parabola are, using the notation of Fig 136:

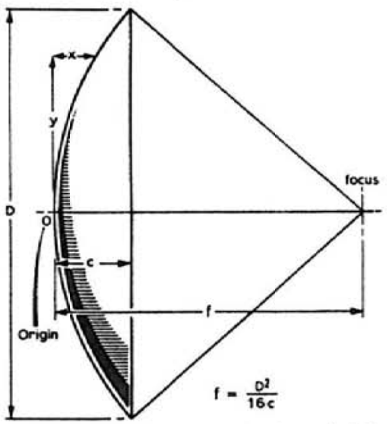


Fig 136. Basic geometry of a paraboloid

$$y^2 = 4fx \quad (1)$$

$$y^2 = 4Dx(f/D) \quad (2)$$

where $f = \frac{D^2}{16c}$

where y has both negative and positive values
D = diameter of corresponding dish
f = focal length
c = depth of parabola at its centre

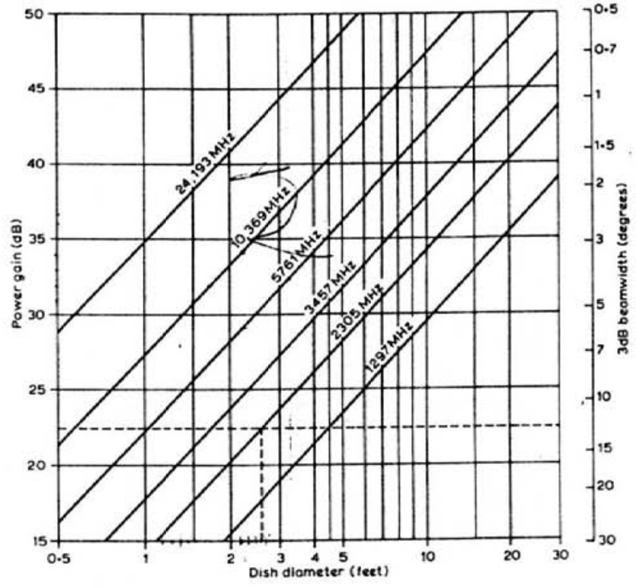
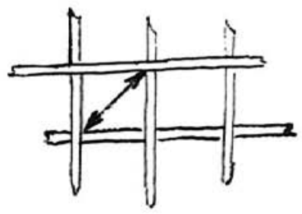


Fig 138. Relationship between the size of a dish and its gain and beamwidth as a function of frequency. An overall efficiency of 50 per cent is assumed. As an example, a dish 2·5ft in diameter at 2,305MHz will have a gain of 22dB and a beamwidth of about 12°

Paraboles grillagées

Note: La maille doit être telle que la diagonale soit inférieure à λ/10



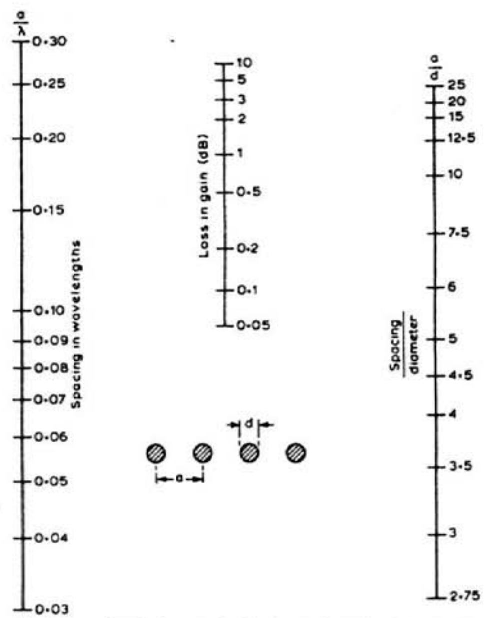


Fig 140. Loss in gain for a mesh reflector as a function of mesh size

Illumination des paraboles

Optimum-feed Beamwidth As A Function of f/D

The optimum-feed beamwidth in degrees at both the 3- and 10-dB down points, for illuminating a parabolic reflector whose edges intercept the beam at the 10-dB-down level for *f/D* ratios of 0.25 to 1.1, is shown in the following table.

f/D	3-dB beamwidth (deg.)	10-dB beamwidth (deg.)	f/D	3dB beamwidth (deg.)	10db beamwidth (deg.)
0.25	155	180	0.70	46	83
0.30	120	165	0.80	40	73
0.40	83	150	0.90	35	64
0.50	65	120	1.00	31	57

9.74 VHF/UHF MANUAL

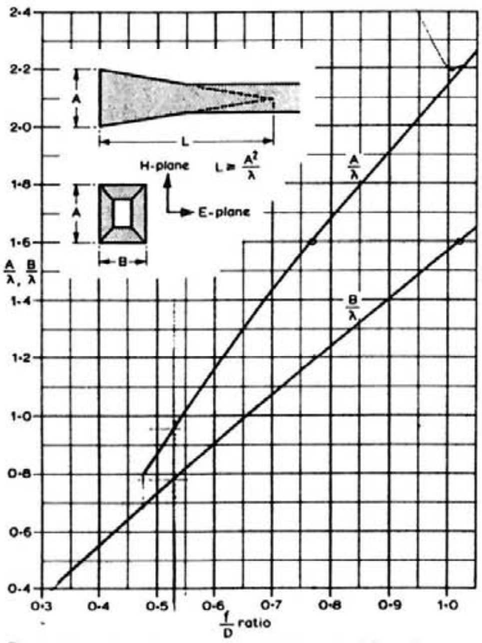


Fig 157. The dimensions of a pyramidal horn feed for a dish as a function of the ratio of focal length to diameter

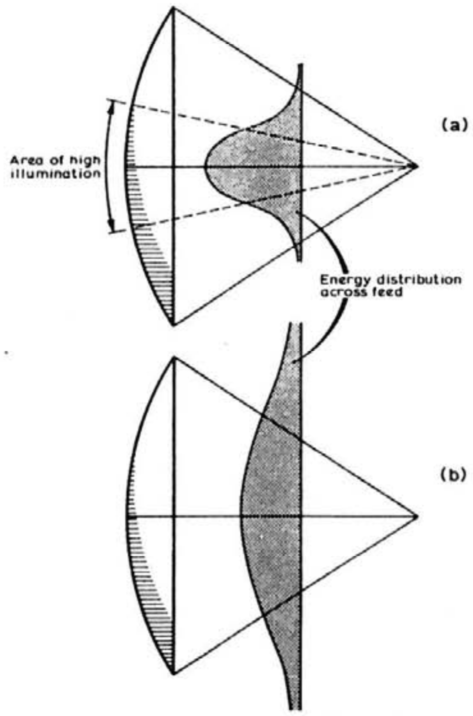


Fig 149. Non-optimum illumination of a dish. (a) Under-illuminated. (b) Over-illuminated

As an example of the design of a horn for a specific dish, consider a dish of diameter $D = 36$in, which has a depth at its centre $c = 4{\cdot}26$in, to be fed at 10,050MHz for which $\lambda = 1{\cdot}174$in. The focal length of the dish is given by $D^2/16c = 19{\cdot}0$in, and the *f/D* ratio therefore is 0·53. From Fig 157 the values corresponding to this ratio are:

H-plane aperture $A/\lambda = 0{\cdot}96$:
$A \times 0{\cdot}96 \times 1{\cdot}174\text{in} = 1{\cdot}127\text{in}$
E-plane aperture $B/\lambda = 0{\cdot}78$:
$B = 0{\cdot}78\text{in} \times 1{\cdot}74\text{in} = 0{\cdot}916\text{in}$
$L \geq A^2/\lambda = 1{\cdot}127^2/1{\cdot}174 = 1{\cdot}081\text{in}$.

At this frequency, a convenient waveguide is WG16, so a practical horn would have an aperture of 1·127in by 0·916in tapering to 0·9in by 0·4in, and this design is shown in Fig 156.

By the same process of design, a horn feed for any dish with the same *f/D* ratio but for 1,296MHz would have an aperture of 8·74in by 7·10in, tapering to 6·5in by 3·25in, if WG6 were used, and one for 24GHz would have an aperture of 0·472in by 0·384in tapering to 0·420in by 0·170in for WG20.

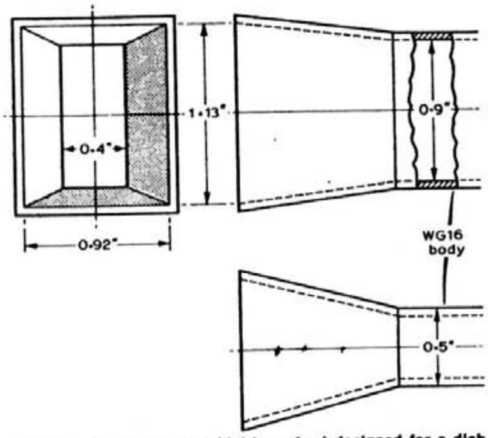


Fig 156. A typical pyramidal horn feed designed for a dish having an f/D ratio of 0·53 for use at 10GHz

Cornets

Large horn antennas

Large pyramidal horns are an attractive form of antenna, particularly for use at the highest microwave frequencies. They are fundamentally broadband devices which show a virtually perfect match over a wide range of frequencies. They are simple to design, tolerant of dimensional inaccuracies in construction and they need no adjustment. Horns are especially suitable for use with transmitters and receivers employing free-running oscillators, the frequency stability of which can be very dependent on the match of their load. Another advantage is that their gain can be predicted within a decibel or so, which makes them useful in both initially checking the performances of systems and also in acting as references against which the performance of other types of antennas can be judged. Their main disadvantage is that they are bulky compared with other types of antenna having the same gain.

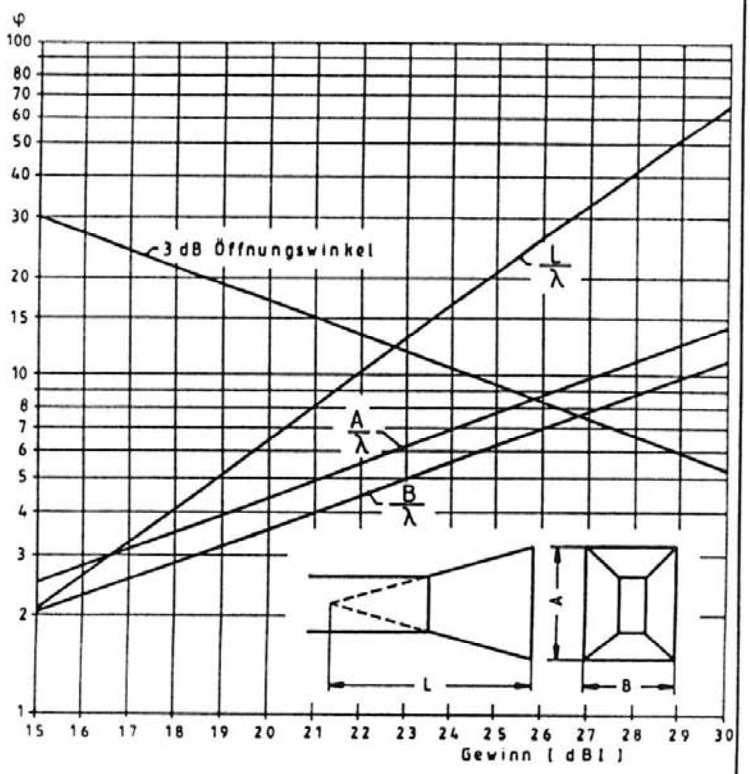
An example of a horn antenna for 10GHz is shown in Fig 171. It consists of a length of waveguide appropriate for the frequency of use, which is smoothly flared in both planes so that a wave inside the guide can expand in an orderly manner. When the length of the horn is very large compared with the aperture, the wave emerging is nearly planar and the gain of the antenna is close to the theoretical value: $4\pi AB/\lambda^2$, where A and B are the dimensions of the aperture. For a horn of moderate length, the wave is spherical with its centre at the apex of the horn. Accordingly, the field near the rim lags in phase compared with that along the centre line of the horn and this causes a loss of gain. If the length of the horn is reduced further so that this phase lag exceeds $\lambda/2$, then large minor lobes will be produced. A practical horn is therefore a compromise between achieving the desired directional pattern and reducing the overall length of the horn.

The dimensions of an optimum horn and the approximate 3dB beamwidth are shown in Fig 172. The dimensions are given in terms of wavelengths, the actual measurements of course are obtained by multiplying the values by the wavelength in air at the design frequency. Fig 172 is based on the following relationships which assume an efficiency of 50 per cent:

$A/\lambda = 0{\cdot}443\sqrt{G}$ where G = gain in absolute value
$B = 0{\cdot}81A$
$L/\lambda = 0{\cdot}0654G$

Dimensionen für optimale Hornantennen

$A = \varphi \cdot \lambda$
$B = \varphi \cdot \lambda$
$L = \varphi \cdot \lambda$
$\lambda = \frac{300\,000}{f\,[\mathrm{MHz}]} = [\mathrm{mm}]$ für 10.368 MHz $\lambda = 28{,}935$ mm



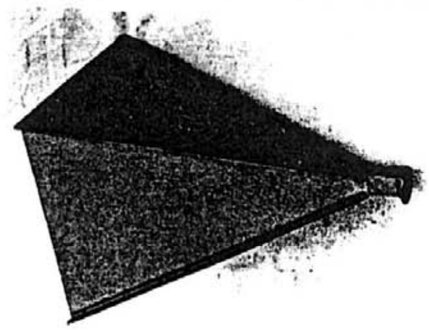


Fig 171. A large horn antenna for 10GHz

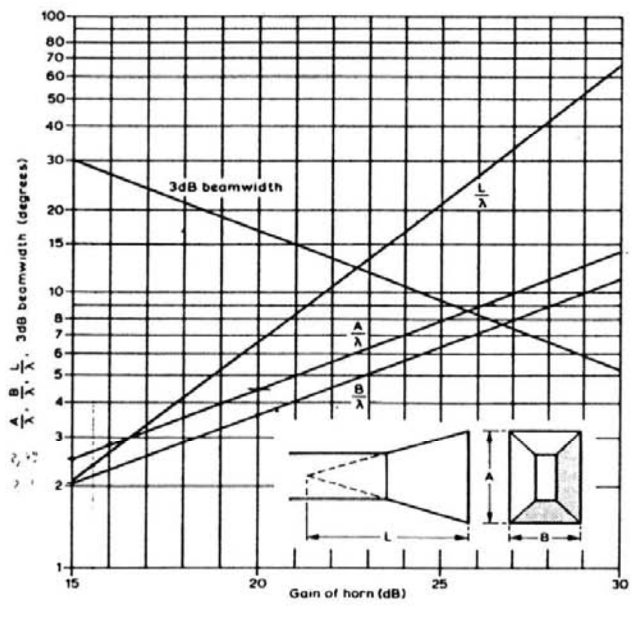


Fig 172. The dimensions and beamwidth of an optimum horn antenna

As an example of the use of this data, consider the design of a 20dB horn for use at 5,760MHz, for which $\lambda = 2{\cdot}05$in. From Fig 172:

$A/\lambda = 4{\cdot}4$; $A = 4{\cdot}4 \times 2{\cdot}05 = 9{\cdot}0$in
$B/\lambda = 3{\cdot}6$; $B = 3{\cdot}6 \times 2{\cdot}05 = 7{\cdot}4$in
$L/\lambda = 6{\cdot}5$; $L = 6{\cdot}5 \times 2{\cdot}05 = 13{\cdot}3$in

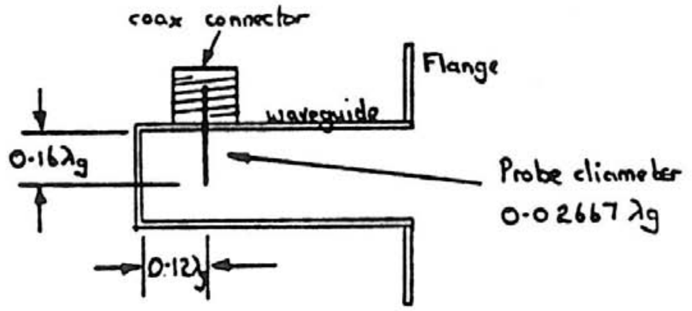
So the horn would have an aperture of 9 by 7·4in, tapering over a length of 13·3in to 1·372 by 0·622in if WG14 were used. The 3dB beamwidth of the horn would be approximately 16°.

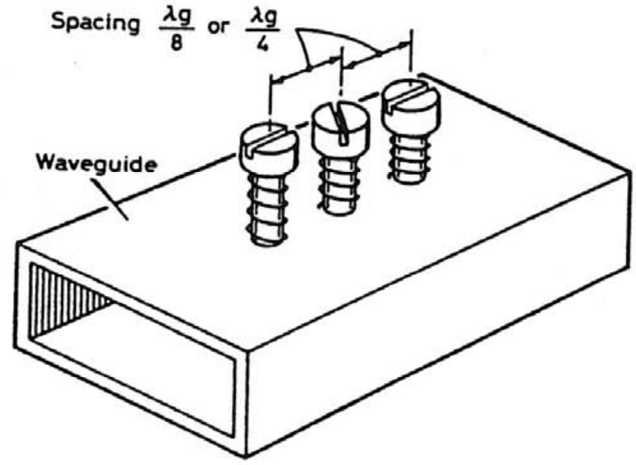
As a second example, a 30dB horn for 24GHz would have an aperture of 6·7 by 5·1 in and a length of 30·7 in.

Note that for a given aperture, the optimum length L varies inversely with frequency. If a horn is used at a somewhat higher frequency than that for which it was designed, its gain will be marginally less than the predicted value. If used at a much higher frequency, then gross distortion of its radiation pattern may occur with consequent serious loss in gain.

At the lower microwave frequencies, the bulkiness of horns becomes a significant disadvantage, and therefore they are little used. For example, a 20dB horn for 1,296MHz would have an aperture 40 by 33in and a length of 5ft. The same gain could be achieved by a parabolic dish about 3½ft in diameter or a single long Yagi.

Transitions Guide - Coaxial

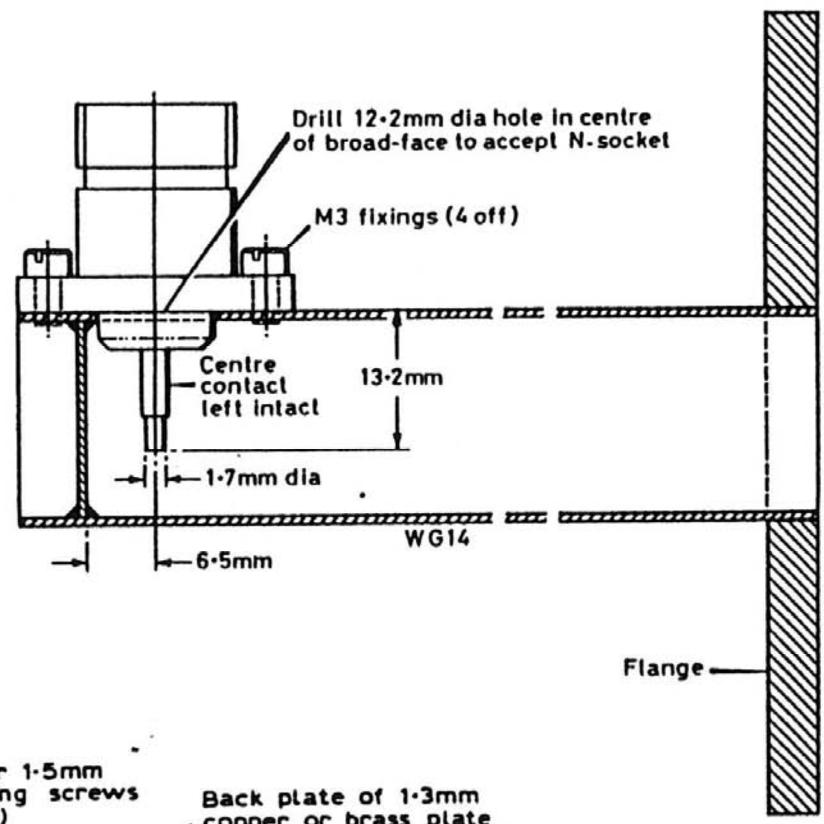


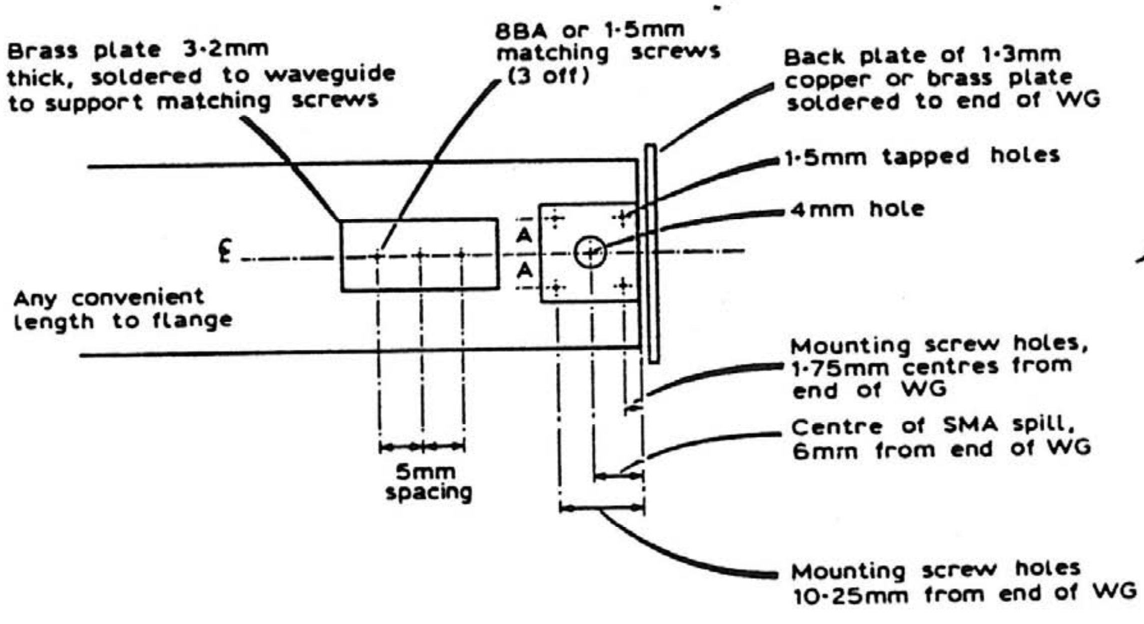


The design is based upon some results for 10GHz supplied by G3JVL, when the above dimensions are required (in terms of waveguide wavelength) to produce a transition to a 50 Ohm transmission line.

An alternative to making the length between the probe and back plate 0.12λg is to make it 0.62λg. This then means there is sufficient room to include a tuning screw, so that there is effectively some adjustment of this length possible. Making the probe removable - bolting rather than soldering - will make it easy to trim the length of the probe if the ultimate in performance is sought.

5,7GHz





10GHz

ROUND-TO-RECTANGULAR WAVEGUIDE TRANSITION
FOR X-BAND

A simple and easy to make X-band waveguide transition from dominant mode rectangular to dominant mode circular waveguide is presented. The design uses standard 3/4 inch Type-M copper water pipe for the circular waveguide and a brass rectangular flange for WR-90 (small X-band, 1/2 x 1 inch O.D. guide) rectangular guide.
The copper pipe is readily available at popular home repair stores, hardware stores and plumbing supply houses in the U.S.A. Rectangular flanges can often be removed from odd parts obtained at radio flea markets. Although choke flanges (ones with the circular groove around the guide face) reduce leakage from the flange interface, the plain flat surface flanges are easier to use.

The transition is made by squeezing one end of an 8 inch length of copper pipe using two blocks of wood and a vise or C-clamp. The taper should be smooth over the entire length without distorting the circular end. A snug fitting wooden dowel may be used to maintain the integrity of the circular end.
The rectangular end is fitted with a rectangular metal bar mandrel made to the inside dimensions of the rectangular waveguide, 0.40 x 0.90 inches. The mandrel bar should have its first half-inch edges rounded so that it will initially fit into the squeezed end of the pipe.
With the mandrel kept firmly into the pipe, a hammer may be used to swedge the soft copper into the exact rectangular shape. As the swedging proceeds the mandrel is forced further into the pipe until a section of the pipe approximately 1/2 inch long is formed into the required rectangular shape.
Visually inspect the taper inside from the round end to determine if the taper is symmetric with respect to the rectangular end. If not, the blocks and clamp may be used along the taper to "true" it up.

It is fortunate that the outer circumference of the 3/4 inch copper pipe is almost the same as the outer perimeter of the standard rectangular WR-90 waveguide, so that the copper pipe after being squeezed into a taper, can also be swedged into a rectangular shape that will fit into the rectangular flange opening.
This waveguide transition may be scaled to other size guide provided that a suitable copper pipe can be found which satisfies the perimeter requirement.

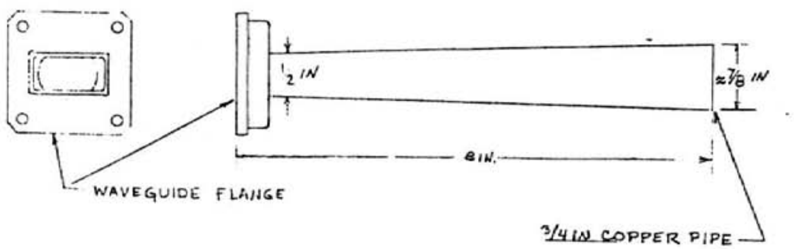
Fit the rectangular end of the pipe into the flange, making adjustments so that the fit is snug and inner walls of the swedged pipe are parallel with the flange edges. Small rounding of the swedged corners can be tolerated since the waveguide electrical fields are small in the corners. Allow the pipe to protrude out of the flat face of the flange by a small amount. This can be filed off after sweating the parts together.

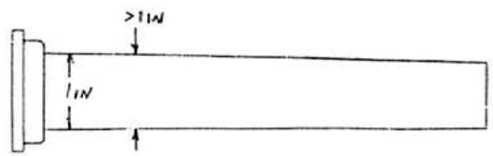
Clean the surfaces that will be soldered together using a fine sandpaper or emery cloth, apply soldering paste then press the parts together and stand vertically (flange down) using a simple clamp jig to hold the parts. Using a carpenters square (or what ever is available) check and adjust the plumb of the waveguide to be exactly square with the flange face (two planes), then sweat the flange in place using a propane torch and core-less solder.

Carefully file away the protruding copper pipe at the flange face, being careful not to file into the flange. For a good final finish, the flange face may be lapped (in the manner of grinding a quartz crystal) using a flat surface and a sheet of fine-medium sandpaper or emery cloth.

The final assembly should look like Figure 1. Note that the copper pipe will bulge in the wide dimension near the flange end. This is to be expected from the simple squeezing technique of fabrication.

While there are numerous ways that a round-to-rectangular transition may be made, the one described here is the easiest to build and will give most satisfactory results for minimum effort. Much shorter transitions are available which use step-tapers that require careful machining. The longer transition described here is to insure smooth impedance and mode conversion with no adjustments or critical dimensions.



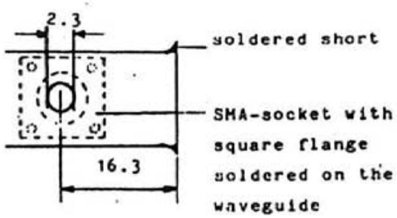


24 GHz

Adapter coax-waveguide

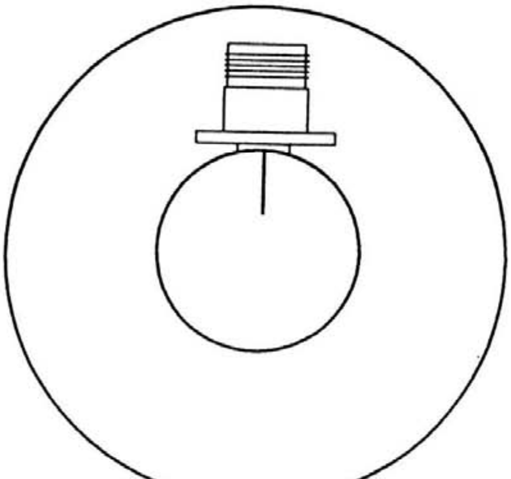
The coupling from a coaxial line to a waveguide can be realized by a capacitive probe which is brought into the maximum of the electrical field. Usually the first maximum is used which is spaced Lambda H/4 from the short of the waveguide.
On 24 GHz this dimension is to small (abt. 5mm) that one will have difficulties mounting a SMA socket on the waveguide.
Such adapter was built with a coupling in the second maximum which is 3 Lambda H/4 (16.3mm) spaced. The bandwith reduction is not important for amateur radio application.
The coupling probe is the inner conductor of the SMA socket without any modification.
The hole which is drilled into the wall of the waveguide has a diameter of 2.3 mm and gives with the conductor of the socket (1.27mm) an impedance of 50 Ohm. Insertion loss measurement has shown that this adapter, compared with a commercial one, has the same performance.

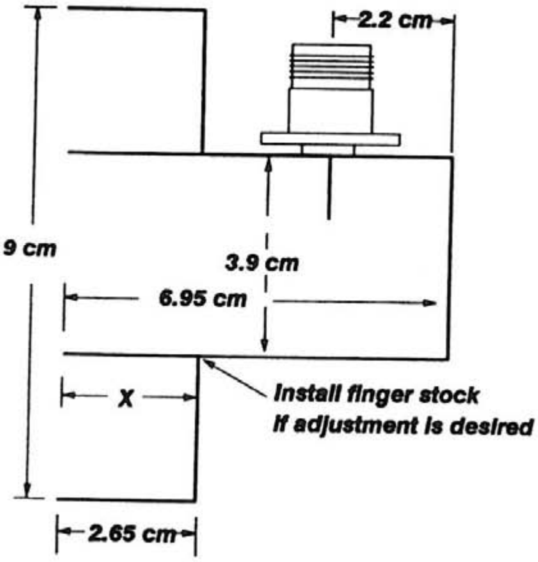
Standard waveguide
a = 10.67 mm
b = 4.32 mm

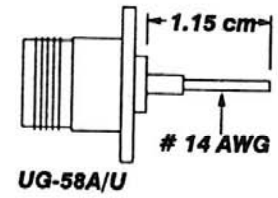


SOURCES 5,7 Ghz

VE4MA 5760 MHz LINEAR POLARIZATION FEEDHORN







Distance X (cm) can be varied for different f/D ratios

f/D	0.5	0.45	0.40	0.35	0.30	0.25
LoNoise	2.13	2.27	0	2.84	3.1	3.2
MaxGain	2.52	0	2.9	3.1	3.3	N/A

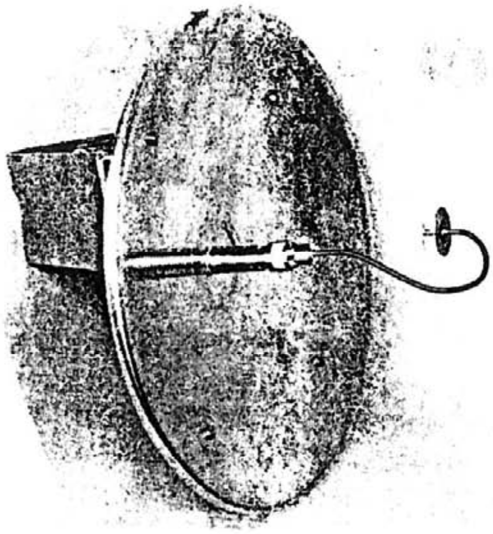
Hole drilled for connector is 3/8 in (0.953 cm).

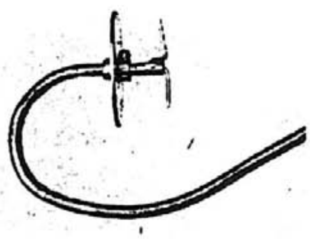
Main waveguide is 1.5 inch Copper Water Pipe

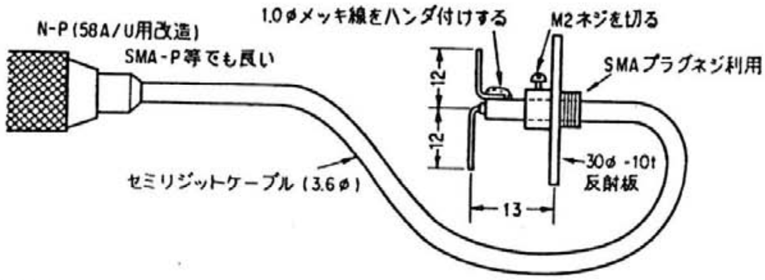
VSWR measured 1.12: 1 (25 dB return loss) With Ring

VSWR measured 1.08: 1 (29 dB Return Loss) No Ring

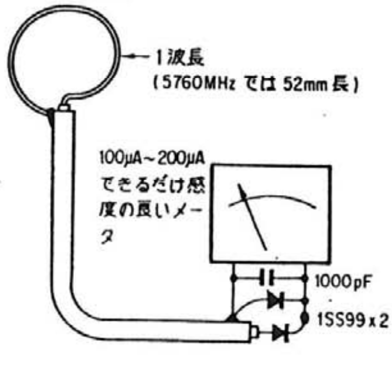
Connector is supported on horn surface using 2 #4-40 screws, then soldered. Do not allow screws to penetrate into main W/G. Fill area under connector with Epoxy for mechanical strength



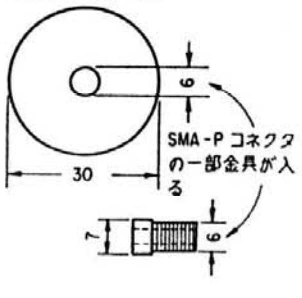




簡易電界強度計



反射板の製作例



5760 MHz Dish Feed:

JA1VOK passing along this interesting and simple dish feed. The article also includes a microwave Field Strength Meter. All dimension are in millimeters, just a few scaling factors and feed will work fine on 2304, 3456, or 10368 MHz.

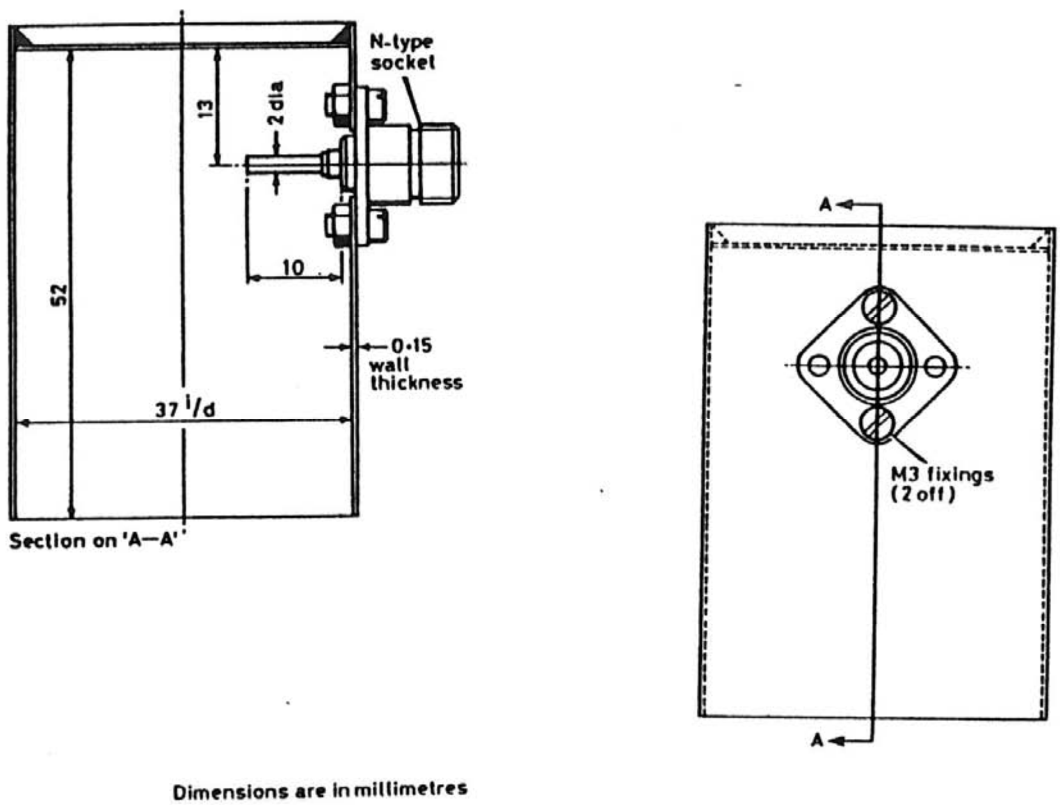
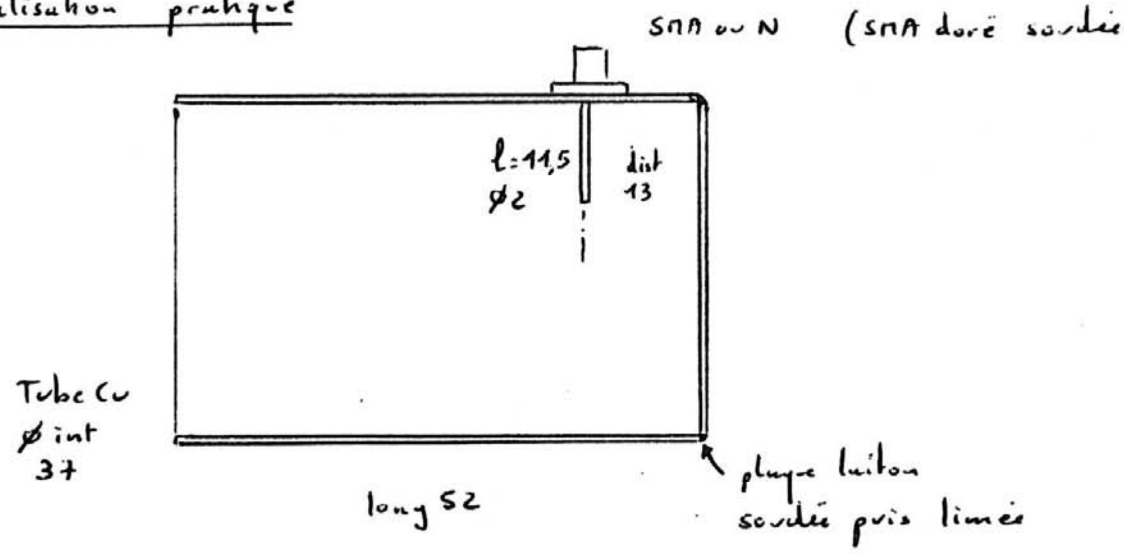


Fig 17.23. 5.7GHz feed horn. Although an N-type socket is shown, an SMA socket could equally well be used

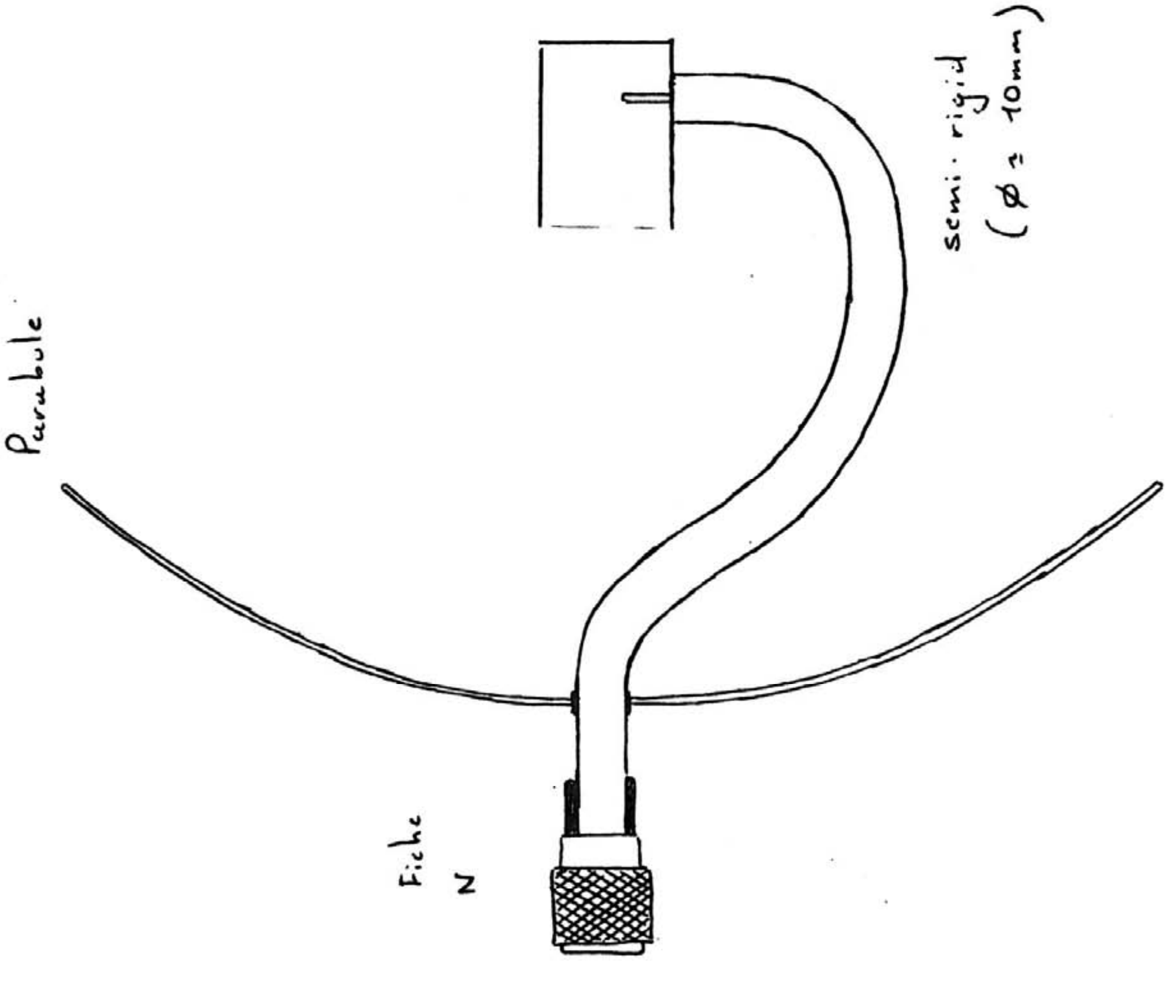
<u>Realisation pratique</u>



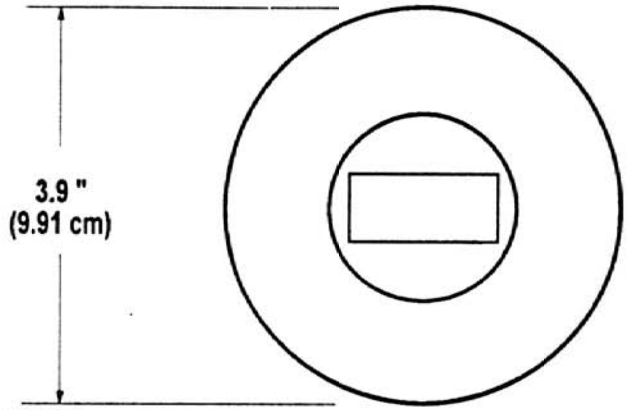
Autre possibilité de montage :

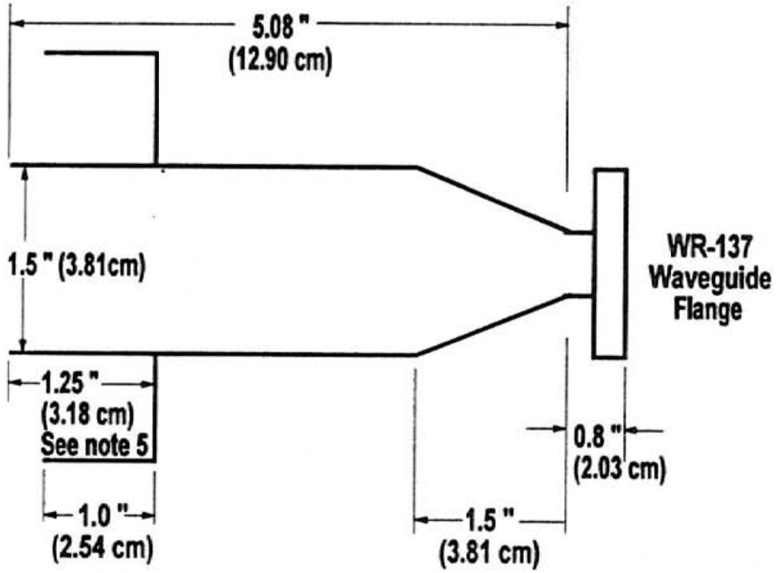
(utilisé par F1JGP/p sur une idée de F6CGB)

Le semi-rigid doit avoir un certain diamètre afin que l'ame fasse ø 2mm. (ou alors monter une sonde de 2mm sur l'ame de petit diamètre)



5760 MHz LINEAR POLARIZATION FEEDHORN WITH WR-137 FLANGE





NOTES
1. Modified original VE4MA scalar feedhorn of date 95 02 28 for use with WR-137 flange. The end of the 1.5 " copper pipe pipe was formed to fit a short length of WR-137 waveguide and soldered.
2. Return Loss measured at 26 dB
3. Copper pipe length should be optimum but can be trimmed for best return loss.
4. Scalar ring is bottom section of a 1 lb. coffee can 1.0 " high. Hole in end of can should be cut slightly smaller in diameter to be a tight fit around 1.5 " pipe.
5. For my f/d of 0.4, I place the opening of the circular waveguide 0.25 " in front of scalar ring. Probably still not optimum. Should be made variable. Reference original VE4MA drawing for suggestions for use with other f/d ratios.
6. I don't believe taper of 1.5 " pipe is that critical as long as length of main waveguide can be trimmed for best return loss.

DRAWING NOT TO SCALE	5760 MHz WR-137 FEEDHORN
07-23-95	Engineering Sketch by Al Ward WB5LUA

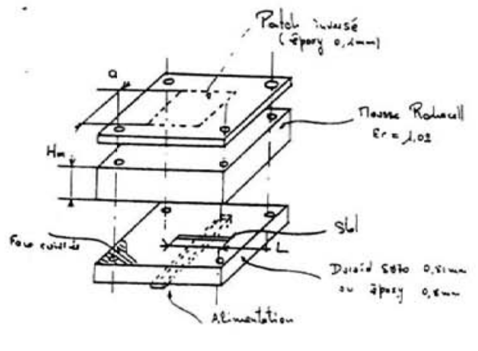
RESEAU D'ANTENNES SSFIP POUR LE 5,76 GHz

PHILIPPE - F1JWF

Cet article présente la réalisation d'une antenne planaire SSFIP par la bande des 6 cm. On peut réaliser ce type d'antenne avec du circuit imprimé.

1 - STRUCTURE SSFIP (Strip Slot Foam Inverted Patch)

De nouvelles structures ont été developpées pour améliorer les performances des antennes hyper. Ce type d'antenne possède 3 plans différents :



Le circuit imprimé inférieur (alimentation) excite le patch supérieur par l'intermédiaire de la fente.

Ces structures possèdent principalement deux avantages :

- Bande passante supérieure aux structures microrubans traditionnelles,
- Rayonnement des lignes d'alimentation dans la direction de propagation négligeable.

Pour l'instant, il n'existe pas de modèle théorique permettant le calcul de ces structures.

La première étape du travail a été la recherche par tatonnement des dimensions d'un élément SSFIP pour le 5,76 GHz.

2 - ELEMENT SSFIP 5,76 GHz

Cette recherche par tatonnement a été effectuée pour deux types de substrat (pour l'alimentation) :

- DUROID 5870 $h = 0{,}51$ mm $\varepsilon_r = 2{,}33$
- EPOXY $h = 0{,}8$ mm $\varepsilon_r = 4{,}3$

A cette étape du travail il était intéressant d'évaluer les pertes dans ces deux matériaux afin de déterminer les dimensions optimales de l'antenne. En effet, dans les antennes planaires, il existe un optimum pour la surface lorsque les pertes du réseau d'alimentation atteignent 3dB, car on peut estimer qu'en doublant la surface de l'antenne on double également les pertes. Donc, les 3 dB gagnés avec l'augmentation de surface sont aussitôt perdus dans les lignes d'alimentations.

Les pertes dans l'époxy ont été mesurées à 18 dB/m !! L'époxy est donc à proscrire en ondes SHF pour des antennes dépassant une dizaine de centimètres.

Par contre, le Duroïd (Duroïd 5870 → 3dB/m) permet l'alimentation d'antennes beaucoup plus grandes. C'est donc ce substrat qui a été retenu pour l'alimentation.

Pour ce substrat, on trouve qu'un élément SSFIP ayant les dimensions suivantes rayonne assez bien :

L = 16 mm   a = 18,5 mm   Hm = 3 mm

Pour cet élément, on mesure :

g = 6,3 dB +/- 0,5 dB (Chambre anéchoïque + antenne de référence)

SWR à 5,76 GHz : 1,07:1 (Network Analyser HP 8510)

Diagramme de rayonnement en annexe 1

On constate que cet élément utilisé seul ne possède qu'un gain limité.

3 - RESEAU D'ANTENNES

Sur la base de l'élément SSFIP du paragraphe précédent, un réseau d'antennes a été constitué.

Les dimensions du réseau ont été fixées par des critères de prix et d'encombrement à 297 mm x 180 mm.

Sur cette surface, il est apparu judicieux de placer 4 x 8 éléments (4 dans le plan horizontal, champ E et 8 dans le plan vertical, plan H). Les raisons de ce choix sont les suivantes :

- **La distance entre élément doit être comprise entre $0{,}5\lambda$ et 1λ. Au dessus de cet intervalle, plusieurs lobes principaux apparaissent. En dessous, le rayonnement n'est plus perpendiculaire à la surface.**
- Il faut laisser suffisamment de place pour les lignes d'alimentation.

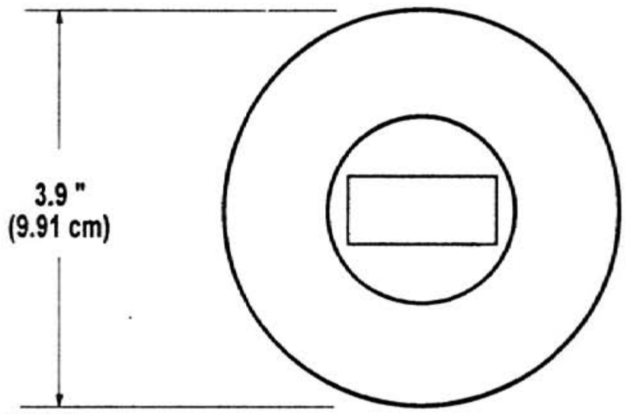
Bien que le maximum de gain soit obtenu lorsque les 4 x 8 éléments sont alimentés avec la même amplitude, il est apparu intéressant de pondérer la puissance sur chacun des éléments de manière à ajuster le niveau des lobes secondaires.
Rappelons que la pondération de la puissance sur les différents éléments du réseau fait varier le niveau des lobes secondaires alors que la variation de la phase permet d'ajuster la direction du lobe principal, (ex. : Balayage électronique).

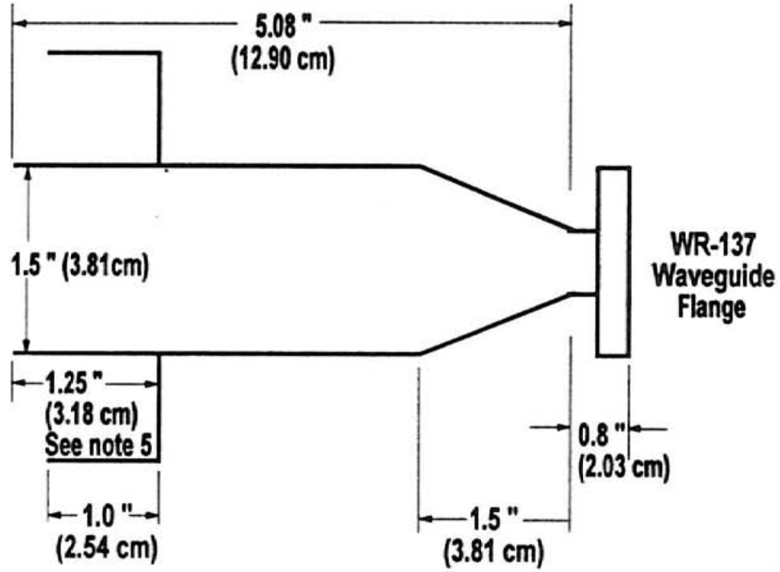
Après plusieurs simulations, (prg CHEBY [1]) en tenant compte du diagramme de rayonnement de l'élément SSFIP du paragraphe 2, on choisit une pondération de puissance selon une distribution de TCHEBYCHEFF (niveau des lobes secondaires constant) avec un niveau des lobes secondaires de :

plan E : - 15 dB
plan H : - 22 dB

Cette pondération possède les caractéristiques suivantes :

5760 MHz LINEAR POLARIZATION FEEDHORN WITH WR-137 FLANGE





NOTES

1. Modified original VE4MA scalar feedhorn of date 95 02 28 for use with WR-137 flange. The end of the 1.5 " copper pipe pipe was formed to fit a short length of WR-137 waveguide and soldered.
2. Return Loss measured at 26 dB
3. Copper pipe length should be optimum but can be trimmed for best return loss.
4. Scalar ring is bottom section of a 1 lb. coffee can 1.0 " high. Hole in end of can should be cut slightly smaller in diameter to be a tight fit around 1.5 " pipe.
5. For my f/d of 0.4, I place the opening of the circular waveguide 0.25 " in front of scalar ring. Probably still not optimum. Should be made variable. Reference original VE4MA drawing for suggestions for use with other f/d ratios.
6. I don't believe taper of 1.5 " pipe is that critical as long as length of main waveguide can be trimmed for best return loss.

DRAWING NOT TO SCALE	5760 MHz WR-137 FEEDHORN
07-23-95	Engineering Sketch by Al Ward WB5LUA

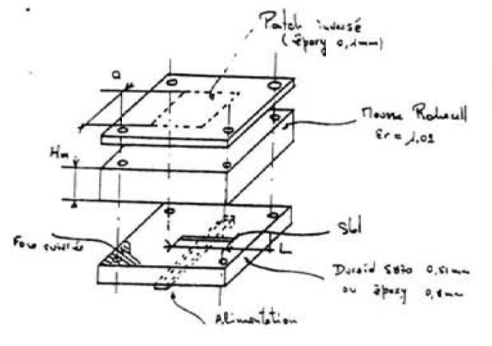
RESEAU D'ANTENNES SSFIP POUR LE 5,76 GHz

PHILIPPE - F1JWF

Cet article présente la réalisation d'une antenne planaire SSFIP par la bande des 6 cm. On peut réaliser ce type d'antenne avec du circuit imprimé.

1 - STRUCTURE SSFIP (Strip Slot Foam Inverted Patch)

De nouvelles structures ont été développées pour améliorer les performances des antennes hyper. Ce type d'antenne possède 3 plans différents :



Le circuit imprimé inférieur (alimentation) excite le patch supérieur par l'intermédiaire de la fente.

Ces structures possèdent principalement deux avantages :

- Bande passante supérieure aux structures microrubans traditionnelles,
- Rayonnement des lignes d'alimentation dans la direction de propagation négligeable.

Pour l'instant, il n'existe pas de modèle théorique permettant le calcul de ces structures.

La première étape du travail a été la recherche par tatonnement des dimensions d'un élément SSFIP pour le 5,76 GHz.

2 - ELEMENT SSFIP 5,76 GHz

Cette recherche par tatonnement a été effectuée pour deux types de substrat (pour l'alimentation) :

- DUROID 5870 h = 0,51 mm ε_r = 2,33
- EPOXY h = 0,8 mm ε_r = 4,3

A cette étape du travail il était intéressant d'évaluer les pertes dans ces deux matériaux afin de déterminer les dimensions optimales de l'antenne. En effet, dans les antennes planaires, il existe un optimum pour la surface lorsque les pertes du réseau d'alimentation atteignent 3dB, car on peut estimer qu'en doublant la surface de l'antenne on double également les pertes. Donc, les 3 dB gagnés avec l'augmentation de surface sont aussitôt perdus dans les lignes d'alimentations.

Les pertes dans l'époxy ont été mesurées à 18 dB/m !! L'époxy est donc à proscrire en ondes SHF pour des antennes dépassant une dizaine de centimètres.

Par contre, le Duroïd (Duroïd 5870 ⇒ 3dB/m) permet l'alimentation d'antennes beaucoup plus grandes. C'est donc ce substrat qui a été retenu pour l'alimentation.

Pour ce substrat, on trouve qu'un élément SSFIP ayant les dimensions suivantes rayonne assez bien :

L = 16 mm   a = 18,5 mm   Hm = 3 mm

Pour cet élément, on mesure :

g = 6,3 dB +/- 0,5 dB (Chambre anéchoïque + antenne de référence)

SWR à 5,76 GHz : 1,07:1 (Network Analyser HP 8510)

Diagramme de rayonnement en annexe 1

On constate que cet élément utilisé seul ne possède qu'un gain limité.

3 - RESEAU D'ANTENNES

Sur la base de l'élément SSFIP du paragraphe précédent, un réseau d'antennes a été constitué.

Les dimensions du réseau ont été fixées par des critères de prix et d'encombrement à 297 mm x 180 mm.

Sur cette surface, il est apparu judicieux de placer 4 x 8 éléments (4 dans le plan horizontal, champ E et 8 dans le plan vertical, plan H). Les raisons de ce choix sont les suivantes :

- La distance entre élément doit être comprise entre 0,5λ et 1λ. Au dessus de cet intervalle, plusieurs lobes principaux apparaissent. En dessous, le rayonnement n'est plus perpendiculaire à la surface.
- Il faut laisser suffisamment de place pour les lignes d'alimentation.

Bien que le maximum de gain soit obtenu lorsque les 4 x 8 éléments sont alimentés avec la même amplitude, il est apparu intéressant de pondérer la puissance sur chacun des éléments de manière à ajuster le niveau des lobes secondaires.
Rappelons que la pondération de la puissance sur les différents éléments du réseau fait varier le niveau des lobes secondaires alors que la variation de la phase permet d'ajuster la direction du lobe principal, (ex. : Balayage électronique).

Après plusieurs simulations, (prg CHEBY [1]) en tenant compte du diagramme de rayonnement de l'élément SSFIP du paragraphe 2, on choisit une pondération de puissance selon une distribution de TCHEBYCHEFF (niveau des lobes secondaires constant) avec un niveau des lobes secondaires de :

plan E : - 15 dB
plan H : - 22 dB

Cette pondération possède les caractéristiques suivantes :

° Plan E 4 x 0,85 niveau des lobes secondaires exigé : - 15 dB

pondération élément 1 1 W
élément 2 0,5637 W

directivité : 8 dB

° Plan H 8 x 0,7 niveau des lobes secondaires exigé : - 22 dB

pondération élément 1 1 W
élément 2 0,7427 W
élément 3 0,3952 W
élément 4 0,2346 W

directivité : 10,3 dB

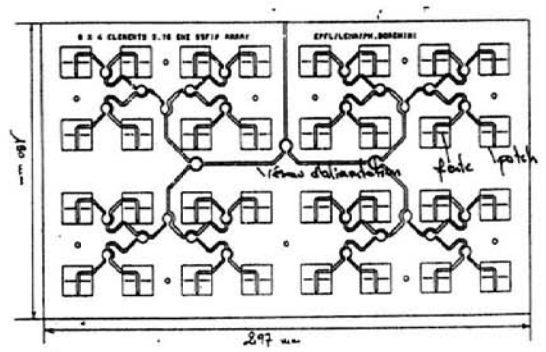
Le gain théorique du réseau sera donc :

$g = go + DE + DH = 6,3 + 8 + 10,3 = 24,6$ dB

go = gain d'un élément
DE = directivité plan E
DH = directivité plan H

Pratiquement la pondération de puissance a été effectuée à l'aide de diviseurs de WILKINSON.

La superposition des trois masques photographiques utilisés pour la gravure des circuits est montrée ci-dessous :

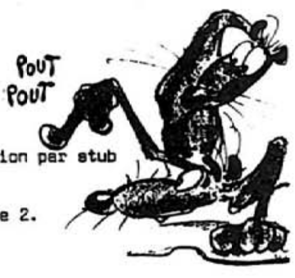


L'ensemble circuits imprimés et mousse est maintenu par des entretoises et monté dans un cadre plastique.

4 - MESURES

Mesures chambre anéchoïque avec antenne de référence.

Gain g = 22,7 dB +/- 0,5 dB
Angle d'ouverture à -3dB plan E : 14°
Niveau lobes secondaires plan E : -16 dB
Angle d'ouverture à -3dB plan H : 10°
Niveau lobes secondaires plan H : -24 dB



Mesures Network Analyser HP 8510

SWR à 5,76 GHz : 1,00 : 1 adaptation par stub
Bande passante SWR 2 : 230 MHz

Les diagrammes de rayonnement se trouvent en annexe 2.

5 - REMARQUES

L'antenne réalisée possède un gain comparable à ce que l'on peut obtenir avec un cornet mais pour un encombrement très réduit.

L'utilisation d'une structure SSFIP permet d'avoir une bonne maîtrise des lobes secondaires car les lignes d'alimentation ne viennent pas perturber le rayonnement principal.

Les pertes dans l'antenne valent environ 2 dB ce qui peut être gênant, (facteur de bruit) dans certain cas.

Le prix de l'ensemble est essentiellement dû au coût du substrat Duroïd, soit 300 à 400 FF.

Notons pour terminer qu'il existe un nouveau substrat faible perte destiné aux hyper :

Polypropylène : $\varepsilon_r = 2,18$
Perte = 0,8 dB/m à 5 GHz (Duroïd 5870 = 3 dB/m)
Prix = 0,20 FF/cm2 (Duroïd 5870 = 0,50 FF/cm2)

A vérifier !

Ce substrat devrait permettre de fabriquer des antennes beaucoup plus grandes pouvant rivaliser avec certaines paraboles.

73 F1JWF

Resultats des simulations et mesures page suivante

BIBLIOGRAPHIES

[1] Antenna design using PC
D. POZAR 86

2] Réseau d'antennes SSFIP pour la bande amateur des 6 GHz
PH. BORGHINI Juin 89

Annexe 1

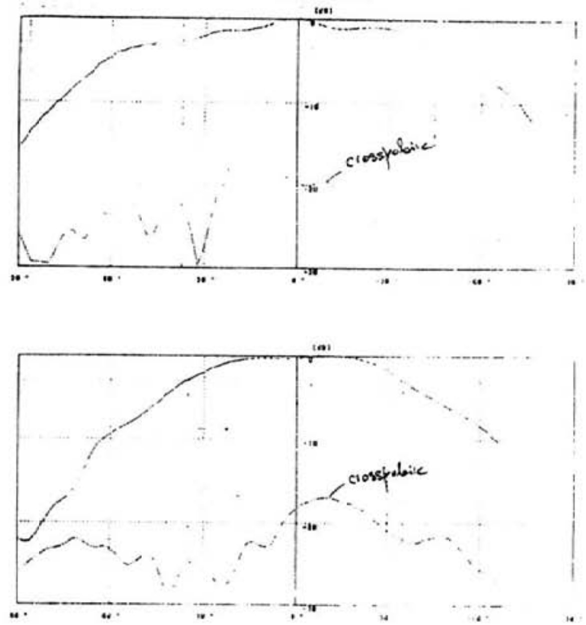
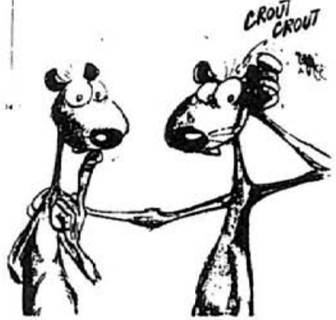


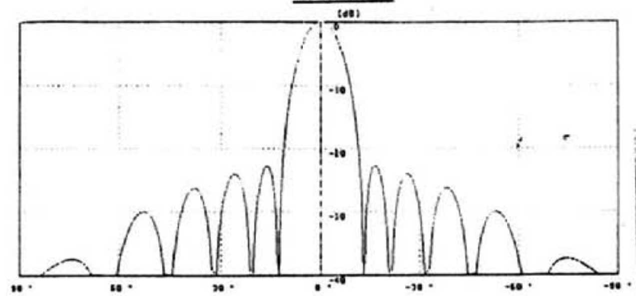
Diagramme de rayonnement de l'élément SSFIP Doroïd.

plan H

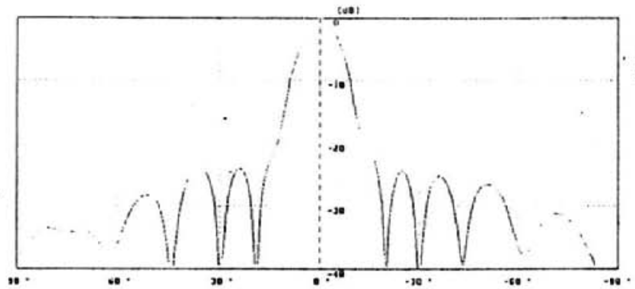
plan E.



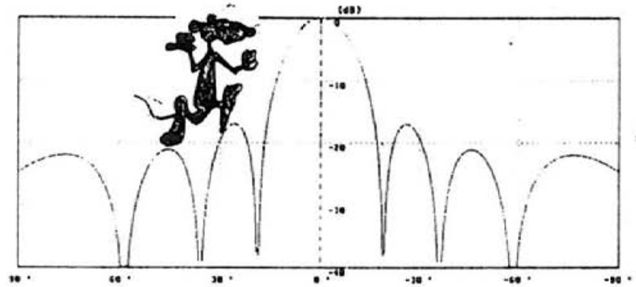
Annexe 2



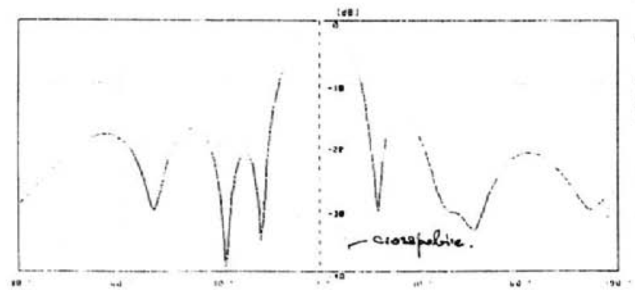
8 x 0,7 d
Simulation



8 x 0,7 d
Mesure



4 x 0,85 d
Simulation



4 x 0,85 d
Mesure.

ANTENNES 10 Ghz

DONNEES POUR LA CONSTRUCTION D'UNE ANTENNE HORN POUR LA BANDE DES 10 GHz

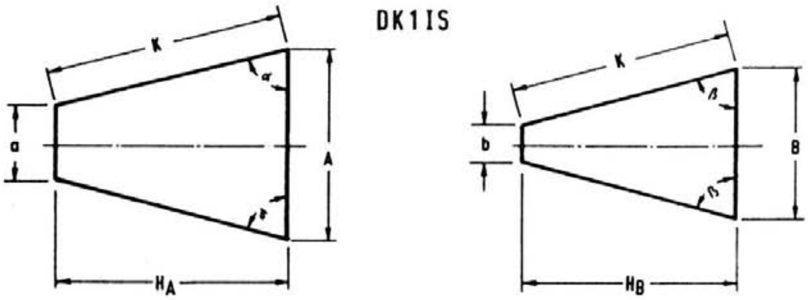
par T. Kölpin, DK 1 IS

De nombreuses dimensions mécaniques ont été données en (1) pour la construction des antennes du type Horn, dans la bande des 3 cms. La construction, en utilisant ces dimensions n'est pas simple. Plusieurs autres valeurs sont nécessaires pour coupler les plaques et les couder. Ces valeurs sont données dans le tableau suivant. Elles sont basées sur une information donnée en (1) et sont valable pour une fréquence d'utilisation moyenne de 10,3 GHz. La liaison est réalisée par un guide d'ondes WR-90 de dimensions internes de: a = 22,86 mm, b = 10,16 mm.

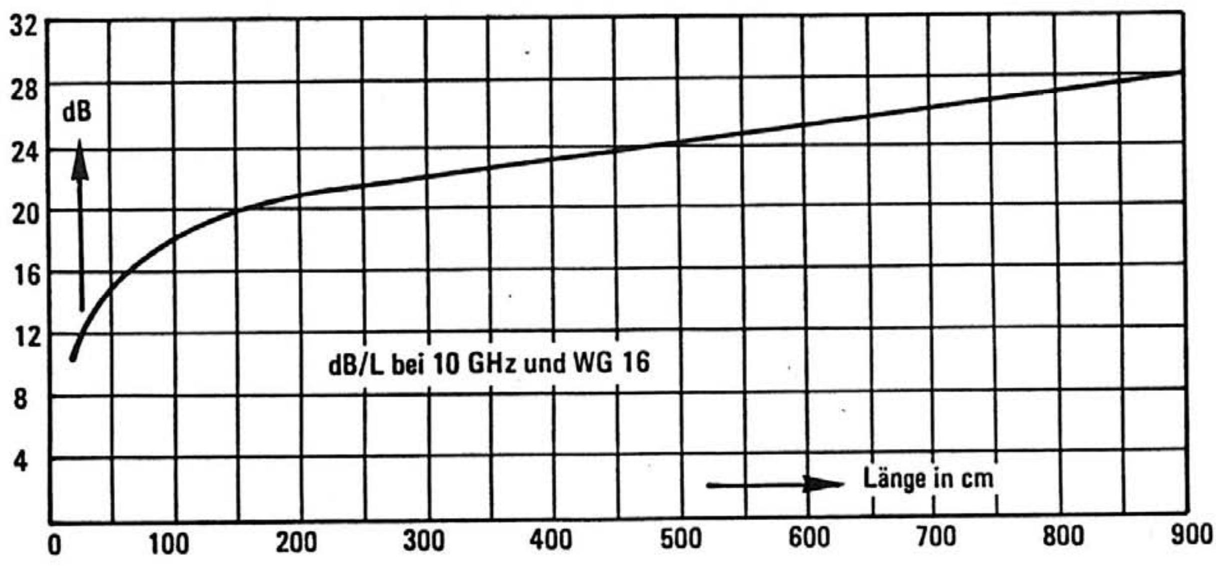
Dimensions internes d'un radiateur Horn pour 10,3 GHz

Gain dB	Côté A mm	Côté B mm	Long.L mm	Haut. H_A mm	Haut. H_B mm	Angle α degré	Angle β degré	K Long. du côté mm
14	68.2	50.5	26.2	33.1	34.6	55.6	59.8	40.1
15	76.5	56.7	36.5	43.4	45.3	58.2	62.8	50.9
16	85.8	63.6	49.8	56.5	58.9	60.9	65.6	64.7
17	96.3	71.3	66.7	73.4	76.1	63.4	68.1	82.1
18	108.1	80.0	88.5	95.1	98.2	65.9	70.4	104.2
19	121.2	89.8	116.2	122.8	126.2	68.2	72.5	132.3
20	136.0	100.8	151.6	158.2	161.8	70.3	74.4	168.0
21	152.6	113.1	196.6	203.2	207.0	72.3	76.0	213.3
22	171.3	126.9	253.7	260.3	264.3	74.1	77.5	270.7
23	192.2	144.3	326.2	333.0	337.0	75.7	78.7	343.6
24	215.6	159.7	418.1	424.7	429.1	77.2	80.1	435.5
25	241.9	179.2	534.5	541.1	545.6	78.6	81.2	552.1

DK1IS



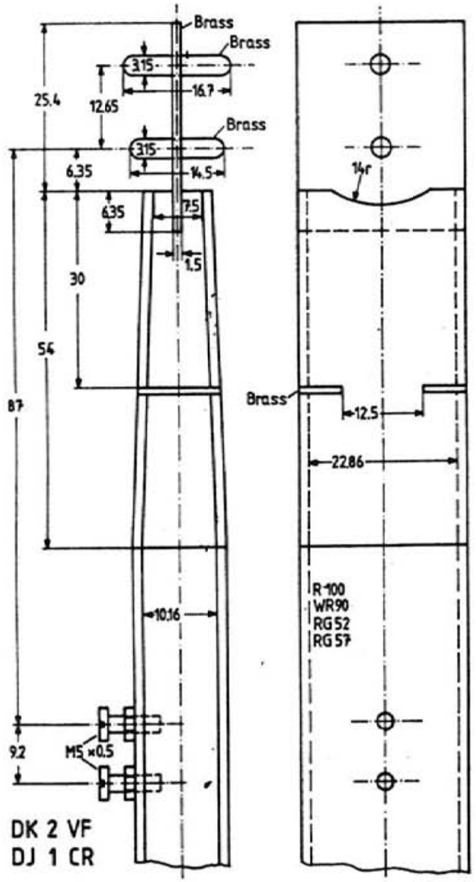
Les calculs ont été réalisés à l'aide d'une calculette programmable SR-56 et les valeurs ont été arrondies pour une application pratique. Une antenne Horn de 20 dB a été construite à partir de ces dimensions, en utilisant une plaque coudée 2 fois et un couvercle soudé en place. De façon à être vraiment universel, le tableau A donne un nombre de données maximales absolument nécessaires à la construction des antennes Horn.



A 3 CM PRIMARY RADIATOR FOR PARABOLIC ANTENNAS

by R. Griek, DK 2 VF, and M. Münich, DJ 1 CR

The drawing given in **Figure 1** shows all required dimensions of the dipole radiator and reflector which are placed directly in front of the open-end of a so-called X-band waveguide R 100 (or WR-90 or WG-16). This radiator is placed through the center of the parabolic reflector from the back so that the shorter dipole is placed at the focal point. This is not only simpler mechanically, but is far more elegant than when using a horn radiator and waveguide fed around the parabolic reflector.



The 10 dB beamwidth (1) of the radiator assembly amounts to approximately 60°, which makes it more suitable for parabolic reflectors having a focal angle between 60 and 80°. The author uses it in parabolic reflectors of 50 cm in diameter, having a focal distance of 17 to 18 cm (f/d approx. 0.3) **(see Figure 2)**.

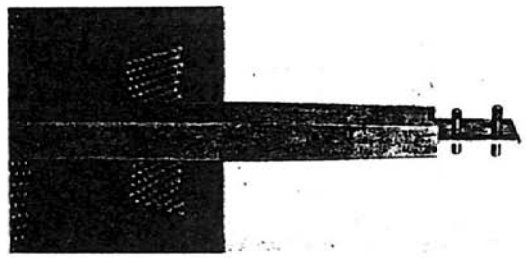


Fig. 2: Photograph of the prototype radiator

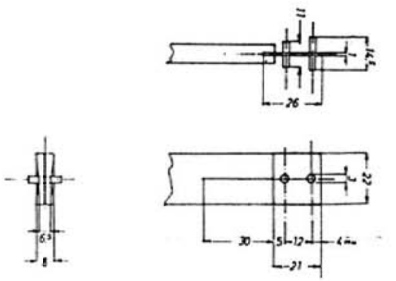
The described primary radiator is taken from (2) and has been further developed in discussions with M. Hamel, DJ 8 VY, and Dr. D. Evans, G 3 RPE, and recalculated for the amateur frequencies in the 3 cm band.

The operation of this radiator is simple: the two dipoles (»radiator« and »reflector«) are soldered to a metal surface that is placed in the open end of the waveguide parallel to its wide side. When using the usual TE_{10}-mode in the waveguide, the E-vector is parallel to the dipoles which means that they will be energized by the radiation. If the metal surface is mounted symetrically in the waveguide, both dipole halves will be energized equally. The narrowing of the waveguide in one plane is used for impedance matching; it also improves the radiation diagram be decoupling the walling of the waveguide from the dipoles. The impedance of the system is also determined by the insertion depth of the metal surface into the waveguide, and by the spacing of the dipoles from its open-end. Furthermore, an iris in the narrow part of the waveguide, and two matching screws in the straight part optimize the matching. The two matching screws are aligned for lowest VSWR, or maximum field strength in conjunction with a local station.

It should be mentioned that all parts are made from brass, and can be silver-plated, although this is not absolutely necessary. It is important, however, that any residual solder between the dipoles and the metal surface is removed, as well as between this surface and the waveguide. Also, it is necessary for the narrowing of the waveguide to be exactly symmetrical.

Bernard MOUROT F6BCU

Pour un gain identique, une petite parabole est moins volumineuse qu'un gros cornet et peut se trouver facilement dans un magasin de luminaires ou se récupérer chez un ferrailleur. Il nous a été signalé que dans la région parisienne, sous la référence "IKEA", des réflecteurs paraboliques étaient disponibles pour un petit prix. Nous vous communiquons les caractéristiques de cette parabole (figure 1).



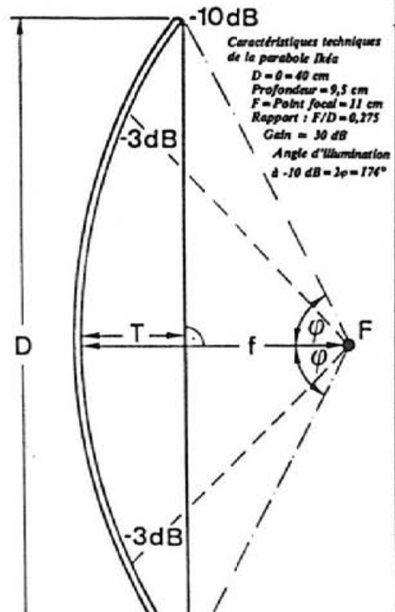


Figure 1

Parabole "IKEA" (réflecteur de luminaire) (idéale pour usage amateur SHF en portable)

UN RADIATEUR SIMPLE POUR LES PARABOLES 10 GHz

par R.Heidemann, DC 3 QS

Les soucoupes paraboliques sont de plus en plus populaires sur les bandes Amateur micro-ondes, principalement parce qu'elles donnent une relation favorable entre le gain et le travail de construction mécanique nécessaire.

Afin de garantir un gain maximum, il faut bien s' assurer que la parabole est complètement illuminée. Les radiateurs Cornet ou Tubulaires (voir pages 134-140) conviennent très bien pour une construction-maison, du fait que leurs caractéristiques de radiation (largeurs de faisceau) et donc, leurs dimensions mécaniques, peuvent être facilement calculées pour correspondre à la parabole dont on dispose. Un désavantage certain dans l'utilisation d'un radiateur cornet sur la bande 3 cm (10 GHz) est la difficulté de montage de l'alimentation du guide d'onde.

Un radiateur de la bande X, populaire dans les applications Radar est décrit ci-après; il représente un compromis acceptable des radiateurs Cornet, Tubulaires et Dipoles. L'alimentation décrite convient aux soucoupes ayant un angle focal f/D de 0.58. Les matériaux nécessaires à cette construction sont un morceau de guide R-100 (WG 16) et une plaque de cuivre 10/10 de 26 mm x 62 mm.

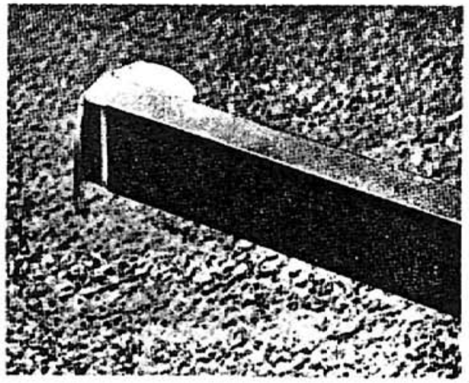


Fig. 1 & 2: Antenne pour la bande 10 GHz de 38 cm de diamètre.

La Figure 1 montre l'alimentation installée dans une parabole de 15" (38 cm) ayant un f/D de 0.58. L'alimentation elle-même est détaillée en Figure 2. Les détails de construction sont donnés aux Figures 3 et 4.

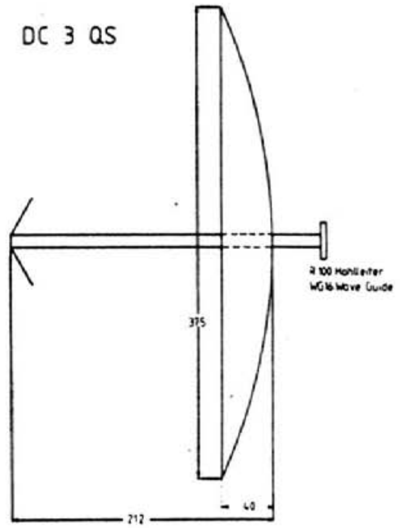


Fig. 4: Dimensions de l'antenne présentée en Figure 1.

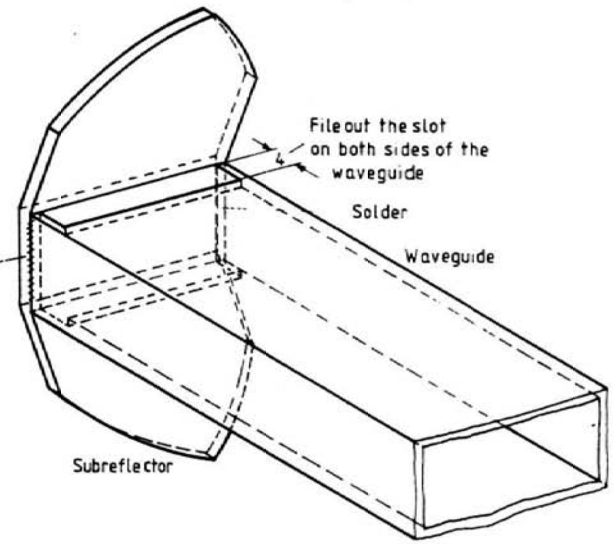
Le radiateur est construit en enlevant à la lime 4 mm dans les côtés larges du guide d'onde (Figure 3). La plaque de cuivre est alors préparée comme indiqué en Figure 3 et soudée aux côtés étroits restants du guide d'onde; après quoi, la plaque devra être recourbée en direction de la parabole, pour former l'angle de 30° requis.

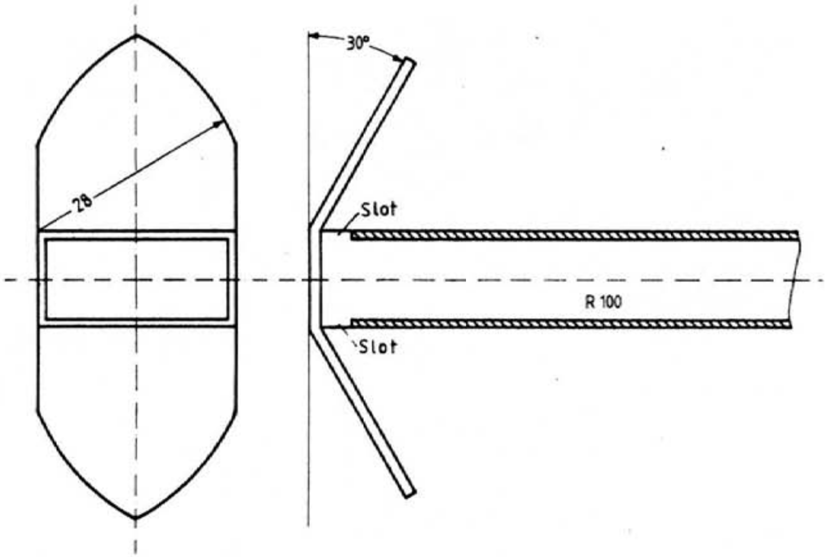
Le montage de l'alimentation dépendra de la parabole utilisée et de ce fait, cet article ne peut en donner aucun détail. Toutefois, il est conseillé de rendre le guide d'alimentation ajustable dans le sens axial (écartement avec la parabole) afin de pouvoir optimiser l'illumination de la parabole. L'adaptation peut être améliorée en ajoutant un réglage à 2 vis. Le TOS sera de l'ordre de 1.2 dans la portion de fréquence nous intéressant, avec un réglage pour un gain maximum.

REFERENCE

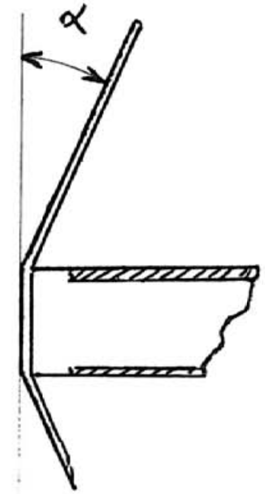
VHF COMMUNICATIONS 11 (1979), Edition 3, Pages 151-153
R.Heidemann, DC 3 QS
A Simple Radiator for 3 cm parabolic dishes

DC 3 QS





Construction of the subreflector
M 1:1



$\alpha = 5°$

pour $f/D \simeq 0{,}27$

$\alpha = 30°$

pour $f/D \simeq 0{,}58$

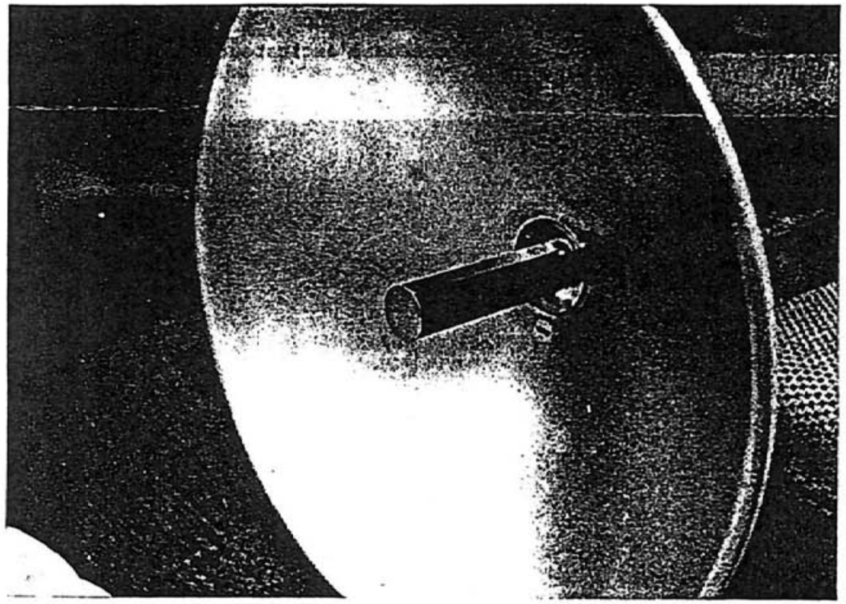
Fig. 3: Les contours du sous-réflecteur peuvent être tracés sur la plaque de métal.

E.4.9.5 : **Excitateur 10 GHz pour la "parabole IKEA"**

La "parabole IKEA" est actuellement une des antennes des plus populaires dans la bande 10 GHZ. Il s'agit d'une pièce réalisée en tôle d'acier laquée de 40 cm de diamètre, offrant à peu près le bon profil et vendue en tant qu'abat-jour sous l'appellation LOFT par une maison de meubles bien connue (prix environ 70 Francs en 1987).

Avec un rapport f/D de 0,25 cette parabole IKEA est assez profonde (par rapport au foyer) et donc assez difficile à "illuminer". Différents excitateurs ont cependant été proposés pour cette antenne, l'un d'entre eux se distingue par la simplicité de sa réalisation. C'est celui développé par G4ALN; il a déjà été décrit dans la presse spécialisée("QST-Zeitschrift" de Février 81). On en présente ici les performances.

Fig.1212: La parabole et son excitateur chez DJ9HO (ensemble réalisé par DL1RQ).



Le contenu de ce chapitre est dû à l'OM Henning (DF9IC), l'ensemble du montage (parabole et excitateur) été testé par l'OM Thomas (DK1UN).

Usiner deux fentes à l'une des extrêmités d'un guide d'ondes et y souder avec précaution une plaque de laiton. Cet ensemble doit de préférence être fixé à la parabole à l'aide d'une bride munie d'une vis latérale. La fixation réalisée par DL1RQ permet de plus grâce à ses quatre vis transversales un démontage rapide de la parabole et de l'excitateur; l'OM Henning recommande également de rapporter une plaque d'aluminium découpée de façon adéquate à l'intérieur de la parabole afin de renforcer la robustesse de l'ensemble. Le réflecteur est situé à 105 mm du fond de la parabole.

Le prototype ainsi réalisé par DF9IC a aimablement été testé par DK1UN en l'absence de toute réflexion parasite.
Cette "parabole IKEA" munie de l'excitateur décrit ici se révèle pour l'amateur 10 GHz une antenne puissante, facile à réaliser et de faible coût de fabrication.

Fig.1213: Gros plan sur l'extrêmité de l'excitateur. On y reconnaît la fente usinée.

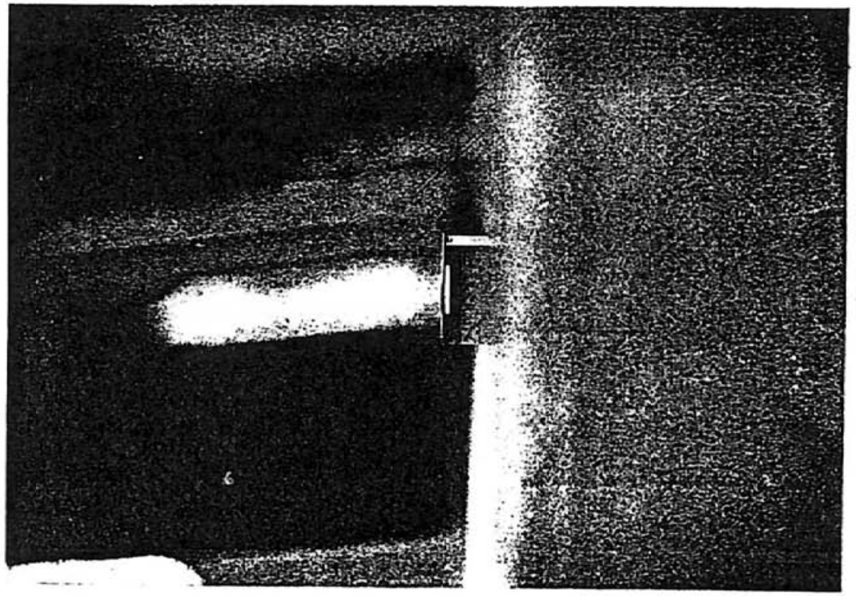


Fig.1214: Dimensionnement du montage de DF9IC. Les deux dessins sont respectivement aux échelles 1:1 et 2:1 (!)

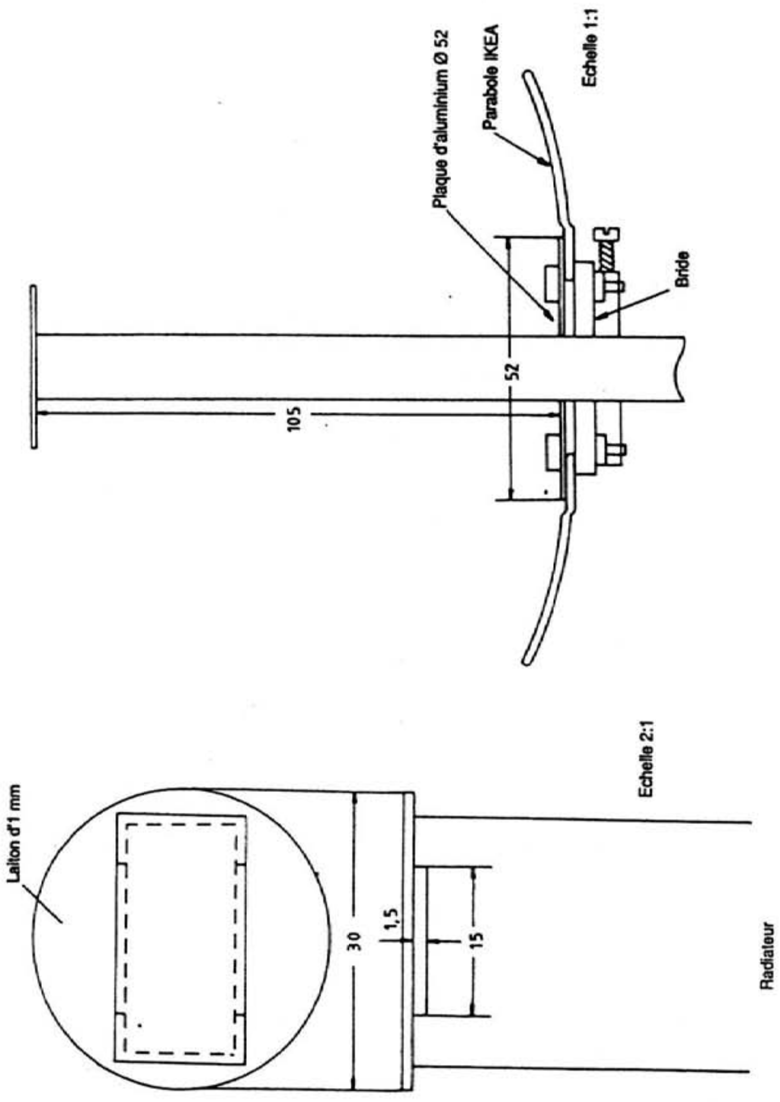
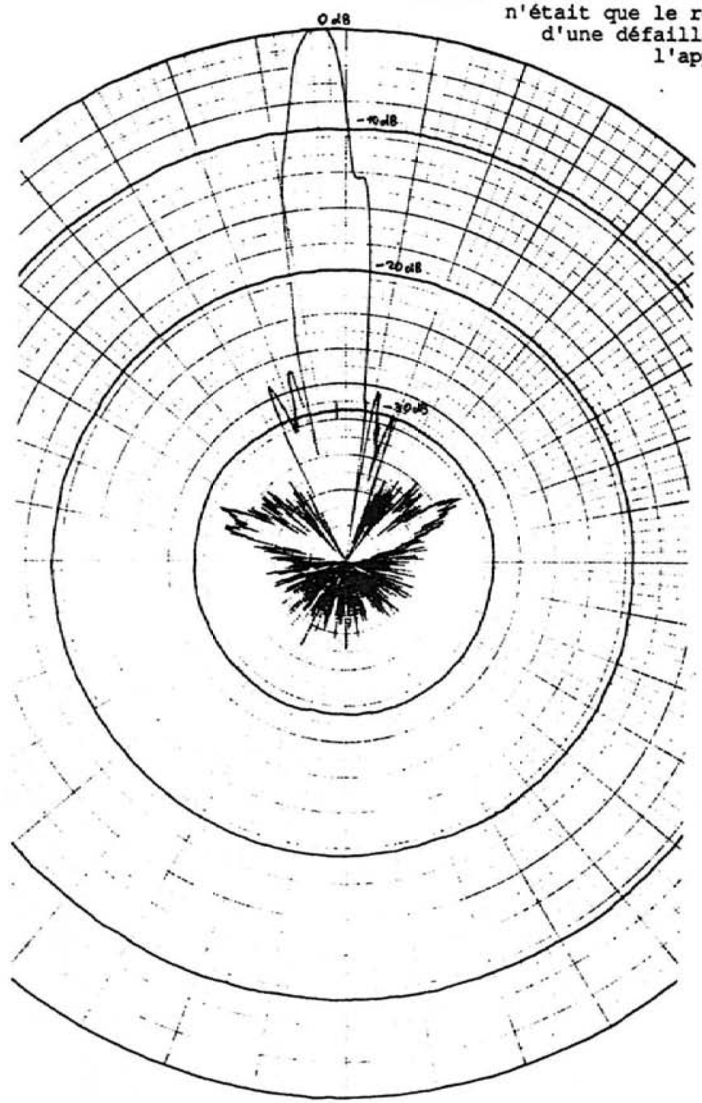


Fig.1215: Diagramme de la parabole de DF9IC, réalisé par DK1UN.

Angles d'ouverture :
- à -3 dB = 5°
- à -10 dB = 8,5°
- à -20 dB = 15°

L'atténuation du pic secondaire est de plus de 27 dB.

Le fort bruit de fond relevé au centre à l'occasion des mesures n'était que le résultat d'une défaillance de l'appareil.



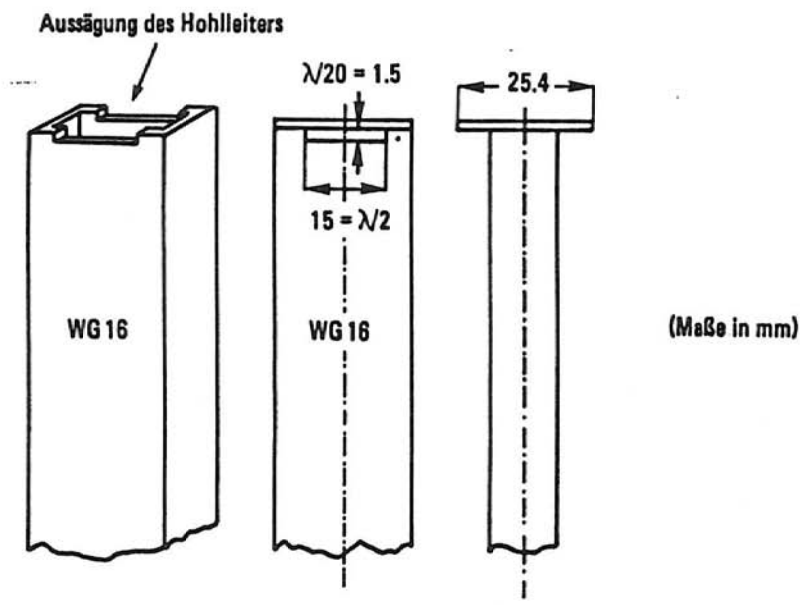


Abb. 95. Plättchen-Strahler für das 10-GHz-Band mit WG 16

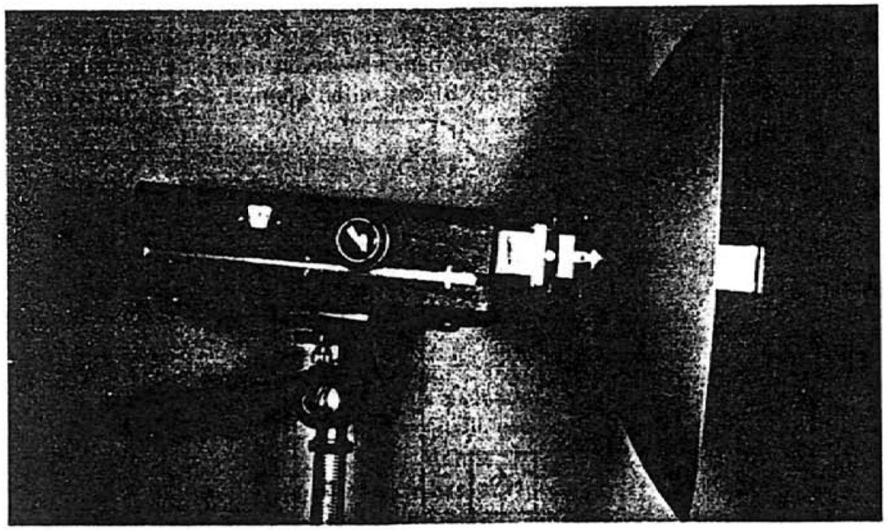


Abb. 96. Praktische Ausführung eines Plättchen-Strahlers für 10 GHz

A simple waveguide feed for short focal length dishes

The dishes that amateurs inherit are often of the short focal length type; that is, the ratio of the focal length to the diameter of the dish typically is in the region 0·25–0·3.

The design of a suitable feed is shown in Fig 161. It is constructed by cutting two grooves in the end of a length of waveguide of appropriate size, and soldering on a circular end disc. The length of the slot formed, and also the diameter of the disc, are probably not critical within a few per cent, and the width of the slot even less so. Values for λ and λ_g for frequencies of amateur interest, together with details of suitable waveguides, are given in Table 14. Signals having the standard horizontal polarization are produced when the broad faces of the guide are vertical.

The feed can be used without any attempt to improve the match—the vswr is typically about 1·5:1. The match may be improved by conventional matching screws which preferably are fitted behind the dish as shown in order to reduce unwanted resonances. An elegant alternative method, which at the same time can be used in weatherproofing the system, is shown in the top figure. In this, a Perspex sleeve is made a sliding fit on both the end disc and the waveguide. By adjusting its position, the right proportion of power in the correct phase is fed back into the feed to cancel that reflected by the mismatch.

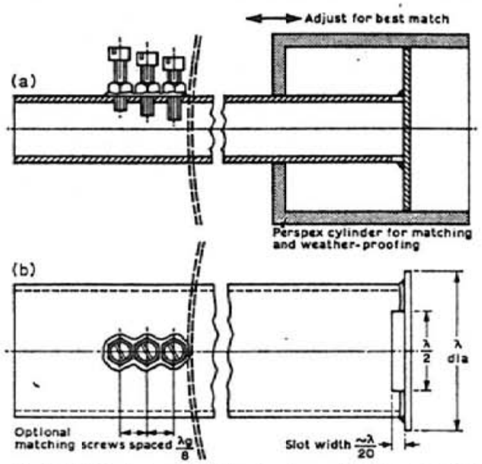


Fig 161. A simple feed for dishes having an f/D ratio of 0·25–3. Matching can be done either by matching screws as shown or as in (a) by using a Perspex matching (and weatherproofing) sleeve. (b) Side view of feed

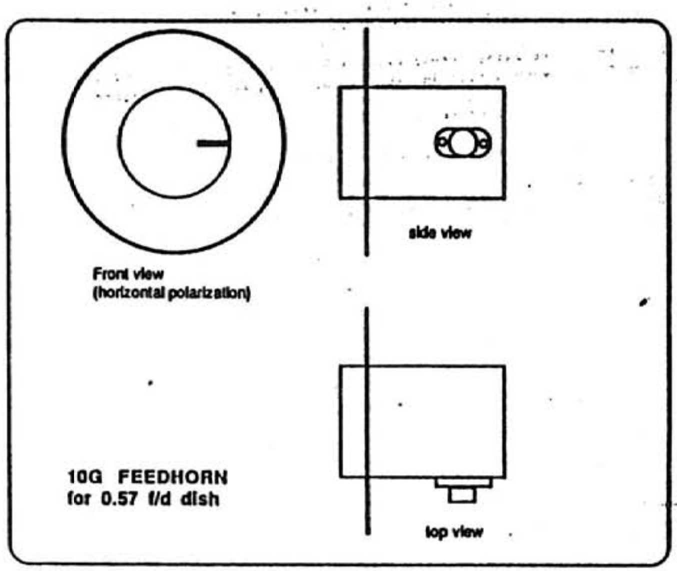
Table 14

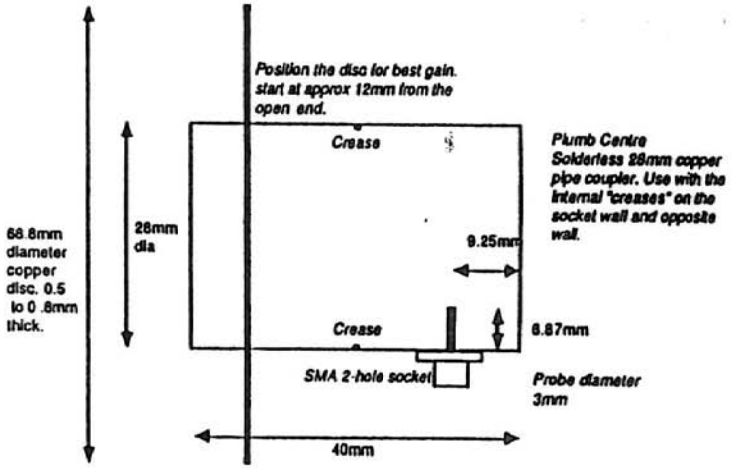
Centre frequency (MHz)	Suitable waveguide	λ (mm)	λg (mm)
1,297	WG6	231	324
2,305	WG8	130	162
3,457	WG10	86·7	109
5,761	WG14	52·0	78·2
10,050	WG16	29·8	39·4
10,369	WG16	28·9	37·3
24,193	WG20	12·4	15·2

A DISH FEED FOR THE "N.E.C." DISH -- by G4DDK

An issue or two ago we mentioned that a number of 60cm dishes were available at the this year's RSGB Convention. We believe it was Dee Comm (not TAR Communications as previously stated) that were selling these nice dishes. Both your editors and several other people purchased a dish (no doubt still available) and to our delight found that the f/D was 0.57 rather than the 0.42 stated by the trader. Sam, G4DDK has now come up with the following feed design, easily manufactured out of standard copper pipe fittings. Comments are invited from anyone who tries the feed or indeed may have alternative ideas.

$f/D = 0{,}57$

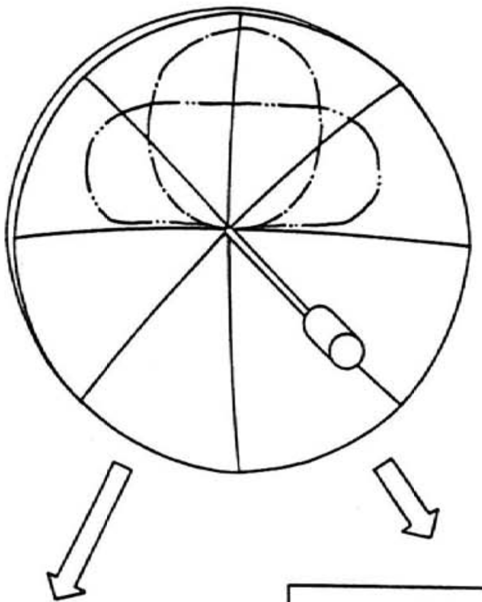




Die Offset - Parabolantenne
Einsatz im Amateurfunk

Christian Huber, DL2MFB

Abb. 1: Runde Parabolantenne



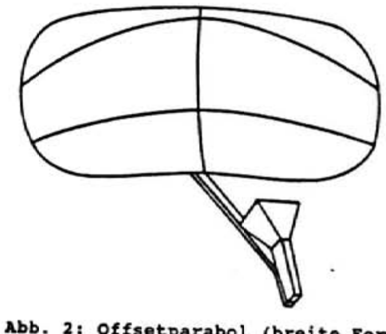


Abb. 2: Offsetparabol (breite Form)
z. B. für Radaranwendungen

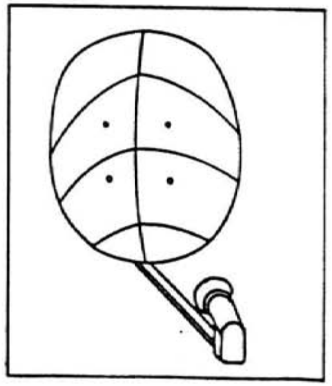


Abb. 3: Offsetparabol (hohe Form)
z. B. für Sat-TV-Empfang

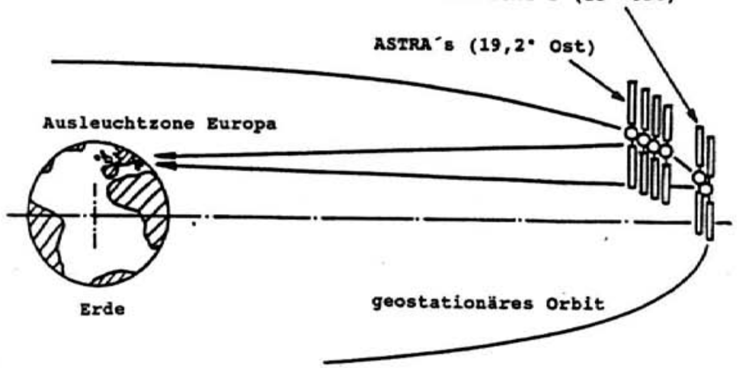


Abb. 4: Ursprüngliche Verwendung der Offsetparabolantenne für den Sat-TV-Empfang

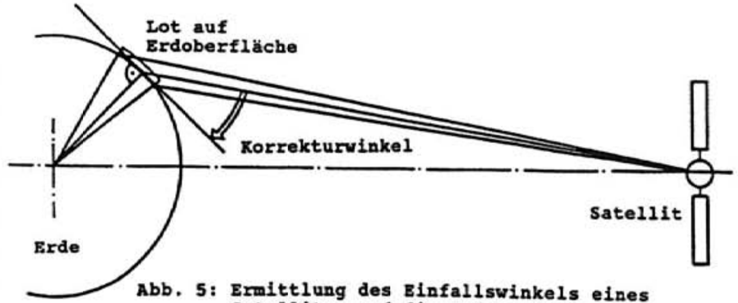


Abb. 5: Ermittlung des Einfallswinkels eines Satelliten auf die Erdoberfläche

ACHTUNG: Diese Darstellungen sind nicht winkelgetreu!

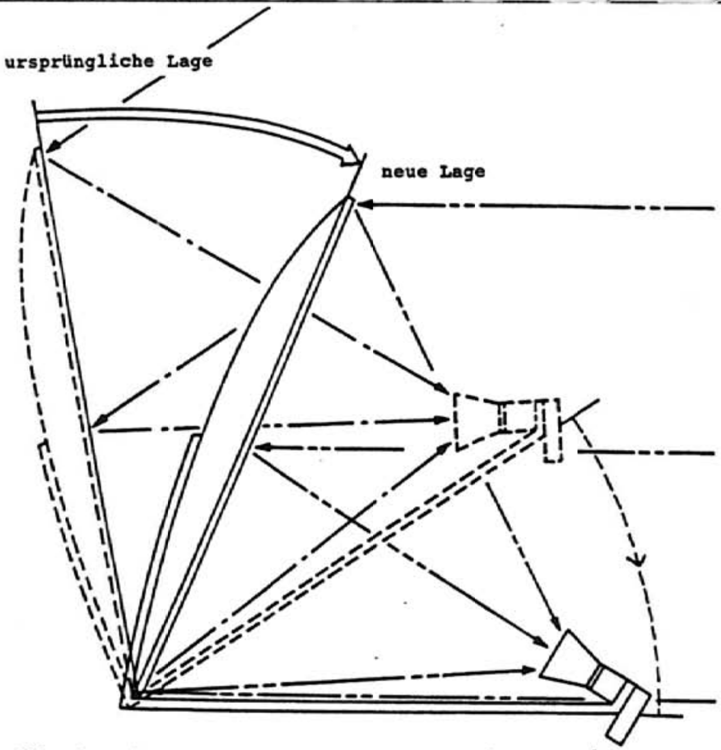
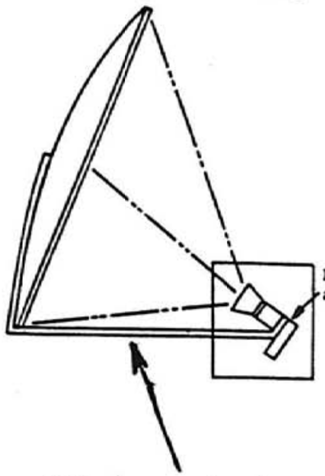


Abb. 6: Schwenken der Offsetparabol-Anordnung um den Korrekturwinkel nach vorne

Abb. 7: Modifizierung der Einspeiseanordnung



Attention : le bras n'est pas obligatoirement horizontal

ACHTUNG: Einkopplung horital eingezeichnet

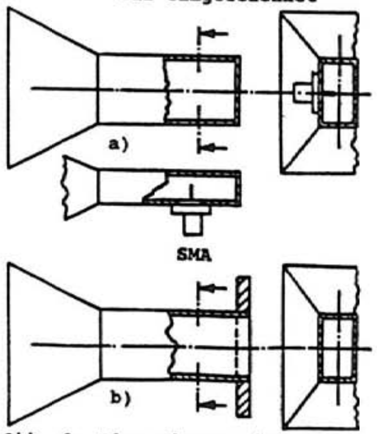


Abb. 9: Einspeisung mit Rechteckhohlleiter
a) über Einkopplung
b) direkt

ACHTUNG: Einkopplung vertikal eingezeichnet

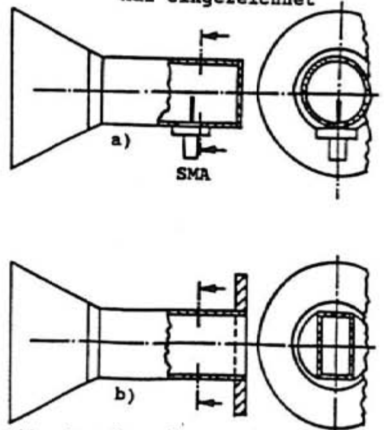


Abb. 8: Einspeisung mit Rundhohlleiter
a) über Einkopplung
b) direkt

Abb. 10: Mechanischer Lösungsvorschlag mit Hohlleitereinspeisung

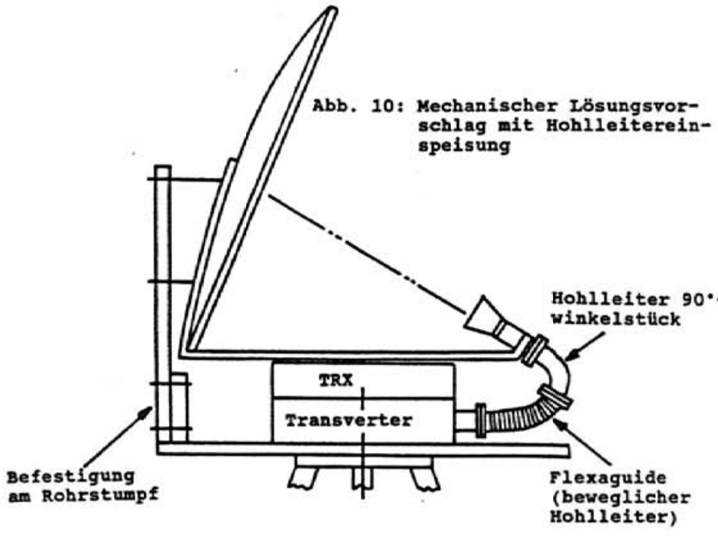
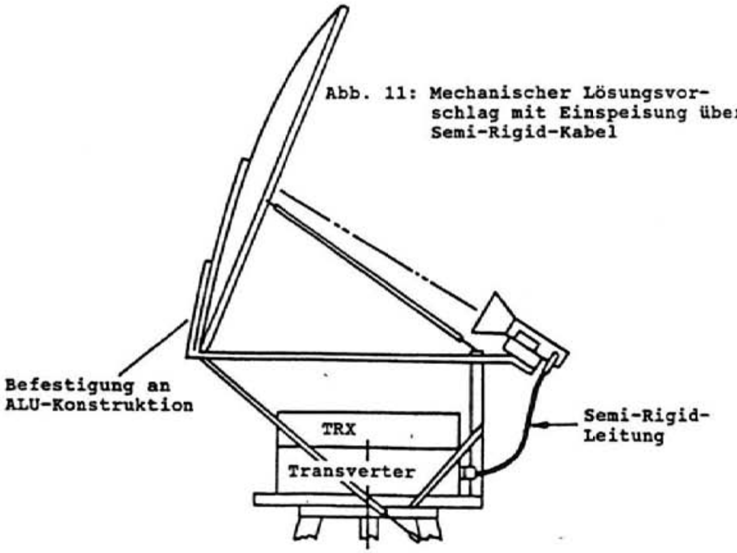
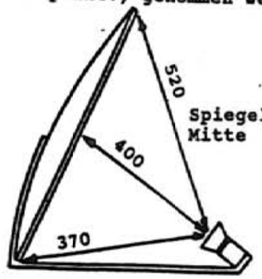


Abb. 11: Mechanischer Lösungsvorschlag mit Einspeisung über Semi-Rigid-Kabel



Anhang: Realisierung der Offset- Parabolantenne mit Feed's

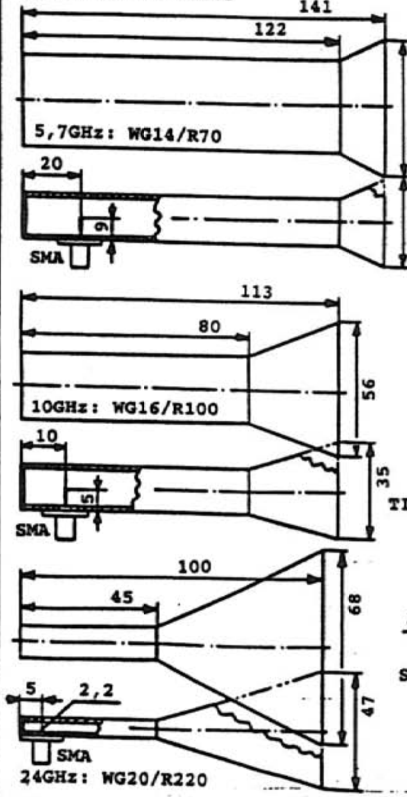
ACHTUNG: In der Regel kann je nach Hersteller des Offsetspiegels die Lage des LNCs als Maß für die Lage der Feed (Brennpunkt!) genommen werden!



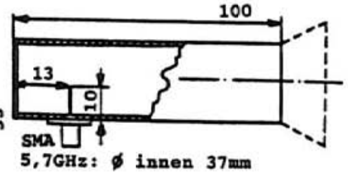
Offsetparabol
ø 65cm, f/d=0.45

f in Ghz	gain in dB	3 dB in °
5,7	27	6,6
10	32	4,6
24	38	2,1

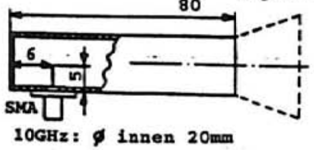
Einspeisung
Rechteckhohlleiter



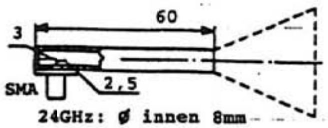
Einspeisung
Rundhohlleiter



oder abgesägtes LNC



TIP: Der Übergang vom Rundhohlleiter zum Rechteckhohlleiter wird durch Quetschen des runden Querschnittes erreicht.



ACHTUNG: Diese Darstellungen sind nicht maßstabsgetreu!

DL 2 MFB 12/95

Literatur

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* J. N. Gannaway, G3YGF, M. W. Dixon, G3PFR: The 10 Ghz (3cm) Band, Chapter 18 in „Mircowave Handbook", Volume 3 (Bands and Equipment), page 18.12 RSGB, Pottersbar, Herts, England, 1992

* Kent Britain, WA5UJB: 10 GHz-IMU-Feedhorn, Update in „The ARRL UHF/Microwave Projekts Manual", Chapter 10, Antennes, page 10-23, ARRL, Newington, CT, USA, 1994

* G. J. Jessop, G6JP: A Dustbin Lid Antenna in „VHF/UHF Manual", Chapter 9, Microwave, page 9.68 - 9.70 RSGB, Potters Bar, Herts, England, 1985

* Sepp Reithofer, DL6MH: „Praxis der Mikrowellen-Antennen", diverse Stellen, Verlag UKW-Berichte, Baiersdorf, 1987

* Ing. Jiri Otypka: Berechnung des Brennpunktes beliebiger Offsetparabolantennen in UKW-Berichte, Heft 1/95, Seite 39-43, Verlag UKW-Berichte, Baiersdorf, 1995

NB: Je dispose de l'article complet, que m'a passé José F1EIT, mais en allemand...

F1GHB

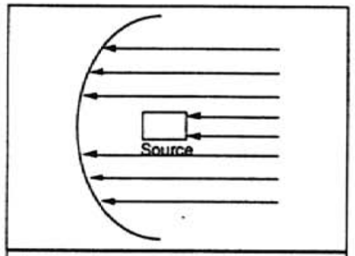
I) L'ANTENNE (F6IWF)

Les antennes peuvent prendre différentes formes. On distingue deux grandes familles :

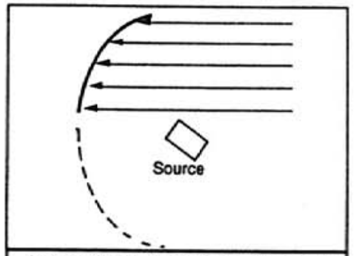
- Les Paraboles
- Les antennes Plates.

Les antennes plates sont constituées par un réseau de dipôles couplés par des lignes imprimées. Leur bande passante et faible ce qui les rend inutilisables pour nôtre application.
Les antennes paraboliques conviennent par contre fort bien en raison des propriétés apériodiques du réflecteur. 95 % des réflecteurs étant maintenant de technologie "OFFSET", nous ne nous intéresserons seulement à ce type :

Un réflecteur OFFSET est en fait un morceau d'une antenne circulaire :



Ant.Circulaire. Rendement : 55 à 65 %

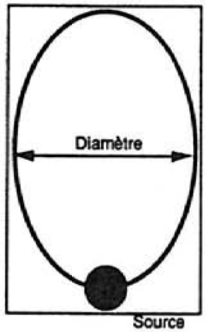


Antenne Offset. Rendement : 60 à 70 %

Le rendement des antennes offset est supérieur à celui des circulaires, surtout pour les antennes de petite taille ou le diamètre de l'ensemble tête-source est important comparativement à la taille de l'antenne. La partie réceptrice étant une projection d'un cylindre d'onde sur un paraboloïde de révolution, la parabole offset n'est pas ronde mais ovale.

Une antenne offset est caractérisée par :

1) Son diamètre : Le diamètre est égal à celui du cylindre d'onde intercepté par l'antenne. Il est mesuré sur le petit axe de l'ellipse.



La taille de l'antenne et son rendement déterminent le gain de l'antenne pour une fréquence donnée.

Pour fixer les idées, le gain d'une Offset à 10,5 GHz est de l'ordre de :

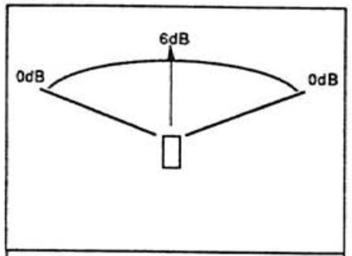
Ø (cm)	Gain (dBi)	Ø (cm)	Gain (dBi)
50	33	70	36
60	34,5	80	37

Il n'est pas recommandé de dépasser 80 cm en raison du faible angle d'ouverture des antennes à grand gain et des difficultés d'alignement qui en résultent (± 1,5° pour une 70 cm).

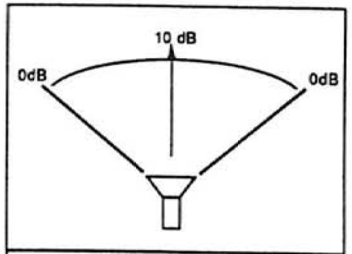
50 à 70 cm suffisent généralement et sont plus faciles à pointer dans la direction de l'émetteur.

2) Le rapport distance Focale / Diamètre :

Le rapport F/D est compris entre 0.5 et 0.7 au lieu de 0.3 à 0.5 pour les antennes circulaires. Par conséquent les sources sont différentes. Alors qu'un simple tube de 23 mm de diamètre intérieur suffit à éclairer un réflecteur d'un F/D = 0,4 ; les offsets demandent un petit cornet (gain environ 10 dB) pour respecter la loi d'éclairement.

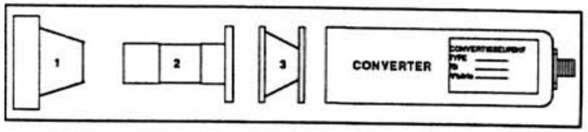


Antenne circulaire. F/D : 0.3 à 0.5



Antenne Offset. F/D : 0.5 à 0.7

Le plus souvent, la source est faite de 3 parties :

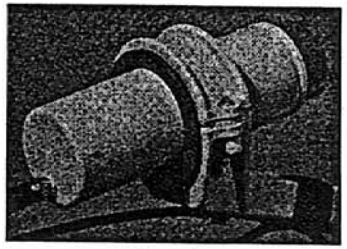


1 : un cornet

2 : un guide d'onde

3 :une interface d'adaptation à l'entrée de la tête (aussi appelé "STEP").

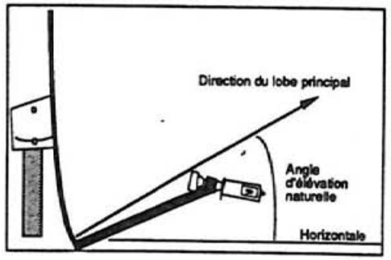
A l'heure actuelle, ces parties et la tête sont souvent d'une seule pièce et il est difficile d'avoir accès à la source.



exemple d'une tête compacte

3) L'élévation naturelle :

Une caractéristique importante de ces antennes offset est le décalage de l'axe de réception (d'ou le nom offset) qui n'est plus perpendiculaire au plan du bord de l'antenne. Le lobe principal et cette perpendiculaire forment un angle appelé : "élévation naturelle".



Pour un usage amateur, le lobe principal doit être horizontal. Il est donc nécessaire d'incliner l'antenne vers le bas pour ramener le faisceau vers l'horizon.

4) Les matériaux :

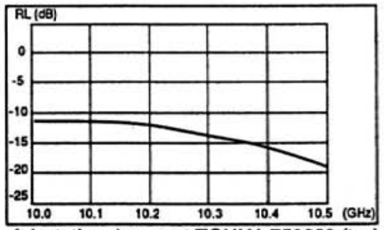
Les réflecteurs sont fabriqués en métal (acier ou aluminium) ou en fibre de verre moulée (matériau composite) recouverte d'une métallisation. L'avantage des matériaux composites est leur grande robustesse bien adaptée à une utilisation en portable par exemple (insensibilité aux chocs durant le transport).

Pour une installation fixe, on pourra préférer un modèle aluminium pour des raisons de poids, attention dans ce cas au trop grandes antennes qui deviennent un-réglables avec nos rotors classiques; 50 cm sont déjà très bien. Se méfier aussi des antennes en acier peint qui sont moins résistants envers la corrosion, spécialement des modèles en tôle perforée qui présentent déjà 0,5 à 1 dB de gain en moins que les modèles pleins.

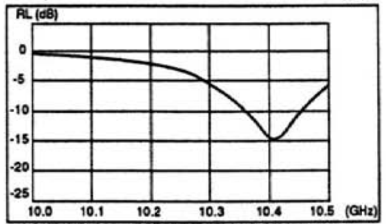
Choix d'un modèle du commerce :

Mon choix s'est porté sur une antenne de la gamme TONNA société bien connue pour ses aériens Amateurs et qui fabrique également d'excellentes antennes satellites.

Un des avantages est l'existence dans cette gamme d'un cornet doté d'un guide de 22 mm de diamètre intérieur. Cette source était conçue au départ pour accepter un polariseur circulaire/linéaire pour la réception des polarisations circulaires de TDF 1 ou de TVSAT. L'adaptation est meilleure que 12 dB sur la bande 10.0 - 10.5 GHz. Le montage de la source est possible sur toutes les antennes TONNA.



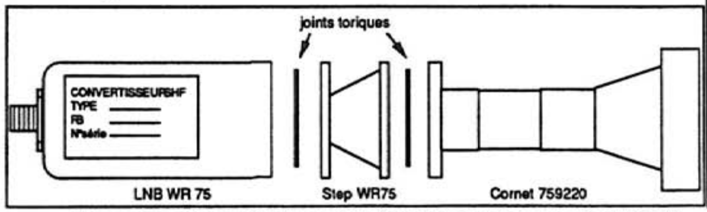
Adaptation du cornet TONNA 759220 (typ)

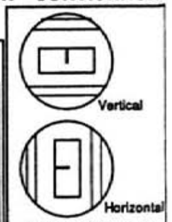


Adaptation d'un cornet C120 (typique)

Les guides d'onde sont souvent au standard C120 (17,475 mm) et fonctionnent comme un filtre passe haut coupant vers 10,4 GHz ce qui les rend inutilisables pour nos applications.

Les modèles "TONNA 49 cm"en fibre de verre et "TONNA 68 cm" conviennent bien aux applications Amateurs.



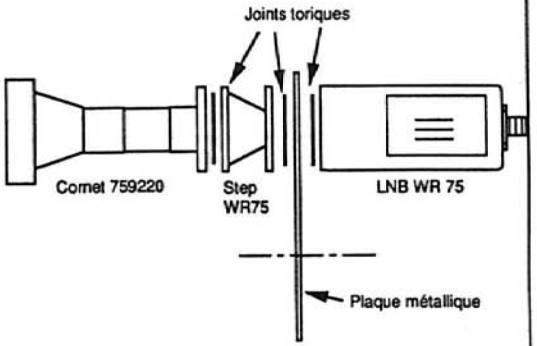


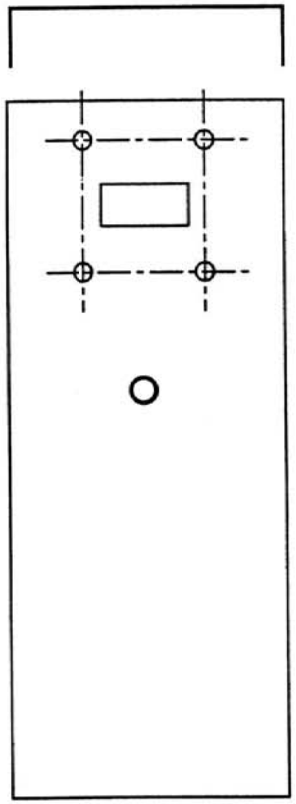
Position de la sonde

 Montage d'une tête à entrée WR75 sur un cornet 759220

Note concernant la polarisation d'une antenne 49 cm :

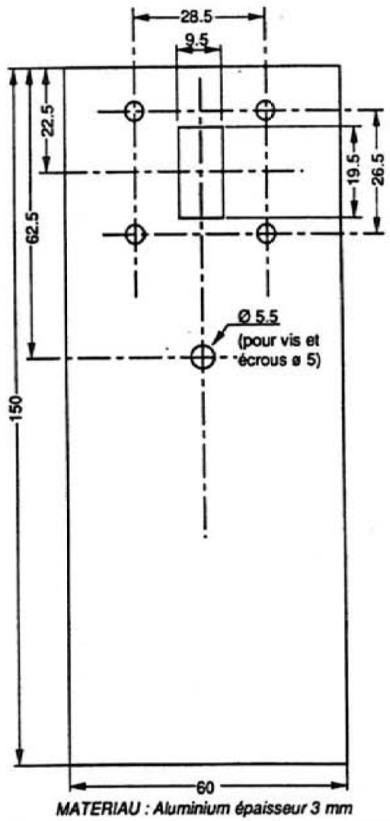
Le cornet et la tête sont fixés de part et d'autre d'une plaque qui impose la polarisation verticale pour nos applications.
Les transmissions amateurs s'effectuant principalement en horizontal, il est préférable de fabriquer une autre plaque pour ce mode.





(plaque d'origine)

Fonctionnement en polarisation verticale

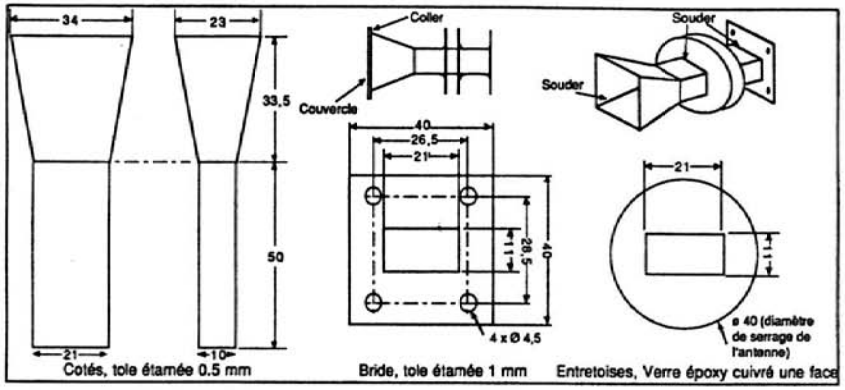


MATERIAU : Aluminium épaisseur 3 mm

Fonctionnement en polarisation horizontale

Construction d'un cornet :

Pour les autres antennes, il est toujours possible de remplacer la source C120 par une autre. Comme les cornets coniques ne sont pas très faciles à construire, on peut fabriquer un modèle pyramidal. La loi d'éclairement d'une antenne offset demande un cornet d'environ 10 dB de gain.



Cotés, tole étamée 0.5 mm — Bride, tole étamée 1 mm — Entretoises, Verre époxy cuivré une face

Les antennes micro-ondes étant prévues pour être utilisées dehors, il est nécessaire de prévoir un dispositif d'étanchéïté. Le couvercle doit être en plastique résistant aux UV et transparent aux µ-ondes. Le meilleur est le P.T.F.E. mais il est difficile à coller. Généralement, les plastiques clairs ou transparents sont bons pour les µ-ondes mais résistent mal aux UV. Les foncés ou les noirs sont bons pour les UV mais pas pour les µ-ondes. Les fabricants utilisent différentes combinaisons de P.T.F.E. pour garantir la tenue aux UV et une bonne étanchéïté en même temps qu'un collage efficace.

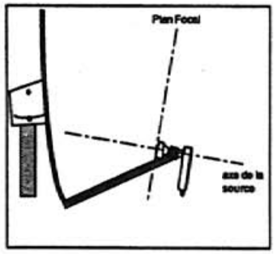
Des tests sont nécessaires pour trouver un matériel correct. Il est aussi possible d'essayer une mince pièce de verre qui se colle très bien au mastic silicone et qui est complètement étanche.

Pour placer le nouveau cornet au bon endroit :

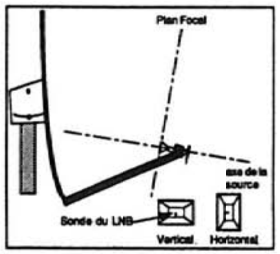
Il est nécessaire de conserver l'axe de la source initiale et le plan focal.

La position n'est pas très critique. Plus ou moins 5 mm en avant ou en arrière donnent presque les mêmes résultats.

Toutes les mesures effectuées ont démontré l'efficacité supérieure des antennes offset.



Antenne avec tête compacte

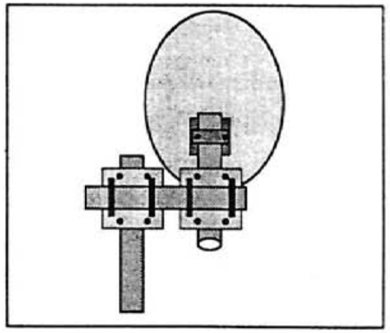


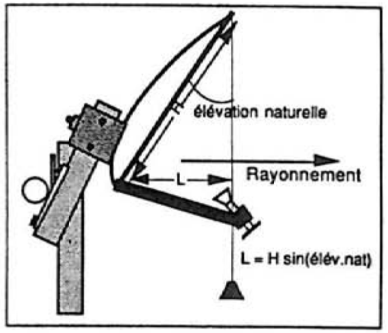
Ant. avec le nouveau cornet

Alignement de la direction de l'antenne :

Les antennes satellite étant pointées rarement vers l'horizon, les constructeurs conçoivent les orienteurs d'antennes pour des angles d'élévation de 15 à 50°. Nous avons besoin de 0° pour les faisceaux terrestres.

Pour connaître la valeur de l'élévation naturelle, placer l'antenne sur un mât, regler le réflecteur dans une position parfaitement verticale et lire la valeur sur la monture. Incliner l'antenne vers le bas de la valeur de cet angle. Comme les montures ne sont pas prévues pour atteindre le "0", un assemblage mécanique simple est nécessaire. Adopter l'espacement minimal pour une meilleure rigidité.


Vue arrière



Vue de profil

Le pré-réglage de l'antenne peut être effectué avec un mètre et un fil à plomb attaché à la partie supérieure du réflecteur.

Pour le réglage fin, il faudra impérativement se servir d'un signal généré par une balise ou envoyé par un correspondant situé à quelques kilomètres et ajuster au maximum de niveau.

Cette modification d'antenne a été développée pour la TV large bande mais peut convenir également à la SSB ou aux autres modes de trafic.

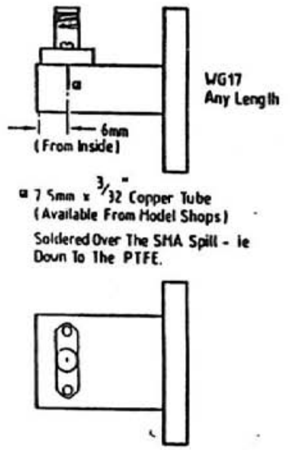
5³

Montage des offsets

USING WAVEGUIDE 17 AT 10GHz

– Some useful tips from Mike, G3JVL & Tony, G4CBW (who did the drawings)

WG17 TO SMA ADAPTOR

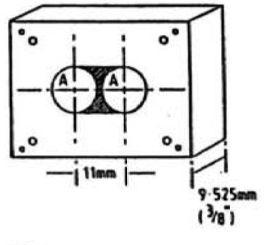


a 7.5mm x 3/32" Copper Tube (Available From Model Shops) Soldered Over The SMA Spill - ie Down To The PTFE.

Instructions
Secure The SMA Using M2 x 5mm Ch. Hd. The Screws Project Into The Guide But Seems Fine Without Filing Off. Solder SMA If Required After

Drill 5mm Diameter At The Probe. (Clearance Hole For Launch)

WG17 TO WG16 TRANSFORMER



Note:
Hole:
A = 10mm Diam - Drilled Holes.
Material:
All Used But Any Metal Can Be Used.
▨ File Out The Metal Between To Link The Holes.

Mounting
Drill & Tap M3 Each Side To Match WG17 & WG16;
Holes Are Just Clear Of Each Other.

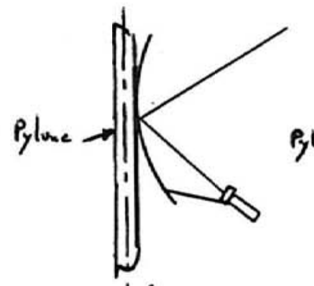
Dimensions Chosen To Optimise Broadly Around 10368 MHz.

Mounting Surplus Offset feet dishes: DE WA5VJB

G3WDG mentioned this method they use in England to mount an Offset Feed Dish. There are several advantages designing a dish for an offset feed. The feed is out of the way, and reflections off the feed and struts don't cause sidelobes. Feed spill over is looking at the 4 deg K sky instead of the 280 deg. K ground. And in Northern climates, the dish will be leaning over so far to see the equator, snow falls on the back side of the dish, not the reflecting surface.

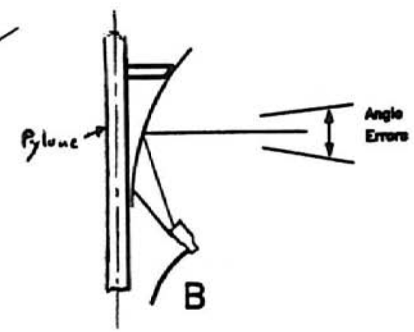
The beamwidth is about 3 degrees, you can replace the LNB with a feed, mount the dish, and try and find the horizon. (Fig B). After a few dozen trips up the tower, you might just find the horizon. The guys who learned the hard way suggest Fig C. Here the feed is mounted off to the side, it's pretty easy to "Eyeball" the horizon, and any left/right guesses are covered by the rotator.

vue de coté



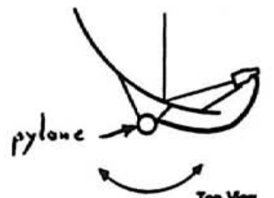
A

vue de coté



B

vue de dessus



C Top View

A DUAL MODE HORN FOR 10GHz USING STANDARD COPPER PIPE FITTINGS

by Peter Day G3PHO

There are many dish feed designs to be found in the various microwave texts and journals. When the writer changed from a "Penny Feed" 18 inch dish system to a perforated Amstrad, 60cm satellite dish (with offset feed) a couple of years ago, he found a tremendous improvement on 10GHz narrowband. A circular, dual mode, feed horn, taken from a Marconi "Blue Cap" (Amstrad) LNB was available and pressed into service as a dish feed and used with a "brute force" transition to WG16 (i.e a WG16 rectangular flange butted against the circular port on the horn!! As G8AGN showed (1), this horn is not of optimum dimensions for the amateur band and has a rather poor return loss. His article described a much more efficient scaled version of the Amstrad feedhorn. To make Barry's feedhorn requires machining facilities and the writer, not having such luxuries, stuck with the original Amstrad horn until very recently. There was room for improvement however and the following paragraphs describe the route taken to improve the dish feed efficiency and thus recover some precious dBs of antenna gain.

The following diagram shows the W2IMU dual mode feedhorn recently made to feed a 60cm ex-satellite dish for 10GHz portable operation. Dual mode horns are very suitable for dishes with f/Ds of around 0.5 to 0.6. They can produce a very symmetrical radiation pattern in both E and H planes, unlike many other feeds. Not only that, it is common for other feeds to have different phase centres in each of the planes, thus making it difficult to properly focus the dish. Most of us manage to muddle through with our penny or dipole/reflector feeds and get results but we are most likely operating with dish efficiencies well below 45%. The dual mode horn is also a very "clean" feed in that side and rear radiation is reduced to a low level (better than -30dB). This is due to the dual mode nature of the feed. The small section of the horn supports the lower waveguide mode and flares into the wider horn section which supports two waveguide modes. The size of the flare determines the relative amplitude of each mode and the length of the larger section is designed to cancel the two modes at the outer edge of the horn. This cancellation greater reduces sidelobe radiation and thus enables more energy to be propagated towards the dish reflecting surface (2).

Being more sharply defined, the horn sees the dish and not the ground behind it and thus is also a quieter feed in that less ground noise is picked through "spill over" around the edge of the dish. Because the phase centres of both planes are almost identical the horn is easier to position at the correct focal point of the dish.

The writer recommends the excellent article (2) by N1BWT which appeared in Microwave Update '94. Here, Paul Wade, N1BWT, makes an exhaustive study of several types of dish feed and highlights the critical importance of the following factors when trying to get the utmost in dish efficiency:

- Illumination taper
- Spillover loss
- E and H plane asymmetry
- Focal point accuracy
- Feedhorn sidelobes
- Blockage by the feedhorn and support struts
- Inaccuracies in the parabola's geometry
- Feeder loss

Focal point accuracy is often overlooked. N1BWT found that an error of only 0.25 inches (ie. 6mm) resulted in a loss of 1dB at 10GHz with a 22 inch dish of 0.39 f/D. Dishes with low f/Ds are very critical in this respect. While dishes of larger f/Ds are better, it is still vital to have the phase centre of the feed exactly positioned at the focus of the dish. Feeds with asymmetrical E and H planes are harder to position accurately. The popular rectangular horn feed, for example, has difficulty in producing a common phase centre and equal radiation on both planes. Computer designs can help here though.

The offset, circular horn dish feed seems ideal in view of the above criteria. A properly designed dual mode horn would enable high orders of efficiency (at least over 60%) to be obtained.

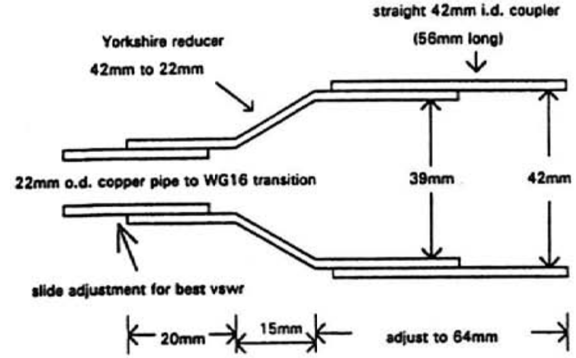
The horn is based on two articles that appeared in Microwave Update '91, published by ARRL (3). The original W2IMU design used a flared pipe reducer that had a 40 degree flare angle (due to a short taper length). This was in excess of the more appropriate 30 degrees taper required for 10GHz. As a result, a ring of 1mm diameter soft copper pipe had to be fitted inside the reducer at the wider end of the taper. This seemed an unnecessary complication to the author of the second article in Microwave Update '91 which showed a modification made by WA5VJB, of 10GHz EME fame. Here a reducer of longer taper length was used. Thus the flare angle was reduced to a more suitable figure for the 10GHz band allowing a more gradual transition from one horn to the other

A visit to the local D.I.Y superstores found plenty of 22mm i.d. copper pipe and couplers for the same but no suitable reducer fittings or 42mm straight couplers. Only a specialist plumbers' supplier could come up with the necessary items! The writer's supplier is shown at the end of this article (5). It is important to obtain solderless fittings. Any solder inside the feed will cause unacceptable losses. The diagram is largely self-explanatory but you may note the sliding adjustment provided at the junction of the horn and the 22mm o.d. copper feedpipe. (Note also that couplers are measured internally, while normal tubing is measured externally). Using a directional coupler, a good VSWR can then be obtained. Only a 5 to 10mm overlap is needed here. The narrow end of the reducer can be slotted and fitted with a hose clamp to enable a secure fit once the VSWR is set. The copper pipe feed could be extended all the way down to the transverter provided the pipe is as straight as possible. 22mm pipe is both cheap and efficient as a 10GHz feeder but bends should be avoided as far as possible or mode changes may occur. The writer uses a 100mm length of pipe whose far end has been shaped, with a suitable forming tool, to fit a WG16 flange (4). A short length of flexiguide then connects the whole feed system to the portable transverter.

No definitive measurements have been made on the writer's system but, for interest's sake, the horn was tried on the Astra satellite channels and excellent pictures were received, at least as good as the normal Amstrad type horn, even though the new horn was designed for a frequency almost 1 GHz lower.

The finished horn was mounted on the Amstrad feed clamp, although some extra packing had to be put around it as it is a little narrower than the old Blue Cap horn. Adjustments were made using the local GB3MLE beacon. A more appropriate method might be to use a low power source located several hundred feet from the dish and mounted at the same height. Field adjustments can easily be made as all the parts are "slideable" and can be permanently fixed with solder on the exterior of the horn when satisfied.

The "proof of the pudding" will be in its eating....i.e. the 1995 cumulatives!



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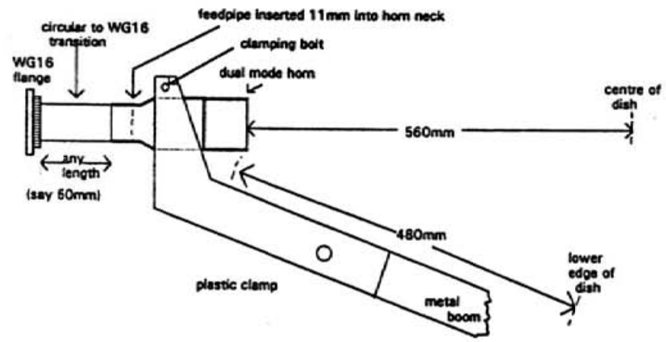
1. Notes on a feed for the 60cm Amstrad dish - by G8AGN. RSGB MICROWAVE NEWSLETTER, May 1992.
2. Secrets of Parabolic dish antennas - by Paul Wade, N1BWT.. ARRL MICROWAVE UPDATE '94
3. A simple dual mode (IMU) feed antenna for 10386MHz - ARRL MICROWAVE UPDATE '91 and RSGB MICROWAVE NEWSLETTER, September 1990. 10GHz IMU feedhorn update - by WA5VJB. ARRL MICROWAVE UPDATE '91
4. Forming tool for circular pipe to WG16 transitions - RSGB MICROWAVE MANUAL Vol.3, page 18.6
5. Parts required for IMU feedhorn: Available from Cowen Barrett Ltd., 570-576 Chesterfield Road, Sheffield S8 0ST (Telephone 0114 2501 122). Prices are shown below (add 17.5% VAT & postage)

- 1 off York Reducer 42mm x 22mm price: £5.48 + vat
- 1 off Delcop Straight Coupler 42mm price: £2.24 + vat

UPDATE ON THE DUAL MODE HORN FOR 10GHz

In response to a number of requests for assembly dimensions for this horn, as featured in the April 1995 issue of the Newsletter, the following diagram shows the critical lengths as measured on the author's system. The focal point is at the open end of the horn (ie midway across the plane of the aperture). The author's dish is a genuine Amstrad part, complete with arm and plastic clamp for the original LNB (A Marconi "Blue Cap" type). Other offset dishes purchased by readers may not have the same mechanical construction as this one. The plastic clamp needed filing out a little to accomodate the wide part of the horn. The outer, widest section of the horn, if cut to the dimensions specified in the April article, will just rest against the clamp. Note that the 22mm feed pipe is inserted some 11mm into the narrow end of the horn. This produced the best result on a received beacon and has been confirmed as the optimum insertion for best VSWR by a number of correspondents who have set up their systems with directional couplers. If your dish's mounting arm and clamp are not the same as the author's, then set up your new horn so that the open end is initially in the same position as your dish's original satellite TV LNB horn. A slight +/- adjustment might then be needed for optimum results.

By the way, since G3VVB became a silent key some time ago, we do not know of anyone else who is prepared to make properly machined 22mm copper pipe/WG16 transitions. The author used a G3VVB one in his system but has since made another using brute force "kitchen table" techniques, with some success! However it is not as pretty as Cyril's fly-pressed version! Is anyone prepared to make a few, at reasonable cost for the readers of the Newsletter? Please let the editor know.



G3PHO DUAL MODE HORN ASSEMBLY DIMENSIONS
USING A 60cm AMSTRAD OFFSET-FED SATELLITE DISH

USING BSB DISHES ON THE 10GHz BAND -- by Mike, G3LYP

The availability on the surplus market (eg. from Satellite Surplus, Stirchly Lodge, Stirchly Village, Telford, Shropshire.) of 35 centimetre dishes, designed for receiving BSB satellite TV transmissions, at a price of about £15 has made their use on the 10GHz amateur band an interesting possibility, for those wanting a small, but efficient antenna for home or portable use.

The price quoted above is for a new, boxed, kit of parts including the dish, LNB, and a selection of useful hardware for mounting purposes. Second hand assemblies are also available for £7.50.

Over the last few months, a number of experiments have been carried out with G3BEX, the results of which have been sufficiently encouraging to be worth passing on to others who may wish to use this approach.

The assembly of the dish is very simple following the instructions provided in the kit, and it is only necessary to devise a system of mounting the dish on a mast in such a way as to allow adjustment in the vertical plane. This can be done using the hardware supplied, and two "U" bolts to suit the diameter of the mast used. In this case 1.5 inch exhaust fittings, available from car accessory shops for about 50 pence each, were used. Based on experiments with a signal from GB3SEE, it was found that the plane of the dish should be set at an angle of about 25 degrees to the vertical mast (ie. tilted forward by this amount).

An initial experiment using the three stage amplifier in the LNB as a receiving pre - amplifier was not very successful, mainly due to difficulties in getting a good mechanical and electrical connection to the drain of the third GaAsFET on the PCB. As purpose designed amplifiers are available from G3WDG, it was decided to scrap the electronics in the LNB and use only the feed horn in future experiments.

When the PCB and the plastic radome are removed, the polyrod lens is exposed. The purpose of this component is twofold. In the first place, it modifies the radiation pattern from the horn and allows more effective illumination of the small dish. The second function is to allow the antenna to receive left or right handed circularly polarised signals. It will be seen that the pick-up spill on the PCB is set at an angle to the blade on the underside of the polyrod lens. If the antenna is to be used with linearly polarised signals, the spill will have to be parallel with the blade on the polyrod.

The polyrod can be removed from the horn by inserting a piece of dowel, with a "V" shaped notch, into the horn and tapping carefully with a hammer. The shape of the notch must be such, that when placed over the blade of the lens, the pressure is applied on the shoulders, rather than the thin tip of the blade. If this is not done the blade will almost certainly be broken. When the lens is withdrawn, it will be found to have lugs on either side which fit into slots in the top of the horn. Although there are two sets of slots provided, neither of these are suitable for linear polarisation, and two new slots must be filed with a needle file or other small file. The lens will later be re-inserted in the new slots, taking care that the sealing "O" ring seats properly in it's groove. As considerable pressure is required during this operation, to avoid damaging the tip of the lens, a hole is drilled in a block of wood so that the sides of the lens seat on the top of the hole, but it's tip does not reach the bottom of the hole.

The base of the LNB is levelled by removing two small lugs, and the boss on to which the 7805 regulator was bolted, and finally rubbing on a sheet of abrasive paper on a flat surface. A brass plate (16 SWG) is cut to fit over the base, and is attached using the original 3.5 mm screws which were used to mount the PCB. (These screws will have to be shortened by about 3 mm before re-use.) The position of the holes on the brass plate can be accurately placed by using the cast aluminium cover removed with the PCB, as a drilling template. The next job, and potentially the most difficult, is to mark through the horn, the centre of a hole on the brass plate which must be on the same centre line as that of the horn. The first idea tried was to turn a steel rod to be a sliding fit inside the horn, and then turn a sharp point on the rod to act as a centre punch to mark the centre of the hole. Unfortunately the inside of the horn tapers slightly in either direction away from the centre, and so this method does not provide the accuracy originally expected. In the end it was necessary to use a combination of drill, reamer, and half round file to make a hole slightly larger than the outside diameter of the horn and concentric with it.

The construction of the remainder of the transition depends on the type of termination required for connection to the rest of the system. Where an SMA or similar connection is required, a cavity is made by boring a piece of 7/8" diameter brass rod to make a tube with internal diameter of 18 mm (to match the diameter of the horn), and of about 36 mm in length (not critical). A shoulder is turned on one end to allow the tube to seat in the hole in the brass plate. A flat, large enough to allow a two hole SMA connector to be mounted with the mounting holes in line with the axis of the tube, is milled or filed along the length of the tube. A hole is drilled 6 mm from the end of the tube furthest from the mounting plate for the spill of the SMA connector. Initially this hole should be drilled 1.3 mm diameter, and the connector placed in it, while the two mounting holes are drilled. Finally the hole is drilled to 4 mm. The mounting holes can be tapped 8 BA or an equivalent metric size. Three holes for matching screws are then drilled and tapped 8 BA at 5 mm spacing along the flat between the connector and the horn. Finally, a shorting plate is soldered across the end of the tube nearest to the connector, and the whole assembly is soldered to the mounting plate, taking care to avoid solder entering the cavity. The SMA connector is modified by having a piece of copper tube about 8 mm long and 3/32" diameter (1.3 mm I.D.) soldered over the spill (See Fig 1).

Where it is desired to go directly from the horn to waveguide, a modified version of the above transition can be used. In this case, the length of the 18 mm I.D. tube is reduced to about 25 mm, and the end of the tube furthest from the mounting plate is reduced in diameter to be a sliding fit inside a piece of 22 mm copper water pipe. A taper of about 2 degrees is turned on the inside of the brass tube so that there is a smooth transition between the brass tube and the copper pipe. Using a form tool as described in "The Microwave Handbook" Vol 3, page 18.6 by G8AGN, the other end of the copper pipe is transformed from circular to rectangular, with the dimensions of waveguide 16, and soldered to a suitable flange. As before, three 8 BA matching screws are placed at 5 mm spacing on the brass tube in a position where they line up with the blade of the polyrod lens in the LNB horn. Finally, the brass tube, the copper pipe, and the mounting plate are soldered together, taking care that all the components are correctly orientated with respect to each other, and, as before, that solder does not get inside the waveguide. (See Fig 2).

After the polyrod lens is re-inserted as described above, the radome is replaced and sealed to prevent ingress of moisture. The modified LNB is now mounted on the dish using the plastic bracket provided, and the whole assembly set up pointing into free space for adjustment.

Using a signal source on 10.368GHz (eg. a WDG001 module), and a directional coupler ("Microwave Handbook" Vol 2, page 10.18), the matching screws are adjusted to reduce the reflected power to a minimum.

For those who do not wish to tackle the metalwork involved in the above approaches, small cast aluminium horns are available on the surplus market (eg. from Sandpiper Communications, Aberdare, Mid Glamorgan.) which are terminated with a waveguide 17 flange, and which, using one of the transitions described by G3JVL in "Microwave Newsletter", October 1992, page 8, can be connected easily to the rest of the system. The only modification to these horns which is recommended, is the inclusion of three matching screws as in the two designs described above. Although slightly larger in diameter than the BSB horns, they will fit the same mounting brackets as the former, although some risk of breakage is possible, particularly if the plastic becomes brittle through exposure to light and air. (See Fig 3).

Results with the above feed systems have been very satisfactory, and all outperform the slightly larger 18 inch "Practical Wireless" dish fitted with a penny feed. The BSB horns appear to be slightly better than the third type, but the difference is fairly small.

As these dishes are quite small, the possibility of using separate dishes for transmitting and receiving could be considered, thus eliminating the need for costly SMA relays, or bulky waveguide switches.

As a final note, if it is intended to use the modified BSB horns in a permanent installation, steps will have to be taken to ensure that the joints between the brass plate and the aluminium casting of the LNB are well sealed to prevent water seeping into the joint. If this is not done, electrochemical reaction between the brass and the aluminium will result in severe corrosion.

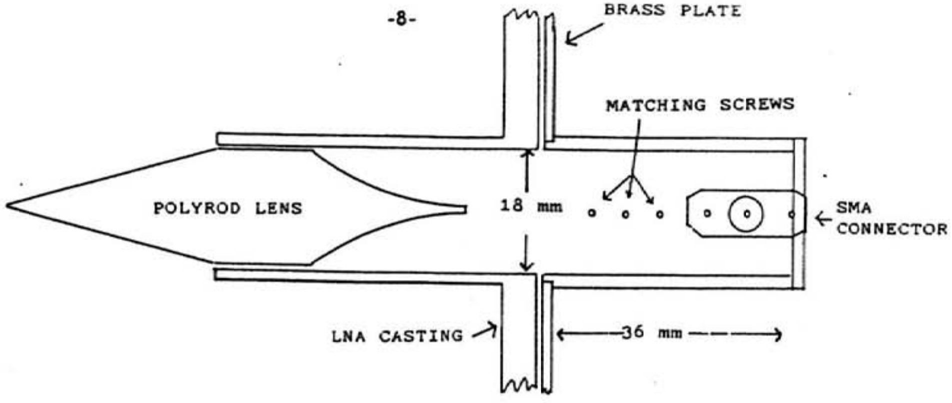


FIGURE 1

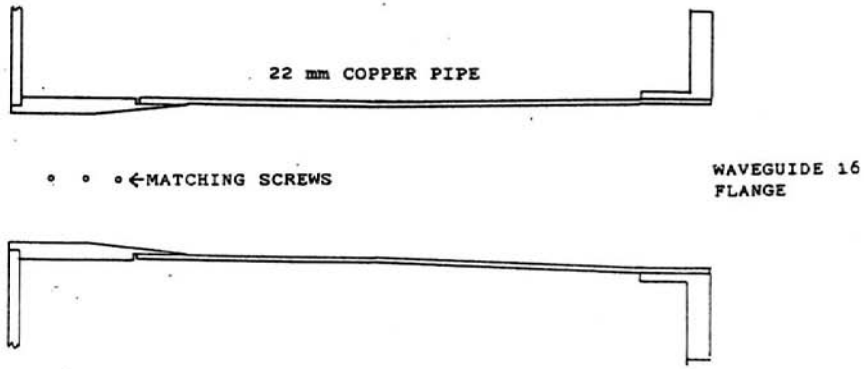


FIGURE 2

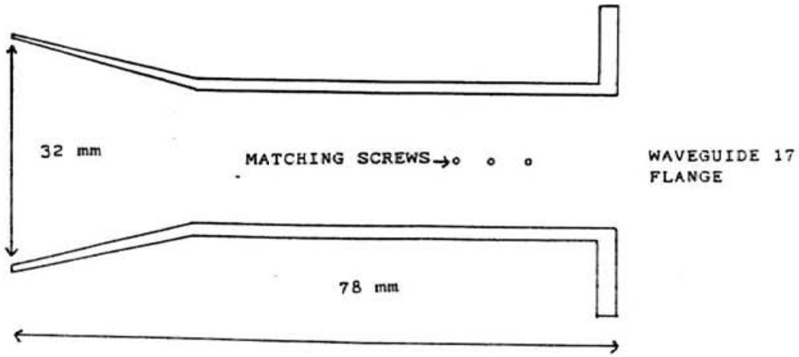


FIGURE 3

DESIGN AND REDESIGN OF SAT-TV DISHES FOR 10 GHZ.

by Ole Nykjær - OZ2OE
Birkeholm 37
DK-8700 Horsens
Denmark

The last years have seen a tremendous increase in the number of individual satellite-TV receiving systems in Europe. Today there are about 9.5 mill. systems installed and more than 2.5 mill. are added every year - a part of those being replacements of older systems.
With so much equipment in circulation, it's easier than ever to find a used satellite dish at low cost - or no cost!
These antennas are designed for 11-12 GHz (10.950-12.750 GHz), they are well made - electrically and mechanically, they have the right size with adequate gain without beeing too difficult to handle and they are available.
However to get the most out of a surplus antenna, a number of points are important when you want to convert them to our 10 GHz band.

A little theory.

The antenna actually consists of both the dish and the feed ! It's important to pay attention to the feed, because you can loose several dB's of gain if not done correctly. (You don't use any old dipole on a new long yagi either - or do you?)
The principle of using a parabolic shape to collect light into a single point - the focus - or alternatively to convert the light from a point source into a parallel beam, is known to every schoolboy.
There are many form of parabolic shapes - from very flat to very hollow - but they all have a focal point. The ratio af focal distance to dish diameter, or f/D is an important parameter when designing feedhorns. See fig. 3.
When explaining how a parabolic dish works, we always uses the analogy with light. However that description only fits when the wavelength of the signal (-light) is of no significance with respect to the size - diameter - of the dish.
When working with radiowaves we all know that we dont get a parallel beam from our transmitting antenna - there is a certain beamwidth forcing the signal to spread out. Correspondingly when receiving the signals don't converge to a point - but rather into a "sphere" around the focus and the job for the feedhorn becomes that of collecting this cloud of energy into the transmission line.

The relation between size of the dish, gain and beamwidth is shown in fig 5.

CENTER FEED DISHES

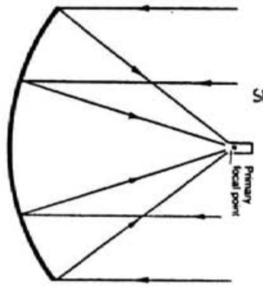


Fig 1. Primary focus

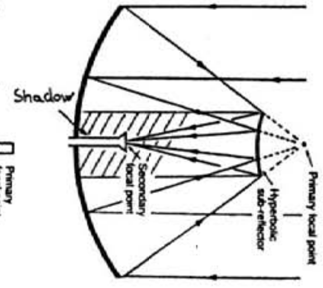


Fig. 2. Cassegrain

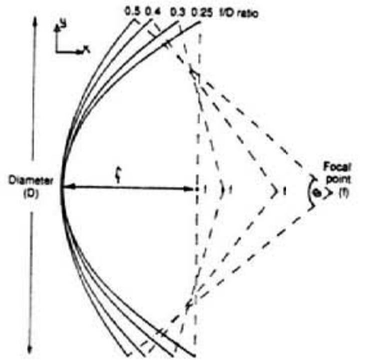


Fig 3. Focal point moves with f/D.

Parabola:
$y^2 = 4f \cdot x$

If f/D is unknown measure:
r = radius of dish
c = depth of dish
$f = \frac{r^2}{4c}$

OFFSET FEED DISH

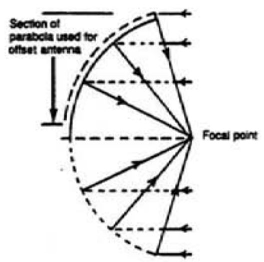
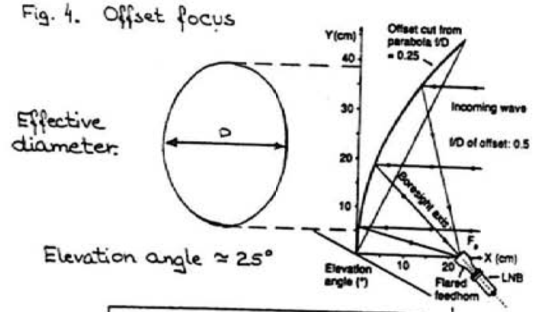
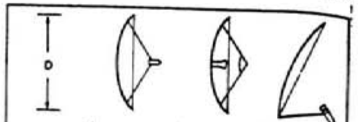


Fig. 4. Offset focus



Elevation angle ≈ 25°



	Centre focus	Cassegrain	Offset
D/λ at main application	D>20λ	D>75λ	D>10λ
Area efficiency	Good	Very good	Good
Sidelobe attenuation	Good	Good	Very good
Construction	Good	Complex	Moderate

But remember that this curve only applies when the antenna is designed properly, that is when the shape of the dish and the radiation pattern of the feed matches. The purpose af the feed (- in the transmitting case) is to concentrate the energi on the parabolic surface without spilling too much to the outside, but also to illuminate it as even as possible. The total efficiency of the antenna is the combination of the illuminating efficiency (- how even the dish is illuminated) and the spillover efficiency (- how much signal is lost due to spillover from the feed). The total efficiency is the product of these two,and as you can see from fig. 6, the optimum occurs with an edge illumination of -10dB.

As the optimum is rather broad, any value from -8 dB to -16 dB can be used. It will have an effect on sideloop level - see fig 8. - and on the sideloop noise pick-up.

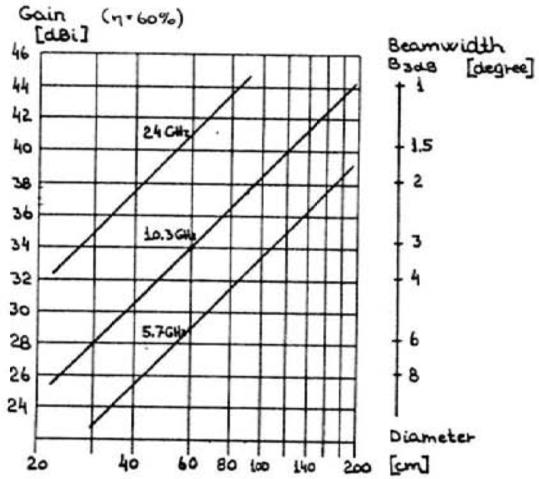
Unfortunately we dont get over 80% efficiency in "real life". The result of fig 6. works on the assumption that the feed has a perfect symmetrical radiation with only one main loop. In reality there is energy wasted in minor loops as well as unequal radiation in the vertical and horizontal plane. This is often the limiting factor in feeds constructed on the basis af rectangular waveguides (-such as small horns) as well as simple circular ("beer can") feeds, where radiation from currents outside! the waveguide creates a "diffuse" radiation patterns.

The measured radiation pattern from a 60 cm offset dish is shown in fig 7. The low sideloop level is a sign of a well design antenna.
Usually sat-TV dishes have a very clean pattern and a gain close to optimum - as the signal margin from the sattelite is very small with virtually no room for errors. If the dish is manufactured without close attention to tolerances, the radiation pattern will be distorted with high sideloop level that "blends" into the main beam.

Different types of dishes.

Virtually all the different forms of parabolic shapes appear on the sat-TV market. (-also types different from the parabolic - flat arrays, dielectric lenses, fresnel zone "lenses", large horns etc.)
Fig 1, 2 and 4 shows 3 different types - prime focus, cassegrain and offset. They each have advantages and disadvantages, but all works on the principle af concentrating energy into a "point".
The most common type for small sat-TV systems is the offset type, it has better efficiency (=gain) and lower noise pick-up than the prime focus and is easier (- and cheaper) to produce than the cassegrain. Some people tends to dislike the offset type because "you cant see where its pointing", in contrast to the two others. That is however just a matter of getting used to the type.

Fig 5. GAIN AND BEAMWIDTH OF PARABOLIC ANTENNA.



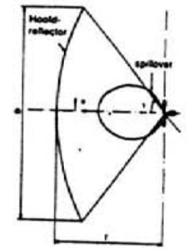
$$G = \frac{4 \cdot \pi \cdot A}{\lambda^2} \cdot \eta$$

A = area of dish
λ = wavelength
η = efficiency

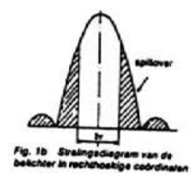
$$BW \approx \frac{70 \cdot \lambda}{D}$$

D = diameter of dish.

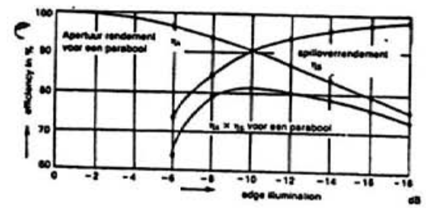
Fig 6. EFFICIENCY OF FEED / DISH.



Illumination of the dish varies with the angle ψ.
Reduced illumination at the rim of the dish.



Spill over from the feed is lost power! - and extra noise in receiver mode.



Total - efficiency combined of illumination and spillover.

The f/D for prime focus antennas is nearly always in the range of 0.36 to 0.42, and for the offset type around 0.6 to 0.7 (-this is a practical choice based on the types of feedhorn on the market).

Used as an amateur antenna the offset still holds the advantages. It preserves the quality of low noise pick-up (-which the cassegrain looses when pointed at the horizon) and you can put your transverter at the feed (-avoiding transmission line-loss) without blocking the signal in front of the dish.

Different types of feedhorn.

Normally the feedhorn takes the form of a circular waveguide which ends in a small horn or just an open waveguide. In order to control the radiation from the feedhorn - to obtain the all important correct illumination of the dish - a number of ridges are added either around the open waveguide or inside part of the horn. These ridges forces the RF-currents at the mouth of the open waveguide in such a way as to give the desired radiation (- like controlling the RF-currents on a wire antenna by placing quater-wave chokes at selected places.)
Certain feedhorns for offset dishes comes without these ridges. Instead they have a number of discontinuities on the inside diameter to control the modes and hence the radiation from the feed.

How to redesign the dish and mounting.

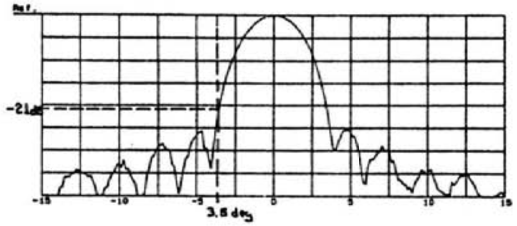
There is not much to do with the shape of the dish - except to check it for faults. Unless it is visible damaged it's normally ok. Small local deviations will have very little effect - just as dishes made from perforated plates can be perfect reflectors as long as the holes are small compared to the wavelength.
You always need to know where the focus is. If you don't have the original feed (-or feedholder) the focus can be found by measurements and calculation - or simply by holding a piece of paper in front of the dish on a sunny day.
As most dishes are designed to receive signals at an angel of 10-30 degree above the horizon, they will rarely be capable of pointing to the horizon. The mount can be modified by drilling new holes for the bracket. With offset dishes you often have to move the entire mounting bracket to the lower part of the dish or alternatively rotate it 90 degree and mount it "on the side".

How to redesign the feedhorn.

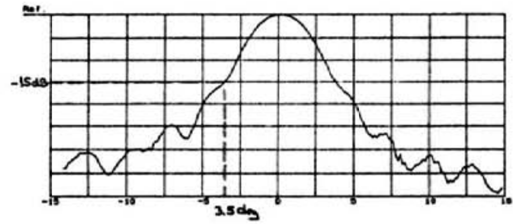
You can build your own feed - see fig 9 for designs. But if at all possible use the original feedhorn. (-for 10 GHz).
By doing so you have almost secured a guaranty to obtain high gain and clean pattern. Feeds from other sat-TV antennas can also be used (-remembering that f/D doesn't change much among the same "family" of dishes), but be sure to observe whether the feed was for prime focus or for offset dishes originally.

Fig 7.

Measured radiation pattern - 60 cm offset dish.



Correct parabolic shape.

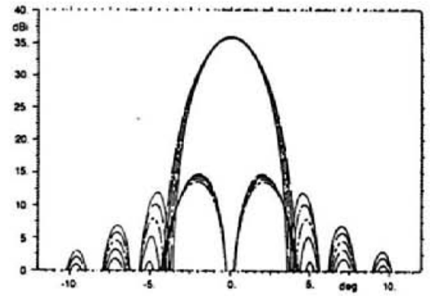


Incorrect shape - the depth is 4 mm too small.

Fig 8.

Radiation pattern - 60cm offset

Copolar (· horizontal) and Crosspolar (· vertical)

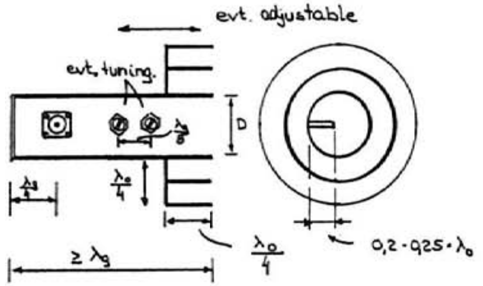


Effect on radiation pattern from changing the edge illumination -8dB to -16 dB in 2dB step.

The easiest to modify are the ones with a connecting flange. If you come up with an integrated LNB-feedhorn, you have to cut the LNB away with a hacksaw (-as close to the LNB as possible).
Remember to save the plastic cover for weather protection (- and the rest, as a defect LNB is full of useful components).

The drawing in fig 10. shows the modifications to a prime focus feedhorn. Modifying a feed for an offset dish is exactly the same, as you are working inside the waveguide part of the feed.
As teminal a SMA connector is screwed on the side of the feedhorn (-made plane by a file) with the centerpin acting as a small monopole inside the circular waveguide. To preserve the 50 ohm impedance into the guide a 3.0 mm hole is drilled to accommodate the pin diameter of 1.25 mm. In order to maximize the bandwidth of the monopole, a short piece of 3 mm brass tube is soldered to the center pin. One quater wavelength (guided wave wavelength!) behind the monopole the guide is shortcircuited by a metal plate (aluminum). Two M2,5 screws placed 1/8 wavelength apart in front of the monopole acts as a tuner to adjust the VSWR.
Measuring the reflected power on the SMA-connector (f.ex. with a network analyzer) you can adjust the return loss to below -36 dB (VSWR 1.03) - outside the accuracy of most instruments!
(But remember - on a prime focus antenna reflections from the dish back to the feed changes the VSWR, so you must do the adjustment with the feed in the proper place. With offset antennas this is not a problem.)
If you can't measure just leave the tuning screws out - the return loss will be in the vicinity of -10 dB (VSWR 1.9:1) which is quite acceptable on microwave.

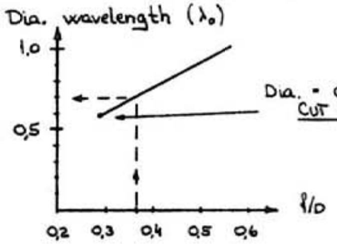
DESIGN OF CHOKED HORN ANTENNA



λ_o = free space wavelength

λ_g = guided wavelength $\left(\lambda_g = \frac{\lambda_o}{\sqrt{1-\left(\frac{\lambda_o}{3{,}412 \cdot r}\right)^2}} \right)$

Choose diameter to fit f/D of dish.



Eks. A dish with f/D = 0,36, choose horn diameter 0,7·λ_o

OTHER HORN DESIGNS.

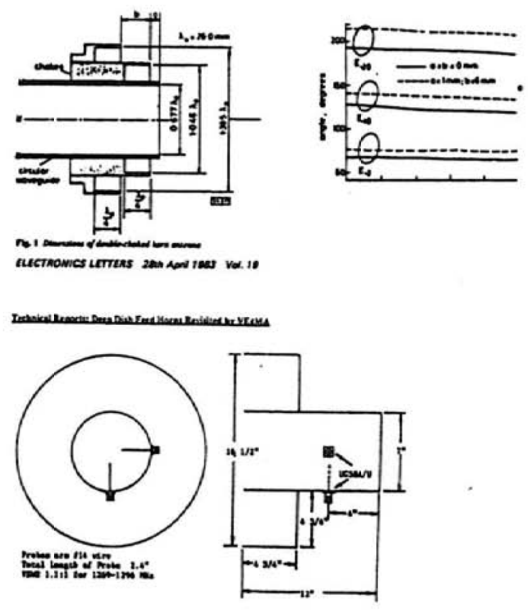
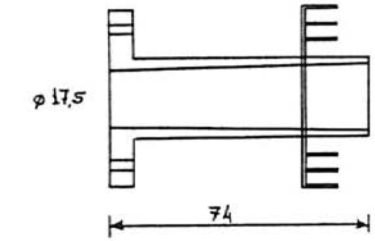


Fig. 9 - designs

10 GHz feed-made from a 11 GHz sat TV feed.



Mean dia. φ 18

$\lambda_g = \frac{\lambda}{\sqrt{1-\left(\frac{\lambda}{3{,}412 \cdot r}\right)^2}}$

λ_g = 86,54 mm

$\frac{\lambda_g}{4}$ = 21,6 mm

$\frac{\lambda_g}{8}$ ≅ 11 mm

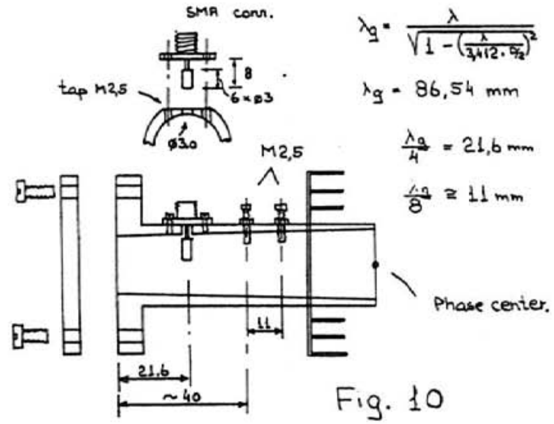
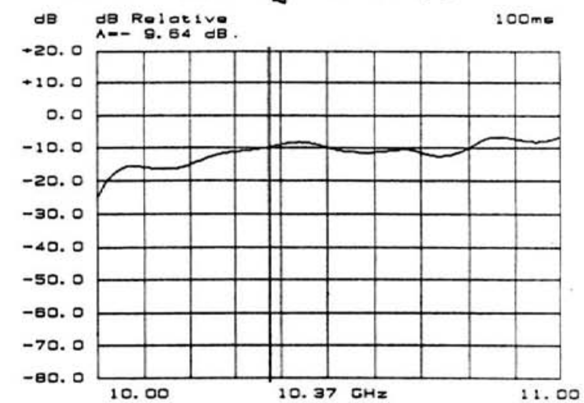
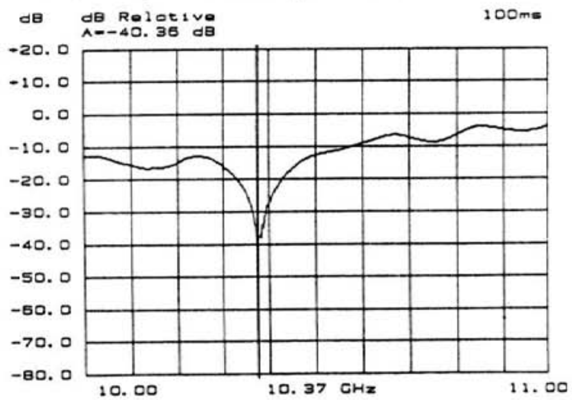


Fig. 10

Feedhorn - no tuning - VSWR 2:1



Feedhorn - with tuning - VSWR 1.03:1



SUR UNE CHAUDE ROUTE D'ETE 1990 · Scene 3 **F1JBP**

Cette article n'a pas pour but de traiter en détail un systeme Cassegrain. Il y a de tres bons livres qui analysent ce sujet. Mais plus simplement, détailler les calculs necessaires à la realisation pratique en supposant deux élements connus:

a) Le rapport F/D de la parabole
b) L'angle d'illumination de la source vers le subréflecteur, ou le diametre du subréflecteur

Pour ceux qui seraient tentés de se lancer dans ce type d'illumination, la premiere question que l'on peut se poser est pourquoi ? . Pour moi, c'est ne pas faire comme tout le monde et chercher a comprendre autre chose. En fait plus serieusement, quels en sont les avantages et inconvenients.

Avantages:

Le principal avantage est surtout dans une utilisation du type E.M.E. où l'angle d'élévation de la parabole est le plus souvent important. Dans ce cas la source ne voit plus le sol, mais le ciel. De ce fait la temperature globale du sytème est moins dégradée par le bruit ramene par le sol, dû au débordement de la source sur le bord de la parabole, dans le cas d'une illumination directe.

Le fait que la source n'est plus au foyer de la parabole principale, mais au foyer de la parabole équivalente, permet de placer le preampli et l'amplificateur au plus pres de la source ce qui contribue encore a ameliorer la temperature du systeme. De plus la mécanique est simplifiée.

Un autre argument en faveur de ce système d'illumination, lié a la notion de parabole équivalente, est le grandissement (rapport entre la focale du réflecteur equivalent et celle du réflecteur principal). Du fait de ce grandissement les aberrations dues au défaut de géometrie sont diminuees dans des proportions non negligeables (la focale étant au dénominateur dans les équations définissant ces aberrations).

Inconvenients.

Le principal inconvenient est l'effet de blocage au centre de la parabole crée par le subreflecteur, qui est supérieur dans ce type d'illumination, compare a une illumination directe.

Ces pertes par blocage sont exprimees par:

Pb=10*LOG(1-(d/D)²)   d diametre du subreflecteur
                       D " de la parabole

Ce qui donne pour fixer un ordre de grandeur: 0.04db pour un reflecteur de 3 mètres et un subréflecteur de 0.3 metres de diametre.

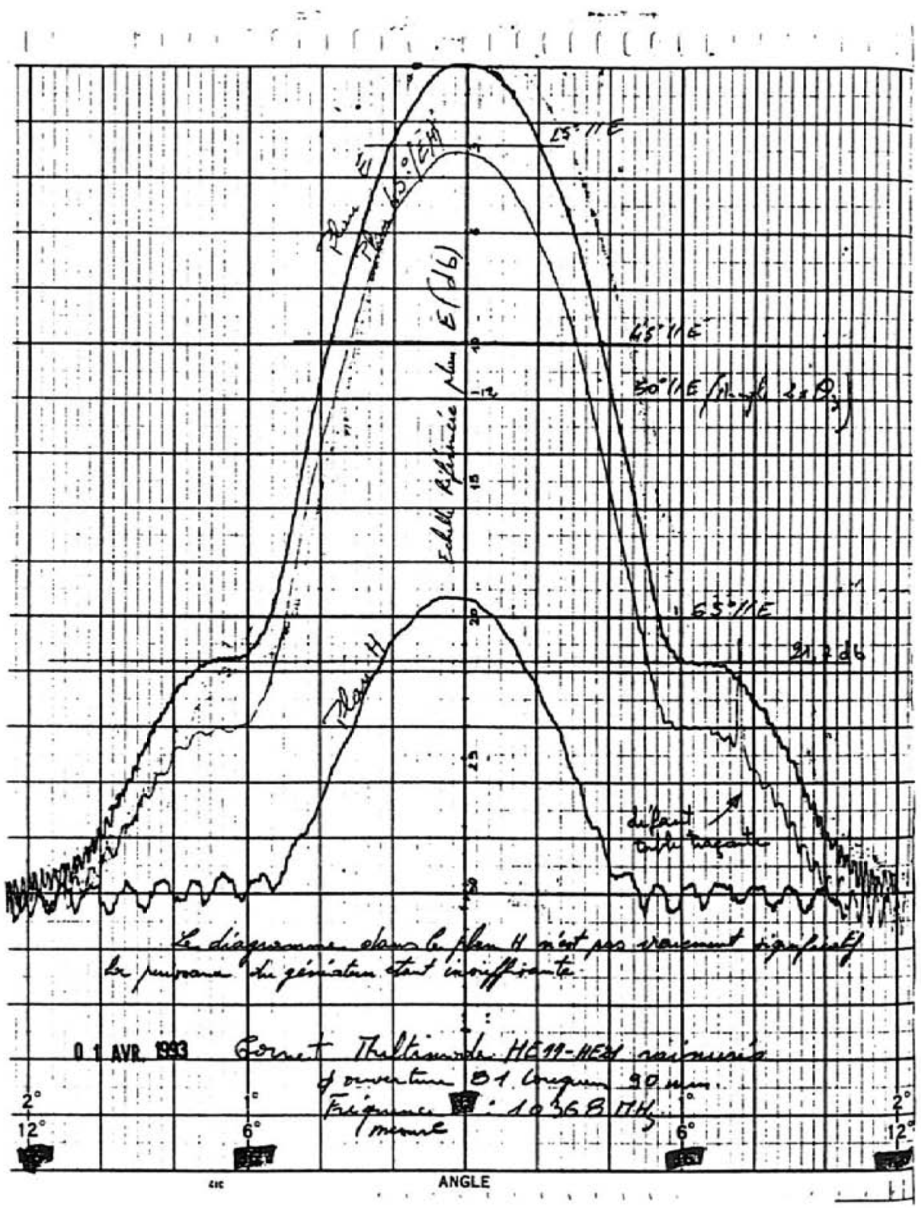
Sans que l'on puisse parler d'inconvenient il y a une contrainte due a la geométrie du système. Le subreflecteur ne doit pas être en champ proche vu par la source. En consequence la distance minima entre la source et le subreflecteur est donnee par:

F2 > 2*a²/lambda   a = diametre de l'ouverture de la source
                    lambda = longueur d'onde utilisee

Par ailleurs le diamètre de l'ouverture de la source doit au moins inclure le diametre correspondant au premier nul de la tache de diffraction, qui est dans le cas du système Cassegrain celle de la parabole equivalente:

a>=2.4*m*lambda*f/D   m = facteur de grandissement
                       f = focale du system
                       D = diametre de la parabole

F1JBP Gerard

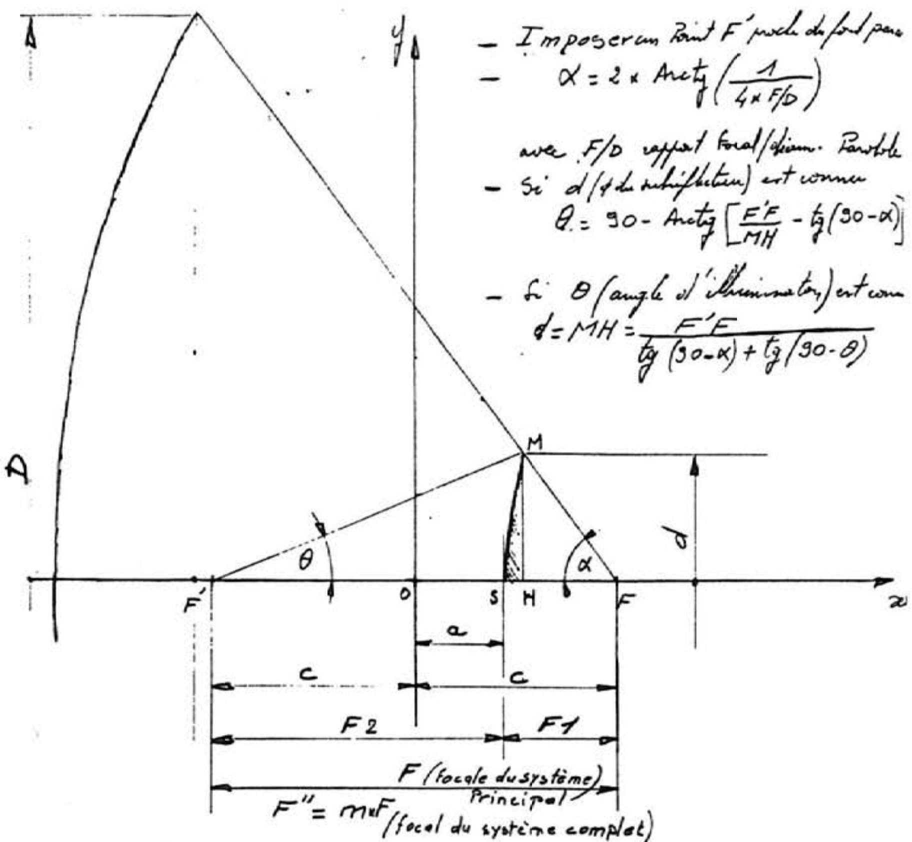


Conditions

- Imposer un point F' proche du fond pour
- $\alpha = 2 \times \text{Arctg}\left(\frac{1}{4 \times F/D}\right)$

avec F/D rapport focal/diam. Parabole

- Si d (ϕ du réflecteur) est connu
  $\theta = 90 - \text{Arctg}\left[\frac{F'F}{MH} - tg(90-\alpha)\right]$
- Si θ (angle d'illuminateur) est connu
  $d = MH = \frac{F'F}{tg(90-\alpha) + tg(90-\theta)}$



$F'H = \frac{MH}{tg\,\theta}$

$F'M = \sqrt{MH'^2 + F'H^2}$ $\quad FM = \sqrt{(FF' - F'H)^2 + MH^2}$

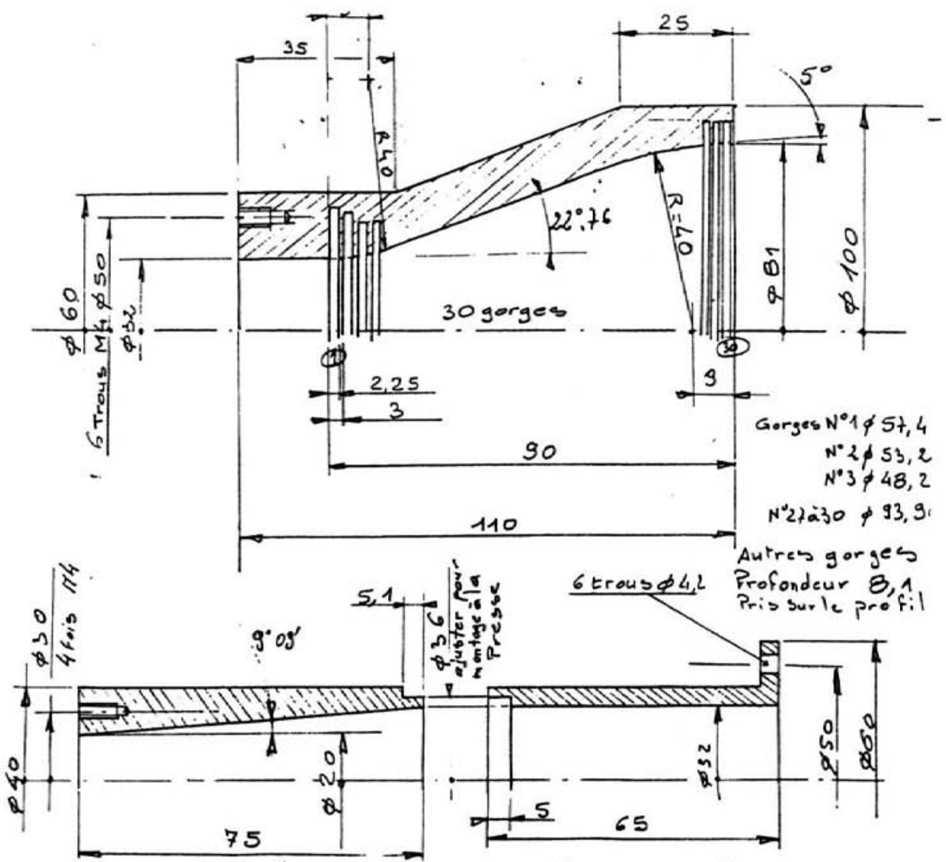
$a = \frac{F'M - MF}{2}$ $\quad F'S = \frac{FF'}{2} + a$

facteur de grandissement : $m = \frac{F_2}{F_1}$

L'équation de l'hyperbole s'écrit $y = \frac{b}{a}\sqrt{x^2 - a^2}$

avec $b = \sqrt{c^2 - a^2}$

En prenant Oy comme axe de symétrie et en faisant varier x de OS à O'H on peut construire point à point l'hyperbole en vue de sa réalisation



Détail d'une source optimisée pour une illumination du type Cassegrain. Fo = 10.400 MHz.
Rloss > 20 db
Largeur de bande ≃ 1 GHz.

Bibliographie : Calcul et conception des dispositifs en ondes centimétriques et millimétriques. TOME 2
Léo Thourel - Cepadues Editions.

ANTENNE MICROSTRIP 10 GHZ

La confection d'une antenne sur 10 GHz se trouve grandement facilitée si l'on fait appel aux techniques "microstrip". C'est ce que démontre cet article.

Angel VILASECA, HB9SLV & Jean-Pierre MOREL, HB9RKR

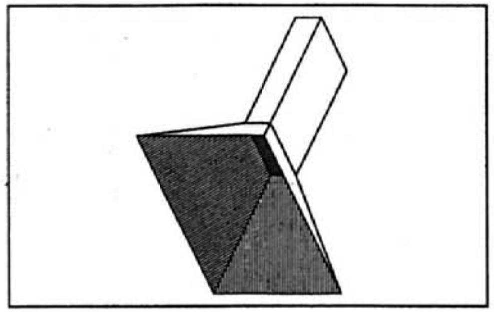
A 10 GHz, comme aux autres fréquences, la confection des antennes couramment utilisées nécessite toujours un certain travail mécanique, consistant en l'usinage des différentes pièces. Que ce soit par exemple une antenne cornet (figure 1), une parabole ou un guide d'onde à fentes, le travail d'usinage à faire est non négligeable et nécessite de l'habileté ainsi que, bien souvent, un outillage important (tour, fraiseuse, etc...)

Bien au contraire, l'antenne décrite ici consiste en un simple circuit imprimé et permet donc de s'affranchir du travail de mécanicien qui vient d'être décrit.

UTILISATION

Cette antenne pourra être utilisée telle quelle, ou bien en tant qu'illuminateur de parabole. Dans ce dernier cas, on peut concevoir des antennes à plus ou moins grand nombre d'éléments, qui auront ainsi un lobe de radiation plus ou moins pointu. Ceci afin d'avoir une illumination optimale d'une parabole donnée, en fonction de son rapport focale/diamètre (figure 2). Outre la simplicité de réalisation, un autre de ses avantages est de pouvoir être connectée directement à l'entrée du convertisseur de réception, respectivement à la sortie de l'émetteur. On élimine ainsi les pertes dans le relais d'antenne, ainsi que celles qui ont eu lieu dans les transitions guide-coax.

L'antenne est représentée à la figure 3. Elle se compose de 10 éléments rayonnants (patches), en forme de losange. Les éléments sont connectés au moyen de tronçons de ligne microstrip, dont la longueur et la largeur sont calculées en fonction des déphasages à apporter et des impédances à adapter. Le matériel utilisé est du circuit imprimé verre - teflon (Cu Clad Keene), spécialement conçu pour les applications hyperfréquences. La figure 3 montre le côté où se trouvent les éléments. L'autre face du circuit est totalement cuivrée et sert de plan de masse.



1 - Une antenne cornet

L'alimentation se fait à la pointe du V au milieu du dessin, et si l'impédance de l'antenne est de 50 ohms. On pourra y brancher un câble coaxial semi-rigide, comme indiqué à la figure 4, ou bien y connecter directement le circuit désiré (figure 5).

MESURES

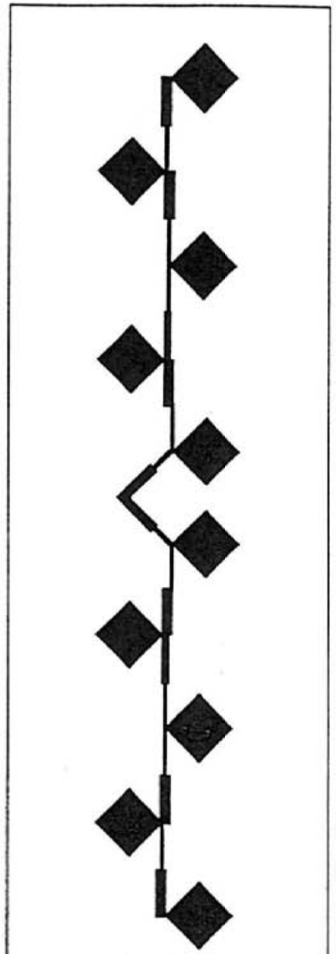
1) TOS

L'antenne réalisée présente un TOS de 1:1 à 10,16 à GHz (figure 6) et elle est à bande étroite.

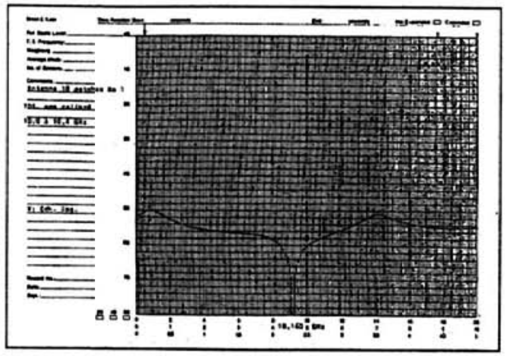
2) DIAGRAMME DE RAYONNEMENT

Le diagramme de rayonnement est visible à la figure 7. En comparaison d'une antenne cornet de 16 dB de gain, le diagramme de rayonnement est plus large vers l'avant, ce qui signifie que l'illumination d'une parabole devrait être particulièrement efficiente avec cette antenne. En effet, si l'on considère la figure 8, on voit qu'une parabole reçoit un maximum de HF en son centre et progressivement moins au fur et à mesure qu'on s'en éloigne. En termes de surfaces réfléchissante de la parabole, on aura de ce fait, les 10% centraux de la parabole qui recevront peut-être 50% de la HF totale, alors que l'anneau extérieur n'en recevra que le quart, bien qu'il représente les 56% de la surface totale. La situation est représentée à la figure 9.

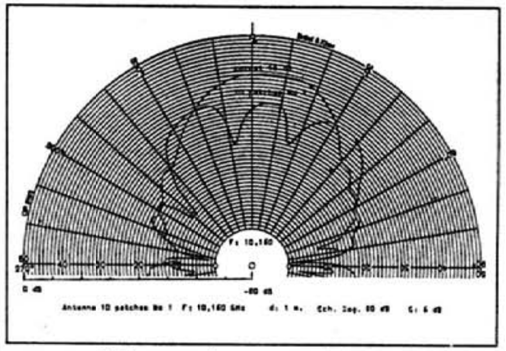
Idéalement, il faudrait que le diagramme de rayonnement de l'illuminateur soit tel qu'on puisse se rapprocher de la situation de la figure 10.



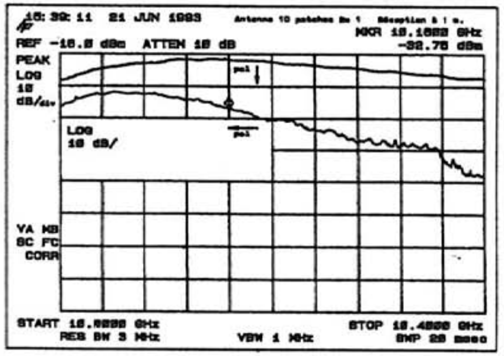
3 - Dessin du circuit imprimé.



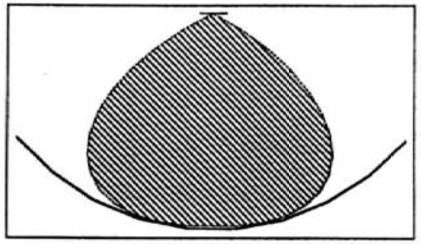
6 - TOS de l'antenne en fonction de la fréquence.



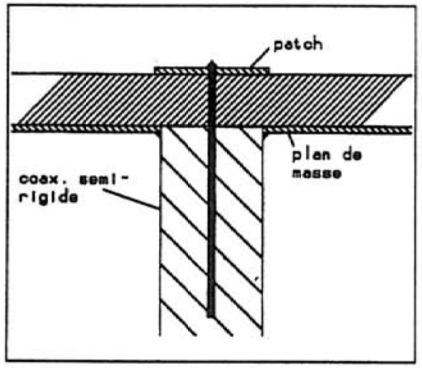
7 - Diagramme de rayonnement de l'antenne.



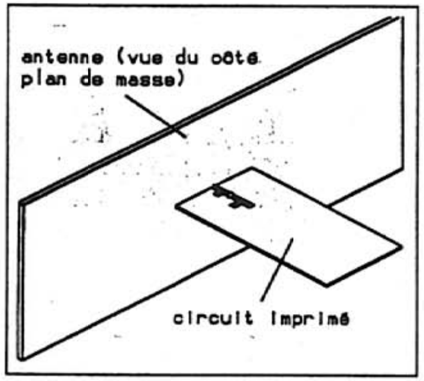
12 Rayonnement en fonction de la fréquence et atténuation obtenue en croisant les polarisations.



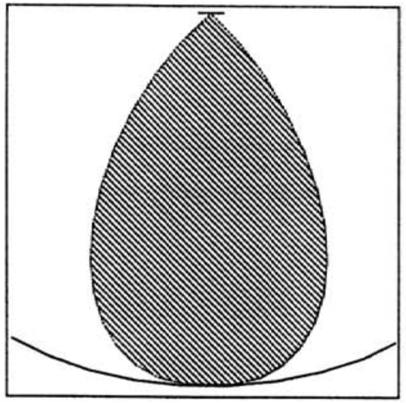
2 a) - Parabole profonde : la focale est courte, donc le rapport focale/diamètre est bas. Le diagramme de rayonnement de l'illuminateur doit donc être large.



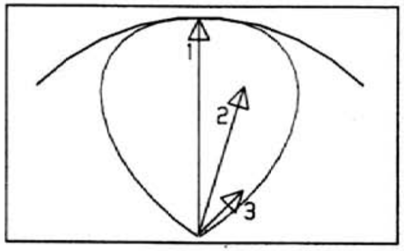
4 - Alimentation de l'antenne par un câble coaxial.



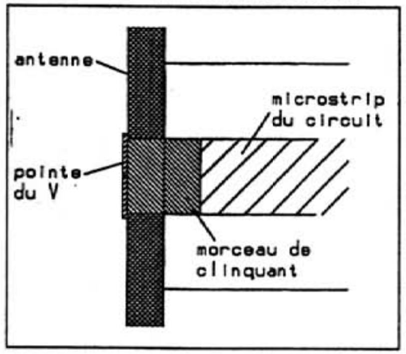
5 b) - Connexion directe d'un circuit microstrip à l'antenne.



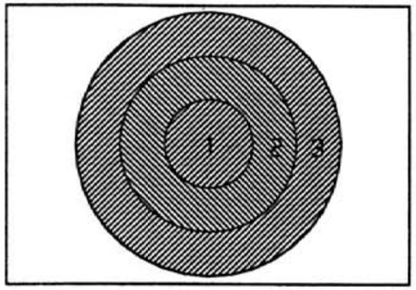
2 b) - Parabole "plate" = focale longue. L'illuminateur doit donc rayonner selon un angle plus étroit.



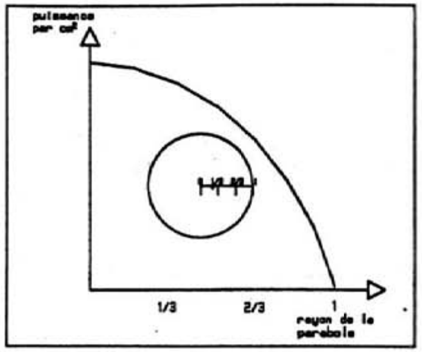
8 - Exemple d'illumination d'une parabole selon différents angles . 1 : 50% de la HF totale. 2 : 40% de la HF totale. 3 : 10% de la HF totale.



5 a) - Alimentation de l'antenne par une ligne microstrip



9 - L'aire n°1 représente seulement 10% de la surface totale, mais reçoit la moitié de la HF. L'aire n°3 représente, par contre, la moitié de la surface totale, mais ne reçoit que le 10% de la HF rayonnée par l'illuminateur.



10 - Répartition de l'énergie rayonnée par un illuminateur réel.

C'est-à-dire que la puissance émise par l'illuminateur, exprimée par centimètre carré de la surface de la parabole, soit constante et tombe très rapidement à zéro aux bords de la parabole. Or comme on le voit à la figure 6, l'antenne microstrip est plus proche de l'idéal que l'antenne cornet, ce qui devrait se traduire par une meilleure efficience, c'est-à-dire un gain supérieur de l'ordre de 1 dB et moins de bruit thermique.

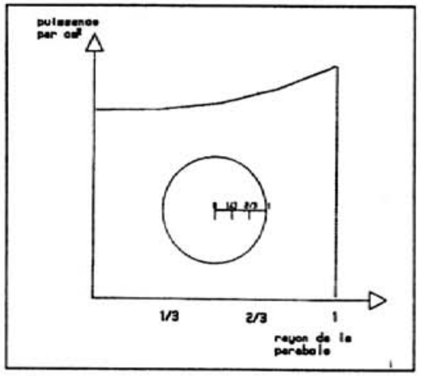
Le nombre d'éléments (losanges) joue un rôle important, dans le diagramme de rayonnement de l'antenne. Tout comme pour une Yagi, il faut s'attendre à ce que plus le nombre d'éléments est important, plus le lobe de rayonnement soit pointu (figure 2).

3) RAYONNEMENT ET POLARISATION

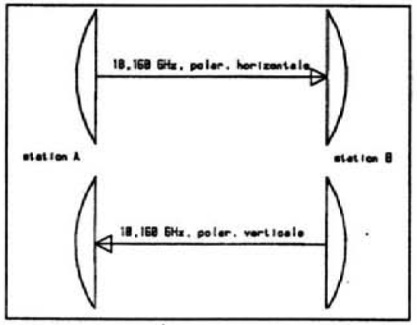
La figure 12 montre que le rayonnement maximum a bien lieu à la fréquence du TOS minimum (10.160 GHz). On constate aussi l'atténuation obtenue en croisant les polarisations. Cette atténuation est minimale vers 10 GHz et atteint la valeur respectable de 30 dB à 10,4 GHz. A la fréquence nominale de l'antenne (10.160 GHz), l'atténuation n'est que de 15 dB, ce qui serait peut-être tout juste suffisant pour établir une liaison duplex en polarisations croisées (figure 13).

CONCLUSION

Cette antenne met en application un nouveau concept encore peu utilisé par les amateurs, l'antenne microstrip, qui se prête bien à l'utilisation à 10 GHz. Sa facilité de réalisation la rend particulièrement bon marché, ce qui a permis déjà de nombreuses applications commerciales, en particulier pour la réception de la TV par satellite.



11 - Répartition de l'énergie telle qu'elle devrait théoriquement être rayonnée par un illuminateur idéal.



13 - Une liaison duplex en polarisations croisées.

ANTENNES 24 Ghz

et au dessus...

RADIO-REF 6 -

ANTENNE CORNET 24GHz - GAIN 25 dB

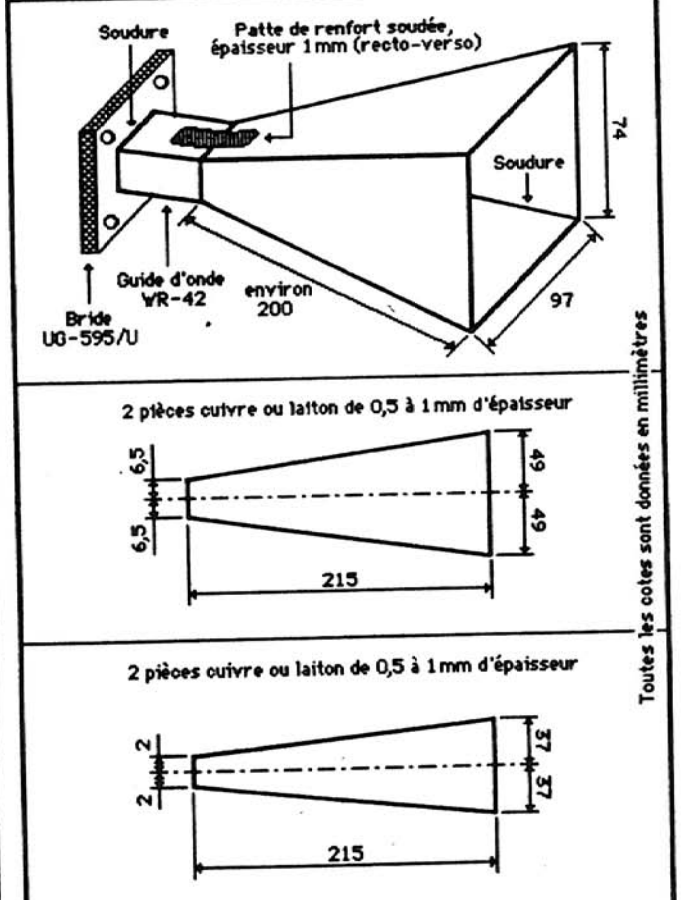
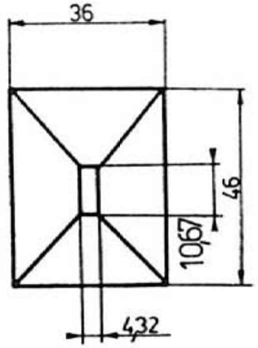
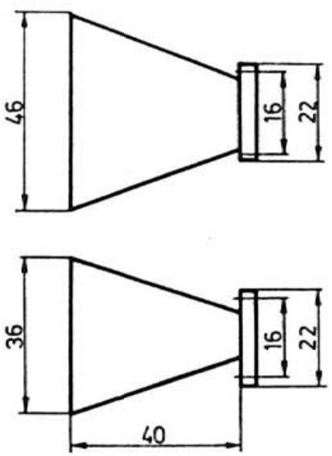


FIGURE 2

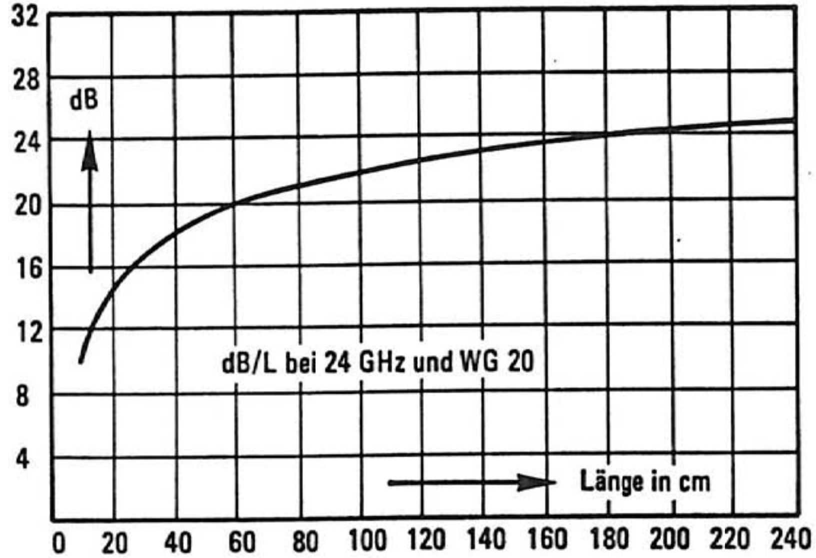
RADIO - REF

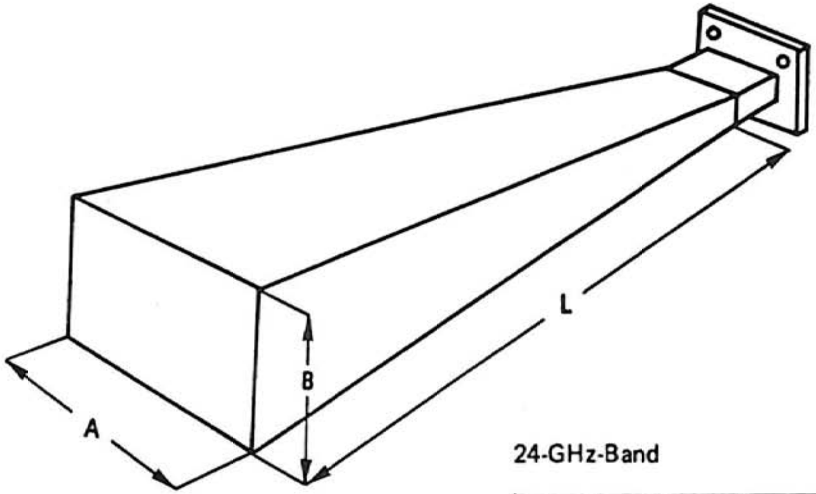


Détails du cornet 17 dB à 24 GHz.
(les cotes sont en millimètres)



820



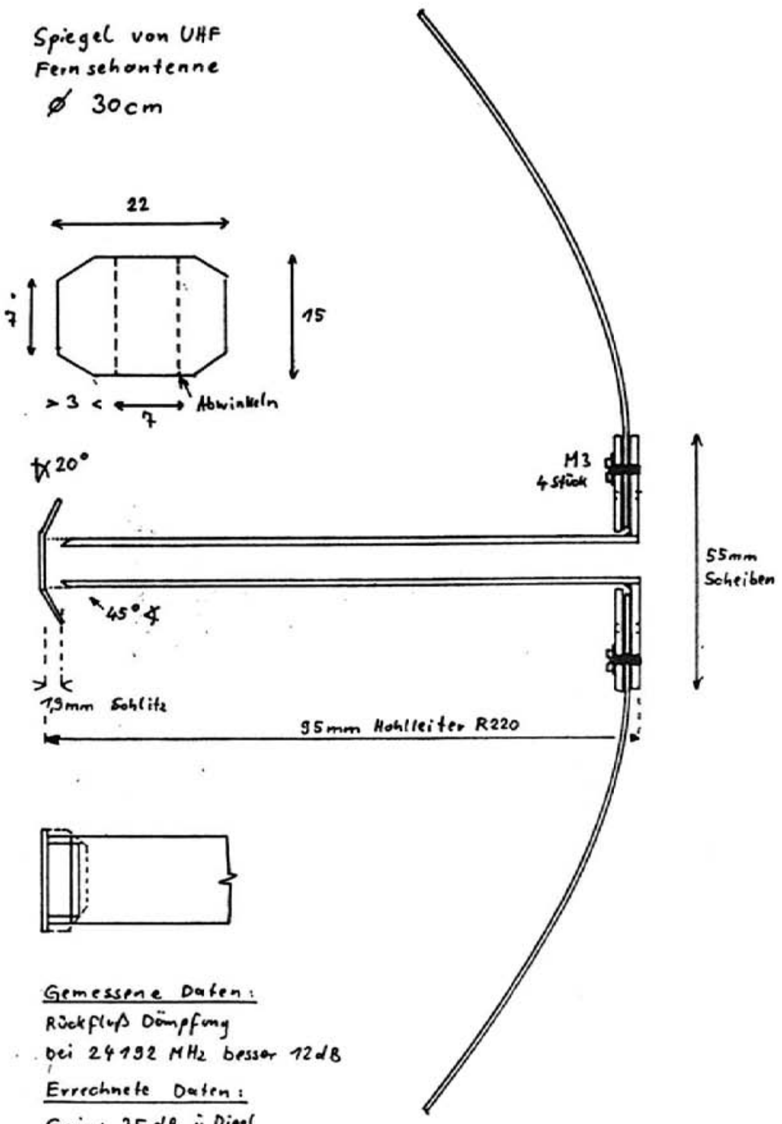


24-GHz-Band

Gewinn	A	B	L
dB	mm	mm	mm
10	18	13	10
16	37	27	21
20	58	43	65
21.5	67	50	96
23	83	61	140
25	103	77	230
28	147	108	213

Schlitzstrahler für Spiegel mit f/d von ≈ 0,3

Michael Kuhne **DB 6 NT** 9.86



Gemessene Daten:
Rückfluß Dämpfung
bei 24192 MHz besser 12dB

Errechnete Daten:
Gain: 35 dB ü Dipol
Öffnungswinkel bei 3dB: 2,2°

A dish feed for 24GHz

The dimensions of the 24GHz feed are shown in Fig 162(a). The method used to construct the feed was as follows. A piece of WG20 of sufficient length to reach the focus of the dish was taken, and its ends squared off by filing. The positions of the slots were marked out using vernier calipers and a right angle, and the slots filed out with a needle file. Repeated checking of the dimensions of the slots during filing ensured accuracy, most attention being paid to the length of the slots.

The end disc was made from 0·036in-thick brass sheet. A 0·5in square piece of this was cut out and soldered to a 0BA brass washer. Using the washer as a guide, the corners were filed off until the piece of brass was the same size as the 0BA washer. A small amount of further filing was then sufficient to reach the final size. The brass disc was then unsoldered from the washer, deburred, and the solder filed off.

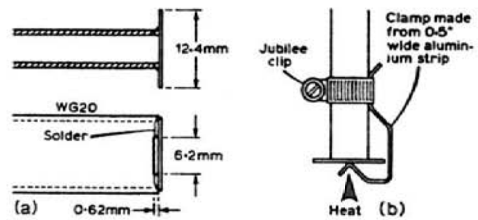


Fig 162. Constructional details of the 24GHz dish feed. (a) Dimensions. (b) Clamp to hold end disc in place during soldering

The assembly of the disc on the waveguide required special care to ensure accurate alignment. The clamping arrangement shown in Fig 162(b) was used to hold the disc firmly against the end of the waveguide. The disc was then moved around until it was centrally located, as indicated by measurement with vernier calipers. With the clamp still in place, the disc was soldered to the wavelength above a small gas flame, with the waveguide held vertically. Even though a minimum of solder was used some solder flowed into the slots, and this was removed after soldering by cutting it away with a scalpel blade, followed by the insertion of the end of a junior hacksaw blade into the slots (after removing one of the pins from the hacksaw blade).

The assembly was completed by sliding a ⅛in-thick brass plate, with a 0·25 by 0·5in slot filed in its centre, on to the waveguide. This plate is for bolting to the dish to hold the feed in place. A home-made WG20 flange was then soldered on to the end of the waveguide. The assembly was held in the dish, and the feed slid backwards and forwards to find the point of maximum gain by listening to a remote signal source. The brass plate was then soldered in position, using a right angle to ensure that the plate was perpendicular to the waveguide in both planes.

Using this feed in a 0·35*f*/*D* 4ft dish, approximately 0·5dB of sun noise was seen, which is consistent with the calculated performance, based on a measured 18dB receiver noise figure, indicating very good performance of the antenna.

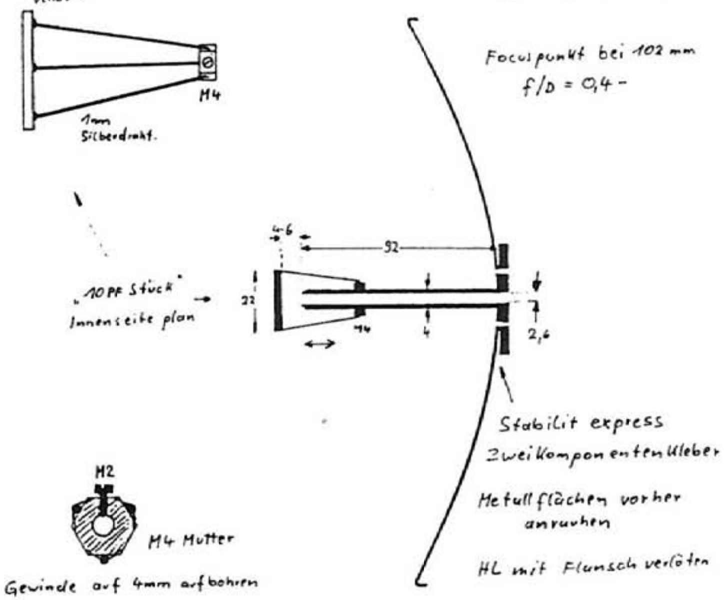
PENNY FEED

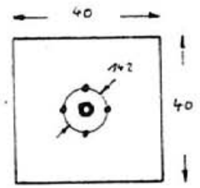
25cm PROCOM Spiegel für MM-Amateurbänder

DB 6 NT 5.91

Maße für 76 GHz !

24, 47 GHz et au dessus





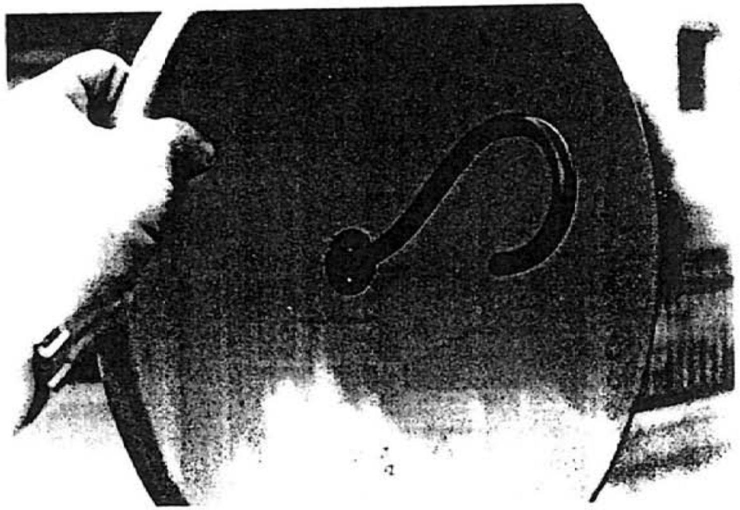
Flanschbohrungen · 2,2mm Ø

HL = 4mm

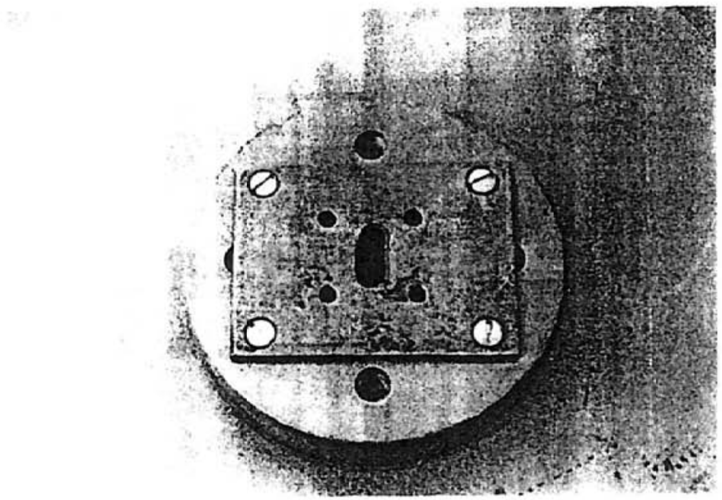
Messingflansch 2mm stark

Frequenz GHz	Errechnete Gain ü. Dipol	Öffnungswinkel	Rundhohlleiter innen Ø	
24	31,5	-3dB 3,5°	8..10mm	
47	37	" 1,8° !	4 mm	
76	41,1	" 1,1° !	2,6mm	Graupner 564-12
145	46,7	" 0,5 !	1,4..1,5mm	

24 GHz Strahler aus Kupferrohr (innen 10mm).



Tube de cuivre à 24 GHz



ANTENNES

OMNIDIRECTIONELLES

Antenne « Slotted waveguide » pour balise

F5jwf
Philippe

La description qui suit présente la réalisation d'une antenne « slotted waveguide » utilisable pour un émetteur balise sur 6cm. Ce type d'antenne est réalisé à l'aide de guide d'onde et permet d'obtenir une dizaine de dB de gain tout en gardant un rayonnement plus ou moins omni dans le plan horizontal.

Le calcul des dimensions de l'antenne est relativement aisée. (cf Microwave antennas §4.9.2). Le facteur prédominant est le couplage des slots par rapport au guide. Plus le nombre de slots est important (donc plus le gain croit) plus le couplage doit être faible. C'est évident, il faut laisser de l'énergie dans le guide pour les slots suivants. La désaxe du slot par rapport au centre du guide permet de modifier le couplage. Celui-ci est nul lorsque le slot est centré sur le grand côté du guide.
La longueur d'un slot doit être de $\lambda_0/2$. La distance entre deux slot doit être de$\lambda_g/2$. La largeur d'un slot est plus délicate à déterminer: elle devrait être de 1/20 de λ_g mais j'ai obtenu de meilleurs résultats avec une fente plus étroite (≈ 1.6mm).

Calcul des différentes dimensions:

Longueur d'un slot:	$Ls = \lambda_0/2$
Largeur d'un slot:	$Ws \approx 1.6mm$ (ou ev. $\lambda_g/20$)
Espacement entres slots	$Ss = \lambda_g/2$

Désaxe des slots:

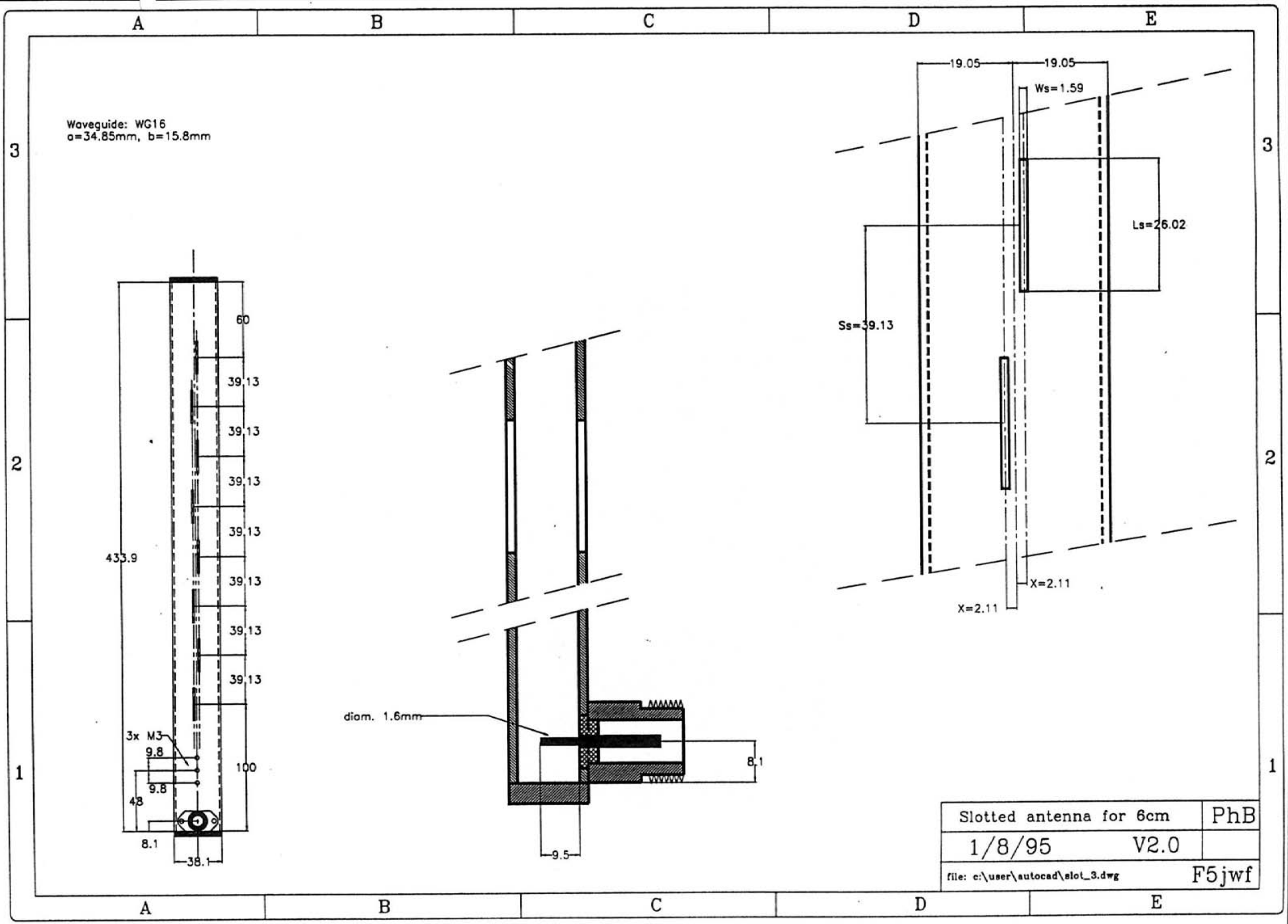
$$X = \frac{a}{\pi} \cdot Arc\sin\left[\sqrt{\frac{g}{g1}}\right] \quad \text{avec} \begin{cases} g = \dfrac{1}{N} \\ g_1 = 2.09 \cdot \dfrac{\lambda_g}{\lambda_0} \cdot \dfrac{a}{b} \cdot \cos^2\left(\dfrac{\pi \cdot \lambda_0}{2 \cdot \lambda_g}\right) \end{cases}$$

Espacement entre le sommet du guide et
l'extrémité du dernier slot: $L_{end} = i * \lambda_g/2$ avec i: impair

__Antenne réalisée pour le 6cm.__

f_0= 5.76GHz	dimensions guide WG16: a=34.85mm	$\lambda_0 = 52.03mm$
N= 16 slots	b=15.8mm	$\lambda_g = 78.25mm$

Longueur d'un slot:	Ls = 26.02mm
Largeur d'un slot:	Ws ≈ 1.6mm
Espacement entres slots	Ss = 39.127mm
Désaxe des slots:	X = ± 2.109mm
Espacement entre le sommet du guide et l'extrémité du dernier slot:	L_{end} = 39.127 (Valeur théorique) Optimisation Return loss: Lend ≈ 47mm

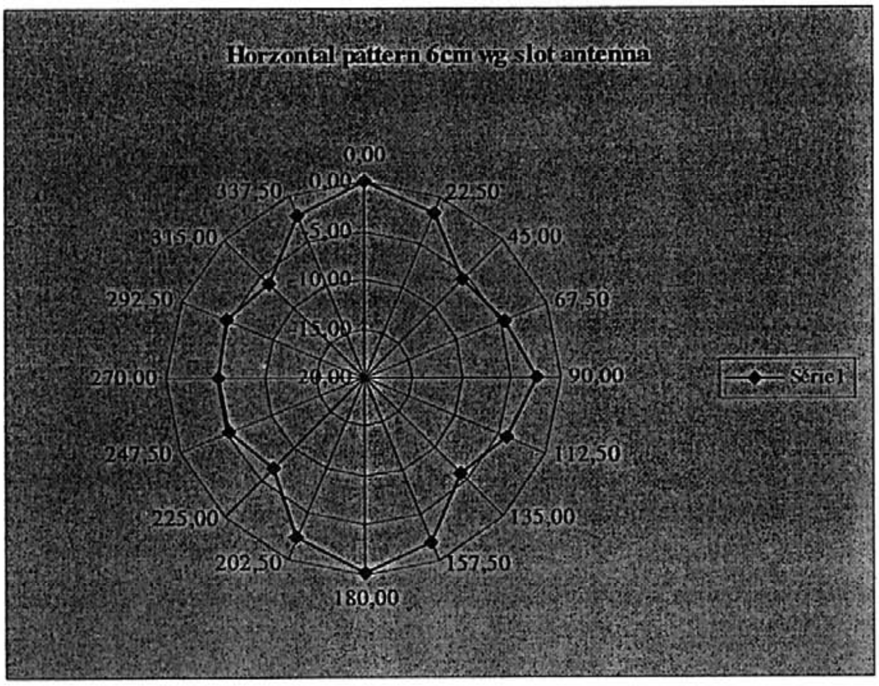

Waveguide: WG16
a=34.85mm, b=15.8mm
60
39.13
39.13
39.13
39.13
39.13
39.13
39.13
100
433.9
3x M3
9.8
9.8
48
8.1
38.1
diam. 1.6mm
8.1
9.5
19.05
19.05
Ws=1.59
Ls=26.02
Ss=39.13
X=2.11
X=2.11
Slotted antenna for 6cm
PhB
1/8/95
V2.0
file: c:\user\autocad\slot_3.dwg
F5jwf

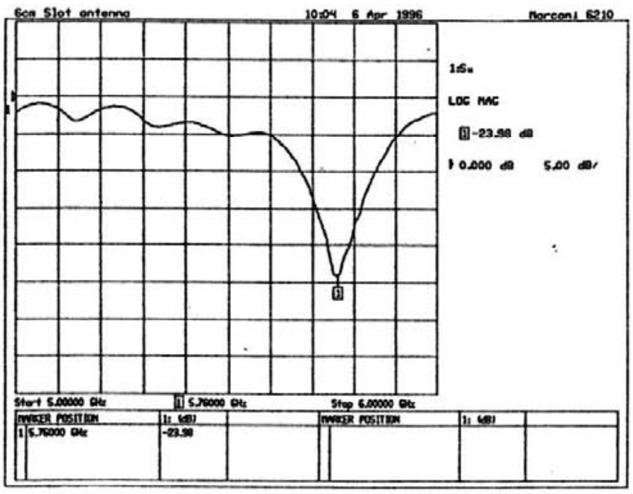
Mesures

J'ai mesuré cette antenne à l'aide d'une cornet de référence. J'obtiens 12.3 dB de gain. La circularité n'est trop mauvaise: le point de rayonnement minimum est 7dB en dessous du rayonnement dans l'axe.
Le return loss est de l'ordre de -24dB (sans l'aide des vis d'accord).

Pour ceux que ça intéresse, j'ai éventuellement quelques longueurs de WG16 d'avance (tel 50 56 72 03).

73 à tous et bonne bidouille.

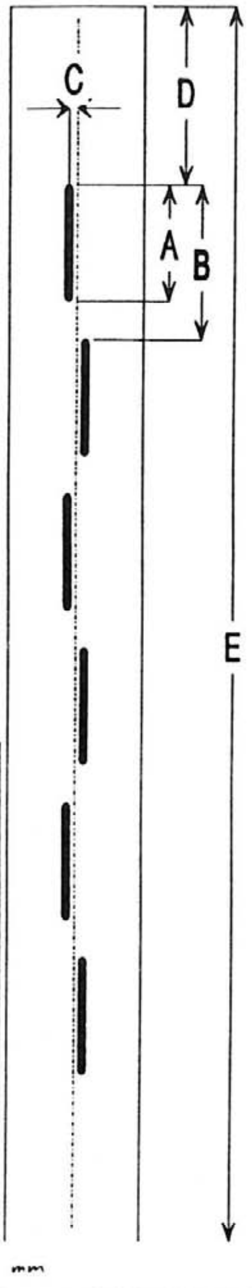




Waveguide Slot Construction

by Dave Meier N4MW

This is a rehash of information previously published in Microwave Update Proceedings by K5SXK and WA5VJB and in *Feedpoint* by AA5C. My only addition is the production of templates for layout and drilling of the slot end holes. I have available the 5760 8 slot and the 6 and 12 slot per face WR-90 antennas. Others can be produced upon request. Templates are available from me for an SASE. Specify which antenna is desired. Note that the number of slots per face dictates the slot to face center distance, so do not vary the number of holes from the intended number for a particular template.



This is how I construct these antennas using hand tools:

- Cut out, carefully align and tape the template to the waveguide.
- Center punch the slot end holes.
- Drill the slot end holes. All antennas in the table use 0.0625 (1/16) inch slots.
- I used a Dremel type saw tool (0.040 width) to "connect the dots". (Be careful!)
- File all slots to final size using a jewelers file.
- Deburr inside and out. Major burrs must be scraped from inside. Relieve slots completely.
- Finish the inside with steel wool by pushing through end to end Follow with soft cloth pulled through waveguide to remove steel wool residue.
- One end is closed off at the dimension shown. Solder plate on closed end. Trim flush with waveguide.
- Length to the feed end can be arbitrary. Solder flange on feed end or otherwise prepare as as required.
- Clean in preparation for painting, stuff inside with paper and paint if desired. Remove paper when paint is dry.

Frequency	Waveguide	Slots per face	Slot length (A)	Slot spacing (B)	Slot offset (C)	Slot start (D)	Minimum length (E)
5760	WR-137	8	1.025	1.539	0.134	1.796	15.39
10368	WR-90	2	0.56	0.75	0.140	0.85	3.01
10368	WR-90	3	0.56	0.75	0.110	0.85	3.76
10368	WR-90	4	0.56	0.75	0.095	0.85	4.51
10368	WR-90	5	0.56	0.75	0.085	0.85	5.26
10368	WR-90	6	0.56	0.75	0.075	0.85	6.01
10368	WR-90	8	0.56	0.75	0.065	0.85	7.51
10368	WR-90	10	0.56	0.75	0.060	0.85	9.01
10368	WR-90	12	0.56	0.75	0.055	0.85	10.51
10368	WR-75	2	0.56	0.89	0.120	1.00	3.45
10368	WR-75	3	0.56	0.89	0.090	1.00	4.34
10368	WR-75	4	0.56	0.89	0.080	1.00	5.23
10368	WR-75	5	0.56	0.89	0.070	1.00	6.12
10368	WR-75	6	0.56	0.89	0.060	1.00	7.01
10368	WR-75	8	0.56	0.89	0.055	1.00	8.79
10368	WR-75	10	0.56	0.89	0.050	1.00	10.57
10368	WR-75	12	0.56	0.89	0.045	1.00	12.35

5760 → 26,035 39,09 3,4 45,61 390,9 mm

Attention . les cotes sont en "inch"

THE DESIGN AND CONSTRUCTION OF SLOTTED WAVEGUIDE ANTENNAS

By Barry, G8AGN (cotes en inch, angles en °)

Discussions with visitors to the RSGB MICROWAVE COMMITTEE stand at the recent NEC event has uncovered a need for design data on slotted waveguide antennas......at least in amateur radio literature. The following notes should therefore prove useful if you are thinking of making a horizontally polarised microwave antenna with an omni-directional horizontal pattern and with some vertical gain. Such an antenna would be useful for a beacon or home station or even a hand-held 10GHz rig!

DESIGN:

The basic idea behind the antenna is that if a slot is cut in a wall of a waveguide, so as to interrupt the current flow, then the slot will radiate.Hence, by choosing a suitable slot configuration and correctly combining the radiation from a number of such slots, a useful pattern will result.

For our purpose, the best slot configuration is one cut into the broad wall of a rectangular waveguide so that the slot is longitudinal to, and displaced from, the waveguide axis (FIG.1).

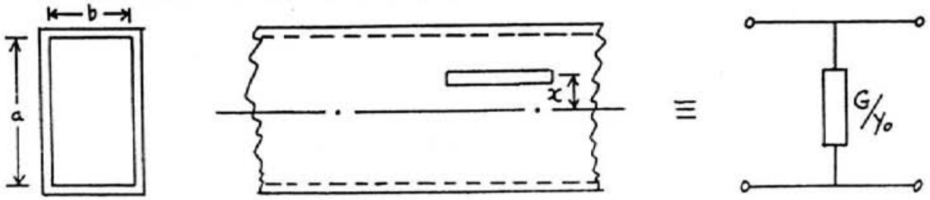


FIG.1

a and b are the waveguide internal c-s dimensions.
x is the slot displacement from the centre-line.

When the slot length is chosen so as to be resonant at the operating frequency, the slot acts like a half-wave dipole whose radiated E field is polarised perpendicular to the slot axis. The equivalent circuit of the resonant slot is that of a shunt conductance whose normalised conductance G/Yo is given approximately by:

$$G/Yo \sim 2.09 \times \frac{\lambda g}{\lambda} \times \frac{a}{b} \times \cos^2\left(\frac{\pi\lambda}{2\lambda g}\right) \times \sin^2\left(\frac{\pi x}{a}\right) \quad (1)$$

where λ = free space wavelength
λg = waveguide wavelength
and a, b, x are defined in FIG.1.

The formula shows that the slot conductance, and hence the field radiated from the slot, increases as the latter is displaced further away from the waveguide broad wall centre line.

A number of slots may be cut in the waveguide wall to form an array, as shown in FIG.2. Here the waveguide is terminated in a short circuit and the centres of the slots are placed at positions along the waveguide corresponding to voltage maxima in the standing wave pattern. The resulting array, of the so-called "resonant" type, has a very small bandwidth ---of the order of +/- 50%/N where N is the number of slots.

Broader band, "non-resonant" arrays can also be realised but as these are more difficult to design and construct they will not be considered further.

The slots shown in FIG.2 are each $\lambda/2$ long, with a centre to centre spacing of $\lambda g/2$. For all the slots to radiate in phase they must be positioned alternately about the waveguide wall centre line so as to compensate for the successive 180 degree phase changes undergone by the wave as it propagates every $\lambda g/2$ along the inside of the waveguide.

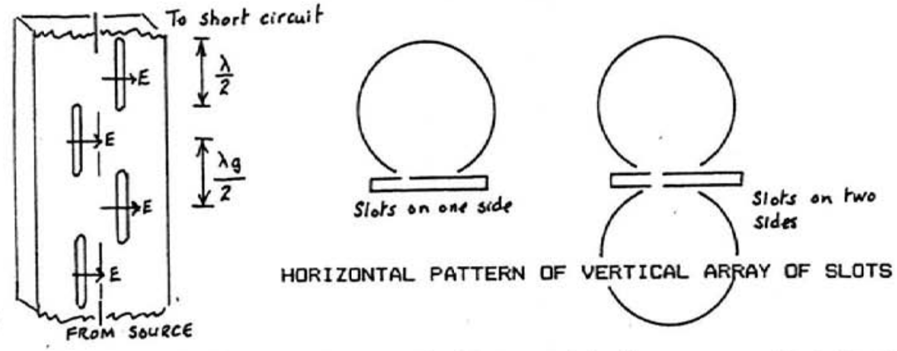


FIG.2

The vertical radiation pattern of the vertical array of slots is determined by the number used, the 3dB beamwidth being given approximately by:

$$\theta_{3dB} \sim \frac{102}{N} \text{ DEGREES} \quad (2)$$

where N is the number of slots on one wall of the waveguide and all the slots are assumed to have equal conductance.

The horizontal radiation pattern is dependent on whether slots are cut in one or both waveguide broad walls. From FIG.2 it can be seen than an omni-directional pattern results when:

(a) the slots are cut in both waveguide broad walls in such a way that the slots in each wall are aligned (i.e. you can look right through the waveguide).
(b) the narrow wall dimension b of the waveguide is made very small (eg 0.1" rather than the 0.4" for standard WG16). If this is not done the pattern will resemble a figure of 8. In practice, then, the antenna must incorporate a taper section if it is to be fed from a standard size of waveguide. The taper, in the b dimension, should be at least 2 wavelengths long.

For amateur use the simplest array to design and build is one where all the elements (slots) are excited in phase and with nominally equal currents. This corresponds to all the slots being displaced from the waveguide broad wall centre line by the same distance.

Consider a design for an omni-directional antenna having a vertical 3dB beamwidth of about 20 degrees. Hence, from the equation (2), the number of slots N needed to achieve this is five.

Let the array centre frequency be 10.4GHz. Then the free space wavelength λ = 2.885cm and for WG16 the guide wavelength λg = 3.718cm

For WG16 the internal dimensions are:

a = 0.9" = 2.286cm
b = 0.4" = 1.016cm

but for a good omni-directional pattern b should be small, say 0.1" (= 0.254cm).

The antenna has 5 slots on each broad wall. Hence the total number of slots = 2x5 = 10 and the normalised conductance of each slot is
G/Yo = 1/2.N
= 1/10 = 0.1

Equation (1) can now be used to find x, the slot displacement.

CONSTRUCTION
****

If you are fortunate and have access to workshop facilities, the slots can be milled in the waveguide walls using a small cutter. A cutter diameter of 1/16" has been found suitable provided that a slot is milled in several passes. Any attempt to do it in one pass will almost certainly result in a broken cutter! The ends of the slots can be left semi-circular.

If the slots are to be cut by hand, use a 1/16" drill to define the ends of each slot and then use a modelling saw and needle files to complete the job.

The main effect of inaccuracies in making the slots will be to raise the vertical radiation pattern side lobe level but this will not be too serious for amateur applications.

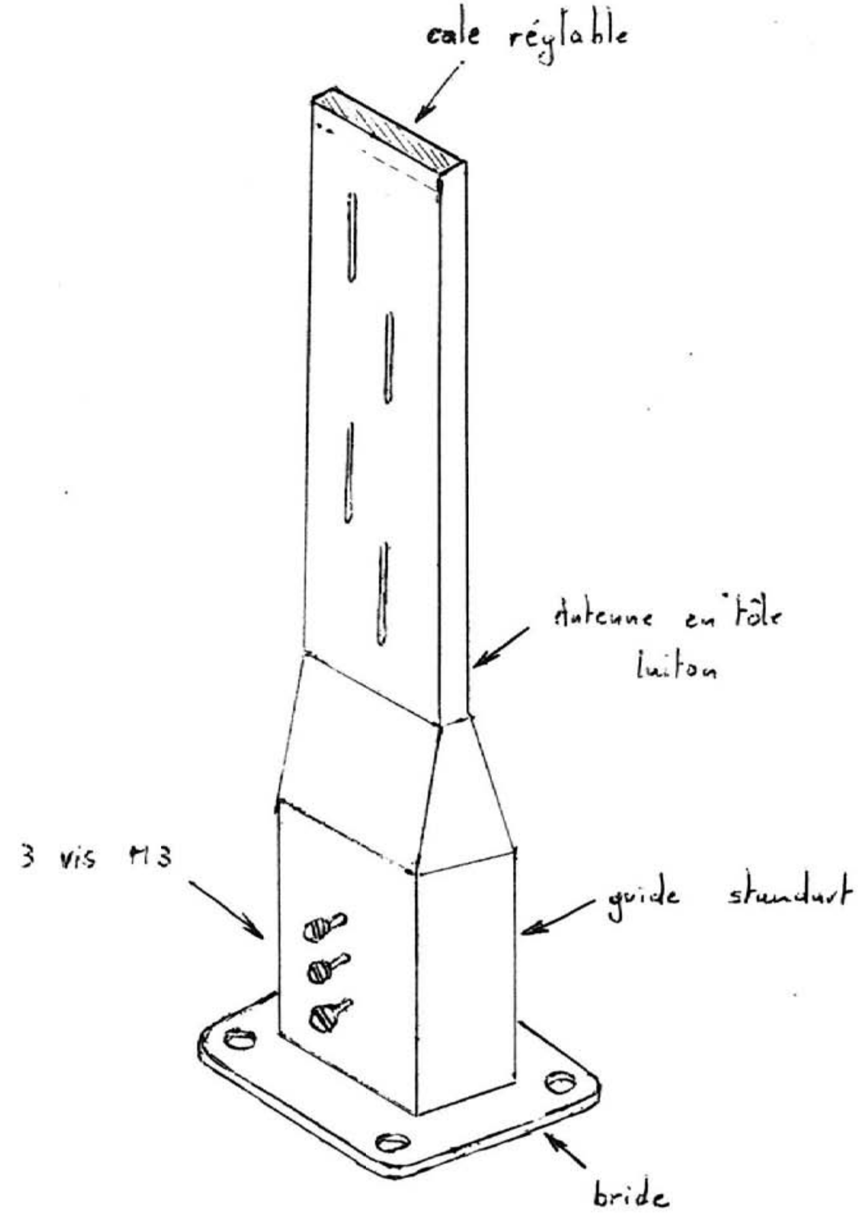
A word of warning at this stage! Do not be tempted to use a very large number of slots (say more than 20) in order to achieve a very small vertical beamwidth. If you do so then the slot displacement x will need to be so small that, because of their finite width, the slots may actually straddle the waveguide wall centre line and hence will not radiate as intended.

As mentioned earlier the slotted waveguide section will normally need to be fed via a taper to a standard waveguide size, although the writer has built an array at 3.4GHz which incorporates a coax to waveguide transition in non-standard waveguide cross section.

The other end of the array needs to be terminated by a short circuit plate and, although this is nominally positioned $\lambda_g/4$ away from the centre of the last slot, its exact position can only be determined by experiment.

The array can be weatherproofed temporarily by covering the slots with THIN mylar tape or even Sellotape. Do not use thick tape or the array's resonant frequency will shift (down?). A more permanent installation can be made by enclosing the array in a length of thin-wall plastic tubing whose diameter is large enough to keep the plastic wall at least one wavelength away from the slots, to prevent detuning. Be sure to check, however, that the plastic used is transparent to microwaves.

GOOD LUCK WITH YOUR ANTENNA...WRITE IN WITH COMMENTS AND EXPERIENCES.



F6DPM (CJ)

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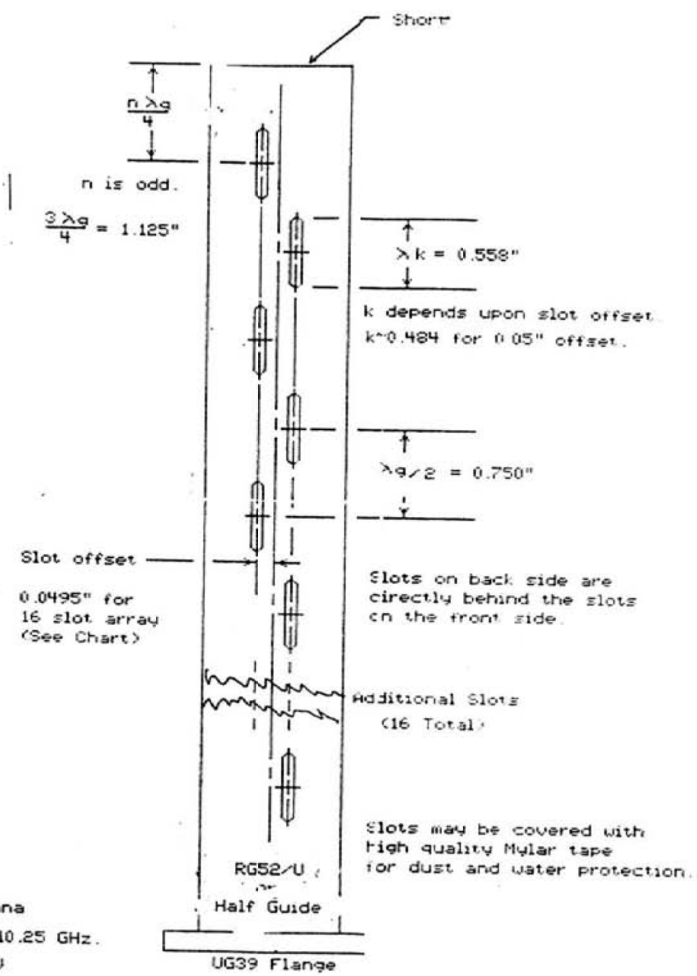

16 Slot Array Antenna

Design Frequency: 10.25 GHz.

C. Suedblom, WA6EXU

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SLOT.GRF - page 1

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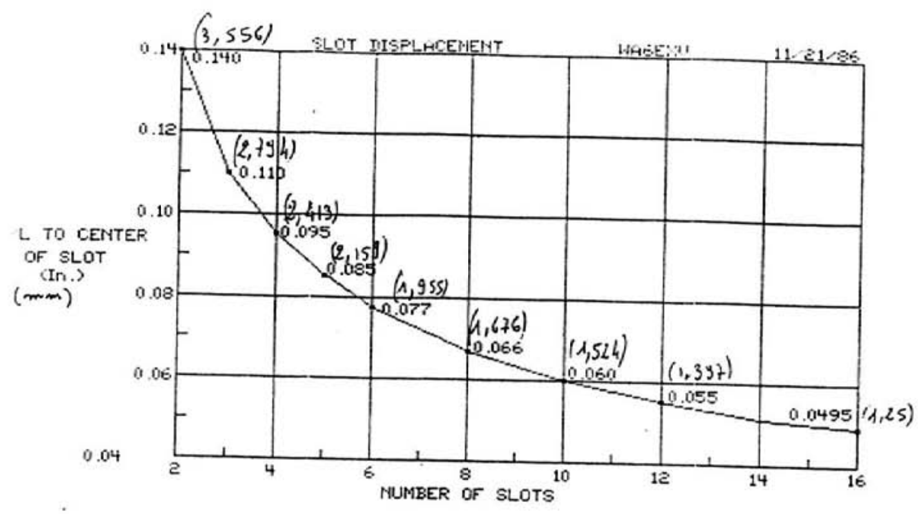

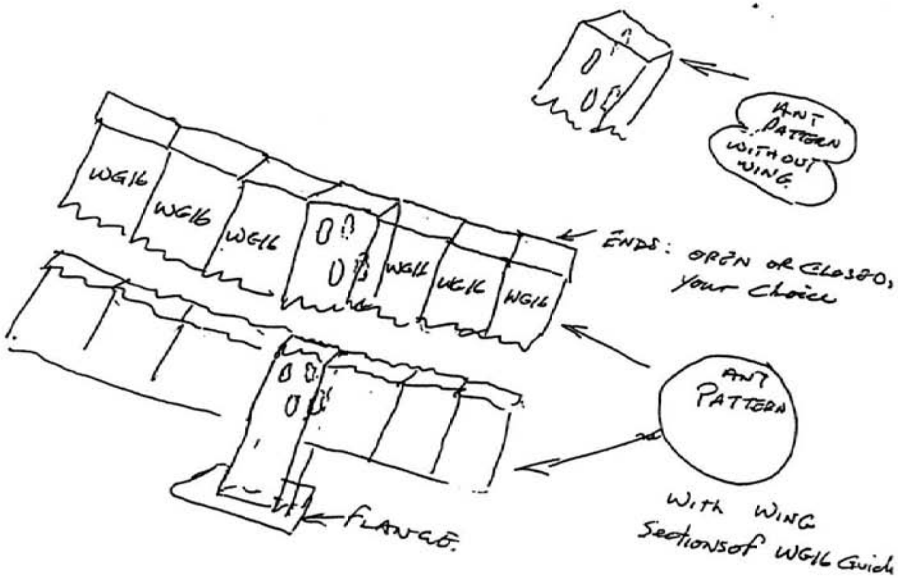

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Hohlleiterschlitzstrahler für Horizontalpolarisation

DB 6 NT 12.95

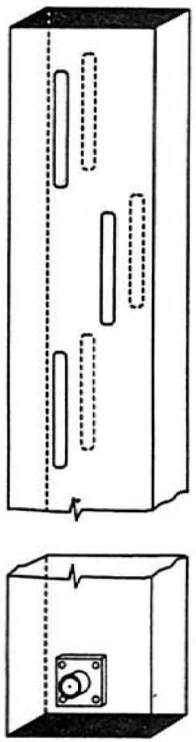
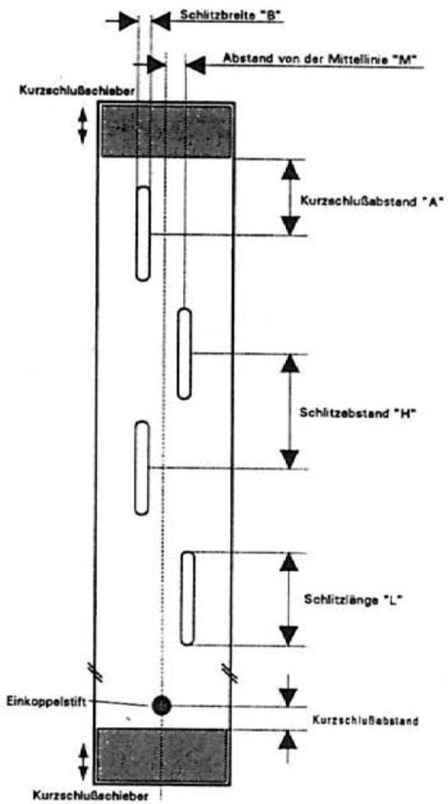


Bild 1



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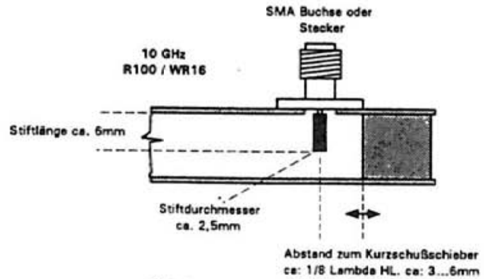
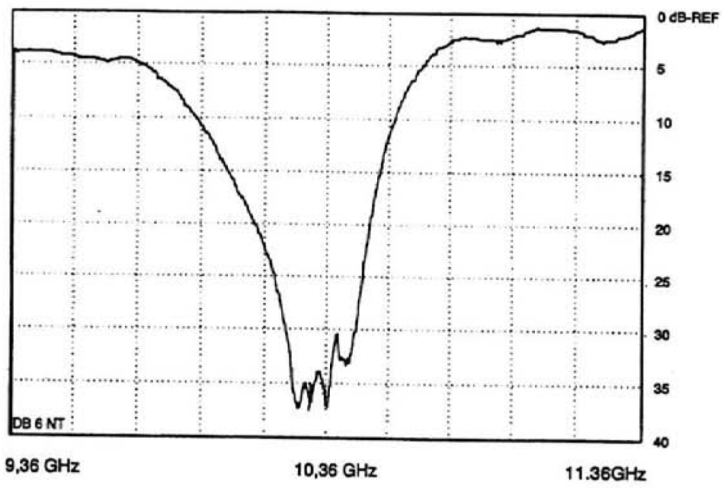


Bild 3

Rückflußdämpfung der abgeglichenen 10 GHz Antenne -DB 0 KI Bake-



Maße für eine 10 GHz Bakenantenne mit Standarthohlleiter WR16

Abmessungen	Normal	Korrigierte Werte nach DK 3 BA
Schlitzbreite "B"	1,44mm	1,2mm +/- 30%
Schlitzlänge "L"	14,46mm	15,3mm
Höhenabstand "H"	18,66mm	18,7mm
Abstand - Mittell. "M"	2,17mm	2,4mm
Kurzschlußabstand "A"	28mm 3/4L	9,33mm 1/4 Lambda

Breitseite:	22.9mm
Schmalseite:	10,2mm
Anzahl der Schlitze:	16 (8 Schlitze je Seite)
Wellenlänge:	28.93mm
Hohlleiterwellenlänge:	37.32mm
Frequenz:	10368 MHz

Die Kurzschlußschieber sollten auf bestes SWR eingestellt werden.

Die korrigierten Werte nach DK 3 BA und DH 6 SBN wurden mit Ihrem PC Programm HLSSA Version 2.17 erstellt.

Diese kurze Zusammenstellung von Zeichnungen und Daten soll etwas Licht in das "Dunkel" über Schlitzstrahler bringen. Es ist eine Zusammenfassung der Artikel von DK 3 BA und DH 6 SBN aus den UKW-BERICHTE 1/91 S.50 ff. und 2/91 S.71 ff.

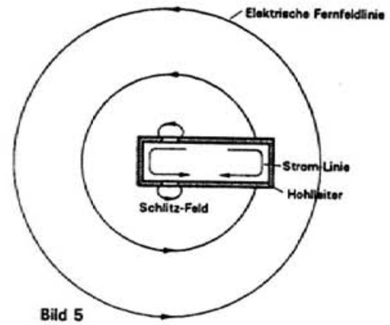


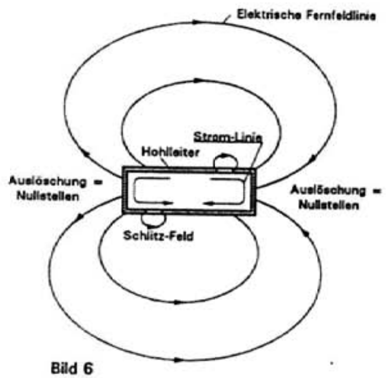
Bild 5

Bild 5

Feldlinienverlauf einer Antenne mit zweiseitigen Schlitzen.

Rundumstrahler mit ca. +/- 1,5 dB Einsattelungen.

Je flacher der Hohlleiter um so gleichmäßiger die Abstrahlung.



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Feldlinienverlauf einer Antenne mit zweiseitig versetzten Schlitzen

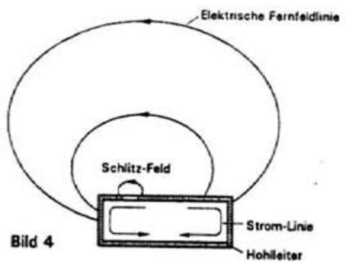


Bild 4

Bild 4

Feldlinienverlauf einer Antenne mit einseitig angebrachten Schlitzen.

Gerichteter Strahler

OMNIDIRECTIONAL X-BAND ANTENNA WITH CIRCULAR POLARIZATION

by Ulf Hülsenbusch, DK 2 RV

E.:

The bicone is an antenna type exhibiting the properties in the head line. It is used preferably in satellite communication systems. Radio amateurs can use it for beacons and transponders.
In the following a brief review of the theory is given. The diagrams of an X-band antenna are shown, which is made as a diminished model for S-band satellite antenna.

Theory: The magnetic equivalent of a linear electric dipole is a slot in a metal plane. In contrary to the dipole, the slot emits a wave, which is polarized perpendicular to the slot.
The bicone has slots in a tube, which are arranged in an angle of 45° with respect to the tube axis. the tube is part of a coaxial line. Two discs are arranged beside the slots (s. cover picture). Without the discs only a linear polarized wave would be emitted. The generation of a polarized wave can be explained in the following way: The wave, linear polarized with an angle of 45°, can be split into a horizontal and a vertical component (tube assumed to be vertical). Suitable dimensions of the discs will produce a phase shift of 90° between both components (s. formula (1) in german text).
Suppose A = B, then formula (2) holds. A and B are choosen to be 0.7 .

Construction: The dimensions of the coaxial line are to choose so that only one TEM mode will propagate and no higher modes can occur. For this formula (3) must be fulfilled.
The upper end of the coaxial line is closed by a sliding ring which short-circuits the coaxial line. It is adjusted to optimum matching. Each slot is the halve of a wavelength long. They can be made by drilling holes at their ends and cutting between them with a circular saw. The width of the slots is not very critical. It should be abt. 0.07 . The lower end of the coaxial line is soldered to a N-type connector.
The antenna is realised with following dimensions: A = B = 20 mm; L = 14 mm; 8 slots each 15 x 2 mm; inner conductor 6 mm diam.; tube 16 x 2 mm.

Electrical Properties: The vertical radiation angle (-6 dB) is abt. 120° (fig. 2). Vertical and horizontal diagram are measured using a rotating horn antenna with linear polarization for to measure also the quality of circularity. It can be seen by means of the ripple in the diagrams. It is minimum in the main radiation directions. Matching in the main frequency ranges can be seen in the Smith chart (fig. 4).

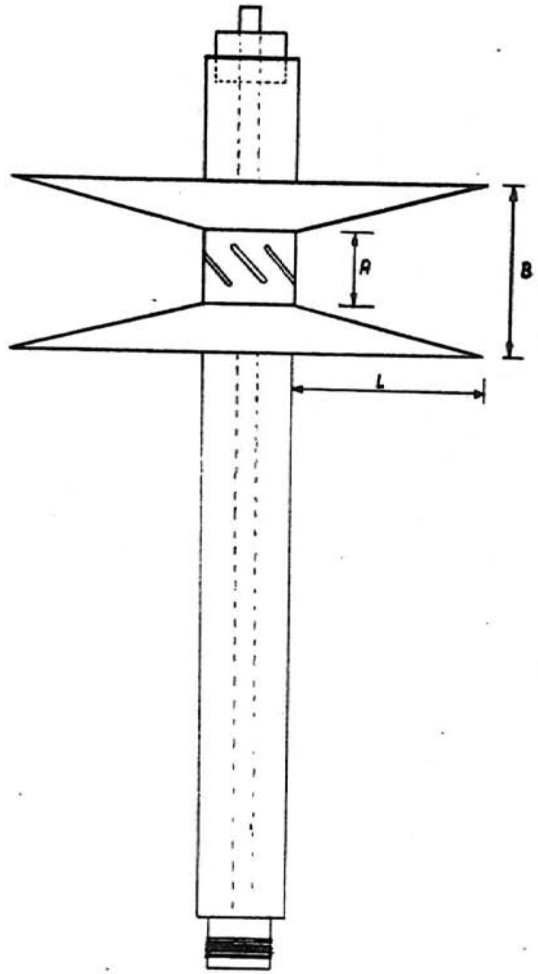
Alignment: At first both discs are moved on the tube until optimum circularity is acheived. For this the horn antenna is used which can be tuned into the vertical and the horizontal position to observe both components to have equal amplitudes.
Then the sliding ring is moved to best matching. Matching can be enhanced furthermore by line transformation with stepped inner conductor.

$$\frac{\lambda_c}{4} = L - \int_0^L \sqrt{1 - \frac{\lambda_c^2}{4\left(A + \frac{B-A}{L}x\right)}}\, dx \quad (1)$$

$$L = \frac{\lambda_c/4}{1-\sqrt{1-(\lambda_c/2A)^2}} \quad (2)$$

A bzw. B wählt man zu $0{,}7 \cdot \lambda_c$

$$\lambda_c > \pi \frac{D+d}{2} \quad (3)$$



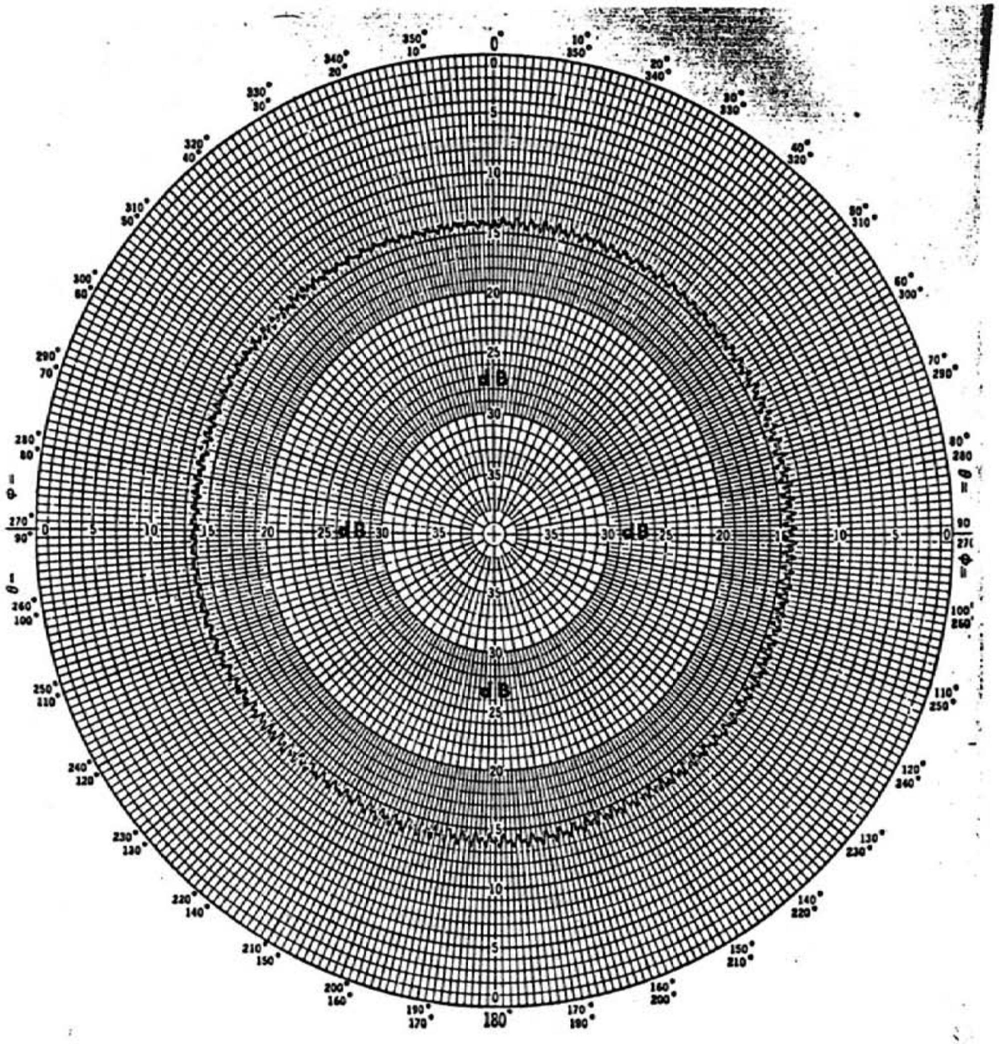


Fig.3 Horizontaldiagramm

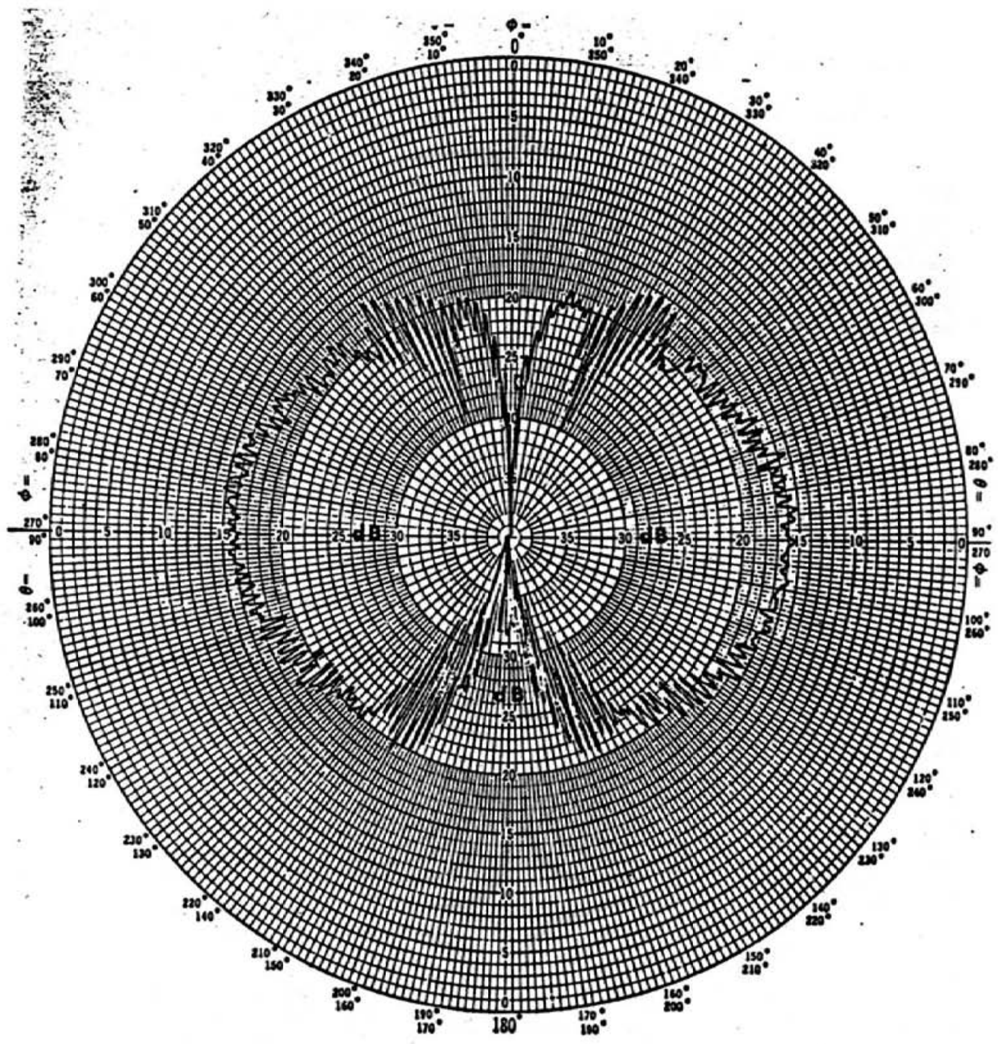
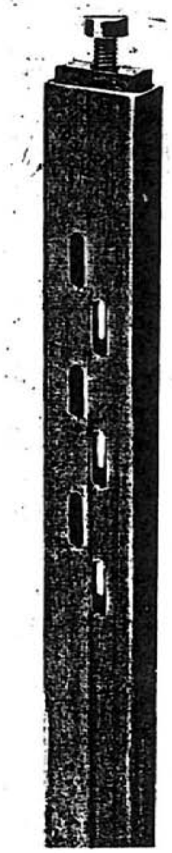
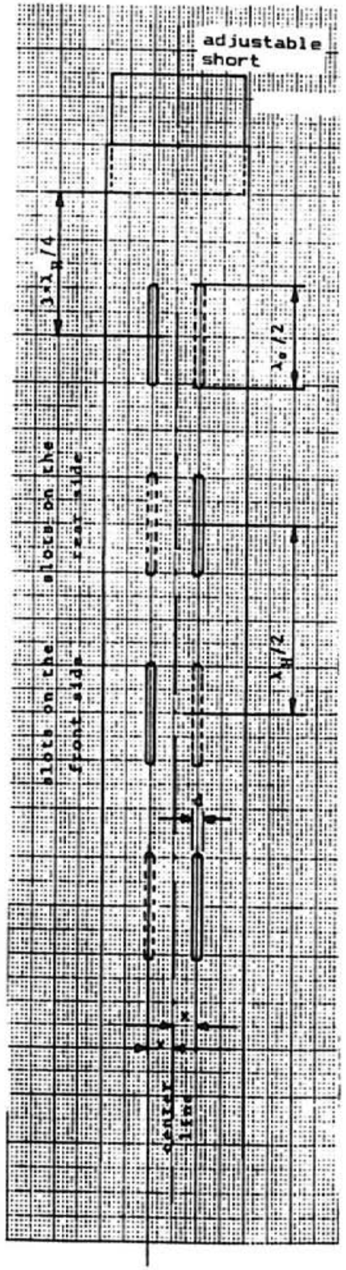


Fig. 2 Vertikaldiagramm

24 GHz





Stacked slot-antenna

For application with an omnidirectional diagram a stacked waveguide-slot-antenna was built. The polarization is horizontal and the gain is about 11 dB for 12 slots. The diagram has in the +-90 deg.-direction a decrease in gain. It depends on the waveguide's hight b. The smaller b the better the circularity. For the standard waveguide which is used, the decrease is about 6 dB. The short on the top end of the antenna can be adjusted for minimum return loss. The antenna was calculated with the equations published by G3RPE.

a = waveguide's inside width
b = waveguide's inside hight
Lambda O = wavelength in free space
Lambda H = wavelength in waveguide
x = Deviation from centerline
y = slot width
N = total number of slots
G = gain

a = Hohlleiter Innenbreite
b = Hohlleiter Innenhöhe
Lambda O = Wellenlänge im freien Raum
Lambda H = Wellenlänge im Hohlleiter
x = Abstand von der Mittellinie
y = Schlitzbreite
N = Anzahl der Schlitze
G = Gewinn

Dimensions for standard waveguide
Abmessungen von Standard Hohlleitern
(WR42, R220, WG20, RG53)
Frequency 24192 MHz (21 x 1152 MHz)

a = 10.67 mm	x = 1.4 mm
b = 4.03mm	y = 1.5 mm
Lambda O = 12.4 mm	N = 12
Lambda H = 15.24mm	G = 11.7 dB

$$\lambda_H = \lambda_0 / \left(\sqrt{1-(\lambda_0/(2a))^2}\right)$$

$$\vartheta = \arcsin(\lambda_0/(2a)) \quad \text{degrees}$$

$$A = 2.09 \frac{a}{b} \cdot \frac{\cos^2(90\cos(\vartheta))}{\cos(\vartheta)}$$

$$x = \frac{a}{180} \arcsin\sqrt{1/(NA)}$$

$$d = \lambda_0/20$$

(1)

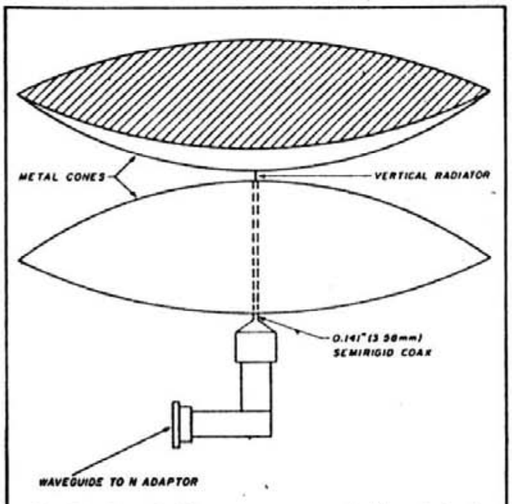


fig. 5A. Biconical horn antenna, vertically polarized.

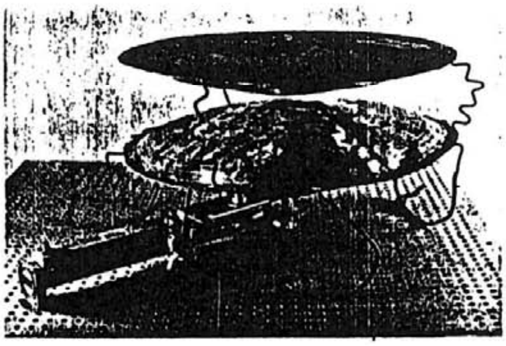
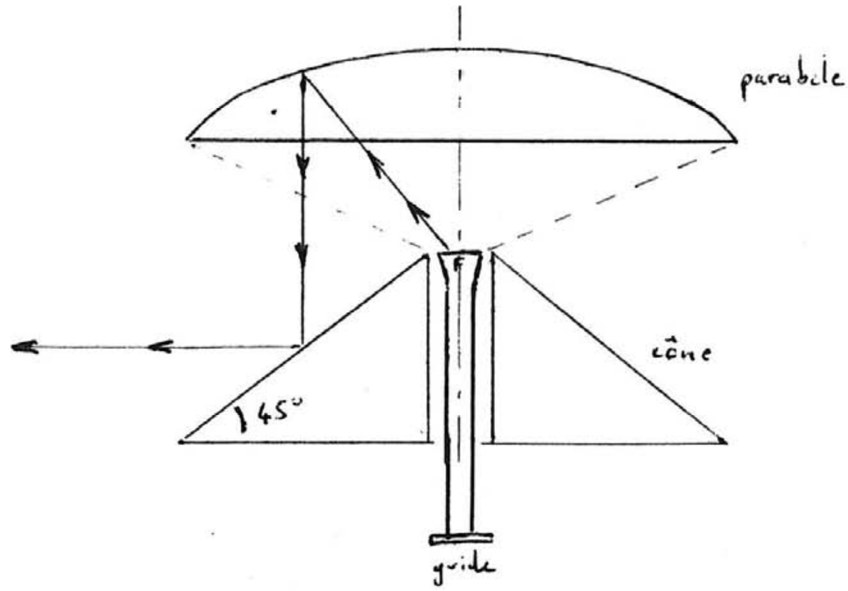


fig. 5B. Prototype X-band biconical horn.

(2)



ANTENNES MIXTES

Wide Band Horn 1,2.....2,4 GHz

by Peter Riml, OE 9 PMJ

D.: Dieser Hornstrahler ist zur Ausleuchtung von Parabolreflektoren mit einem f/D Verhältnis von etwa Ø.5 (Ø.43-Ø.58), für den Frequenzbereich 1.2-2.4 GHz, konstruiert. Mit einer speziell ausgeführten Koppelsonde wird eine gute Anpassung über den ganzen Frequenzbereich erreicht (siehe Diagramm). Das Phasenzentrum (H-u.E-Ebene) liegt sehr nahe bei der Aperaturebene (etwa 5mm dahinter).

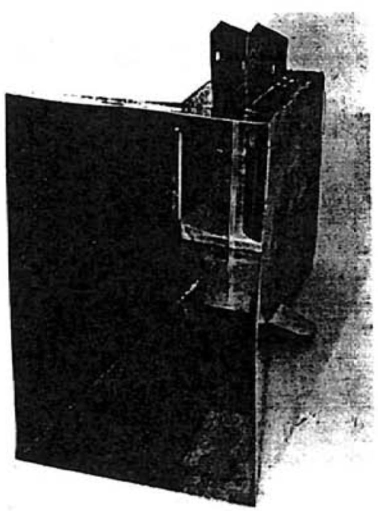
Das entsprechend der Zeichnung fertig gestellte Horn ist von P. Riml, Box, A-6971 HARD, erhältlich (DM9Ø), ebenso eine verkleinerte Ausführung (xØ.225) für 5.3-1Ø.6GHz mit SMA-Buchse.

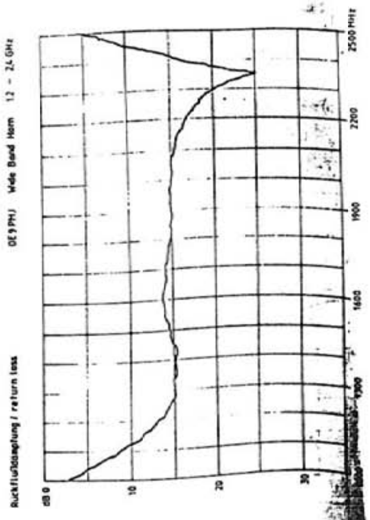
E.: This horn radiator is designed for illumination of paraboloid reflectors of abt .5 f/D ratio (.43-.58), for the frequency range 1.2....2.4GHz. A good return loss (see diagram) over the complete frequency range is obtained by a specially formed coupling post. The phase centre (H. a.E-plane) is located very closed to the aperature plane (abt. 5mm behind).

The already finished horn according to the drawing is available from P. Riml, Box, A-6971 HARD, Austria (DM9Ø), also a scaled version (xØ.225) for 5.3 to 1Ø.6GHz with SMA socket.

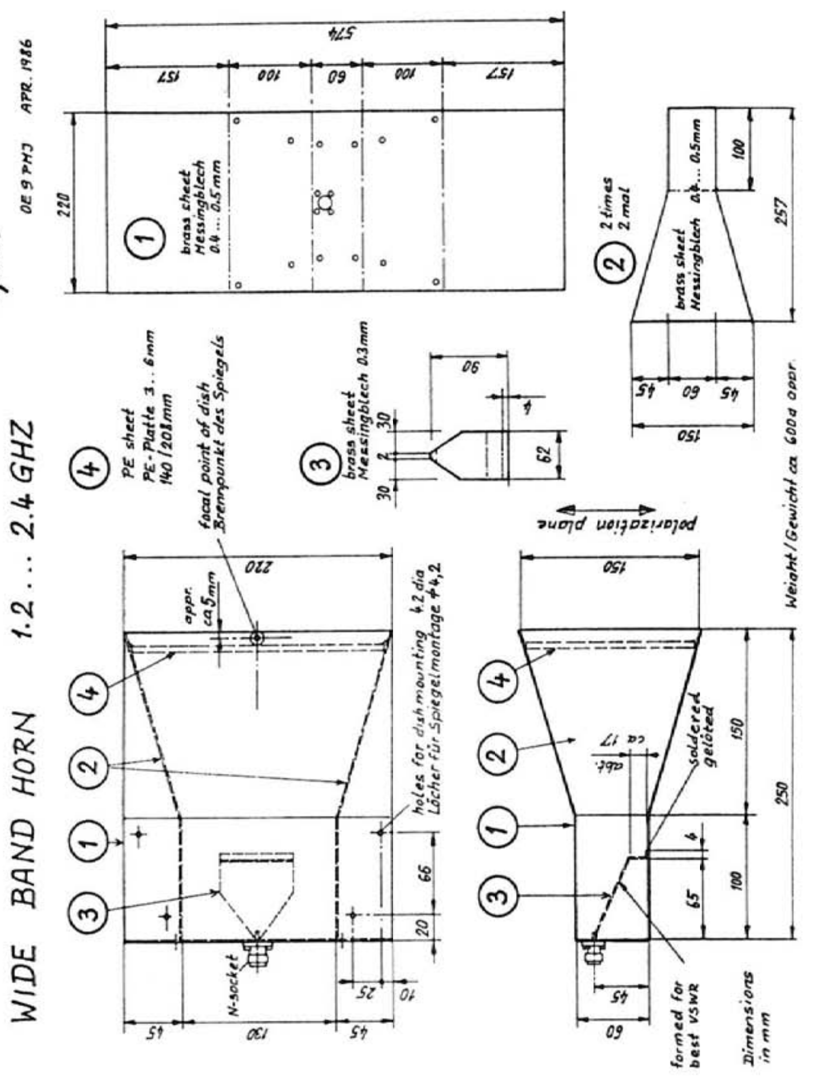
Literatur:
References:

1.) Feeding parabolic dishes with horn antennas, Ulf Hülsenbusch, DUBUS 1/1986, 17-28.
2.) Pyramidel horn feeds, D.S.Evans, G.R. Jessop, RSGB VHF/UHF Manual, 8.62-8.65.
3.) Multi-Band-Strahler 1-12GHz, Claus Neie, DUBUS 2/198Ø, 66-76.





0,225



5,3 à 10,6 GHz
Multiplier les cotes par 0,225

CQ02 5-86-B3

Antennen für die SHF-Bänder

Hans Schinnerling, DC8CE, Weserstr. 37, 2390 Flensburg

Als Erreger für einen Parabolspiegel eignet sich sehr gut eine logarithmisch-periodische Antenne. In der Ausführung, wie sie hier beschrieben wird, überstreicht sie die Frequenzen von 1,0 GHz bis 6,0 GHz. Die Antenne kann mit den Leistungen betrieben werden, wie sie heute auf den Mikrowellenbändern üblich sind.

Da der Nachbau keine speziellen Bauteile (außer einem Stück Kupfermantelkabel) oder Werkzeug erfordert, wird die Herstellung einfach und unkompliziert. Eingebaut in einen Parabolspiegel, erhält man eine Antenne mit einem sehr guten Gewinn für jedes Band, und, was viel wichtiger ist, es entfällt der Antennenbau, der nach jeder Fertigstellung eines Transverters nötig wird.

Die logarithmisch-periodische Antenne hat im Durchschnitt einen Gewinn von 6 dB und eignet sich aufgrund des −10-dB-Öffnungswinkel für einen Parabolspiegel mit einem f/D-Verhältnis von 0,5. Die folgende Tabelle zeigt die Antennengewinne für einen Parabolspiegel mit einem Durchmesser von 1,2 m.

Frequenz	Gewinn
1,3 GHz	23,5 dB ←
2,3 GHz	28,5 dB ←
3,5 GHz	32,0 dB
5,7 GHz	36,0 dB ←

Die logarithmisch-periodische Antenne wird komplett aus Messing gefertigt. Andere Materialien wie Kupfer oder Aluminium sind ebenfalls zulässig. Die Abb. 1 und 2 geben ein Bild der Antenne und deren Maße wieder. Es werden zwei gleiche Hälften gebaut, wobei die eine Hälfte nur ein längeres Antennenrohr erhält.

Zur besseren Stabilität der Elemente werden an den entsprechenden Stellen 2-mm-Löcher in die Antennenrohre gebohrt. In diese werden die Elemente aus 2-mm-Rundmessing gesteckt, die man vorher auf Länge gesägt hat. Zu den in der Zeichnung angegebenen Maßen addiert man vor dem Zuschnitt ca. 1 bis 1,5 mm, und erst nach dem Einlöten der Elemente werden diese auf richtige Länge gesägt oder gefeilt.

Durch das längere Rohr wird das Kupfermantelkabel gesteckt und an beiden Seiten angelötet. Der Innenleiter wird so kurz wie möglich zur anderen Hälfte geführt und dort innen am Rohr angelötet. Es ist darauf zu achten, daß zwischen den Antennenrohren ein Abstand von 1 mm bestehen bleibt. Eine Verbesserung des Stehwellenverhältnisses bei höheren Frequenzen wurde dadurch erreicht, daß man parallel zum freiliegenden Innenleiter ein Stück Kupferstreifen lötet. Der Abstand sollte etwa 1 mm betragen.

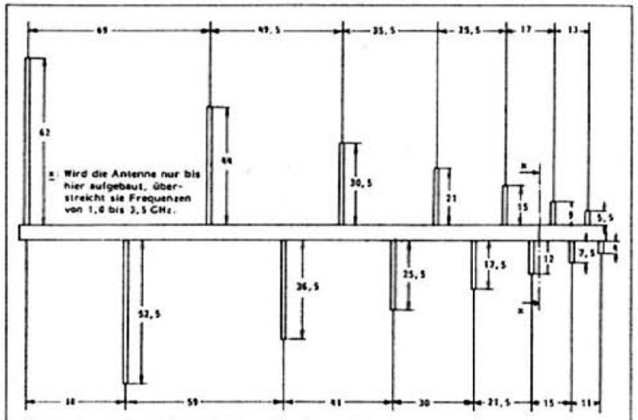


Abb. 1: Breitbanderreger für die Bänder 23 cm, 13 cm, 9 cm und 6 cm

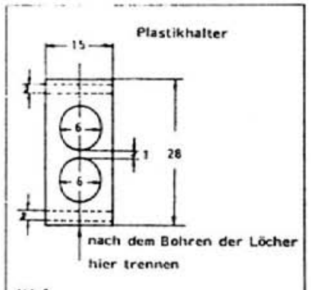


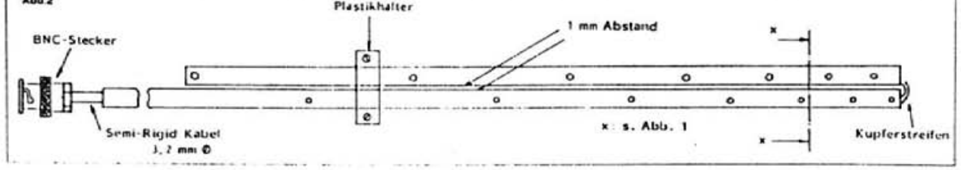
Abb. 3

Eine stabile Halterung der Antennenhälften wird aus einem Stück Plastik gefertigt (siehe Abb. 3). In den Plastikblock werden im Abstand von 1 mm zwei 6-mm-Löcher gebohrt. Über bzw. unter den Löchern werden im rechten Winkel zwei 3-mm-Löcher für die Nylonschrauben gebohrt. Dann wird der Plastikblock durch die 6-mm-Löcher halbiert, so daß man zwei Klemmbacken erhält, wobei die Nylonschrauben als Klemmschrauben dienen. Versuche, die beiden Hälften mit doppelkaschierter Epoxy-Platine zusammenzulöten, schlugen fehl. Das Stehwellenverhältnis verschlechterte sich dadurch deutlich.

Als HF-Anschlußstecker können solche der BNC-, N- oder SMA-Norm verwendet werden. Um BNC-Stecker an Kupfermantelkabel anzubauen, eignet sich sehr gut eine 4-mm-Messingmutter, die nach Abisolieren des Kabels auf den Kupfermantel gelötet wird. Die Ecken der Mutter werden abgerundet, bis sie einwandfrei in den Stecker paßt. Nach dem Zusammenbau des BNC-Steckers erhält man einen guten HF-Übergang.

Nach dem Besprühen mit Plastikspray oder Einbau in einen Radom ist die Antenne einsatzbereit.

Abb. 2



Breitbanderreger für die Bänder 9 cm, 6 cm und 3 cm

Eigentlich sollte die Antenne die Amateurbänder ab 13 cm bis 3 cm überstreichen. Auf 2,3 GHz ist das Stehwellenverhältnis nicht sehr gut ausgefallen. Praktische Tests haber aber ergeben, daß der Gewinn der Antennengröße entspricht.

Speziell für die Bänder 9, 6 und 3 cm erhält man bei Einbau in einen 60er Parabolspiegel eine leistungsstarke Antenne. Das f/D-Verhältnis des Spiegels sollte etwa bei 0,6 liegen.

Abb. 7 zeigt die Abwicklung mit Bemaßung des Trichters, der aus 0,5-mm-Weißblech hergestellt wird. Aus 2 mm starkem Messing- oder Kupferblech werden die beiden „Strahlerhälften" angefertigt. Die Maße zur Herstellung einer Schablone stehen in der Wertetabelle. Eine Strahlerhälfte wird um den Durchmesser des Semi-Rigid-Kabels kürzer gefertigt.

Nach Herstellen des Trichters werden die Strahler gegenüberliegend in den Trichter gelötet. Zum Schluß werden Kragen, Semi-Rigid-Kabel und der Deckel angelötet. Das Semi-Rigid-Kabel wird mit der vollen Länge an die „Strahlerhälfte" gelötet. Der Innenleiter wird in einem vorher eingesägten Schlitz verlötet. Nach Anbringen einer Buchse oder eines Steckers ist die Antenne einsatzbereit.

Das Diagramm zeigt das VSWR im Bereich von 2,0 bis 6,0 GHz. Der Gewinn der Antenne liegt im unteren Bereich bei 4 dB und bei 3cm bei 8 dB.

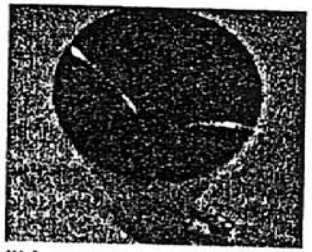


Abb. 8

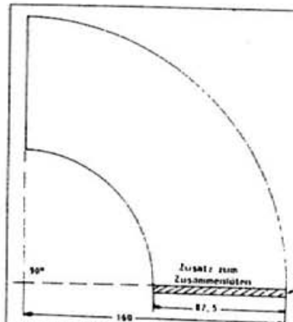


Abb. 7: Abwicklung des Trichters

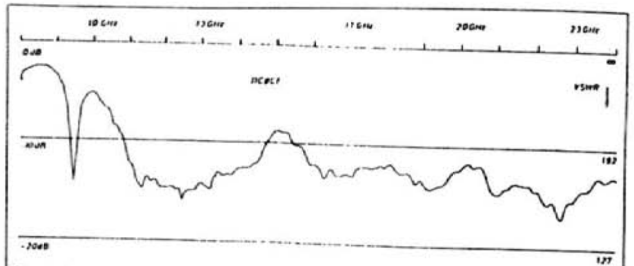


Abb. 4: VSWR-Diagramm des Breitbanderregers für 23 cm, 13 cm, 9 cm und 6 cm

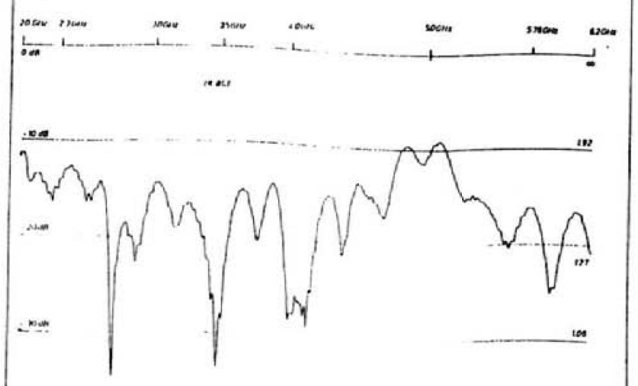


Abb. 5: VSWR-Diagramm (Fortsetzung zu Abb. 4)

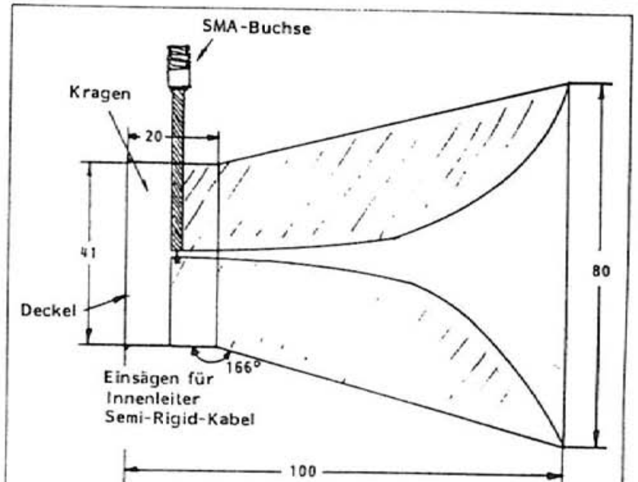


Abb. 6: Breitbandhorn

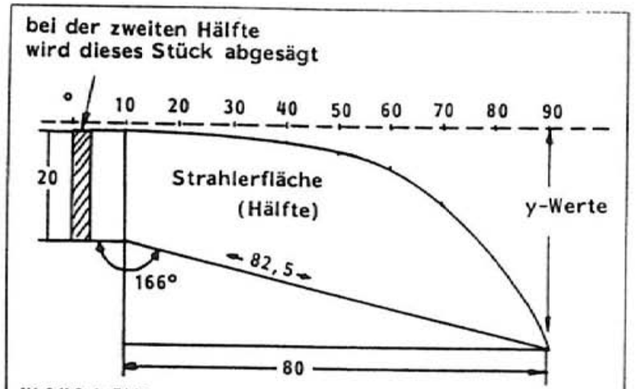


Abb. 9: Maße des Trichters

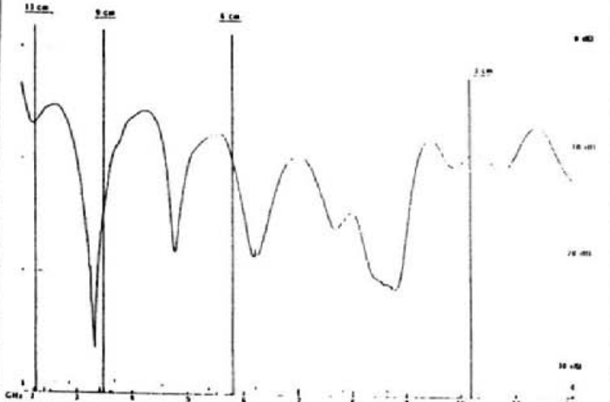


Abb. 10: VSWR-Diagramm des Breitbanderregers für 9 cm, 6 cm und 3 cm

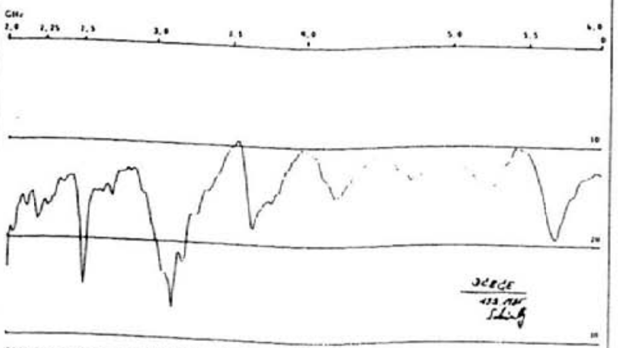


Abb. 11: VSWR-Diagramm des Breitbanderregers für 13 cm, 9 cm und 6 cm

Logarithmisch-periodische Antenne für die Bänder 13 cm, 9 cm und 6 cm

Wer erst ab 13 cm einen kleinen Parabolspiegel verwenden möchte, kann diese Antenne verwenden. Durch die geringen Abmessungen der Antenne läßt sich aus einem normalen Plastikmeßbecher aus der Küche ein Radom bauen. Somit ist ein großes Problem beseitigt.

Da die Boomrohre nur einen Durchmesser von 4 mm haben, wird zur Speisung der Antenne ein Semi-Rigid-Kabel von 2,5 mm Durchmesser benötigt. Ansonsten ist die Antenne genauso aufzubauen wie die von 1,0 bis 6,0 GHz.

Die Zeichnung gibt die Maße der Antenne wieder. Es werden zwei Hälften hergestellt, wobei die eine Hälfte ein längeres Boomrohr bekommt, mit dem sie später befestigt wird. Durch dieses wird auch das Semi-Rigid-Kabel geführt.

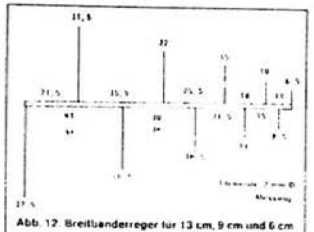
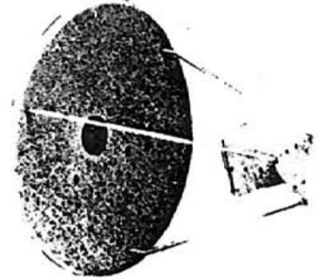


Abb. 12: Breitbanderreger für 13 cm, 9 cm und 6 cm

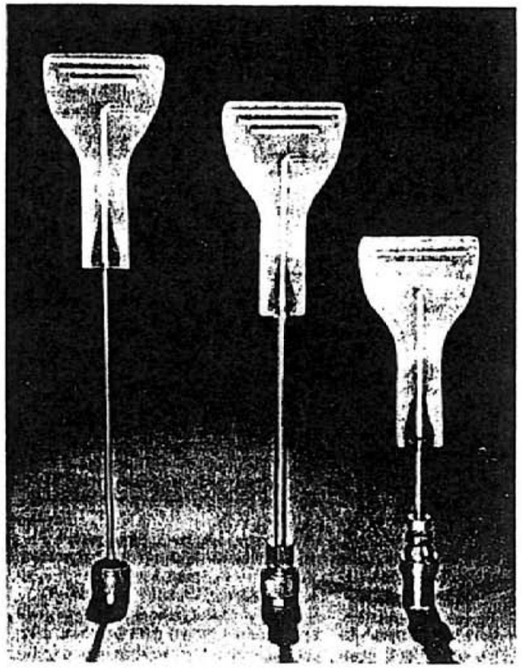
Norddeich: Noch immer nimmt der Telegraphieverkehr bei Deutschlands größter Küstenfunkstelle **„Norddeich Radio"** den führenden Platz ein: 315 000 solcher Telegramme wurden 1984 im Seefunkverkehr über DAN abgewickelt. Dem standen 168 000 Telephonieverbindungen gegenüber, das ist ein Anteil von einem Drittel. Steigend ist die Zahl der TELEX-Verbindungen im Geschäftsverkehr; 241 unter deutscher Flagge fahrende Schiffe sind bereits mit Telexanschlüssen ausgerüstet.

Seit 1907 versieht Norddeich Radio seinen Dienst, jetzt mit Empfangs- und Betriebszentrale in Utlandshörn und der 15 km abgesetzten Sendestelle in Osterloog. Das Rufzeichen DAN wurde der Küstenfunkstelle bereits 1929 beim damaligen „Weltfunkvertrag" von Washington zugeteilt. - DANs wichtigste Aufgabe wird im Beitrag für die Sicherheit auf See gesehen, wofür Tag und Nacht Peilfunk, Seenot-Bereitschaft, Wetterberichte, Eis- und Sturmwarnungen, aber auch ärztliche Beratung durch „Medico"-Telegramme eingesetzt werden. Der private Funkverkehr schwillt zu den Festtagen zum Jahresende beträchtlich an, und so manches Mal wird wieder Deutschlands größtes Fahrgastschiff „Europa" - DLAL - aufgerufen worden sein: cq cq cq de DAN = QTC DLAL + k



Cornet tout fait :

Voir SSB electronic



A Triband Microwave Dish Feed

Been looking for a slick way to get on 2304, 3456 and 5760 MHz with a single dish antenna? Look no farther!

By Tom Hill, WA3RMX
19335 NW Walker Rd
Beaverton, OR 97006

QST 08-90 A5

Many hams today think of microwaves as the province of wizards and experimenters. Fortunately, that stigma is disappearing now that commercial transverters, amplifiers, antennas and other needed accessories have become widely available, and now that no-tune-transverters[1,2] and simplified construction ideas are in wide use. *This* construction article is intended for everyone; no machine tools or exotic materials are needed. In fact, this project doesn't require anything expensive or hard to obtain. After the parts are gathered, you can accomplish the construction work in one concentrated evening, or over a leisurely weekend. It's a great project for groups interested in starting up some microwave work for events such as the ARRL VHF/UHF contests.

A triband microwave antenna? Why not? If we can do it for HF, we can do it for the microwaves! This feed covers the 2304, 3456 and 5760-MHz bands in one unit that's designed for use in a single dish—with no adjustments—while you switch among the three bands. If you want to build your own dish feed, the simplicity of this design makes it a real winner. And, it's available—ready to mount to your feed line or connector—from Down East Microwave.[3] Dish antennas are available at hamfests and from other sources.[4]

[1]Notes appear on p 27

The Past

I used to use separate feeds for each band. These were the well-known, dipole/splash-plate feeds, which are excellent performers. These feeds require machine work to build, and often quite a lot of fussing to change one for another when switching bands. The alternative is to have a separate dish for each band, which is not very practical for a fixed station, and is simply unworkable for portable operation. Another disadvantage is the cost of the dipole/splash-plate feeds: After the large initial investment ($70 or so each if purchased new), the possibility of damage still looms. When the wind picks up, as it is wont to do, the dish may fall over on its face, squashing the feed.

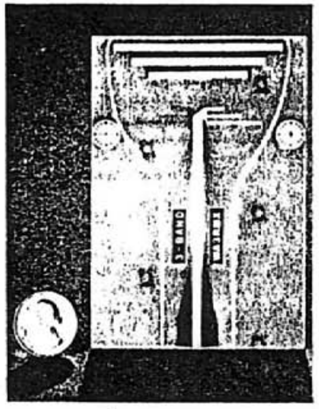


Fig 1—The triband dish feed is etched on common FR4 PC-board material.

Initial Requirements

After building a new triband SSB rig for the microwaves, I decided that a new feed arrangement was also needed to simplify setup and operation. I developed a list of requirements based on my past experience with dishes:

1. The new system must cover all three bands at once. (No more feed changing during DX pileups!) Also, no adjustments should be needed when changing bands, such as moving the mounting hardware to accommodate differing phase centers.

2. Complete broadbandedness is *not* desirable; the antenna should reject signals outside of the amateur bands, such as radar, satellite-TV uplinks, etc.

3. It should be easy to build (a PC board would be best). No machine work should be required; hand tools only.

4. It should be cheap. (Not so much crying when it's broken during a windy mountaintop expedition, as spares can be on hand.)

5. No exotic materials should be needed. It must be made from commonly available parts.

Fig 2—The first prototype triband feed, mounted in a 19-inch dish, has performed well from my rooftop for almost two years.

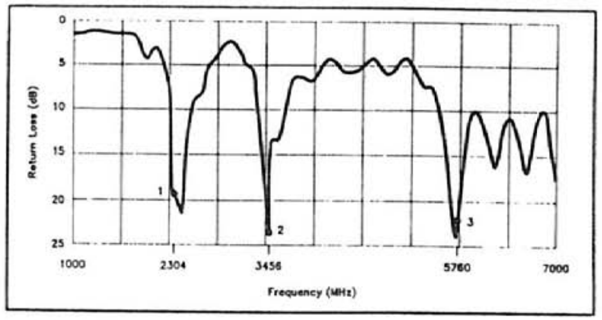


Fig 3—A network-analyzer plot showing the return loss (another way of expressing SWR) of a prototype feed. The greater the return loss, the better the SWR. (For more information on return loss, see K. Kleinschmidt, Ed., *The 1990 ARRL Handbook* (Newington: ARRL, 1989), p 35-38, and W. Hayward and D. DeMaw, *Solid-State Design for the Radio Amateur*, second printing (Newington: ARRL, 1986), pp 154-155.

6. Must be rugged and easy to carry (flat is good).

7. Must not be affected too adversely by rain. My dipole/splash-plate feeds have a section of transmission line open to the air. Here in Oregon, the frequent rain fills up those feeds, rendering them useless until emptied (and often leaving them corroded as well).

8. Performance must not be more than 2 dB worse than the single-band feeds, and hopefully not even that bad.

The resulting triband feed meets all of these goals. The feed is etched on both sides of a standard FR4 (G-10) circuit board, then sprayed with clear urethane coating to protect the copper against weathering. The board requires no holes, nor any connections between the front and back sides of the circuit board. See Fig 1. The finished assembly is shown in Fig 2, mounted in a dish with semirigid coax.

How it Works

The triband feed is a variation of the original dish feeds, which consisted of a dipole driven element and a single reflector. The triband feed has three driven elements attached to a common feed point, and three separate reflectors. The lengths of the three driven elements have been adjusted to compensate for proximity to, and the detuning effects of, the other elements.

The elements are positioned for a common phase center for all three bands. This obviates the need for adjustments when changing bands. The 5760-MHz dipole is farthest from the dish surface. The lower-frequency dipoles distort the 5760-MHz dipole's radiation pattern more than if the order was reversed, but this placement facilitates the common phase center.

The balun is a simple, slowly tapered transition from microstripline at the end of the board where the connector mounts, to balanced line as it moves toward the dipoles. Although it's a compromise to allow printing the whole assembly, this technique is surprisingly effective.

Material and Results

The SWR is typically better than 1.5:1 on the two lower bands and better than 2:1 on 5760 MHz. See Fig 3. SWR varies somewhat from one feed to another, and is affected slightly by the mounting method. The feed helps to reject some of the extraneous signals sometimes found outside the amateur bands on the same mountaintops that you'll occupy for your DXpeditions!

The board material dramatically affects these results. I used a 3- × 4-1/2-inch piece of 1/16-inch-thick FR4 material with 1-ounce copper on both sides, and presensitized with positive-acting resist. (Although I used Injectorall type 40P board from the local parts store, PC-board material without the positive resist shouldn't affect performance.) Other manufacturers' FR4 boards will probably work fine, but if you use another material (phenolic, Teflon®, epoxy-paper, etc), or one of a different thickness, you will have to make major changes to the dimensions of both the transmission line and the elements.

I have tested only the configuration shown here. It works so well, both electrically and mechanically, that I didn't try others. Teflon (either woven mat or the amorphous types, such as Rogers Duroid™) would exhibit slightly lower loss, but at the price of much less mechanical strength.

I used a protective spray coating from the local parts store (Fine-L-Kote UR spray urethane conformal coating, made by Tech Spray, stock no. 1711-16S). I suspect that many other plastic spray coatings will work fine, but I have not tried any, so, as in all microwave work, if you change the recipe, you are on your own. Extensive tests have shown that the resonant frequencies of the feed move less than 25 MHz after the spray is applied, causing only negligible changes in SWR. The copper patterns have been designed to account for the presence of the plastic coating, but you can omit it without performance problems. Still, I recommend the plastic coating—especially around the edges of the board, which can absorb water if left unprotected—for outdoor use.

When tested in a 1-meter dish (f/D = 0.31), and compared to dipole/splash-plate feeds, the triband feed's gain, although somewhat less than that of optimized single-band units, is still very good. See Table 1. Some of this loss is due to sub-optimal dish illumination and some is a result of dielectric loss in the circuit-board material (more on this later). The three reflectors are not optimal (they replace three separate round discs), and the three driven elements "argue" with each other. But that's the price of a PC-board, do-all feed! For critical long-haul, weak-signal work, consider keeping a set of optimized, single-band feeds handy.

This feed handles enough power for a very effective mountaintop station, and I

Table 1

Gain Differences Between PC-Board Triband Feed and Optimized Dipole/Splash-Plate Feed

Frequency	*Triband Feed Loss*
2304 MHz	0.75 dB
3456 MHz	1.25 dB
5760 MHz	1.5 dB

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have regularly put 20 W through it with no trouble. But there is a limit: Al Ward, WB5LUA, tested a copy of this feed with 200 W of 2304-MHz RF for an extended time during the January 1990 ARRL VHF Sweepstakes contest. Even a small amount of dielectric loss was enough to precipitate spectacular heat damage, as shown in Fig 4. The board was burned so badly that all the copper fell off, predictably causing a rather severe SWR increase. I recommend not applying more than 20 W to this feed![5]

Construction

To build the triband feed, first etch the patterns on the front and back of the board. The full-size patterns are shown in Fig 5. The front pattern is dimensioned so that you can easily check the board size before etching. Fig 6 is an X-ray view of the board showing the feed's apparent phase center. Accurate registration of the front and back patterns is fairly critical; testing has shown that the two sides should be aligned to within at least 0.030 inch for good performance and low SWR. Pattern alignment can be achieved either by drilling two pilot holes in the unetched board at the locations of the two bullseyes on the artwork, or by carefully taping the edges of the artwork together and clamping the unetched board between them before exposure. (I prefer the drilling method.)

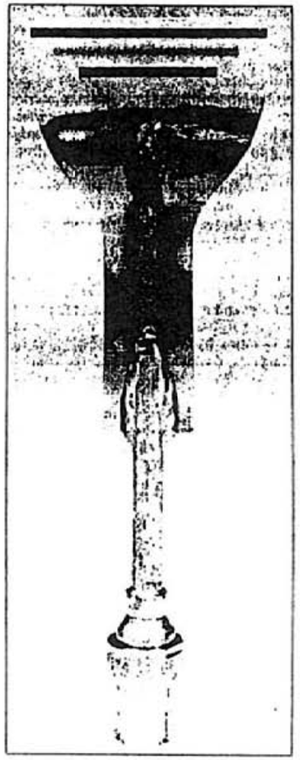


Fig 4—This triband feed was tested with 200 W of 2304-MHz RF; it failed. Don't apply more than 20 W to this feed!

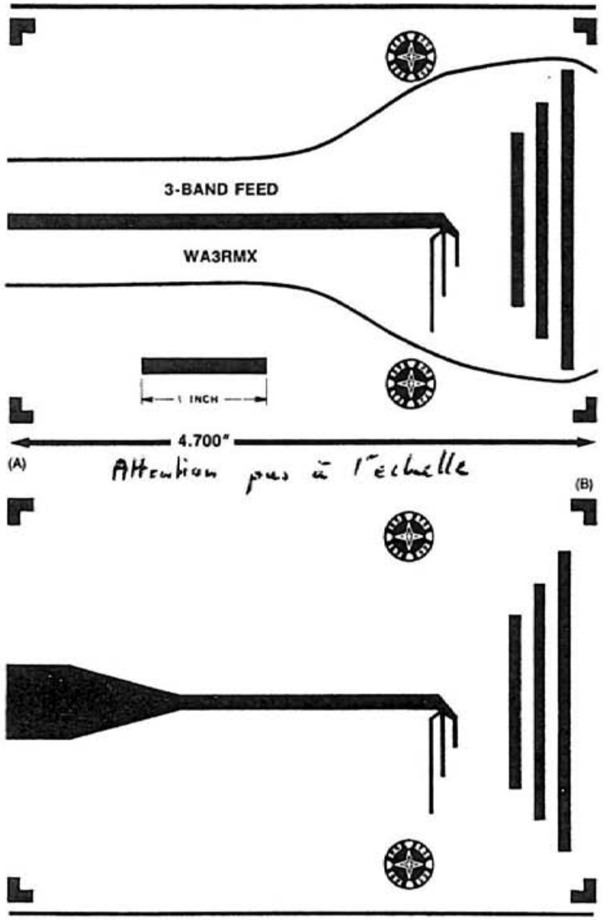


Fig 5—PC-board pattern for the triband dish feed. At A, the front pattern is shown. It includes a rule for checking the board size before etching. At B, the back side of the board is shown. Accurate registration of the patterns is important; the alignment should be within 0.030 inch for best performance.

After etching and washing the board, cut away the excess board material just inside the cut lines on the front artwork. Be sure to remove *all* metal from the cut lines.

Mount a connector to the board in whatever arrangement suits your dish. I suggest you use semirigid 50-Ω coax, either 0.250 or 0.375 inch in diameter, with a connector to fit the feed line to the rig (see the title photo). Prepare the board and the coax to fit each other as shown in Fig 7. You can also mount a connector right to the board, as shown in Fig 8, trimming off the excess copper on the top. In any case, use the shortest leads possible: Even 1/16 inch or less excess wire kills performance at 5760 MHz!

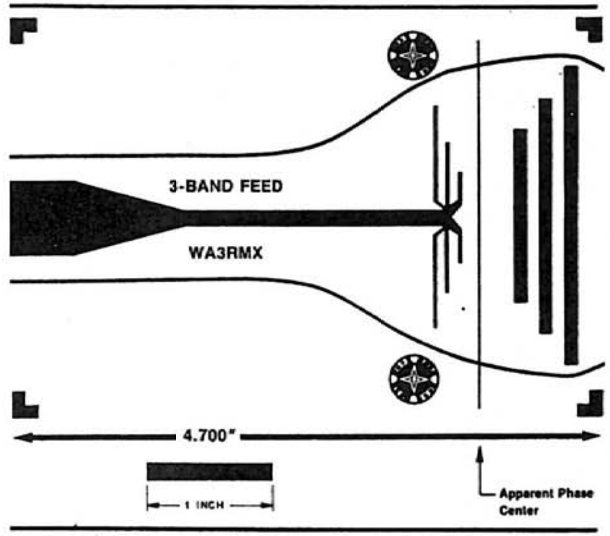


Fig 6—An X-ray view of the PC board, showing the apparent phase center of the feed. Place this part of the feed at the focal point of your dish, as described in the text.

I built one triband feed using the popular 0.141-inch-diameter semirigid coax (UT-141), as this is readily available at hamfests and from suppliers that cater to microwave hobbyists. Although this works electrically, UT-141 is too weak to hold the feed in place except with very gentle handling. If UT-141 is all that you have available, use it; it works fine for light-duty service. If you do use such small Hardline, flatten the part of the shield to be soldered to the back side of the board. The board is thicker than the spacing from the center conductor to the shield, and the center conductor shouldn't be as long as would be necessary for it to wrap around to the front side of the board.

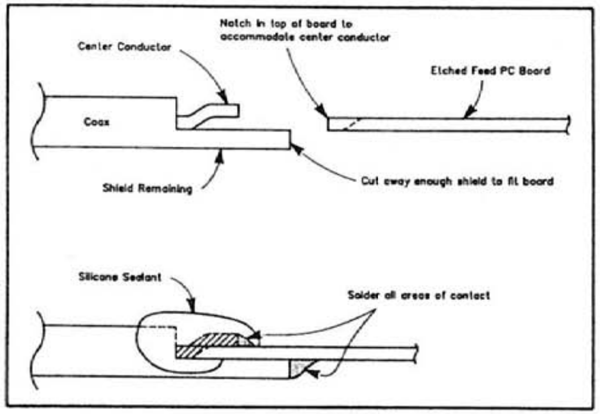


Fig 7—Prepare the Hardline for mounting to the dish-feed PC board by cutting away half the shield and dielectric from the cable over a distance long enough to ensure a solid mechanical connection to the board. Then, bend the center conductor slightly and fit it into a notch in the PC board, as described in the text.

I use a GR874 connector on my portable version of the feed, which allows quick assembly and disassembly, but it also allows water to enter the connection if it's used in heavy rain. My permanently mounted versions all use N connectors for water-resistant, low-SWR connections. If you expect to use the feed in the rain, it is a good idea to mount it in the dish at a slight angle from the horizontal to allow runoff. (If water pools on the flat upper surface of the feed, dielectric loading will detune the antenna.)

After the mechanical and electrical assembly is finished, spray the plastic coating onto the board. After it dries, apply some electronics-grade (non-acidic) silicone sealant to the area of the solder connection to seal out moisture, especially if the feed is to be used extensively outdoors. For this purpose, I use Dow no. 3145 silicone sealant.

Now, mount the feed in the dish, with the apparent phase center (Fig 6) at the focal point of the dish. My tests showed that, although it's a compromise, this is the best feed placement for all three bands. To find the focal point of a dish, use the equation $f = D^2 \div 16h$, where D is dish diameter and h is dish depth (see Fig 9). The triband feed works well with dishes having f/D ratios from 0.25 to 0.4, which is the range over which I've tested the feed.

Operation

With one of these feeds in a 30-inch-diameter dish, I have made 80-mile 2304-MHz FM contacts with 100 mW—with plenty of signal to spare. On SSB, greater range can be obtained, or much lower power used. Lynn Hurd, WB7UNU, and I have made 115-mile contacts with 50 mW of SSB on 2304 MHz using these feeds at each end—stuck straight up into the air, without dishes! In a test to see what is possible using minimal power over a line-of-sight path, we set up 50-mW SSB rigs with 29-inch dishes at each end, each equipped with a triband feed. Communicating over a 66-mile path, we added attenuators in the feed line to one rig until the SSB signal was just barely readable. With *50 dB* of added attenuation, we still had readable signals. (This corresponds to ½ *microwatt* of transmitter power to the antenna!) We were pleased.

Roger McCoy, W7ADV, and I made a 130-mile 2304-MHz contact over an obstructed path using 29-inch dishes

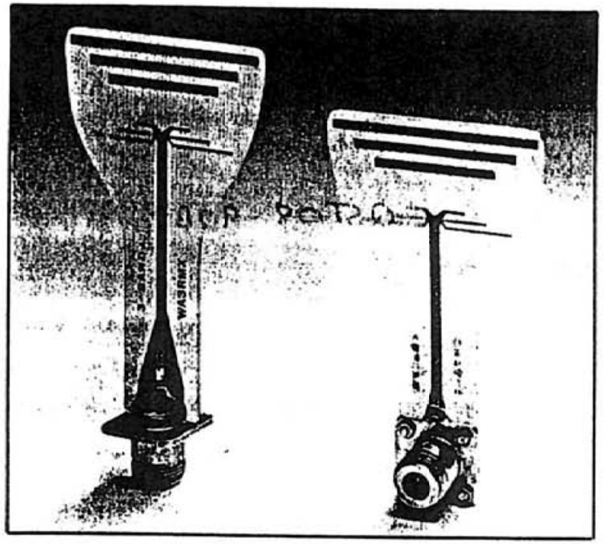


Fig 8—Two prototype triband feeds with N connectors mounted directly to the PC boards. When mounting connectors this way, be sure to minimize stress on the feed resulting from feed-line strain.

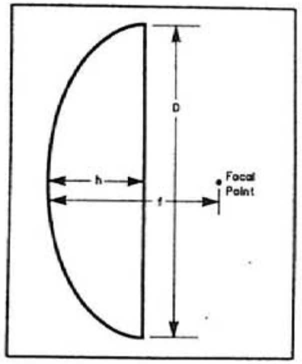


Fig 9—Measure the proportions of your dish and calculate the location of the focus as described in the text.

equipped with triband feeds at each end, by using the tip of Mt Hood (12,000 feet above sea level) as a knife-edge diffractor. We first tried this with 20 W and had fine signals, so we also tried CW and managed a weak contact with only 100 mW.

At the extreme, I have even used a triband feed to make 10-mile contacts with 25 mW *on 10 GHz.* Although far from optimal, the feed still radiates a signal at 3 cm! Three VUCC awards each on 2304, 3456 and 5760 MHz have been earned with copies of this feed. WB7UNU (grid CN85NL) and I (CN85NM) each use these feeds in 19-inch dishes on our roofs, and regularly chat on 2304 and 3456 MHz (5760-MHz signals don't make it too well through the grove of trees on my neighbor's property).

I hope this article helps generate more activity on the microwave bands. With the triband feed and the simple transverters now on the market, it's easier than ever before to put together lots of roving stations for the VHF and microwave contests. VUCC, here we come!

Acknowledgments

Thanks to Deane Kidd, W7TYR, for his help with the artwork and his untiring encouragement. Also, thanks to WB5LUA for his high-power tests, and to W7ADV and WB7UNU for their help field-testing the prototypes.

Notes

[1]R. Campbell, "A No-Tune Transverter for 3456 MHz," *QST*, Jun 1989, pp 21-26.

[2]No-tune transverter kits for 903, 1296, 2304 and 3456 MHz, as well as preamps and accessories, are available from Down East Microwave, RR 1, Box 2310, Troy, ME 04987, tel 207-948-3741.

[3]See Note 2. The triband feed is priced at $20 plus shipping and handling. *The ARRL and QST in no way warrant this offer.*

[4]Spun-aluminum dishes are available in several sizes (24, 36, 48, 60 and 72 inches) from Antenna Center, 505 Oak St, Calumet, MI 49913, tel 906-337-5062. The 24- and 36-inch models are UPS-shippable; prices range from $36 (24 in.) to $190 (72 in.) plus shipping and handling.

[5]For those who have higher power available and want the advantages of the triband feed, I plan to submit a follow-up article to *QEX* that will give a board pattern for Duroid material. That feed won't be nearly as rugged as the FR4 board, but it will handle more power.

Tom Hill, licensed since 1971, is a Principal Engineer in the Microwave and RF Instruments Division of Tektronix, Inc, in Beaverton, Oregon. He's mainly active at VHF and higher, although his station includes antennas and equipment for all bands from 1.8 MHz through 47 GHz, and he's working on others!

Tom has earned VUCC awards on the 3.4, 5.7, 10 and 24-GHz bands, and shares the current North American DX record on 24 GHz and the current world DX record on 47 GHz, all of which he has achieved with equipment he's built from his own designs.

A TRIBAND MICROWAVE DISH FEED - notes gleaned from QST, courtesy of ARRL

The August issue of QST Magazine carries a most interesting article by Tom, WA3RMX, on a triband feed for the 2.3,3.4 and 5.7GHz bands. No adjustments are needed when changing bands. It is cheap to make, using hand tools only and no exotic materials are required. The performance is no worse than 1.5dB down on single band feeds. The feed is etched on both sides of a standard FR4(G-10) pc board, sprayed with clear urethane coating as a weatherproofing. The board requires no holes nor any connections between one side of the pcb and the other.

Three driven elements are etched onto the pcb and attached to a common feed point. Three separate reflectors are employed. The elements are positioned for a common phase centre for all three bands. A simple microstripline balun is mounted on the end of the board, close to the connector. SWR is typically better than 1.5:1 on the two lower bands and better than 2:1 on the highest band. Teflon (PTFE) board was not used for this attenna as it would have a lower mechanical strength than the 1/16 inch thick FR4 material employed (1 ounce copper on both sides).

In operation the feed happily copes with 20 watts but a test at 200 watts led to a severe increase in SWR as the board burnt away!

The construction is very straightforward: etch the patterns shown on the next page onto the front and back of a 3" x 4.5" piece of pcb. The front pattern includes a scale against which the track dimensions can be checked. If you use the pattern shown in this newsletter you will have to enlarge it from A5 size to A4 to get back to full size dimensions. Also shown is an "X-Ray" view of the completed feed. It is important to accurately align both sides of the board to within at least .030". Pattern alignment is obtained by drilling two pilot holes in the unetched part of the board, at the location of the two "bullseyes" in the artwork. After etching be sure to cut away all excess board material to the cut lines shown in the artwork for the front board. A semi-rigid coax feed can be connected or an N socket can be mounted directly on the board. If using the latter technique be sure to trim all the excess copper on the top. The shortest leads possible should be used.

The feed is mounted so that the apparent phase centre (see X-Ray diagram) is at the focal point of thew dish. The feed works well with dishes having f/d ratios around 0.25 to 0.4.

extrait de "Microwaves Newsletter"

(reprise de l'article de QST)

WG20 Dish Mount

This article describes a method of mounting small 24 GHz parabolic dishes on a photographic tripod, when they are fed from the rear with WG20 or a smaller waveguide. Typical dish sizes are in the region 45 cms to 60 cms diameter.

The major problem with WG20 is that it is not really strong enough to support the weight and wind loading of a dish. To overcome this problem the author used a length of WG16 which structurally supports the dish on the tripod. Two square WG16 flanges and two purpose made adapters are used in conjunction with the WG16 to make the WG20 focusing and support mechanism for the dish.

Figure 1 shows a photograph of the completed unit. The dish has been drilled to take the four fixing bolts of a WG16 flange. Between the dish and this flange is mounted a WG16/20 adapter. A short length of WG16 connects the "dish mounting" flange with the tripod mounting brackets and the rear WG16 flange and its WG16/20 adapter. Squares of brass were used for the tripod mounting brackets, but this was only because the author had these to hand and in fact orthogonally mounted rectangular brackets would probably be more suitable. Two brackets were used to allow the waveguide to be mounted either horizontally or vertically. (It was found that the tripod's own mechanism for turning a camera on its side was not satisfactory when supporting the weight involved.) The two brackets were silver-soldered to the WG16, though lead solder is probably strong enough.

The rear WG16 flange has been drilled and tapped radially with four 2BA or M4.5 bolts. These bolts, when **finger tight,** grip the WG20. Ensure that the ends of these bolts are smooth before using them to grip the WG20. The WG 16 must also be drilled such that these bolts pass straight through its wall with some clearance. Before lead-soldering this WG16 flange to the WG16, zinc-plated bolts were screwed into these holes to avoid them filling with solder.

Figures 2 and 3 give material details. It is most important that the WG16 flange is mounted centrally on the axis of the dish. It is also very important that the WG16/20 adapters are made accurately so that the WG20 is mounted in the exact centre of the WG16. If this is not so the radiator will appear off centre in the dish. In practice a small amount of adjustment can be made by replacing the M4 bolts with M3.5, or even M3, and adjusting the position of the two plates before tightening the bolts. A very small adjustment can be made by selecting the order in which the WG20 fixing bolts are tightened. **These bolts should only be tightened finger tight to avoid distorting the waveguide.**

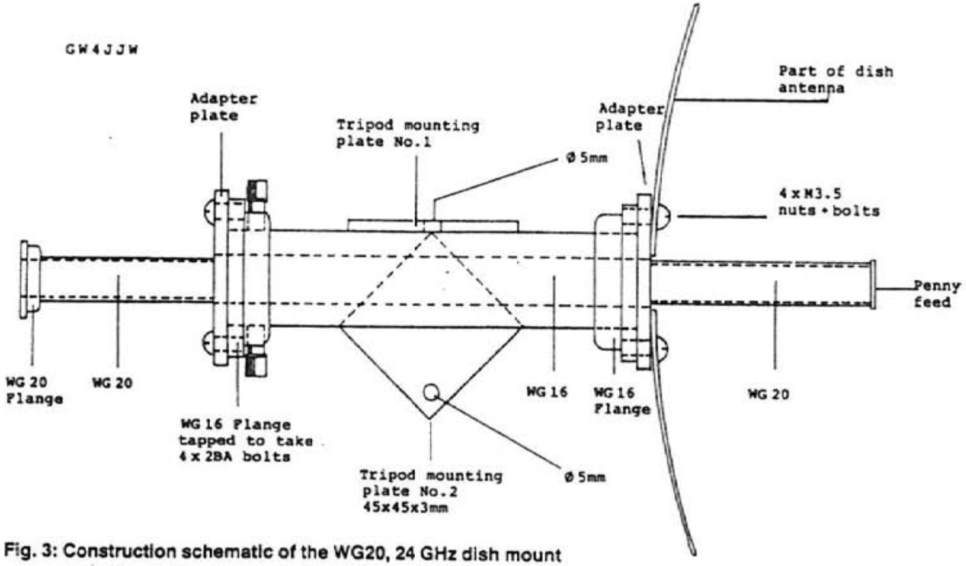


Fig. 3: Construction schematic of the WG20, 24 GHz dish mount

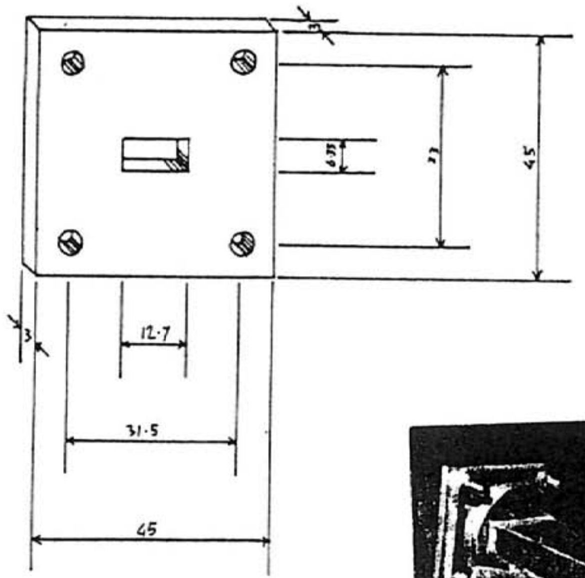


Fig. 2:
WG16/20 adapter plate

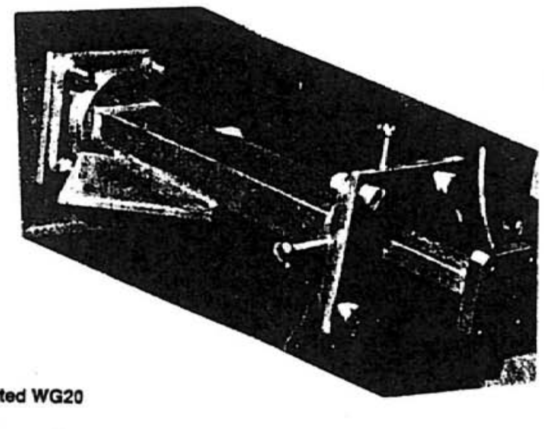


Fig. 1:
The completed WG20 dish mount

UHF 02-90 F3

Andrew Bell, GW 4 JJW

Josef Fehrenbach, DJ 7 FJ

Dual-Band Exciter for 10 GHz and 24 GHz

A reflector, two GHz bands and only one dual-band exciter - this arrangement offers many advantages, whether in terms of cutting down on weight or of the possibility of positioning the aerial at 10 GHz and then working at 24 GHz with the aerial already aligned.

1. INTRODUCTION

Anyone who is already QRV on 10 GHz and would now like to extend his or her activities to the next highest amateur band at 24 GHz has to struggle with a few unusual features in the process. Narrow-band technology is already established, with adequate frequency stability. However, the receiver sensitivity and the transmission power available (if the price is kept reasonable) are still markedly below those now available at the 10 GHz level. Whilst the noise factors of the input stages tumble year by year with the help of HEMT's, transmission power levels of more than 100mW unfortunately continue to remain unattainable for most OM's. Moreover, the 24 GHz technology surplus market provides very little which is of use here.

Apart from the already higher path attenuation, active radio operation is also made more difficult by additional attenuation, e.g. due to water vapour (moisture, mist, rain, snow, hail).

If your receiver noise figure has already been optimised and the transmission power has been matched to your money bag, the only way left open to improve the technical potential is through the aerial. Only by this means is it still possible to make up for a few of the losses generated, for example, by too low a transmission power and by the high path attenuation. For any further gain to be obtained, the aerial has to be

as large as possible. The easiest way to obtain high gain levels is using satellite dishes. The gain from satellite dishes is calculated as:

$$G[dB] = 10 \cdot \log\{(\frac{\pi \cdot d}{\lambda})^2 \cdot \eta\}$$

where:

d = diameter of dish
λ = wavelength
η = aperture efficiency using amateur reflectors - usually 0.5 to 0.6

Unfortunately, the apex angle of an aerial is inversely proportional to its gain. The apex angles of satellite dishes can be easily estimated using the equation below:

$$\varphi \cong 70\lambda/d$$

where:

φ = horizontal and vertical apex angle
λ = wavelength
d = diameter of dish

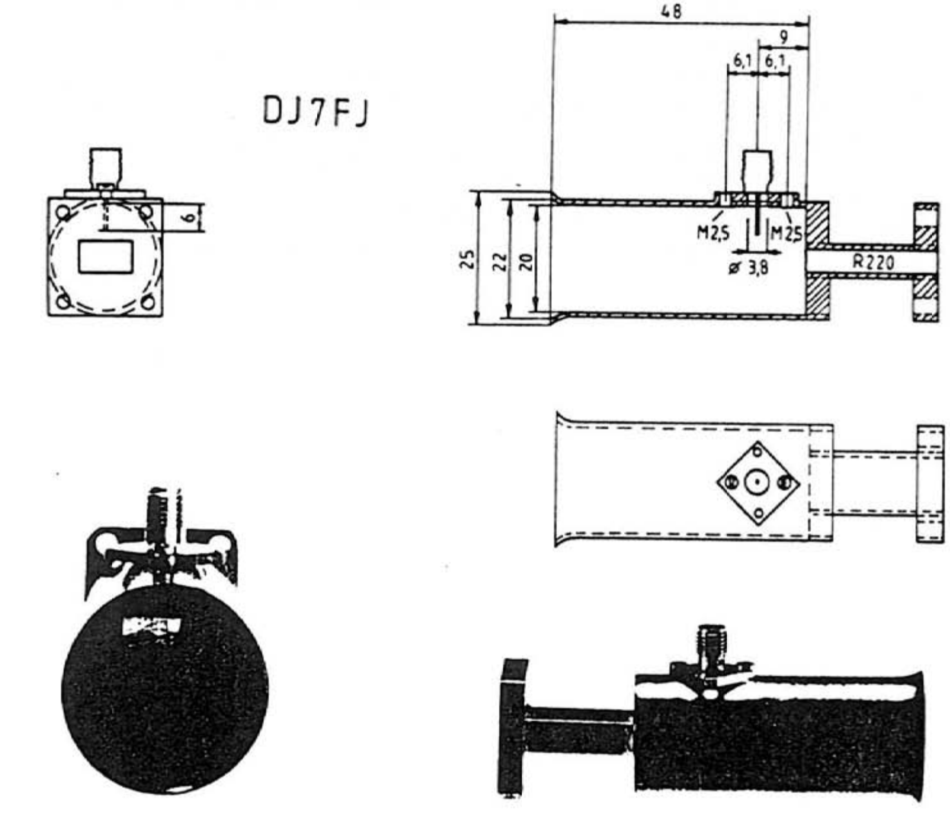


Fig.1: Dimensions of the 10/24 GHz Dual-Band Exciter
Eqpt: Copper Pipe, R220 Waveguide, 2 Flanges and an SMA Socket

Tables relating to the above relationships between aerial size, gain, apex angle and wavelength can be found in the literature, e.g. in (1).

At 24 GHz, satellite dishes between 30cm and 1m obtain from 35 to 45dB with apex angles of 3° to 0.8°. Unfortunately, these apex angles must be respected, not only in the horizontal plane, but in the vertical plane as well.

Consequently, with these preconditions, it is obviously very desirable to operate with an aerial which is precisely aligned even before the QSO begins. With a dual-band aerial which is first optimised in the low-frequency 10 GHz band (with significant signal reserves), this can be achieved considerably more easily than by working directly at 24 GHz. Moreover, such a dual-band aerial is extremely practical for portable mode itself (BBT, among other things).

This article describes a dual-band exciter for 10 and 24 GHz for use in satellite dishes, with a "focus/diameter ratio", f/d, of app. 0.35 to 0.4.

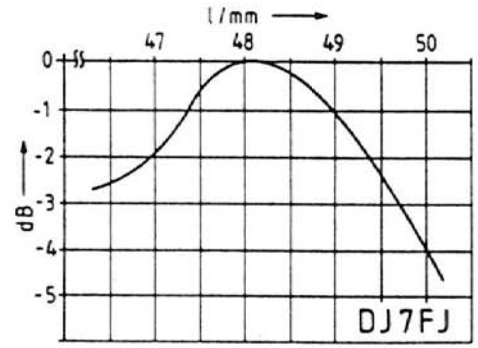


Fig.2: Radiator Length plotted against Gain at 24 GHz

2. OPERATING PRINCIPLE

A pipe radiator for the 13cm band is described in (2). The relationships between f/d and the measurement of the associated feed-horn are also comprehensively explained there. On the basis of a reflector with a "focus/diameter ratio" (f/d) of, for example, 0.38, we obtain a focus angle of about 130°. For a rectangular horn exciter, this gives us an a · λ value of 0.79 and a b · λ value of 0.66 for 10 GHz. If we start with a round horn, from the average of the two values, we arrive at a horn diameter of app. 0.72 · λ. At 10 GHz (λ = 3cm), that corresponds to a horn diameter of 21.6mm

Copper pipes with external diameters of 20mm and internal diameters of 18mm, obtained on the construction market, come very close to this dimension. Provided you don't bend them, these pipes make splendid wave guides for 10 GHz. If you mount such a round wave guide into the focus of a reflector, without an additional horn, this is

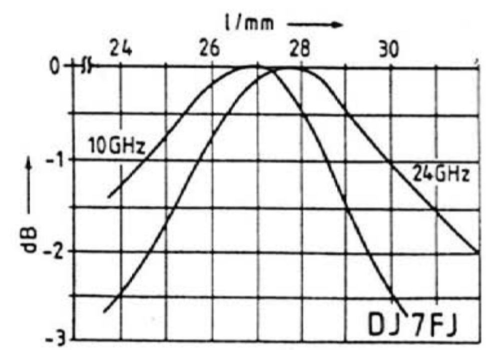


Fig.3: Optimising Gain by changing Radiator Position

already a very good radiator for reflectors with an f/d of app. 0.35. Such a radiator forms the basis of the combination radiator described here.

The 10 GHz section consists of a round wave guide with an internal diameter of 18mm The 10 GHz signal is coupled in through a coaxial wave guide transition by means of a pin.

The length of the wave guide unit is not critical for 10 GHz. The open wave guide end can be used directly as a radiator. You are recommended to press on a small horn (expand the tube end) at f/d ratios approaching 0.4. Experiments have shown that this can increase the aerial gain by up to 1.3dB, as against a wave guide end which has simply been turned. A grooved horn available as basic equipment for 11 GHz satellite television which matched the wave guide diameter gave the same readings.

Fig.1 shows the radiator set-up for 10 GHz and the expansion for 24 GHz. A 24 GHz E220 rectangular wave guide was mounted into the closing plate of the 10 GHz radiator. The lower limiting frequency of the R220 led us to expect total locking for 10 GHz, which measurements confirmed. Measurements of the adaptation at the 10 GHz coupling jack showed that it made no difference whether the pipe was closed off with a continuous plate or with an R220 wave guide inside such a plate.

Measurements of the gain from the 10 GHz section also showed no discernible changes. What we still had to determine was what influences or losses would be generated in the 24 GHz signal by the 10 GHz pin. It also had to

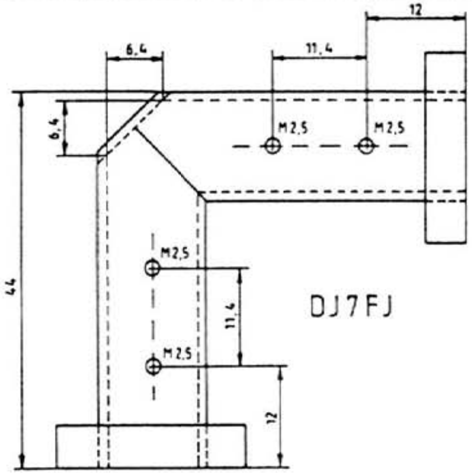


Fig.4: **Construction Dimensions for a "Compensated Bend" made from Waveguide Material**

be determined how the gain at 24 GHz behaves in relation to the length of the round wave guide.

2.1. Experiments with Prototype

A radio path with a length of 300m and a test reflector with a diameter of 70cm and an f/d of 0.38 were used for the experiments described below.

Fig.2 plots the relationship of the radiator length to the gain obtainable at 24 GHz. The radiator position, i.e. its distance from the reflector, was optimised for maximum gain in each case. The optimum readings were clearly obtained with a radiator length of 48mm - and you don't have to be accurate to a tenth of a millimetre. As expected, the variation in the length tested had no influence at 10 GHz.

Further experiments were carried out with dimensions in accordance with Fig.1, i.e. with a radiator length of 48mm The relative gain at 10 GHz and 24 GHz was determined in relation to the optimal radiator position in each case. The maximum readings were about 1cm apart, but the drop in each case is insignificant (see Fig.3). When we copied this model, we had to determine the optimum radiator position using a beacon. Anyone who can't receive beacons for the two bands should optimise using the band available. As the experiments showed, the deviation from the optimum radiator position is not evident.

At 10 GHz and 24 GHz, the matching values gave a return loss of better than 15dB. The coupling from 10 GHz to 24 GHz could not be measured. The coupling from 24 GHz to the 10 GHz coaxial output amounted to app. 10dB. Anyone who wants to generate output using this system at 24 GHz should either build a stop filter into the 10 GHz port or switch the 10 GHz pre-amplifier off when transmitting at 24 GHz.

3. SET-UP

The copper radiator pipe is cut to the appropriate length. Before the holes and threads for the SMA 2-bore flanged bush are bored and cut (4-bore units can also be used), a flat surface approximately 4.5mm wide should be prepared at the appropriate location by milling or filing. The coupling pin consists of the connection pin of the SMA bush and a 1mm silver wire, soldered on and nipped off at the correct length. So that the R220 wave guide can be incorporated more easily, it is recommended that you manufacture an adapter unit about 20-30mm long. To do this, solder two wave guide flanges onto a suitable wave guide unit. If one bush is clamped into a four-jaw chuck and held, the other one can be carefully turned to an external diameter of 18mm This adapter is then pushed into the copper pipe, brought into the correct position and soldered in. The soldering should be done using as little solder as possible, preferably on a hotplate or using hot air. The wave guide flanges can be made to bulge on the side facing away from the connection in question before the first soldering by light blows from a centre punch, so that they sit tightly on the wave guides. Otherwise, you run the risk that the adapter will fall apart again during the final soldering process.

Anyone who doesn't have turning equipment available can, for example, mount a cornered closing plate instead of the bush adapted to the pipe, with a suitable opening for the R220 wave guide.

3.1. Installation in Reflector

The radiator can be fastened using a 3 or 4 strut, and the 10 GHz signal can be fed in by means of a high-quality cable. For 24 GHz, in any case, you are recommended to use a kind of "walking stick" made of wave guide material. Those wishing to produce the corners required for this themselves will find some tips in Fig.4 on the construction of a compensated bend using R220 for

24.192 GHz. The only critical dimensions are the chamfers on to the corner cover, which have an internal length of 6.4mm The M2.5 threaded bores need to be manufactured only once as a pair for the whole walking stick. If necessary, they can take adjustment screws.

4. FUNCTIONAL TEST AND GAIN COMPARISON

Completed systems in 60cm and 90cm reflectors showed that no losses of any kind arose due to the building-on of the 24 GHz section.

At 24 GHz, in comparison with standard horn equipment and monoband dishes, reflectors with dual-band exciters obtained a gain which was always 2.5dB below what monoband excitement would have produced. This can essentially be traced back to the fact that the exciter's 24 GHz lobe was slightly too narrow.

4.1. Practical experiences

Several 24 GHz enthusiasts have been working on copying this exciter for some time. QSO operation at 24 GHz is considerably simplified by the ability to preset the direction precisely during the preceding 10 GHz QSO. It has been shown time and again that the aerial setting really needed no further optimisation following the switch from 10 GHz to 24 GHz. This more than compensates for the loss of the final 2.5 dB by comparison with the uncertainty of direction which would otherwise prevail and which often leads to failed QSO's.

Readings for a 90cm satellite dish with a dual-band exciter:

	10 GHz	24 GHz
Gain	37 dB	41.5 dB
Apex angle	2.3°	1.4°

The author wishes all success to those wishing to copy him, and is already looking forward to many 24 GHz QSO's.

5. LITERATURE

(1) RSGB VHF-UHF Manual

(2) Tubular Radiator for Parabolic Antennas on the 13cm Band DJ 1 SL, VHF Communications no. 4, 1976

Cette source est disponible chez DG1KBF (voir chapitre : REALISATIONS COMMERCIALES)

Prix ≃ 210 FF

ANTENNES SPECIFIQUES

TECHNICAL REPORTS

3 cm PILLBOX - ANTENNE

Ulf Hulsenbusch, DK 2 RV

D. In der Radartechnik verwendete Antennen weisen bekanntlich in mindestens einer Ebene eine starke Bündelung auf. Diese Eigenschaft ist auch für bestimmte Anwendungen im Amateurfunk interessant. Ein Bakensender soll z.B. einen möglichst großen horizontalen Bereich abdecken, während in der Vertikalen nur ein kleiner Ausschnitt benötigt wird. Die Leistung wird so optimal verteilt.
Für Versuchszwecke wurde eine sogenannte Pillboxantenne gebaut. Sie hat etwa die Form eines Abschnittes eines flachen Zylinders (Pillenschachtel).
Die Bündelung ist am stärksten in der Ebene mit der größten mechanischen Ausdehnung. Hier besitzt die Antenne ihren kleinsten öffnungswinkel.
In der anderen Ebene ist der öffnungswinkel sehr groß. Durch Zusammenbiegen der Antennenöffnung bzw. Verkleinern der Aperatur wurde versucht den öffnungswinkel noch weiter zu vergrößern.
Es gibt eine Vielzahl von Erregersystemen, sowohl für vertikale, als auch für horizontale Polarisation. Stellt man die Antenne auf den "Kopf", sodaß die Bündelung senkrecht ist, so ist die Polarisation horizontal.
Die hier verwendete Einspeisung besteht aus einem Koppelstift in 7.5mm Abstand von der Reflektorwand. Die Anpassung kann mit einer gegenüberliegenden Schraube eingestellt werden.
Bekanntlich rechnet sich die Hohlleiterwellenlänge zu:

$$\lambda_z = \lambda_0 \cdot \frac{1}{\sqrt{1-(\lambda_0/2a)^2}}$$

Wenn wir die Antenne als Hohlleiter betrachten, dann ist die breite Seite sehr viel größer als λ_0, so daß $\lambda_z \approx \lambda_0$. Bei Erregung in der anderen Ebene wäre: $\lambda_z \neq \lambda_0$. Das Diagramm wurde in einem Absorberraum vermessen. Die verwendeten Absorber waren für 10 GHz nicht optimal, so daß beim Vermessen der breiten Keule Reflektionen auf der Hüllkurve zustande kamen.
Elektrische Eigenschaften:

Frequenz:	10368 MHz
Gewinn:	10.6 dBi
Horizontale Halbwertsbreite:	4 Grad
Vertikale Halbwertsbreite:	85 Grad
Polarisation:	horizontal
Nebenkeulen horizontal:	- 10dB
Nebenkeulen vertikal:	- 13dB
Rückflußdämpfung:	15dB

Konstruktion:
Es werden 2 Messingbleche 1mm mit den Abmessungen 200x700 mm benötigt, sowie ein Messingstreifen 15x825mm.
Der Koordinatenmittelpunkt zum Berechnen der Parabel liegt mittig an der langen Seite der beiden großen Bleche. Es werden einige Punkte berechnet auf den Blechen eingezeichnet.

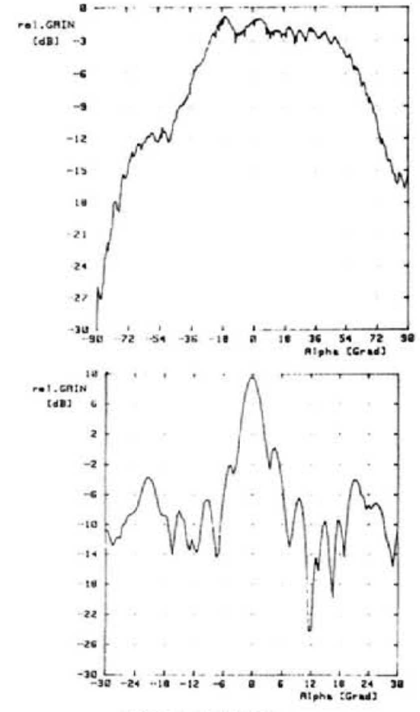
$$y = 200 - x * x / 600 \text{ mm}$$

Anschließend werden die Punkte verbunden und die Parabel mit der Blechschere ausgeschnitten.
Nach dem Bohren aller Löcher werden die Vorderseiten der Bleche leicht abgebogen (siehe Zeichnung).
Vor dem Verlöten der Rückwand werden beide Hälften mit dem Reflektorklotz verschraubt, um eine größere mechanische Stabilität zu erhalten. Der Messingstreifen wird so verlötet, daß beide Bleche einen Abstand von 12mm haben.

E. Antennas for radar technics have a small beamwidth in at least one plane. This attribute is also interesting for certain applications in amateur radio. A beacon antenna should reach a large horizontal area, whereas in vertical plane only a small section is used. With the pattern of the "pillbox-antenna" one gets optimum power distribution.
In the plane with the large mechanical extension the beamshape is very narrow. Thus, the antenna has a very small half-power beamwidth. In the other plane the beamshape is very large and it was tried to increase it by a smaller aperature.
There are plenty of feeding systems as vertical as well as horizontal polarization. Here used a coupling probe spaced 7.5mm from a planar reflector. The return loss can be minimized with a matching screw in opposite of the coupling probe.
The well-known formula for the wavelength in a waveguide is:

$$\lambda_z = \lambda_0 \cdot \frac{1}{\sqrt{1-(\lambda_0/2a)^2}}$$

In tis case the broad side of this "waveguide" is much greater than and $\lambda_z \approx \lambda_0$.
For a feeding system in the other plane $\lambda_z \neq \lambda_0$.
The radiation pattern was recorded in a anechoic chamber. The absorbers were not optimal for 10 GHz, so that the reflexions made a ripple on the envelope in the horizontal plane. Gain was measured with a standard gain horn.



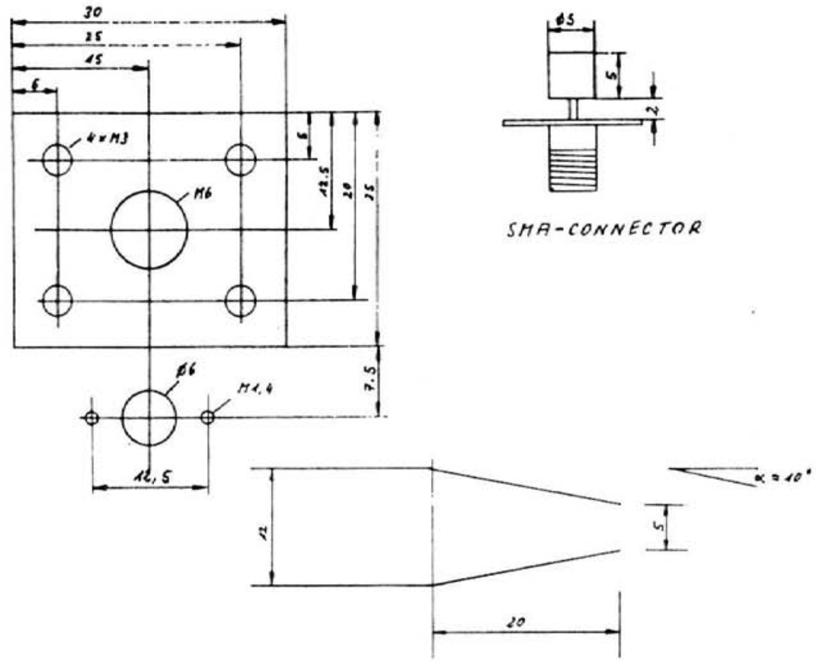
PILLBOX DK2RV 10.368 MHZ

Construction:
We need two brass plates (1mm) 200x700mm and one brass metal strip (1mm) 15x825mm. The center of the coordinate system for the calculation of the parabolic rear side is in the middle of the long side of the two large plates. Now some points are calculated and marked.

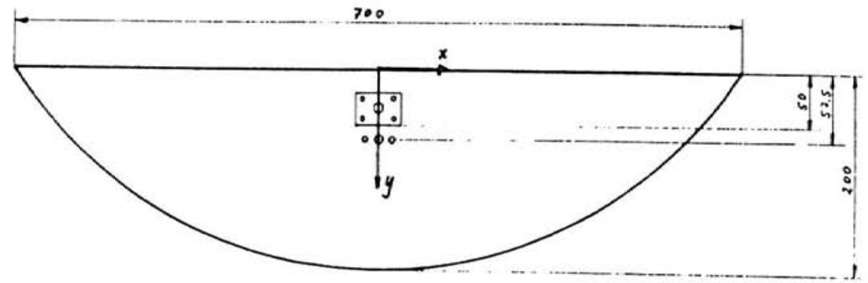
$$y = 200 - x * x / 600 \text{ mm}$$

Then connect the points and cut along the parabolic line. Next drill the holes and bend the straight side of the plates (see figure). For better stability the two plates are screwed together with the brass block (reflector). Now the metal strip can be soldered so that the plates have a spacing of 12mm over all.

Reference: Johnson/Jazik, Antenna Engineering Handbook.



Correction DUBUS 4/85 p. 291: 3cm Pillbox - Antenna by DK2RV
Korrektur DUBUS 4/85 S. 291: 3cm Pillbox - Antenne von DK2RV



a Fresnel-zone plate for 10.4 GHz

An alternative to a parabolic reflector for your Gunnplexer transceiver

An increasing number of Radio Amateurs are stepping up to the 10.4-GHz Amateur band (10.0-10.5 GHz) to experiment with centimeter wavelengths and Gunn diode oscillators. The popular Gunnplexer transceivers offer the Amateur an excellent introduction to the 10.4-GHz band with a minimum of effort. (A recommended text is *The Gunnplexer Cookbook*, by Bob Richardson, W4UCH. It's available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 for $9.95 plus $1.00 shipping.)

The Gunnplexer uses a Gunn diode and a low-noise Schottky diode in a cavity that operates in the homodyne mode. The Gunn diode oscillates at the desired microwave frequency, which is the transmitted carrier frequency. The received carrier frequency is at some offset frequency (could also be the transmitted frequency that is returning to the Gunnplexer with some Doppler shift), which is mixed in a Schottky diode with the transmitted carrier frequency. The resulting i-f is then fed to a conventional high-frequency or VHF receiver for demodulation.

The common method of improving the performance of the Gunnplexer is the addition of a horn or

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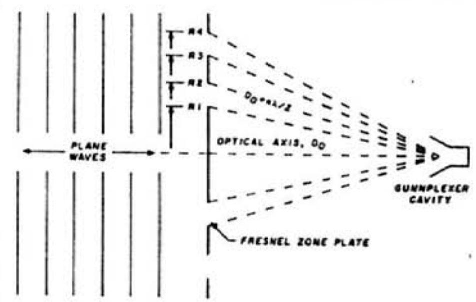

fig. 1. Geometry of the Fresnel-zone plate showing the relationship between the cut-out zones, which pass rf energy, and the center, or optical axis.

parabolic reflecting antenna to get some antenna gain. Some of the disadvantages of parabolic reflectors are that they are expensive, difficult to construct to the required tolerances, and difficult to mount or move because of their weight. This article describes an alternative antenna that yields results comparable to a parabola, yet is inexpensive and lightweight. Such an antenna is a Fresnel-zone plate.

description

The Fresnel-zone plate consists of a flat sheet of material that is opaque to 10.4-GHz energy (aluminum or copper foil) with concentric circular zones cut out to pass rf. The zones are spaced such that each zone is one-half wavelength greater in path length from the plate to the Gunnplexer cavity, out from the center zone, which is a straight-line path (**fig. 1**). The result is that each zone passes rf spaced one wavelength and adds constructively to the intensity of the rf at the focal point. The effect of the plate is to collimate the rf during transmit and focus it during receive, much like an ordinary optical converging lens.

geometry

To see how a Fresnel-zone plate works and to calculate the radii of the zones, refer to **fig. 2**. The outer edge of the nth zone is shown as R_n. According to the Fresnel diffraction theory, a wave that follows the path $L{\cdot}R_n{\cdot}F$ arrives $n\lambda/2$ out of phase with a wave that travels the path $L{\cdot}O{\cdot}F$. To express this mathematically, we say:

$$(S_n + S_0) - (d_n + D_0) = n\lambda/2 \qquad (1)$$

With a little trigonometry we find that:

$$S_n = \sqrt{(R_n^2 + S_0^2)} \qquad (2)$$

and

$$d_n = \sqrt{(R_n^2 + D_0^2)} \qquad (3)$$

and using binomial expansion yields

$$S_n = S_0 + \frac{R_n^2}{2S_0} \qquad (4)$$

and

$$d_n = D_0 + \frac{R_n^2}{2D_0} \qquad (5)$$

Substituting into **eq. 1** yields

$$\left(\frac{1}{S_0} + \frac{1}{D_0}\right) = \frac{n\lambda}{R_n^2}, \qquad (6)$$

which is identical to the thin-lens equation so familiar in classical geometrical optics.

In this case the wave source at L is at some great distance from the point 0, thus the waves incident upon the zone plate are very nearly plane-wave in shape. Hence S_0 approaches infinity and **eq. 6** reduces to

$$R_n^2 = nD_0\lambda \qquad (7)$$

A more precise equation can be derived from more terms in the expansion, which results in

$$R_n^2 + D_0^2 = (D_0 + n\lambda/2)^2 \qquad (8)$$

Thus, the radius of the nth zone is given by

$$R_n = \sqrt{nD_0\lambda + \frac{n^2\lambda^2}{4}} \qquad (9)$$

From the principle of reciprocity, during transmit a point source at F would produce an almost plane wavefront on the opposite side of the zone plate. The system thus behaves as a collimating and focusing lens for transmitting and receiving respectively.

The dimensions for an experimental Fresnel-zone plate of ten zones, with a focal length of 100 centimeters at 10.4 GHz are given in **table 1**. Note that the area of each of the zones is constant, thus each zone will contribute equally to the sum intensity at the focal point. Suppose that we construct a zone plate that passes only the odd zones and blocks the

table 1. Dimensions for an experimental Fresnel-zone plate of ten zones with a focal length of 100 cm at 10 GHz.

radius of zone 1	17.0453 cm
radius of zone 2	24.1918 cm
radius of zone 3	29.7339 cm
radius of zone 4	34.4548 cm
radius of zone 5	38.6564 cm
radius of zone 6	42.4930 cm
radius of zone 7	46.0561 cm
radius of zone 8	49.4047 cm
radius of zone 9	52.5800 cm
radius of zone 10	55.6115 cm

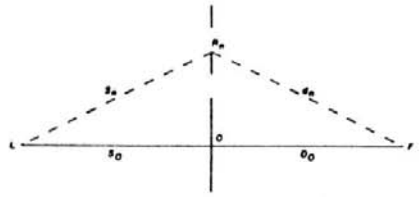

fig. 2. The Fresnel-zone plate is at *0*, the Gunnplexer is at *F*, and the contact station is at *L*. When the contact station is at a large distance (more than 10 wavelengths), the distance S_0 approaches infinity, and the rf wave at *0* appears as a plane wave.

even zones. The amplitude, *E*, at the focal point will be

$$E_T = E_1 + E_3 + E_5 + E \ldots + (2n-1) \quad (10)$$

If we construct a plate that passes the first 10 odd zones, the sum is $10\,E_1$. The incident wavefront gives $1/2\,E_1$, so the amplitude at the focal point, *F*, will be increased 20 times. The intensity is therefore increased 400 times, or 26 dB. Larger zone plates and greater gains are possible as long as the focal point aberrations are less than the depth of the Gunnplexer cavity.

construction

The first Fresnel-zone plate antenna I constructed was made from art matte board covered with aluminum foil and the radii cut out with a knife. Several "spokes" were left in the board to support the inner zones. Subsequent plates have been made with aluminum sheet metal. The resulting antenna has been tested with Doppler-shifted carriers and has confirmed the calculated focal length and gain.

It might be pointed out that modifications of the zone radii would make it possible to make a plate that was not flat and could thus be incorporated into the various shapes of aircraft or other vehicles. In either case, flat or otherwise, the dimensions required for a zone plate are not nearly as tight as those for a parabola, and the resulting antenna is much lighter.

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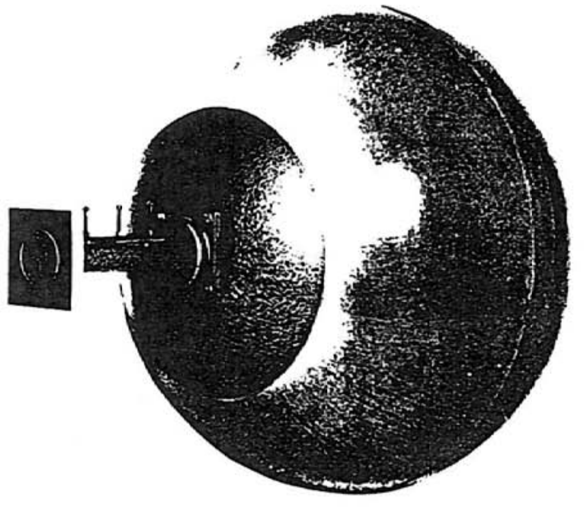
ham radio

LENTILLES DE LUNEBERG



La lentille de Luneberg, placée devant un guide d'onde, un cornet ou tout autre source constitue une antenne très directive et à grande largeur de bande.

Le système d'excitation de petites dimensions peut tourner autour de la lentille fixe de façon à produire une exploration ou un "scanning" très rapide.
Un dispositif d'excitation à plusieurs sources fonctionnant à la même fréquence ou à des fréquences différentes peut être utilisé avec de telles lentilles.

L'emploi de lentilles bistatiques permet aussi d'obtenir des diagrammes de rayonnement dont l'angle d'ouverture peut être réglé à l'avance.

PRINCIPALES REALISATIONS

TYPE	diamètre max. cm	gain à 9375 MHz en dB	masse kg	système de fixation
6215	10	18	0,25	sans
6209	18	23,5	1,3	sans
6214	23,5	25,5	2,9	sans
6205 A	26	26,5	3,9	guide RG 52/U
6206	26	26,5	3,8	sans
6210	32	28,5	7,5	sans
6213	44,5	30,5	20	sans

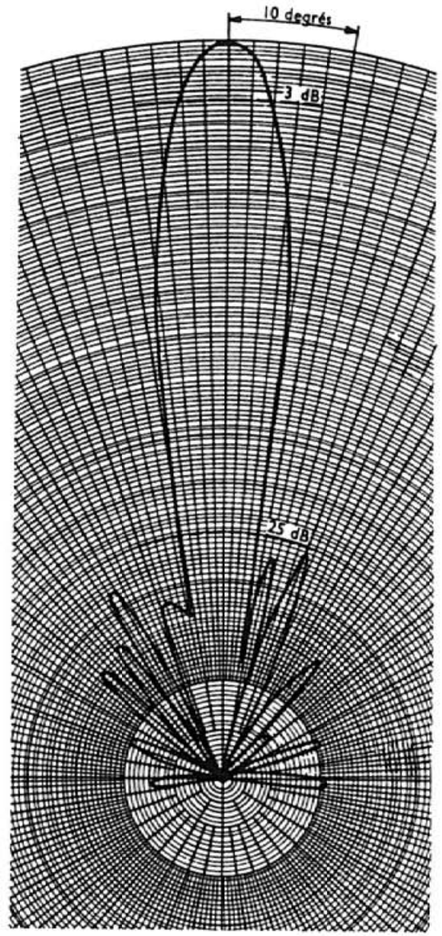


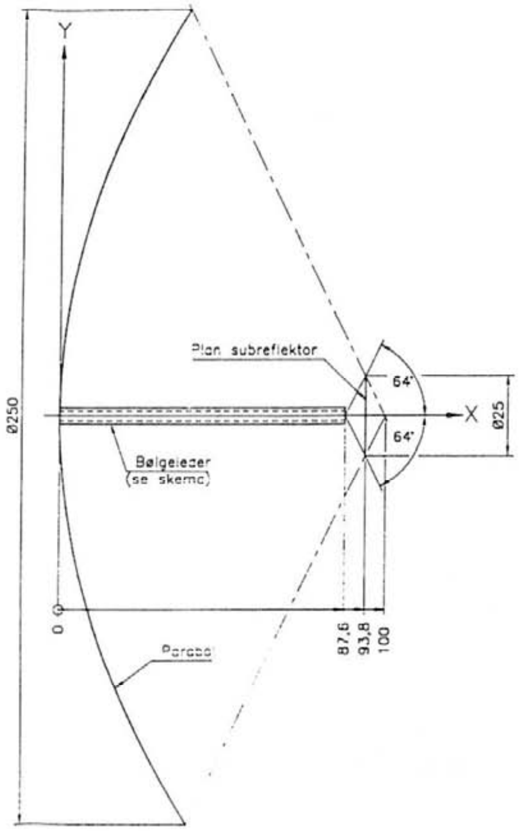
Diagramme de rayonnement typique d'une lentille

Récupérée et utilisée par F5EFD

REALISATIONS

COMMERCIALES

Mikrobølgeafdeling



Frekvens GHz	Bølgeleder
47	WR 19
76	WR 12
144	WR 7
220	WR 4

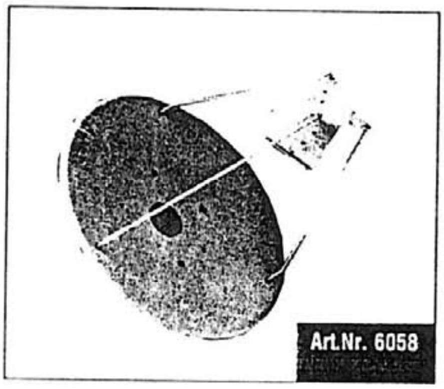
PROCOM DENMARK

Alle mål i mm.
Matr.:
Beh.:
Tol.: DS/ISO 2768–m.
Mål.: 1:1
Tegn.: 10/5–94 JF
Konstr.:
Godk.:
Dato.: 16/6-94

Subreflektorsystem for 47, 76, 144 & 220 GHz

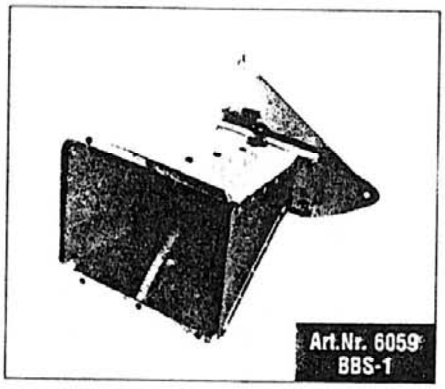
999925,01

Parabol-Spiegel mit
Breitband-Strahler BBS-1
Art.Nr. 6058



Art.Nr. 6058

SSB GMBH Electronic
Ingenieurbüro für Nachrichtentechnik



Art.Nr. 6059
BBS-1

Technische Daten

	Parabol-Spiegel 85 cm ø m. BBS-1				
Frequenz	1300	2300	3560	5600	MHz
Gewinn	18	23	26	31	dBd
Öffnungswinkel	17°	9°	8°	4°	
Gewicht	ca. 4				kg

micro-mechanik von dg1kbf

Hubert Krause Berghagen 60 53773 Hennef
Tel. & Fax: 02248/3943
Bank: Sparkasse Hennef Konto: 708099 Leitzahl: 386 513 90

- Cornets 24 GHz 10 .. 20dB (45 .. 80 DM)
- source mixte 10 & 24 GHz (60 DM)
- Adaptateurs R100 - R120 (60 DM)
- Adaptateurs R90 - R100 (70 DM)

Antennen Hornstrahler

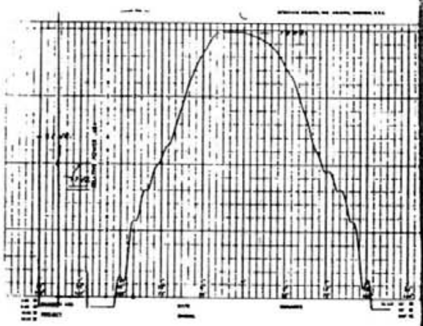
Preise einschl. Mehrwertsteuer

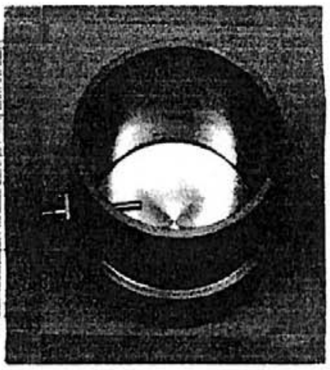
Hornstrahler zum Ausleuchten eines Parabolspiegels.

Technische Daten:

Frequenzbereich:	5550Mhz - 5830Mhz oder 3,4GHz oder 10GHz
Anpassung:	> 18dB
Öffnungswinkel:	149° bei 10dB
Gewinn:	7,2dBi (Gemessen!)
Anschlußbuchse:	SMA
Befestigung:	3 Bohrungen M2,5 im Winkel von 120°

Zur Datenübertragung (Verbindung von Knoten zu Knoten) wird in Zukunft nur noch der 6cm Bereich freigegeben. Sende- / Empfangsbaugruppen existieren bereits. Viele Amateure haben aber sicherlich Schwierigkeiten entsprechende Antennen mit tragbarer Anpassung, vorgegebenen Öffnungswinkel und Gewinn zu bauen. Diese Arbeit haben wir Ihnen hiermit abgenommen. Der von uns entwickelte Hornstrahler kann ohne Probleme in den Brennpunkt eines Parabolspiegels montiert werden.





Hornstrahler 3,4Ghz	1009302	(mit Meßprotokoll)	220,-DM
Hornstrahler 5,7Ghz	1009303	(mit Meßprotokoll)	120,-DM
Hornstrahler 10Ghz	1009304	(mit Meßprotokoll)	130,-DM

Eisch electronic

Eisch electronic
Inh. Annemarie Eisch-Kafka
Abt-Ulrich-Str.16
89079Ulm - Gögglingen
Tel:07305 23208
FAX 07305 23306

et aussi :

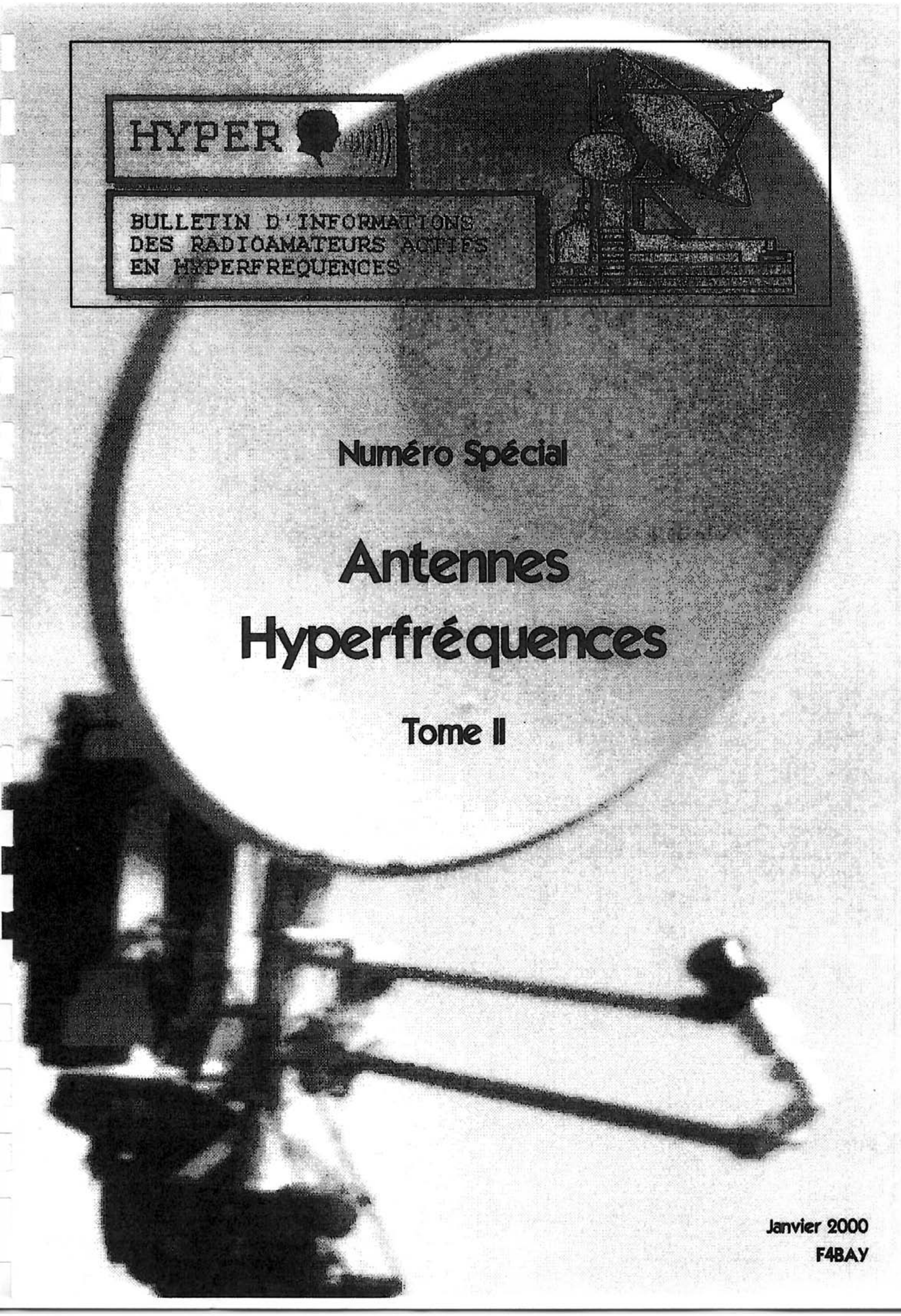
ELECTROPUCES
8 Route de Clisson
44200 NANTES
Tel: 02-40-75-48-44

Parfois des cornets 10GHz pro (ORITEL, THOMSON ...) ou des transitions guide / coaxial

NOTES PERSONELLES :

HYPER

BULLETIN D'INFORMATIONS
DES RADIOAMATEURS ACTIFS
EN HYPERFREQUENCES



Numéro Spécial

Antennes Hyperfréquences

Tome II

Janvier 2000

F4BAY

Je tiens à remercier **F1GHB** qui m'a fait parvenir la plupart des articles, ainsi que : **F1GAA**, **F1BJD**, **F5AYE**, et **Evelyne** pour son aide précieuse.

HYPER SPÉCIAL ANTENNES TOME II

Présentation

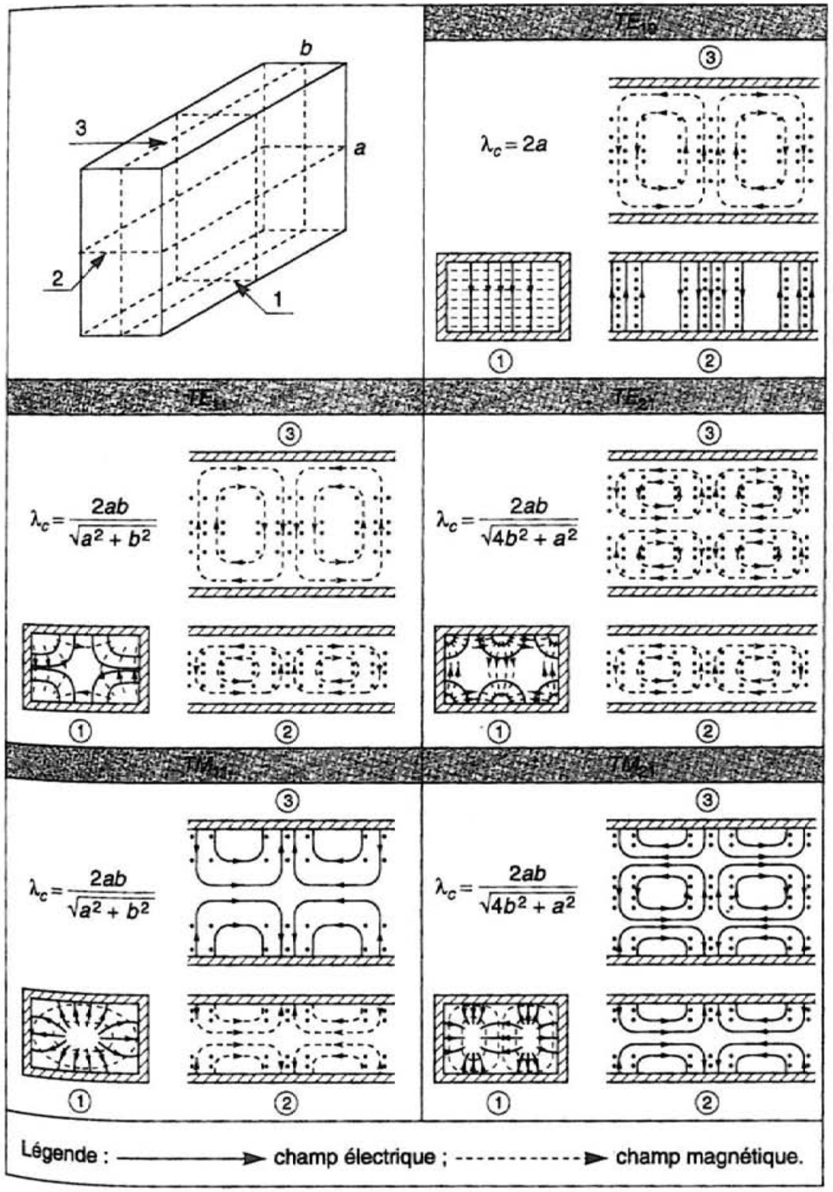
Voici la suite du numéro spécial Antennes Hyperfréquences paru en 1996. Ce tome II est une compilation de 60 nouveaux articles sur les antennes hyperfréquences de 5,7 à 47 GHz classés par catégorie et par bande.
La provenance de chaque article est indiquée au début de celui-ci. Tous les droits d'auteurs ou de reproduction réservés lors de la parution de ces articles sont, bien sûr, conservés. Notre rôle n'est que de les diffuser plus largement et de manière plus ciblée, réunis dans un même document.

Sommaire

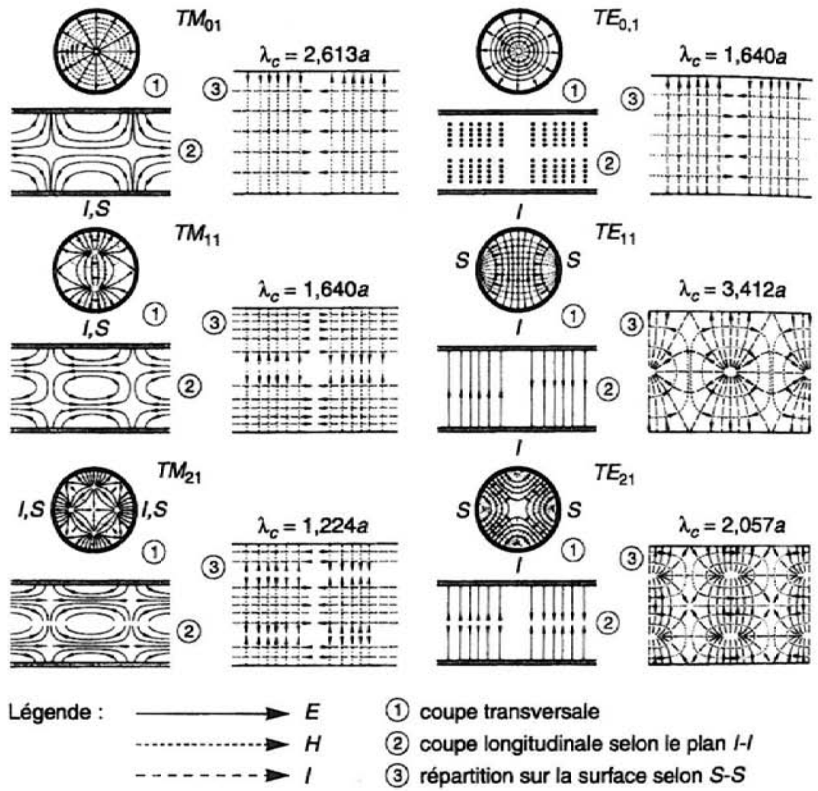
CHAPITRE 1 : LIGNES DE TRANSMISSION

1.1 Guides d'Ondes

Modes du guide rectangulaire



Modes du guide circulaire



Le mode qui apparaît le premier est celui dont la longueur d'onde de coupure est la plus grande ; c'est donc TE_{11} ($\lambda_c = 3{,}41a$) qui est le mode fondamental des guides d'ondes circulaires. Apparaissent ensuite, successivement, lorsque la fréquence augmente :

TM_{01} ($\lambda_c = 2{,}61a$)

TE_{21} ($\lambda_c = 2{,}05a$)

TE_{01} et TM_{11} ($\lambda_c = 1{,}64a$)...

Les guides d'onde rectangulaires

par F4BAY

Fréquence (GHz)	λ (cm)	f_{TE10} (GHz)	λ_{TE10} (cm)	Dimensions (mm)	Ep. (mm)	Tol. (±mm)	EIA (US)	RCSC (UK)	IEC (Int)	P_{max} CW (MW)	Att. (Alu.) (dB/100 ft)	Att. (Laiton) (dB/100 ft)	Att. (Argent) (dB/100 ft)
0.32-0.49	93.68-61.18	0.256	116.84	584.2x279.4	4.775	0.508	WR2300	WG00	R3	246-348	0.040-0.027	-	-
0.35-0.53	85.65-56.56	0.281	106.68	533.4x266.7	4.775	0.508	WR2100	WG0	R4	205-290	0.046-0.031	-	-
0.41-0.625	73.11-47.96	0.328	91.44	457.2x228.6	3.175	0.508	WR1800	WG1	R5	150-213	0.058-0.039	-	-
0.49-0.75	61.18-39.37	0.393	76.20	381.0x190.5	3.175	0.381	WR1500	WG2	R6	104-148	0.076-0.051	-	-
0.64-0.96	46.84-31.23	0.513	58.42	292.1x146.1	3.175	0.381	WR1150	WG3	R8	61.5-87.1	0.113-0.076	-	-
0.75-1.12	39.95-26.76	0.605	49.53	247.7x123.8	3.175	0.254	WR975	WG4	R9	44.2-62.6	0.145-0.098	-	-
0.96-1.45	31.23-20.67	0.766	39.12	195.6x97.8	3.175	0.254	WR770	WG5	R12	27.6-39.1	0.206-0.140	-	-
1.12-1.70	26.76-17.63	0.908	33.02	165.1x82.6	2.032	0.254	WR650	WG6	R14	19.6-27.8	0.266-0.180	0.317-0.214	-
1.45-2.20	20.67-13.62	1.157	25.91	129.5x64.8	2.032	0.254	WR510	WG7	R18	12.1-17.1	0.382-0.259	0.456-0.309	-
1.70-2.60	17.63-11.53	1.372	21.84	109.2x54.6	2.032	0.203	WR430	WG8	R22	8.6-12.2	0.494-0.334	0.588-0.399	-
2.20-3.30	13.63-9.08	1.736	17.27	86.4x43.2	2.032	0.127	WR340	WG9A	R26	5.4-7.6	0.702-0.475	0.837-0.567	-
2.60-3.95	11.53-7.59	2.078	14.43	72.1x34.0	2.032	0.127	WR284	WG10	R32	3.5-5.0	0.953-0.652	1.136-0.777	-
3.30-4.90	9.08-6.12	2.577	11.63	58.2x29.1	1.626	0.127	WR229	WG11A	R40	2.44-3.46	1.270-0.860	1.514-1.026	-
3.95-5.85	7.59-5.12	3.152	9.510	47.5x22.1	1.626	0.127	WR187	WG12	R48	1.52-2.15	1.795-1.231	2.140-1.467	-
4.90-7.05	6.12-4.25	3.711	8.078	40.4x20.2	1.626	0.102	WR159	WG13	R58	1.17-1.66	2.195-1.487	2.617-1.773	-
5.85-8.20	5.12-3.66	4.301	6.970	34.8x15.8	1.626	0.102	WR137	WG14	R70	0.79-1.12	2.910-2.004	3.470-2.390	-
7.05-10.0	4.25-2.99	5.259	5.700	28.5x12.6	1.626	0.102	WR112	WG15	R84	0.52-0.73	3.993-2.761	4.761-3.292	-
8.20-12.4	**3.66-2.42**	**6.557**	**4.572**	**22.9x10.2**	**1.270**	**0.076**	**WR90**	**WG16**	**R100**	**0.33-0.47**	**5.547-3.833**	**6.614-4.570**	**-**
10.00-15.00	2.99-2.00	7.868	3.810	19.05x9.53	1.270	0.076	WR75	WG17	R120	0.26-0.34	6.775-4.590	8.078-5.472	-
12.40-18.00	2.42-1.66	9.486	3.160	15.80x7.90	1.016	0.076	WR62	WG18	R140	0.18-0.25	8.971-6.077	10.70-7.246	6.762-4.581
15.00-22.00	2.00-1.36	11.574	2.590	12.95x6.48	1.016	0.076	WR51	WG19	R180	0.12-0.17	12.08-8.185	14.41-9.759	-
18.00-26.50	**1.66-1.13**	**14.047**	**2.134**	**10.67x4.32**	**1.016**	**0.076**	**WR42**	**WG20**	**R220**	**0.066-0.094**	**18.49-12.97**	**22.04-15.46**	**13.94-9.778**
22.00-33.00	1.36-0.91	17.328	1.730	8.64x4.32	1.016	0.076	WR34	WG21	R260	0.053-0.076	22.20-15.04	26.47-17.93	-
26.50-40.00	1.13-0.75	21.081	1.422	7.11x3.56	1.016	0.051	WR28	WG22	R320	0.036-0.051	29.70-20.12	35.41-23.99	22.39-15.17
33.00-50.00	0.91-0.60	26.342	1.138	5.69x2.84	1.016	0.051	WR22	WG23	R400	0.023-0.033	41.51-28.12	49.49-33.53	31.29-21.20
40.00-60.00	**0.75-0.50**	**31.357**	**0.956**	**4.78x2.39**	**1.016**	**0.051**	**WR19**	**WG24**	**R500**	**0.016-0.023**	**-**	**64.37-43.60**	**40.70-27.57**
50.00-75.00	0.60-0.40	39.863	0.752	3.76x1.88	1.016	0.051	WR15	WG25	R620	0.010-0.014	-	92.15-62.42	58.27-39.47
60.00-90.00	**0.50-0.33**	**48.350**	**0.620**	**3.10x1.55**	**1.016**	**0.051**	**WR12**	**WG26**	**R740**	**6.9-9.8 kW**	**-**	**123.1-83.41**	**77.85-52.74**
75.00-110.00	0.40-0.27	59.010	0.508	2.54x1.27	1.016	0.051	WR10	WG27	R900	4.6-6.6 kW	-	165.9-112.4	104.9-71.07
90.00-140.00	0.333-0.214	73.840	0.406	2.03x1.02	0.508	0.025	WR8	WG28	R1200	3.0-4.2 kW	-	-	146.6-99.32
110.00-170.00	0.272-0.176	90.840	0.330	1.65x0.83	0.508	0.025	WR7	WG29	R1400	1.9-2.8 kW	-	-	200.2-135.6
140.00-220.00	0.214-0.136	115.750	0.259	1.30x0.65	0.508	0.025	WR5	WG30	R1800	1.2-1.7 kW	-	-	288.0-195.1
170.00-260.00	0.176-0.115	137.520	0.218	1.09x0.55	0.508	0.025	WR4	WG31	R2200	0.86-1.22 kW	-	-	372.0-252.0
220.00-325.00	0.136-0.092	173.280	0.173	0.86x0.43	-	0.025	WR3	WG32	R2600	0.54-0.76 kW	-	-	529.2-358.5

Using WR-62 Waveguide on 10 GHz

By Kent Britain, WA5VJB
(From *Proceedings of Microwave Update '91*)

WR-62 is perhaps the most readily available surplus waveguide. Designed for 12 to 18 GHz, it is almost never seen on 10 GHz. With care, it can be used in the upper portion of our 3-cm band. Figs 1 and 2 compare WR-62 and WR-90 waveguide.

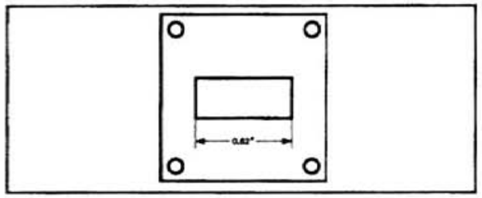


Fig 1—WR-62 waveguide dimensions.

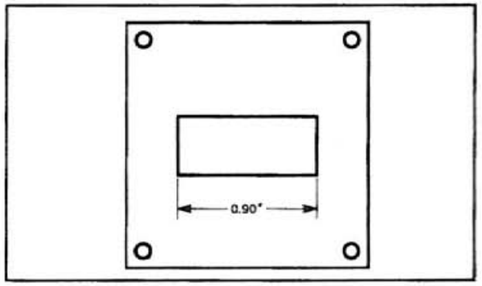


Fig 2—WR-90 waveguide dimensions.

The textbook says WR-62 has an ultimate cut-off at 9.5 GHz. I took a large pile of WR-62 and started bolting it together. I ended up with 8 ft. of waveguide containing 18 flanges and 21 bends. The graph in Fig 3 shows how much loss I had through 39 bends and flanges.

As the textbooks say, WR-62 really doesn't work at 10 GHz, but it works just fine at 10.368 GHz! On average, this means a foot of WR-62 with a few bends and flanges has only 0.2-dB loss. The only problem seems to be the WR-62 to-coax transitions. These are usually centered in the middle of the 12-18 GHz band. Several had about 0.5-dB loss, due to mismatch at 10.368 GHz. A three-screw tuner easily matched a transition.

WR-62 really works: I heard my first 10-GHz signals off the moon through a WR-62 Waveguide Switch.

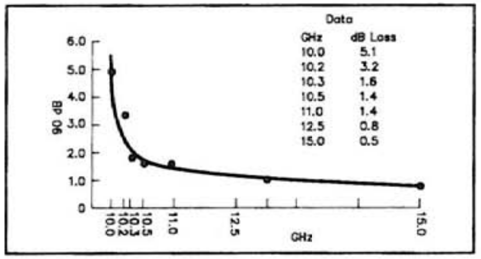


Fig 3—Plot of insertion loss for an 8-foot length of WR-62 waveguide sections having 18 flanges and 21 bends!

A Simple Rectangular/Circular Waveguide Transition for 10 GHz

By Sam Popkin, K2DNR, and Kent Britain, WA5VJB
(From *Proceedings of Microwave Update '89*)

Introduction

Sam noticed that if you squeeze ¾-in. copper water pipe into a rectangular shape it's the same size as a WR-90 waveguide. Sam built several samples and sent them to Kent for loss measurements and other tests. The results were very encouraging!

Theory

What Sam has come up with is a TE-10 to TE-11 or a rectangular or circular waveguide transition. Even constructed with simple tools, the test section only had about 2% loss due to reflections and mismatches. The inch or so of bent pipe between the rectangular flange and the circular pipe forms a tapered transition section with excellent matching.

Construction

Just start out by squeezing the end of the ¾-in. copper pipe in a bench vise down to a 0.4-in. opening. Then rotate the pipe 90° and squeeze the other side to a 0.9-in. opening. Back and forth, back and forth, until you form a 0.4- × 0.9-in. rectangular opening. A pair of large pliers or Visegrips can be very useful in forming the corners. Sam prefers to make his own WR-90 flanges out of sheet copper, while Kent likes to reuse old flanges from various pieces of junk. These flanges are then soldered onto the formed end of the copper water pipe. A few quick strokes with a file on the insides and you have WR-90 flanges on a circular waveguide. When you mount the second flange on the other end, be very careful to align the flanges with each other. There should be zero rotation misalignment.

Use

Circular waveguide has less loss than rectangular waveguide. Copper is an excellent conductor, so loss should be about 2 or 3 dB per 100 feet for your home-built circular waveguide.

There is one big limitation of using circular waveguide: Any protrusion, bend, or discontinuity will cause the wave to rotate. There just isn't anything to keep the E and H field aligned with the walls. Running the signals around a 45° plumbing bend rotated the polarization 20-30°. A 90° bend rotated the polarization about 90°, and with both samples the amount of polarization twist varied with frequency.

Simply use your homebrew waveguide for straight runs then transition back to regular WR-90 for any twists or bends.

One 40-in. section of this homebrew waveguide is even in use in WB5LUA's 10-GHz EME station.

A Quick Reference Guide for Circular Waveguide

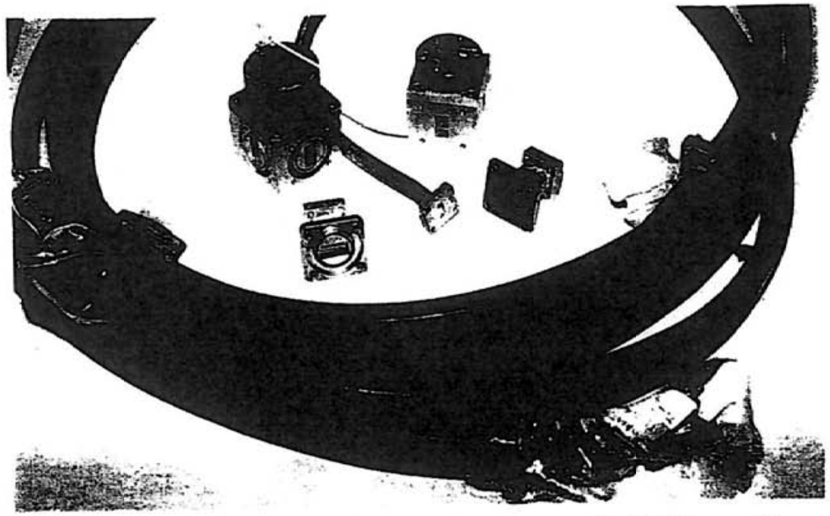
Ron Neyens, NØCIH

(From *Proceedings of the Central States VHF Society Conference '91*)

Amateur Band	*EIA Type Designation*	*Inside Diameter in Inches (Centimeters)*	*Useful Upper and Lower Frequency Range in GHz*
902 MHz	WC 992	9.915 (25.184)	0.800 1.100
1296 MHz	WC 724	7.235 (18.377)	1.100 1.510
	WC 618	6.181 (15.700)	1.290 1.760
2304 MHz	WC 451	4.511 (11.458)	1.760 2.420
	WC 385	3.853 (9.7870)	2.070 2.830
3456 MHz	WC 281	2.812 (7.1420)	2.830 3.880
	WC 240	2.403 (6.1040)	3.310 4.540
5760 MHz	WC 175	1.750 (4.4450)	4.540 6.230
	WC 150	1.500 (3.8100)	5.300 7.270
10 GHz	WC 94	0.938 (2.3830)	8.490 11.600
	WC 80	0.797 (2.0240)	9.970 13.700
24 GHz	WC 44	0.438 (1.1130)	18.200 24.900
	WC 38	0.375 (0.9530)	21.200 29.100
	WC 33	0.328 (0.8330)	24.300 33.200
48 GHz	WC 22	0.219 (0.5560)	36.400 49.800
	WC 19	0.188 (0.4780)	42.400 58.100
	WC 17	0.172 (0.4370)	46.300 63.500

Using WR-62/WG18 on 24 GHz

WA5VJB Kent Britain Microwave Update 98



One of the biggest obstacles to building 24 GHz stations is scrounging up the WR-42 waveguide. WR-62 is designed for 12-18 GHz. It doesn't quite hit either 10 GHz or 24 GHz (*That's what they Think!!*) so tends to be pretty plentiful and cheap at the fleamarkets

WR-42 is spec'ed for 18 to 26 GHz with about 15 dB of loss per 100 ft at 24 GHz,and that's a bunch of loss for portable or home stations. Many stations on the air these days are using oversized waveguide. Such as WR-112 or even WR-187 on 10 GHz with good results. This lead me to play around a bit with WR-62 on 24 GHz. Using 20 ft of flexible WR-62, I was able to wrap the Waveguide in to 3 one ft diameter loops before the waveguide broke up into moding. Keep it pretty much straight and WR-62 works great.

A few of the test setups had a lot of loss. In each case a tuning screw near the WR-62/42 transition or near the active device in the WR-42, flatten out the SWR and loss dropped to virtually nothing.

Enough small talk, the bottom line:

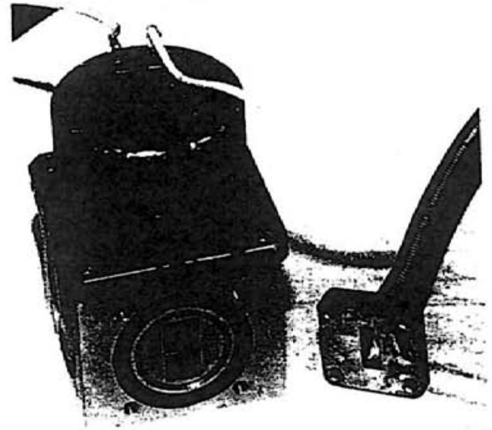
WR-62 Loss at 24 GHz 10 dB/100ft
8 dB/100 ft if you do some matching

Loss in a WR-42/WR-62 transition = .2 dB
(That's just putting them together)

WR-62 Waveguide Relays ≈ .2 dB Loss

This stuff works great, see ya on 24 GHz.

WA5VJB



WAVEGUIDE TRANSITIONS

Microwave Handbook
RSGB

Water pipe is available in a range of standard sizes as shown in Table 18.2, the first few smaller sizes being most readily available at d.i.y. supermarkets, the larger sizes from builders' merchants.

It can be seen that 22mm pipe is usable at 10GHz, 35mm pipe at 5.7GHz, and possibly 54mm pipe at 3.4GHz, though the latter would be operating rather close to cutoff. Since this chapter covers 10GHz, attention was concentrated on assessing the suitability of 22mm pipe, which costs about 50p per foot compared with at least ten times this for new WG16. Before any attenuation measurements could be carried out, some transitions from normal

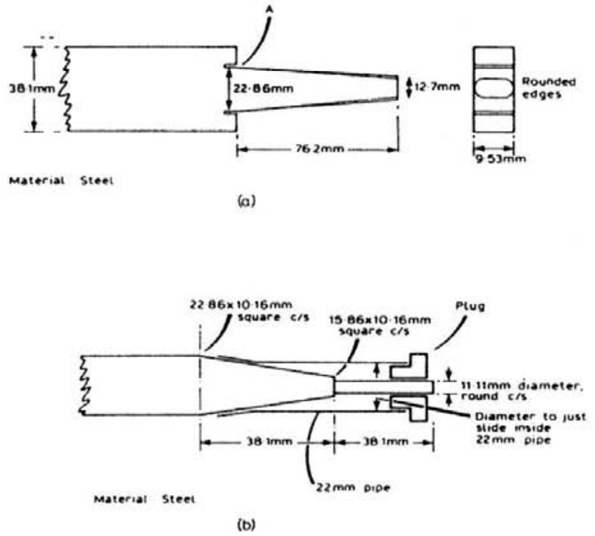


Fig 18.6. Two types of tool for making rectangular to circular waveguide transitions (G8AGN). Tool (b) has a tight fitting plug which prevents the round end of the transition distorting whilst forming the transition

rectangular waveguide had to be built. This was achieved by using short pieces of pipe, approximately 3in (75mm) long and deforming one end of each pipe into an approximately rectangular shape. Initial attempts to do this simply by squeezing the pipe in a vice were not very successful; better results were obtained by gently hammering a tapered plug, as shown in Fig 18.6a, into the pipe and then gently squeezing the rectangular/elliptical cross section of the pipe right up to the plug at point A. The resulting cross-section is then roughly the same as standard WG16. Although the plug tool shown in Fig 18.6a is adequate if used with care, a second design was conceived which has specific provision to ensure that during the deformation of one end of the pipe from a circular to a rectangular cross-section, the other end of the pipe is kept circular by means of a separate plug which is a tight fit into the pipe. The general arrangement is a shown in Fig 18.6b. This second plug tool has the minor disadvantage of being able only to be used on short lengths of pipe; it does, however, enable a better (i.e. more smoothly varying) cross-section transition to be made.

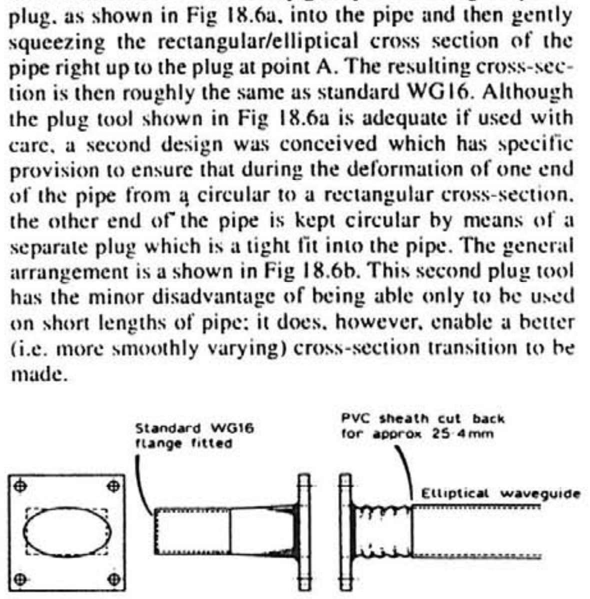


Fig 18.7. Elliptical to rectangular waveguide transitions. These can be made in a similar manner to the rectangular to round transitions, but starting with annealed copper WG16

Table 18.2. Standard copper water pipes used as waveguide

OD (mm)	Wall Thickness (mm)	Cutoff Frequency (MHz)	Next mode Cut-off (MHz)
15	0.5	12557	16404
22	0.6	8452	11041
28	0.6	6560	8569
35	0.7	5232	6835
42	0.8	4351	5684
54	0.9	3368	4400

Normal square waveguide flanges were adapted to fit onto both circular and rectangular ends of the transitions. Standard self-soldering "Yorkshire" fittings can be used to join sections of permanently fixed pipe together, for instance in a home station feeder run. Such a run should, preferably, be kept as straight as possible. Bends are permissible provided that they can be made without the walls of the tube collapsing or becoming corrugated and that they take place over a number of wavelengths, although there is still a risk of mode change. It is stressed that transitions should be made in copper, since this is malleable and ductile, allowing the metal to be "stretched" without fracture, provided the operation is carefully carried out.

The measured insertion loss of a pair of such transitions connected back-to-back was 0.8dB at 10.368GHz.

Sections of flexible or flexible and twistable waveguide are occasionally available from surplus sources and could be used to correct guide misalignments in an otherwise rigid system. However, such waveguide can introduce significantly higher losses into the system together with mismatches which may need to be subsequently tuned out. Such waveguide was illustrated in chapter 6, Fig 6.41 and 6.42.

The reader may also occasionally come across elliptical corrugated semi-flexible waveguide such as that illustrated in chapter 6, Fig 6.43. Due to its cost and difficulty of supply, it is seldom used in amateur installations. Suitable flanges are available but are rarely obtainable at amateur prices from surplus sources. They can, with a little patience, be fabricated from thick brass plate or even from standard square, plain flanges. Terminating such waveguide with these flanges is difficult, but not impossible, for the amateur to do. Again, suitable rectangular to elliptical transitions are not too difficult to make using similar techniques to those described above for rectangular to circular transitions. The starting material should be annealed copper WG16. Such transitions are shown in Fig 18.7. Measured losses are similar to the rectangular to circular transitions.

Another type of waveguide, these days rarely seen, is the so-called "Old English" (OE) guide. This has *internal* dimensions which are the same as the *external* dimensions of WG16, viz. 1in by 0.5in. Thus the OE waveguide is a neat sliding fit over WG16. This can be useful in a number of ways: as a support to join a horn antenna to WG16, as a crude but effective "plug and socket" to join pieces of WG16 together or as a rudimentary form of waveguide switch. A method of joining OE and WG16 together, whilst avoiding significant mismatch, is given in Fig.18.8. Standard flanges to fit OE waveguide do exist but are likely to be even rarer than the waveguide itself.

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WAVEGUIDES FOR MILLIMETER WAVES

By John Anderson WD4MUO/0

DATA

Attached are mechanical data and drawings for waveguides and flanges used at frequencies between 18.0 and 325.0-GHz [1]. I find this information valuable in building adapters and transitions to connect the odd pieces of guide and devices one collects and must integrate into a system.

ADAPTERS

Much of the mm-waveguide available from surplus sources has round flanges. This was the industry standard in the early days and probably still is at the higher frequencies. Newer equipment tends to use square flanges, particularly at frequencies below 40-GHz. To some extent this has dropped the value of round flange items on the commercial surplus market to where Hams can afford pretty good equipment. However, this presents a significant problem when we are faced with a variety of flange configurations and hole patterns on the individual equipment items that we want to integrate into a system.

The guide pin holes in round flanges are tantalizingly close to the holes in square flanges. This has lead some Hams to simply bore out the guide holes and mate the flanges using through bolts and nuts. It works, but is not recommended as the two sets of holes have a small, but significant offset (see flange diagrams) and it is very difficult if not impossible to drill a hole in the correct position in the flange with the existing hole off-center. Thus some filing and elliptical or oversized holes are necessary, misalignment of the joined waveguides normally results. The situation is more serious when mating choke and O-ring sealed flanges, very little lines up and there will probably be a gap somewhere. The correct solution is to use a flange adapter. Unfortunately these are very rare at hamfests and cost a fortune new (>$100) or surplus (I have found some used adapters that are more expensive than new ones!)

So I build my own. I buy cheap pieces of copper, brass or bronze waveguide or equipment with assemblies of waveguide just to get the flanges and salvage short scraps of waveguide. The more dings, holes, crimps, mud, etc. the better - gives me room to negotiate the price. When I need an adapter I usually select a round flange with about 0.5 to 1.0 inch of good waveguide attached. I square up the open end and silver solder a salvaged square flange to it. If I do not have a commercial square flange at hand I make one from a piece of brass plate 0.125 to 0.25 inch thick. Forget the fancy grooves and milled sockets for the waveguide, just cut a flat flange with a jewelers' saw to fit over the waveguide, solder it and then lap/file the mating surface flat. The flange holes can be threaded or drilled as clearance holes as required (you may want both types of holes on the same flange to mate to a particular device). Give some thought to the length of the waveguide between the flanges. If the bolts will be screwed into the adapter then the flanges can be quite close together. But if the bolts must go through the adapter flange and then into "blind" holes [2] in the mating device, you must have a long enough piece of waveguide to insert the bolt and the wrench/screw driver to tighten the assembly. One inch between flanges is about right for allen wrenches.

If a very short adapter is necessary you can build a block type by soldering two flanges back to back or fabricate it from 0.25 inch plate. I usually saw a square with sides as long as the diameter of the round flange, saw and file the center hole to the interior dimensions of the waveguide, and then bore and thread the necessary holes from each side of the plate. When necessary it may be possible to countersink or counterbore some holes so all bolts come from the same direction; be careful of mating choke and O-ring groves. Since the true block adapter does not need to be soldered, aluminum is a good choice for the plate.

TRANSITIONS

Now that everyone(!) wants to get on a mm-wave band (24-GHz), WR-42 waveguide and devices have become very expensive - a relay costs the national debt. Several of us [3] have experimented with using the next lower or higher size of available waveguide. WR-62 appears to work at 24-GHz without over-moding (test it, there maybe a mode close to our frequency) and WR-28 certainly works with its cut-off frequency at 21.07-GHz; loss is a little higher than WR-42. WR-28 might work at 47-GHz, I have not tested it. I have been given or paid pennies for several power meter heads (the old, uncompensated type) that appear to be WR-50. These may be a pain to use (now - they were state-of-the-art in 1960!), but a surplus WR-42 head costs about $400. A length of WR-35(?) flex guide was also free, several WR-62 relays were $5 to $20 each. The problem here is getting a transition from one waveguide series to another [4]. Guess what: these are rarer than flange adapters and cost more - try $400. A transition is only a little harder to make than a flange adapter. Take a length of the larger size waveguide, saw four, thin triangles in the broad walls, squeeze a taper (ideally three guide wavelengths long) and put the necessary flanges on each end, then silver solder [Fig. 1]. Takes about an hour to build one and costs a buck or two (depending on how well you negotiate for scrap waveguide). Devices like the power heads may not be flat across the band, but they will be usable. The transitions are virtually lossless and have very low VSWR.

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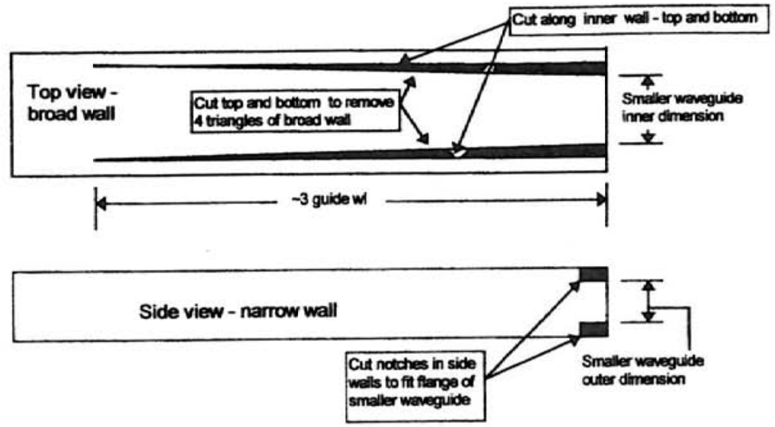
1. I thank Al Hislop of Pacific Millimeter Products for providing the Aerowave inc. catalogue and Ted Kozul of Aerowave for authorizing reproduction of the data pages.

2. Many mm-wave devices have flanges so close to the chassis that it is impossible to get a bolt into the back side of the flange.

3. WA7CJO, AA0BR and WD4MUO.

4. WA5VJB drills matching holes in the flanges and simply bolts the different size waveguides together. It works, but I find transitions somewhat more pleasing, aesthetically if not electrically.



Following preparation of the waveguide as shown above, spring the sides to the proper dimensions for the flange of the smaller series and place the appropriate flanges on each end. Bind the taper with iron wire at several locations to minimize the gap and tie down the flanges so they do not shift when the assembly is heated. Silver solder the flanges and slits with caution, use minimal amounts of solder as excess solder builds up along the inner portion of a slit and is difficult to file out. It is probably easier to close a hole or gap by re-soldering a small portion of the joint than to file out excess solder.

Figure 1

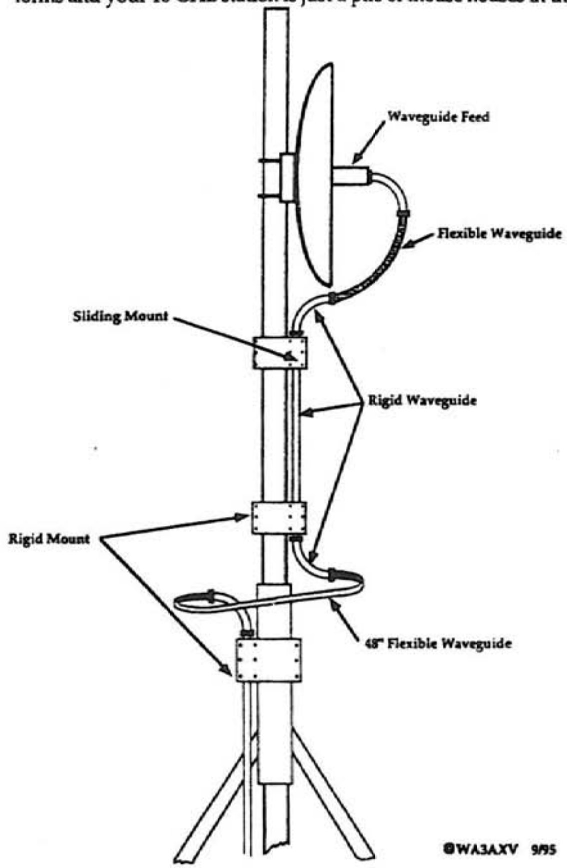
This Means "WAR"!

Waveguide Around The Rotor

WA3AXV
Ronald J. Whitsel

Extrait de FEEDPOINT de Fev/Mar 99

Antenna installations present many challenges to the microwave enthusiast, not the least of which is the feedline. The popular solution to this problem is to operate with a portable station requiring only a very short connection from the radio to the antenna. Feedline losses are kept low and aiming the antenna is accomplished by the old 'Eyeball and Armstrong' method. This method works fine for portable operation, but is quite untenable for the home station. And besides when a good Tropo duct forms and your 10 GHz station is just a pile of mouse houses in the garage, what good is it?



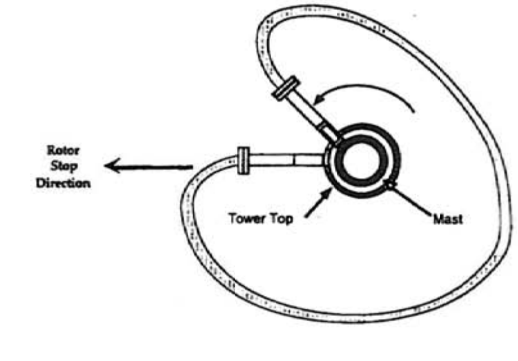
A solution for the home station is to use waveguide for the feedline. One of the first problems that you encounter is the loop around the rotor. One method might be to use waveguide to coax transitions and a piece of coaxial cable for the trip around the rotor. But coaxial cable at 10 GHz is a dummy load! It would work in some limited fashion, but if you are going to the expense and time to install waveguide then you might as well go the extra mile and use waveguide all the way. But how do we do that you might ask? Fear not there is a way.

Flexible waveguide is a viable method of bridging the rotor. Once that problem is solved the rest of the installation is relatively easy. The method described here has been in use at my 10 GHz home station for over a year now with no degradation in performance. Total feedline loss from the shack to the dish is very close to 3.0 dB. Not great if it were 432 Mhz, but certainly not too shabby for a home station on 10 GHz. The total run is about 50 feet to the top of the tower and another 15 feet to the dish. I use elliptic guide to the top of the tower and then the setup shown in the drawing to the left. I don't think anyone needs to be sold on the merits of using waveguide at microwave frequencies whenever possible.

The flexible guide I used is coated with what looks to be a neoprene rubber. The rubber coating is probably the weak link in the installation. Ultraviolet radiation will most likely destroy the rubber in time. Perhaps a flexible paint coating or regular application of silicone would delay the process. The rubber is not essential to the operation of the guide, but does lend some structural stability to the corrugated metal that forms the actual waveguide. After a year there has been no problem.

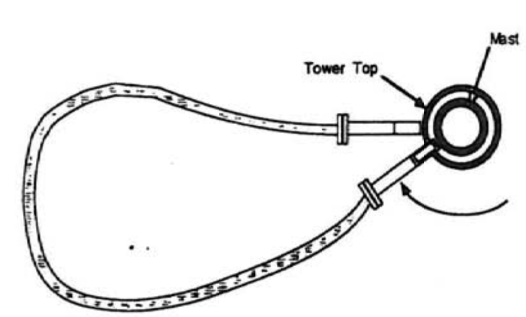
The trick to making this system work is to install the flexible guide so that it coils and uncoils in a plane parallel to the ground. The traditional "rotor loop" installation will not work because the guide has very little "flex" in the plane parallel to its wide side. The only real flexibility is in the plane parallel to the narrow side of the guide. Thus if the guide is installed with its narrow side parallel to the ground, the guide will coil and uncoil to provide a full 360 degrees of rotation.

The diagram at right shows what happens when the mast is rotated in the counter clockwise direction toward the rotor stop. (Note: It is essential that the non-rotating waveguide be positioned exactly at the rotor stop position.) The guide will form a relatively tight coil around the mast when fully rotated. The 90 degree piece of waveguide must be installed such that it clears the 90 degree waveguide that is mounted on the mast. Don't use more vertical clearance then is absolutely necessary because the guide doesn't like to bend up and down.



Top View - Rotating Counter Clockwise

During clockwise rotation the guide will uncoil and form a long thin loop as shown below.

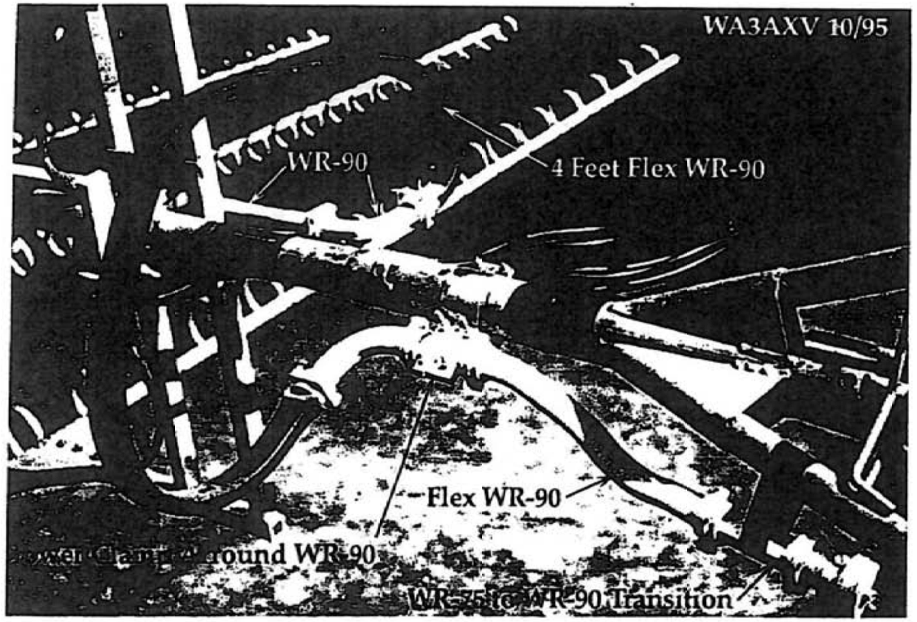


Top View - Rotating Clockwise

The guide in this position is relatively vulnerable to wind and large birds so don't leave it 'parked' in this position. The safer parked position is with the guide wrapped around the mast to some degree.

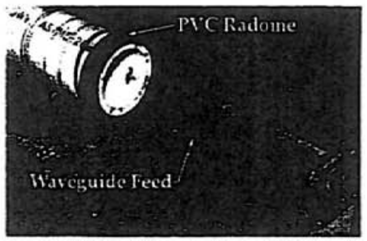
Another area of concern is the rigid guide up the mast to the antenna. Since the mast will bend in the wind some allowance must be made for this motion. In my installation I formed a bracket out of sheet aluminum for the bottom mount such that it firmly holds the bottom of the guide about one inch out from the mast. This must be a fairly substantial clamp since it must support the entire weight of the waveguide that is on the mast. See diagram below.

The top bracket is constructed in a similar manner except that spacers are added to prevent tightening the bracket on the waveguide side. Constructed in this manner the guide can "slip" inside the bracket when the mast bends. This method works not only when the wind is parallel to the wide side of the guide, but since the guide will bend in the opposite direction, it also works for that case as well. Also remember, the guide is copper and does some really serious expansion and contraction. This is another reason to provide for some movement. An alternative would be to use elliptic guide up the mast.



Now that you have this really low loss feedline proudly dangling from the tower top, you still have a few areas of concern. The first is condensation from the warm moist air inside the house being sucked up this really neat 'chimney' you just installed and thought it was just a feedline. The cold winter weather will condense the water vapor in the guide, from your nice warm house, and eventually form a pool of water inside. Water is not a real good dielectric. The solution is to pressurize the waveguide with dry air or nitrogen. Preparing the guide for pressurization also solves the second problem which is small critters taking up residence inside the guide. Some of these little monsters spin really nice cocoons that will ruin your operating day.

Pressure windows [1] should be installed at each end of the waveguide run. O-rings must be used between all flange joints (I found suitable O-rings at a home center).(Note: "Choke" flanges have o-ring grooves, "cover" flanges do not. Never use two choke flanges at the same joint.) Either a waveguide connector with a pressure fitting or a pressure inlet flange must be used to allow connection to a dry air or dry nitrogen system. **The very least you should do is install all the "pressure components" so that you have a sealed system.** The pressure windows will prevent the flow of air up the "chimney" and keep the critters out. If you live in a warm-all-the-time climate or have an unheated shack, then forget the water vapor thing. Practicing safe critter prevention, however, is always required.



I used a pyramidal waveguide feed [2] installed in a white plastic pipe (PVC) 'radome' to feed a 24 inch dish (PVC works at 10 GHz). The radome also keeps the weather and critters out of the feed. The flexible guide from the dish to the mast waveguide serves to further isolate the dish from mast movement.

Waveguide is the way to go. Most of the components are available at flea markets. With the heavy use of satellite and fiber optic links, surplus microwave link equipment should be more available then ever. Just do it!

1. Andrew Corp. Catalog #36, Page 166
2. "Parabolic Antennas and Their Feeds", Dick Comly, N3AOG, Pack Rat Notes, Sept. 1995, Page 5

Make Your Own Waveguide Transitions

By Kent Britain, WA5VJB

(From *Proceedings of Microwave Update '88*)

In putting together several 10-GHz stations out of surplus parts, the first thing you notice is the different sizes of moding, WR-112, WR-90, WR-75, and WR-62. These can be identified by measuring the width of the opening. WR-112 is 1.12 in., WR-90 is 0.9 in., WR-75 is 0.75 in. and, of course, WR-62 is 0.62 in. across. (All are 200-ohm impedance.)

Well, very quickly you'd like to hook a WR-90 thingamagig, to a WR-75 whatchamacallit. I had two commercial adapters and they had a simple milled step, changing the opening from one waveguide size to another. I contacted our local waveguide expert (K5SXK) and asked Harold what was going on. He explained that the impedance of a waveguide is the ratio of width to height, so if you go from one size to another it's like connecting RG-8 to RG-58.

So, I redrilled some flanges and started making some loss tests. At first I had trouble getting consistent results because of reflections. The isolator/circulators proved to be necessary to get consistent numbers when measuring tenths of a dB. The results are shown in Table 1. Note that these measurements are actually for *two* waveguide size transitions, one on either end.

In short, while I would not claim these numbers as the absolute loss values, they show that simply bolting the different sizes together introduces very little loss. Alignment was also noncritical. Misalignment had to reach a point where one of the openings was being partially blocked before loss rose above a few tenths. Get out your drills and start sticking this stuff together!

Table 1
Measured Loss for Various Waveguide Combinations

	Losses in dB			
Flange	*Sample* WR-62	WR-75	WR-90	WR-112
WR-62	<0.1	0.3	0.3	0.4
WR-75	0.3	<0.1	0.1	0.1
WR-90	0.3	0.1	<0.1	<0.1
WR-112	0.4	0.2	0.1	<0.1

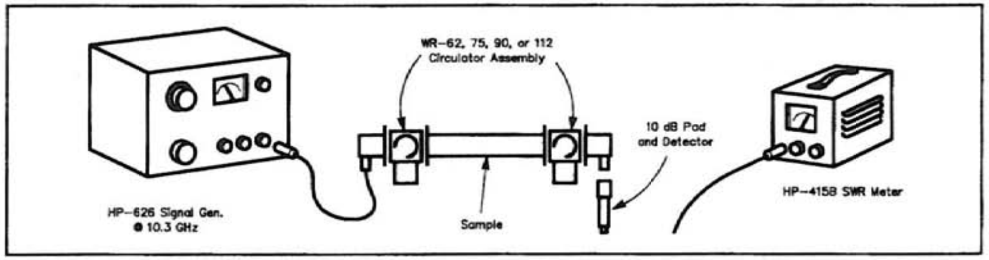


Fig 1—Test set-up for measuring insertion loss of waveguide transitions.

1.2 Transitions Guide-Coaxial

Microwave Handbook
RSGB

18.2.8 Coaxial to waveguide transitions

Coaxial "cables" are not much used at 10GHz, other than in very short lengths, because of the high losses involved compared to waveguide. "Heliax" can be useful, e.g. Andrews FHJ4–50 exhibiting a loss of about 4dB per 20ft and short lengths of conventional flexible cable terminated in N-type connectors may sometimes be found, particularly in older X-band equipment, but it is more likely that short 0.141in (3.58mm) semi-rigid coaxial leads terminated in SMA connectors will be found on more modern equipment. It is useful, therefore, to have coaxial to waveguide transitions available, when experimenting with pcb mounted circuits or some of the more recent professional equipment appearing on the surplus market. Two types are described.

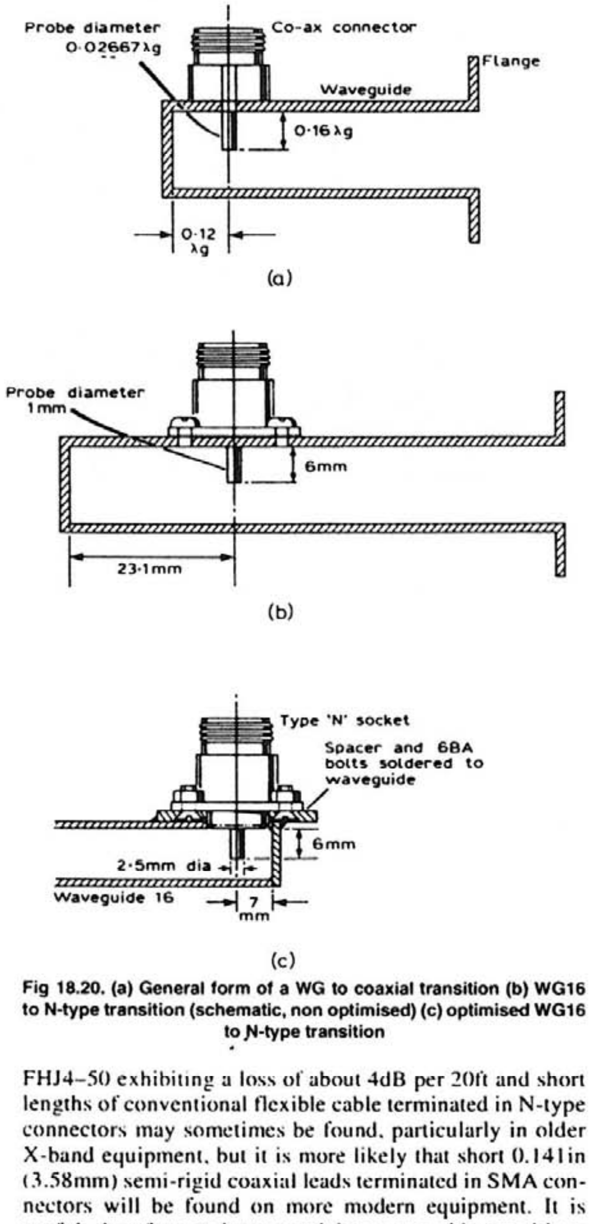


Fig 18.20. (a) General form of a WG to coaxial transition (b) WG16 to N-type transition (schematic, non optimised) (c) optimised WG16 to N-type transition

General design dimensions

The general form of a coaxial to waveguide transition is shown in Fig 18.20a, where D is the probe diameter, L is the probe length and S is the distance between the probe centreline and the waveguide short.

Work carried out by Mike Walters, G3JVL, at 10GHz gave the optimum dimensions for a transition from waveguide to 50Ω coaxial line as being:

$$D = 0.027\,\lambda_g$$
$$L = 0.160\,\lambda_g$$
$$S = 0.120\,\lambda_g \text{ (theoretically } \lambda_g/4)$$
or
$$S = 0.620\,\lambda_g \text{ (theoretically } 3\lambda_g/4)$$

These relationships can be scaled for other frequencies. For instance, the successful construction of such transitions for the 3.4GHz band in WG11 was reported by G4KNZ [6].

For 10.369GHz λ_g is 37.32mm and, from this, the following dimensions are derived:

$$D = 0.995\text{mm (1mm)}$$
$$L = 5.970\text{mm (6mm)}$$
$$S = 4.478\text{mm (5mm)}$$
or
$$S = 23.14\text{mm (23mm)}$$

It is quite in order to use the "rounded" figures given in brackets; no really noticeable change in performance results from this. An exact match can be obtained by fitting a single screw tuner between the probe and the waveguide short to alter the centre frequency and, if necessary, a three-screw tuner between the probe and the flange.

A coaxial (N type) to WG16 transition

N-type connectors are specified for use only up to about 10GHz and can be used successfully although there is a slight risk of over-moding in the connectors or the cable (typically a short length of FHJ4–50) used with them. The use of conventional cables is not advised because the losses involved are high and the flexible nature of the cable can lead to unpredictable impedance changes. However, some of the older surplus X-band equipment is fitted with these connectors.

A square flange N-type socket should be selected. The dimensions of the flange are 18 by 18mm with 13mm fixing centres for 3mm screws. The solder spill is usually 3mm in diameter and hollow. The dielectric insulation carrying the centre pin is normally held in place by a spun collar or rim of metal which protrudes below the flange and goes through a clearance hole in the panel on which the socket is mounted. This collar is normally deeper than the thickness of the waveguide wall (0.05in, 1.27mm) and would protrude into the waveguide if mounted with the flange flush on the waveguide surface. The diameter of the solder spill is also larger than the optimum diameter discussed above. Thus, the socket needs modification before it can be used easily. Occasionally, surplus sockets can be found which do not have this rim; they may also have an elongated, solid metal "spill". This type of socket is very easy to modify, as all that is required is that the spill is turned down to the required diameter and then cut to length.

First the "rim" around the insulation on the back of the socket is removed, by careful filing or sawing, to enable the socket to fit flush with the waveguide face. This may cause the dielectric bearing the pin to become loose in the socket, so care is needed. In the final assembly, the dielectric will be held in place by compression against the outer surface of the waveguide to which the socket is attached. The dielectric is cut back flush with the flange surface, using a sharp knife or scalpel.

Next the spill diameter is modified by cutting it almost flush with the dielectric and soldering a 1mm diameter probe of stiff copper wire of the required length in place of the original spill.

In order to accommodate the socket mounting flange on the waveguide without complicating construction, the probe spacing from the waveguide short has been increased by $\lambda_g/2$, from $0.12\lambda_g$ to $0.62\lambda_g$, i.e. to 23.1mm. This allows the use of a simple, soldered end plate as the waveguide short. The probe enters the waveguide through a hole a little smaller in diameter than the measured diameter of the dielectric, so that the insulation carrying the centre pin of the socket is firmly held in place between the socket body and the waveguide wall. The modified socket can be fixed to the waveguide by soldering or, better, by means of 3mm screws inserted into tapped holes in the waveguide wall. If this method of fixing is used, then the fixing screws should be trimmed in length so that they end up flush with the inner face of the guide wall. This has the advantage that the socket is easily removable for trimming the length of the probe during testing.

In general the use of a larger than optimum diameter probe will increase the effective bandwidth of the transition, which is of little consequence in amateur installations, but may lead to the need to experiment with the length of the probe for best match and signal transfer.

The two alternative forms of construction of an N-type transition are given in Fig 18.20b, optimised as described above, and 18.20c, not optimised, but of acceptable performance.

A coaxial (SMA) to WG16 transition

SMA connectors are specified for use up to 18GHz and are used with 0.141in (3.58mm) semi-rigid coaxial "cables". This series of connectors should be the first choice for this band and special versions are available, with a carefully dimensioned "spill", to act as a microstrip "launcher". However, for the purposes of a WG16 transition, the ordinary SMA socket should be used. This normally has a solder spill which is 1.3mm diameter and 6.5mm long.

There is no need to make the diameter of the spill smaller as this diameter will still provide a reasonable match. The dielectric does not protrude behind the mounting flange and needs no modification. The hole necessary to match the dielectric of the socket is 4mm diameter.

It is possible to mount the socket on the waveguide with a 4.25mm spacing from the end short, provided that it is soldered in place. If four fixing screws are used then this distance must be increased to about 5.5mm to accommodate the rear two screws. Although this is slightly greater than the optimum, it has been found to make little difference in practice. If screws are used they should be 1.5mm, cut so that they do not protrude into the waveguide. Dimensions and a photograph for 10.380GHz are given in Fig 18.21. None are unduly critical and slight mismatching can be corrected by adjustment of the three-screw tuner. A good match with wider bandwidth was still obtained with the probe diameter increased to 3mm by means of a soldered sleeve.

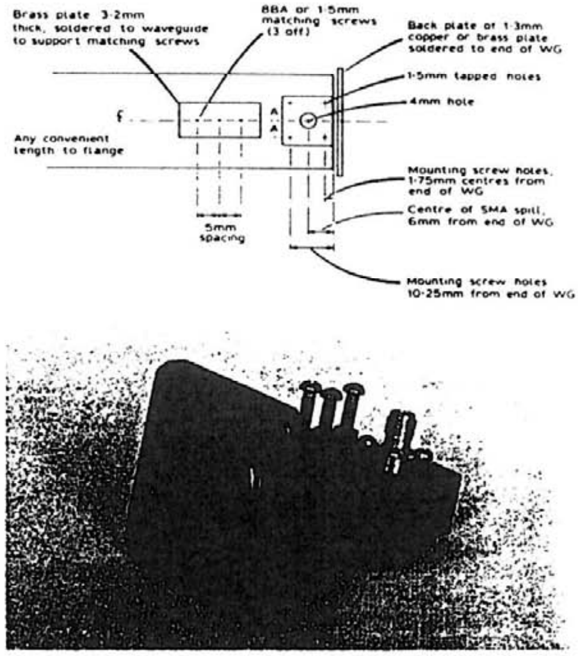


Fig 18.21. (a) Diagram of WG16 to SMA transition (b) WG16 to SMA transition (G3PFR). Photo: G6WWM

SMA to WG16 launch unit for 10GHz

Microwave Newsletter Mars 91

GW4JJW

An SMA to waveguide launch unit was built to permit GasFet based equipment to be connected into WG16. The unit described was built in approximately 2 hours.

A waveguide short circuit was made from a brass plate about 2mm thick, through which a hole of approximately 4mm diameter was drilled to take a short length of PTFE tube. The position of the hole is given in Figure 1 which shows the short circuit placed over the end of the waveguide. The PTFE tube was obtained from a surplus SMA socket which had an extended dielectric, such as the GE65132A. The purpose of the PTFE tube is to maintain the 50 Ohms impedance as the centre conductor of the SMA connector passes through the short circuit. The PTFE tube should be a tight fit through the hole. The SMA socket and PTFE tube were put to one side while the brass plate was soldered across one end of the waveguide using 600 C silver solder and the appropriate flux. Silver solder was used primarily to avoid the brass plate becoming unsoldered later when the assembly was heated up again for the remainder of the soldering operations, for which lead solder was used. During soldering, the short circuit was held in place with a 5 inch nail held in a chemical retort stand. The stand held the nail vertical and the point protruded part way through the hole in the short circuit. The job was then allowed to cool and was cleaned up.

A length of 2mm brass tubing was obtained in a local DIY store. A length of approximately 13mm was cut and one end filed square and the other end to a 45 degree angle. This was done by rubbing the tube on the face of the file. This process was repeated for a 10mm length. A hole was drilled in the appropriate broad face of the waveguide, 12.0mm from the short circuit, and 11.5mm from the inner surface of the appropriate narrow face - see Figures 2A and 2B. (The WG16 wall is about 1.27mm thick.) The diameter of the hole was such that the brass tube was a tight fit in it. (This is important for ease of building!). The 45 degree end of the 10mm length of tube was then forced through this hole. The PTFE tube was slid over the centre conductor of the SMA connector followed by the square end of the 13mm length of brass tubing. The brass tube was then adjusted for best fit where the two 45 degree ends meet. The exact length of the 13mm length may need slight adjustment.

The connector was then removed from the assembly leaving the PTFE tube in place over part of the centre conductor. The centre conductor was tinned with lead solder and the tube was soldered to it taking care to get the correct orientation of the 45 degree edge. The SMA socket was then pushed into the short circuit and soldered directly to it. The joint between the 2mm tube and the broad face of the WG16 was then lead soldered and the surplus tube cut off. Finally the inside joint of the two 45 degree edges of the 2mm tube were soldered together using the minimum amount of solder consistent with a good joint.

Finally a WG16 flange was heated up on a hot-plate and when it was hot enough to melt solder easily the open end of the WG16 was pushed into it and solder rapidly applied. Once complete the unit was cooled slowly with damp tissue paper to prevent other solder joints from melting. The flange chosen was of the type where the waveguide does not go completely through the flange.

Components

2-hole SMA connector
About 30mm WG16
Brass plate 1"x0.5"x about 2mm thick
30mm of 2mm diameter brass tube (Payless DIY)

Ref: Deshpande, Manohar D, Das, BN, and Sanyal, Gitindra S. Analysis of an End Launcher for X-Band Rectangular Waveguide. IEEE Transactions on Microwave Theory and Techniques MTT27 (8),pp 731-735, August 1979.

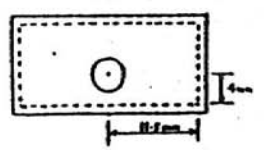


FIG 1

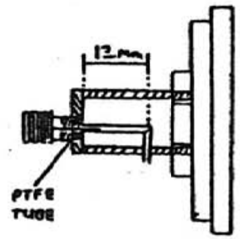


FIG 2A

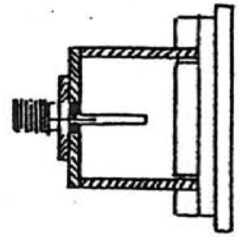


FIG 2B

A COMPACT WAVE GUIDE / SMA TRANSITION

(extrait de Microwave Newsletter)

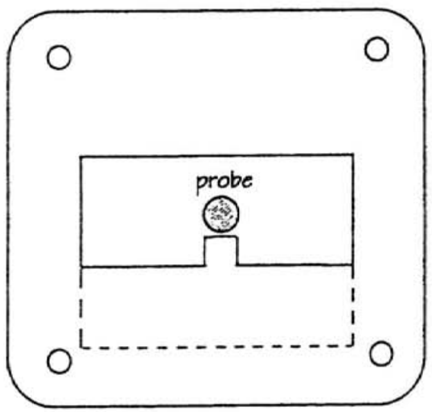


Figure 1

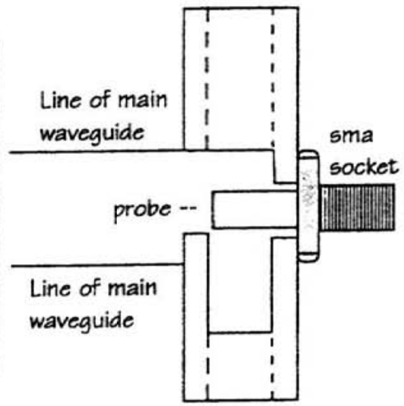


Figure 2

An interesting approach to coax/waveguide transitions appeared in Microwave Engineering, March/April 1998. BSC Filters, of York, UK, has produced the end-launch transition shown above. It is of comparable overall thickness to a standard waveguide flange and looks ideal for assemblies where space is a major consideration.

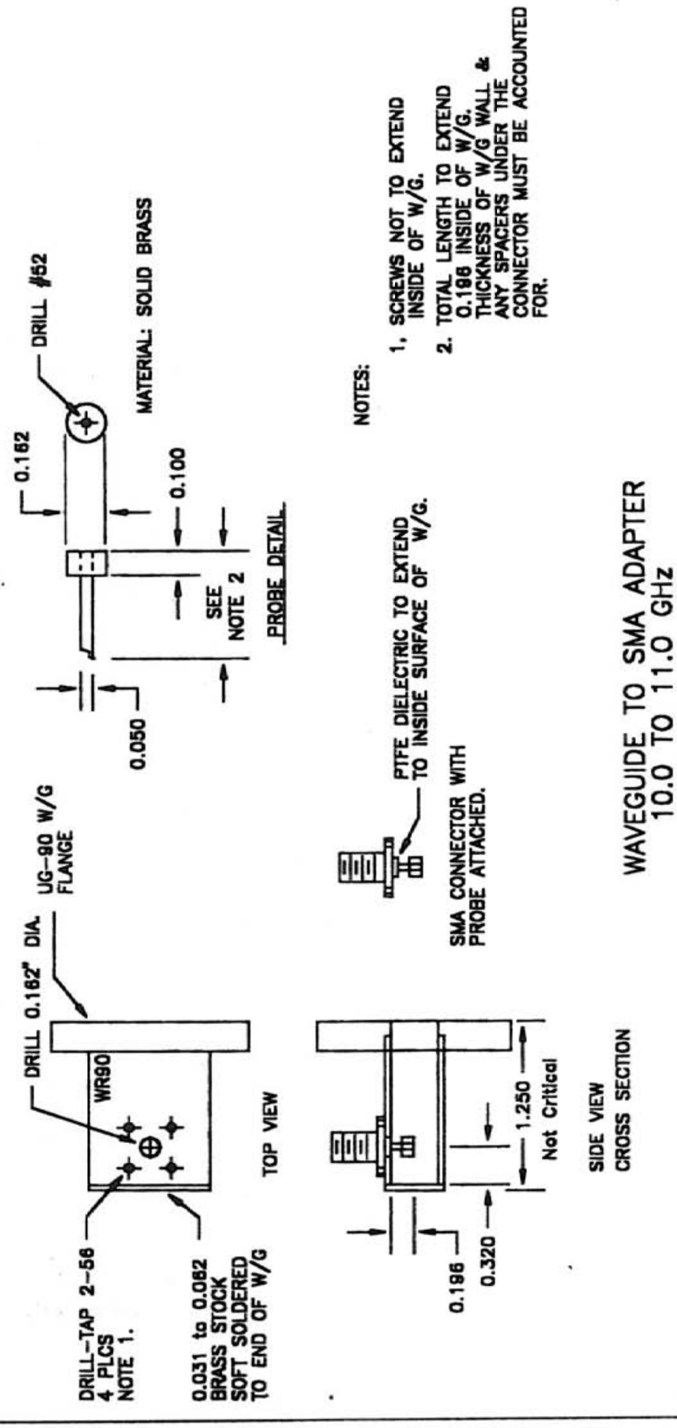
The transition can be thought of as a 90 degree E-plane bend whose vertical arm is short circuited. The probe can thus enter the end wall and yet still couple into the E field. A capacitive window is used at the waveguide flange and produces a good match. As a result, the vertical waveguide is only half the normal height and therefore closer in impedance to the normal 50 ohm coaxial line and connector shown.

Tuning screws (not shown in the drawing) can be added near the coaxial probe to aid the matching process. The VSWR of this novel transition is claimed to be less than 1.1:1 over the range 8.3 -12.4GHz when made to WG16 dimensions. This is a return loss in excess of 26dB.

Figure 1 shows the capacitive window as seen from the front of the transition. The end of the quarter wavelength probe is also shown.

Figure 2 shows a cross section of the transition through the side. the line of the main waveguide feed is shown. The dashed lines in Figure 2 divide the transition into easily reproducible blocks for home construction. The commercial version appears to be in two pieces, a backplate and a capacitively coupled cavity. No doubt enterprising amateurs could make one of these these items from two pieces of WG16 joined together at right angles at the broad face.

The Newsletter would be very interested in hearing from anyone who has success with this method.



extrait de la newsletter SBMS

RF

By Zack Lau, KH6CP/1
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Newington, CT 06111
email: zlau@arrl.org

10-GHZ SMA TO WR-90 TRANSITION

Connecting 10-GHz waveguide to SMA connections requires a precision-constructed transition assembly. This design is meant to be easy to duplicate. Despite the compromises made to simplify construction, you can get a return loss of around 20 dB at 10.368 GHz without tuning. Instead of using expensive test equipment, a relatively inexpensive dial caliper can be used to achieve tolerances of perhaps five thousandths of an inch.

I recommend that you use two- or four-hole flange SMA connectors with captivated center contacts. The captivated contacts are needed to keep the probe in place. Two-hole connectors work best, but they tend to be more difficult to find. The mounting flange of a four-hole connector extends past the capped end of the waveguide because the connector must be placed so close to that end (see Fig 1). The four-hole connectors can be used by filing the mounting flange after you solder the shorting back plate to the waveguide.

You can identify captivated contacts by inspecting the connector and looking for a small circle of glue on the shield next to the 1/4-36 threads or shell. You could also try gently moving the center pin to see if it's locked in place, but don't blame me if you break the connector!

The probe diameter of 3/32 inch (Fig 2) was chosen for convenience; you can make the probe out of hobby brass tubing. A study of the literature indicates that the usual 50-mil center-pin diameter would work better, but connectors with long center pins tend to be harder to find. It's much easier to file pieces of tubing to the right length than to file center pins. If you aren't careful, you can dislodge, bend or even break center pins. A bonus of filing cheap tubing is that you can toss the mistakes till you finally get the right length of 0.270 inches. The tubing is easily measured with a 6-inch dial caliper.

Fig 3 shows the waveguide flange, made from sheet brass, that completes the assembly. Making your own flange is a cheap—and easy—alternative.

I found it important to keep the matching section—the low-impedance transmission line formed by the thick probe passing through a 0.166-inch hole in the waveguide wall. I didn't have much luck getting a no-tune design when I kept the impedance at 50 Ω.

You may add tuning screws to improve performance. Normally, people put a couple of screws along the center line, spaced either an eighth or a quarter of a guide wavelength apart. However, professional transitions have a tuning post off to one side. You might look into this for more advanced designs.

The problem with tuning screws is properly adjusting them. It is relatively straightforward with a precision directional coupler. Ordinary couplers will have much less directivity, perhaps only 12 to 15 dB. This makes them almost useless for SWR measurements. Such a low directivity results in a rather large region of uncertainty. Even a 26-dB directivity coupler can result in noticeable errors.

A simplified but useful approximation for estimating the error appears on an ancient HP slide rule. It assumes that the effective source match is equal to the directivity, and that there is no calibration error.

$$uncertainty = A + A \times rho^2$$

where *A* is the directivity and *rho* is the measured value of reflection coefficient.

If *A* is 0.05 (-26 dB) and *rho* is 0.1 (-20 dB), we get an uncertainty of 0.0505. Thus, the actual return loss could be between 0.1505 and 0.0495, and the measured return loss of 20 dB with such a coupler could actually be between 16 dB and 26 dB (1.35 to 1.1 SWR). Using a coupler with only 15 dB of directivity, the actual SWR could be anywhere between 1.78 and 1.1, for that same measurement. I've included some graphs in Figs 4A, 4B, 4C, and 4D to show this a bit more clearly.

Construction

I begin by getting the necessary materials. Normally, I get waveguide and SMA connectors at hamfests, where they can be found inexpensively. The brass tubing and sheet stock are available from Small Parts.[1] They also sell 2-56 taps and stainless-steel hardware. The thickness of the brass sheet for the shorting plate that seals off the back of the waveguide isn't important—I normally use anywhere from 0.015 to 0.032-inch sheet stock. I use a shear to cut it into 0.500×1.000-inch rectangles. I usually make the waveguide at least 1.2 inches long. You might make it even longer if you intend to add tuning screws.

I next prepare the waveguide by marking it with a dial caliper. I get excellent results by buying an inexpensive caliper and using the jaws as a scribe. I save so much time with this technique that it would be worthwhile even if the jaws wore out every few years. (I've not noticed any wear with the soft materials I mark.) A dial caliper works much better than an expensive digital one for this purpose—I find it easier to count off the increments needed for parts like SMA connectors. For instance, I'll mark the center line of the waveguide, then decrement by 247 mils for the mounting holes. With an oxidized waveguide surface, the scribe lines are quite visible. If you polished it up to a bright shiny finish, it might be necessary to make the lines more visible! Professional machinists use layout dye. I've found that a permanent marker is an acceptable substitute. A good source of low-cost machinists' supplies is Enco Manufacturing Company.[2]

The dimensions shown are for standard SMA connectors. I've not seen nonstandard two-hole flange connectors, but I have purchased unusual four-hole flange connectors. These are easily identified by the flange dimensions: they aren't the usual 0.5-inch rounded squares.

Three holes are drilled for the SMA connector. (See Fig 1.) A no. 19 bit makes the 0.166-inch hole for the probe. The 0.070-inch holes for the 2-56 tapped holes are drilled with a no. 50 bit. The holes are then deburred. The outside holes are easily done with a large drill bit or commercial debur-ring tool. I use a file to smooth the inside surface of the guide. I tap the holes after deburring them. I find that using tapping fluid significantly reduces the number of taps that break. The *Microwave Handbook, Volume 2, Construction and Testing*, has useful information on this sort of metal work.[3]

The 0.50 × 1.00-inch shorting plate is soldered to the waveguide with a 100-W soldering iron while being held in place with a C clamp. Other people use propane torches to solder wave- guide, but I've found the iron sufficient. You can make the plate slightly smaller if you wish. This can make it easier to file the surface of the waveguide flat. This step is needed if you want to attach a four-hole flange SMA connector. This connector will stick out over the edge, so it's not as aesthetically pleasing as a two-hole flange connector. But four-hole flange connectors are often significantly cheaper.

Attaching the waveguide flange completes the soldering job. To save on weight, you might consider making your own flanges out of 25 or 32-mil brass. Thicker material is difficult to work with, while thinner material isn't quite sturdy enough. I highly recommend you compare your flange layout against a known good flange before drilling those asymmetrical holes.

The probes are easily cut with a hacksaw. They can be filed or sanded to precisely the right length. It's normal for them to fit loosely over the center pin, so it may take a few tries to solder them with the proper alignment. Finally, the SMA connectors are attached with 2-56 screws to the waveguide. A minor problem is that the ideal length for the screw shafts is about 100 mils. Of course, the nearest standard-size screw is 1/8 inch, or 125 mils. I've found hex nuts to be precisely the right thickness to space the screws, if you are willing to use Loctite instead of lock washers. Alternately, you could use a pair of lock washers. This is just a little too thin, but it seems to work just fine, even with a little bit of stainless sticking inside the waveguide.

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Notes

(1)Small Parts Inc, 13980 NW 58th Court, PO Box 4650, Miami Lakes, FL 33014-0650. Tel: (800) 220-4242 and (305) 557-8222; fax: (800) 423-9009.

(2)Enco Manufacturing Company, 5000 W Bloomingdale Avenue, Chicago, IL 69639. Tel: (800) USE-ENCO [(800) 873-3626] and (312) 745-1520.

(3) *Microwave Handbook*. This 3-volume set is published by the Radio Society of Great Britain. Edited by M. W. Dixon, G3PFR, and sold in the US by the ARRL.

Figures

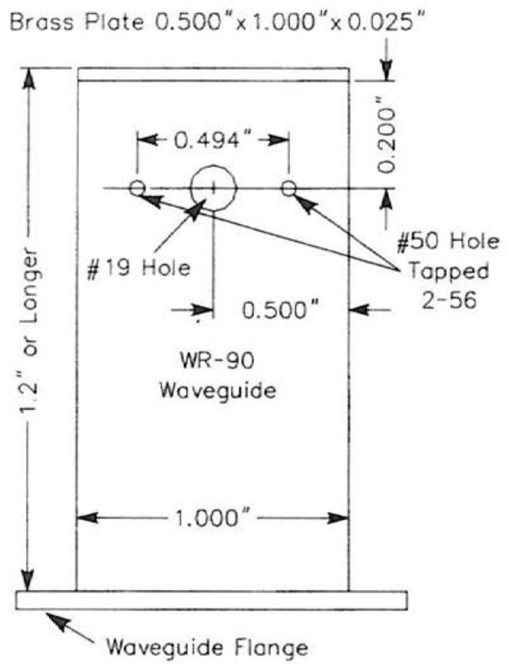


Fig 1—Top view of the WR-90 to SMA transition without the SMA connector in place.

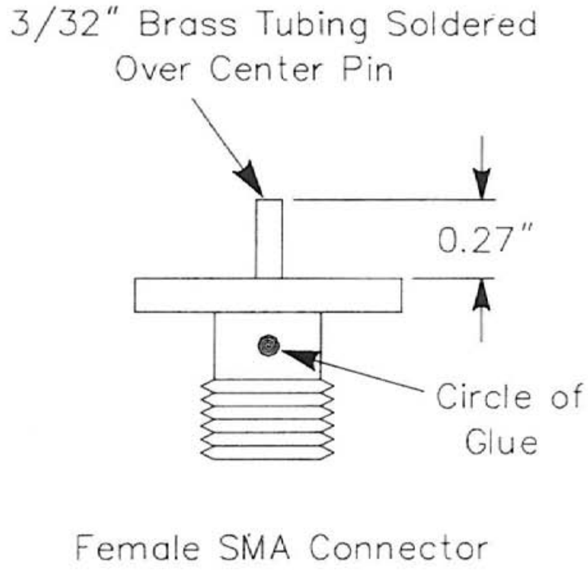


Fig 2—SMA connector and probe details.

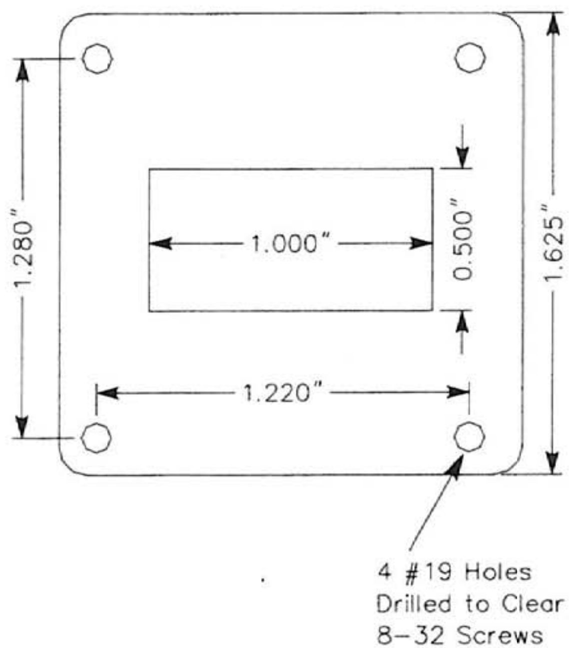


Fig 3—Dimensions for making cheap waveguide flanges for WR-90.

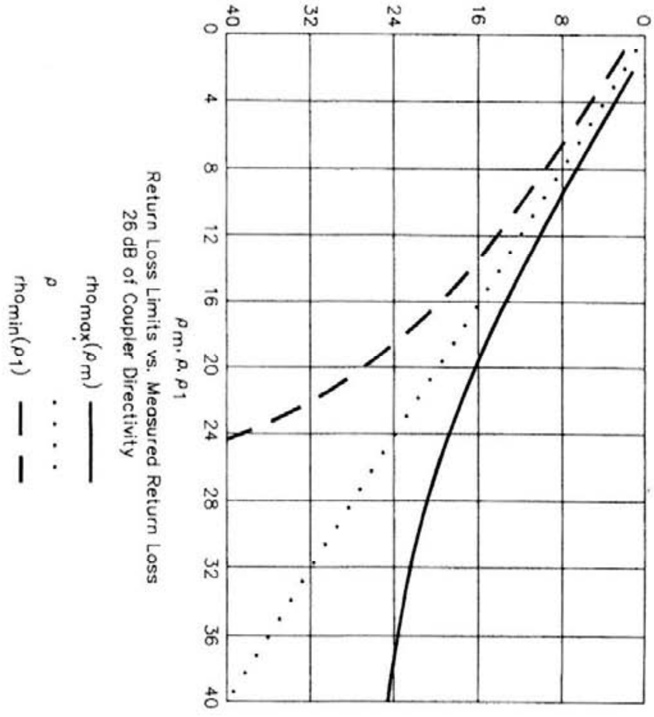
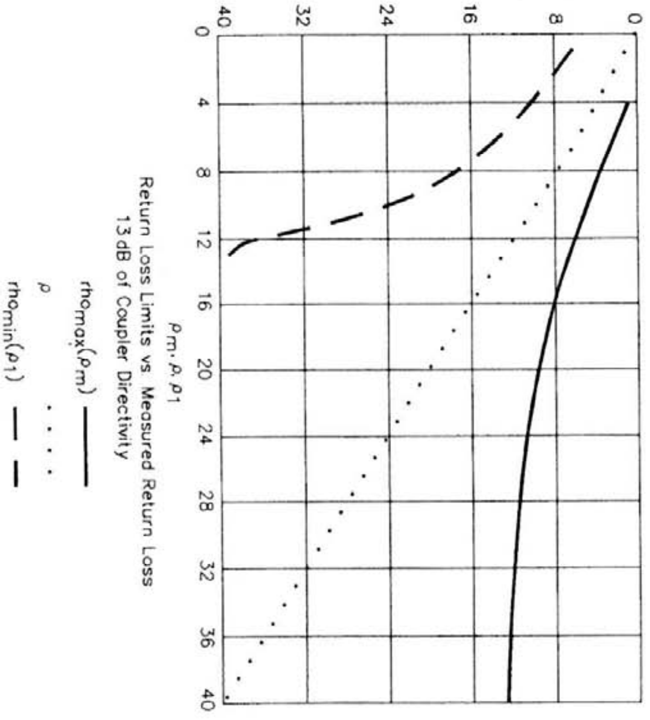
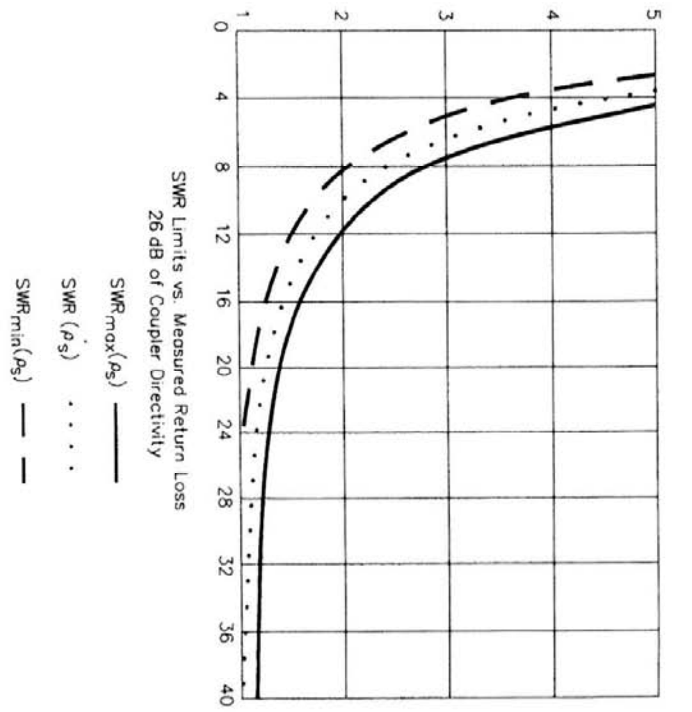


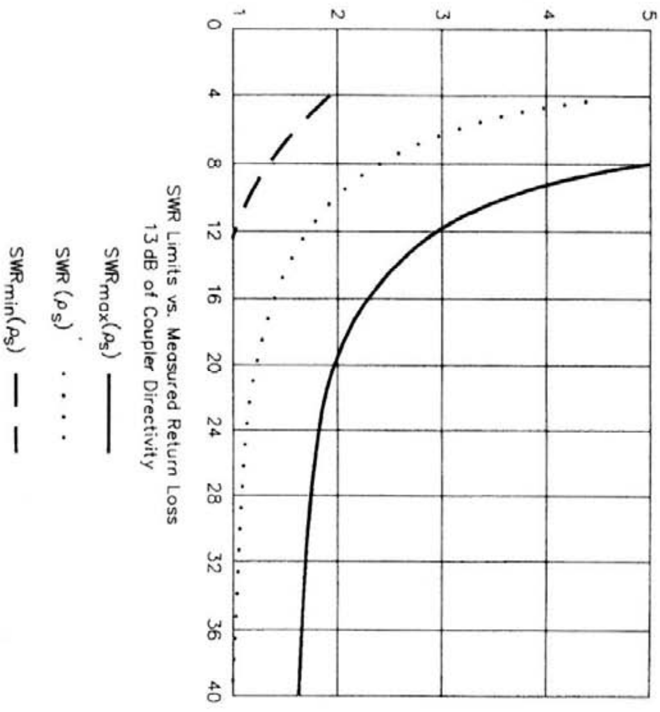
Fig 4A—Graphs showing the possible error of return-loss and SWR measurements made using directional couplers. The greater the coupler's directivity, the more certain the measurement.



4B



4C



4D

CHAPITRE 2 : ANTENNES À FAIBLE GAIN

2.1 CORNETS

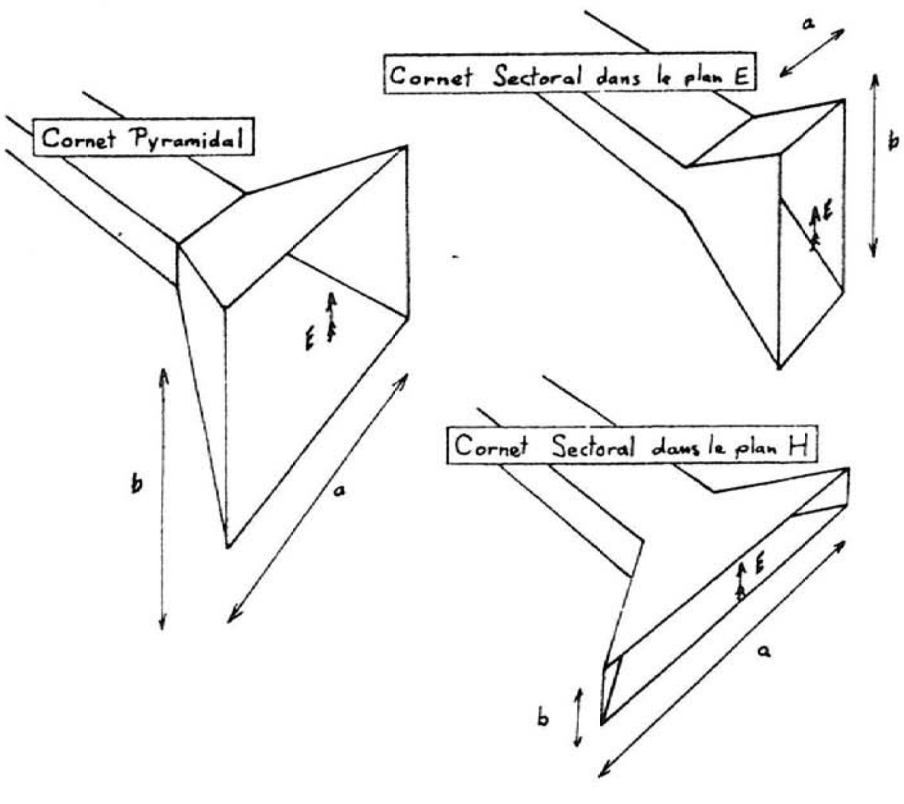
CALCUL DU GAIN D'UN CORNET HYPERFREQUENCE

extrait du bulletin du 10 GHz par F 1DMC

On trouve, depuis quelque temps, dans plusieurs revues OM des tableaux ou abaques qui permettent de déterminer le gain des cornets. Cette méthode simple est parfaite, lorsque l'on veut construire un cornet. Par contre, lorsqu'il s'agit de connaître le gain d'un cornet déjà existant dont les dimensions ne correspondent pas exactement aux tableaux, l'interpolation entre les différentes valeurs peut engendrer des erreurs non négligeables.

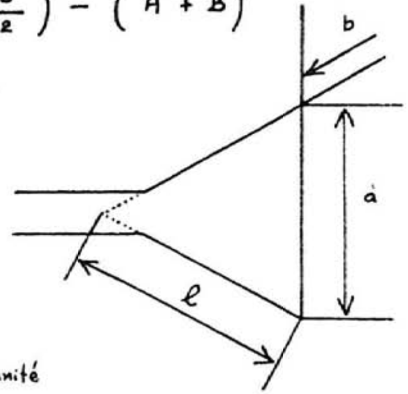
Il existe des formules (dites formules de SCHELKUNOFF) pour calculer exactement le gain d'un cornet, mais leur complexité les exclut d'un emploi OM.

Une formule plus simple donne cependant de bons résultats. Son utilisation est très rapide. Mais rappelons auparavant les trois types de cornets les plus couramment utilisés (il existe plusieurs autres types, mais de construction beaucoup plus délicate).



- FORMULE SIMPLIFIEE DU GAIN D'UN CORNET -

$$G_{dB} = 10\left(1 + \log \frac{a.b}{\lambda^2}\right) - (A + B)$$



a , b : dimensions de l'ouverture du cornet

λ : longueur d'onde dans l'air

A , B : exprimés en dB (donnés par le tableau ci-dessous)

a, b, et λ sont exprimés dans la même unité

Plan H				Plan E			
α	A	α	A	α	B	α	B
0,05	0,025	0,40	1,20	0,05	0,1	0,40	2,6
0,10	0,05	0,50	1,80	0,10	0,15	0,50	4
0,15	0,10	0,60	2,50	0,15	0,30	0,60	5,95
0,20	0,15	0,70	3,25	0,20	0,60	0,70	8
0,25	0,45	0,80	3,95	0,25	0,9	0,80	10
0,30	0,65	0,90	4,60	0,30	1,35	0,90	10,9
0,35	0,90	1	5,20	0,35	1,95	1	11

Plan H $\alpha = \dfrac{a^2}{8.\lambda.\ell}$ Plan E $\alpha = \dfrac{b^2}{8.\lambda.\ell}$

J'espère que ces quelques formules ne rebuteront personne et seront utiles à certains d'entre vous. Elles m'ont rendu de grands services à une époque pas si lointaine où il n'existait malheureusement pas beaucoup de littérature 10 GHz dans les revues OM.

Horns for 10 GHz and Up

By Kent Britain, WA5VJB

(From *Microwave Update '89*)

When that waveguide gets really small, it can be a real challenge to assemble a horn antenna. This assembly method uses a short piece of waveguide and a sheet of hobby brass or sheet tin. File down the inside lip of the waveguide, align the top and bottom pieces and add a drop of "Super Glue" letting it wick under the edges. After the glue sets for a few minutes, bend the top and bottom pieces up a bit, then align and glue on the side pieces.

Next, line up the edges of the opening and spot solder the corners. When you have things pretty well square, solder the outside seams together. Soldering the outside edges helps you keep the lossy lead and tin off the inside surfaces.

Horns have been constructed this way on WR-62 and WR-42 for 10 to 24 GHz, and the method should work up to 50 GHz.

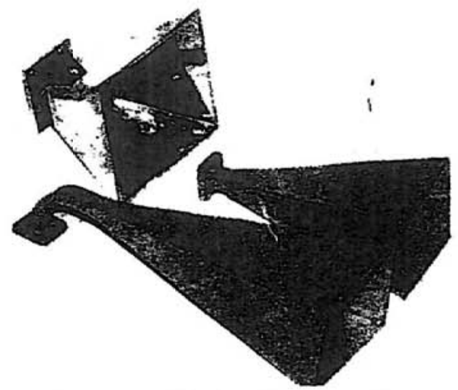


Fig 1—A commercial 17-dBi, 10-GHz horn, and two homebrew 22-dBi, 24-GHz horns.

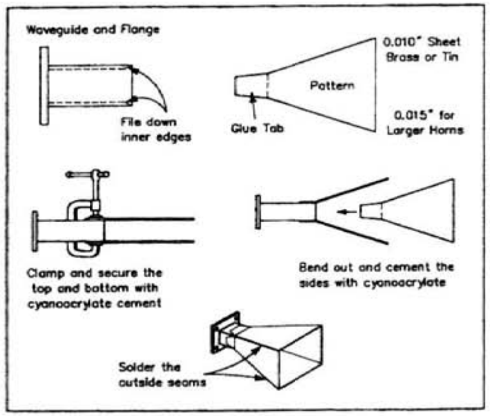


Fig 2—Details of homebrew horn construction.

20.8 ANTENNAS

Microwave Handbook RSGB

20.8.1 Horns

The simplest antenna to make and use is a horn; quite large gains, eg 30dB, can easily be achieved in a compact size. For higher gains, a parabolic dish can be used. There are other alternatives, eg lenses and microstrip antennas, but these are really only of practical interest to professional users.

Small horn antennas are easy to design, using the design methods described in chapter 4, "Microwave antennas". Being so small, they are not particularly easy to make but are, at least, not as difficult as dish antennas of the same gain!

Methods described for 10 and 24GHz horns can be adapted to make horns for these higher frequencies. A satisfactory method is to make a former from hardwood and build up the horn soldering the four sides on a cut-and-try basis, and finishing off with a wrapping of copper wire or some reinforcing plates at the joint of the horn with the waveguide. The same former can be used for several horns, producing transmit and receive antennas for two or more experimental stations. Some examples of calculated horn dimensions for 47 and 76GHz are given in Fig 20.22.

20.8.2 Dishes

Small dishes are useful as directional antennas but large dishes are hopelessly impracticable. For instance, a gain of 46dB implies a beamwidth of less than one degree in both azimuth and elevation, an accurate knowledge of the location of the station to be worked and a very rigid mounting to enable the antenna to be aligned and kept pointed correctly. Exceptionally precise setting-up would be required to point the dish at the other station, probably involving optical sighting tubes or telescopes. Fig 20.23 extends the range of dish size versus gain to the millimetre bands. Note that the diameter is now given in centimetres, not feet!

Parabolic antennas for the millimetre bands can be cut from solid on a lathe. If a block of metal is used, then the reflector can be used immediately. If a block of hardwood is used then it should be covered in kitchen aluminium foil. The foil should be laid in parallel strips with an overlap of at least λ/4 at the lowest frequency of operation and parallel to the electric plane of polarisation. Make strips wide enough so that nowhere are there more than two layers and do not attempt to lay the strips radially as it is too difficult to avoid a "muddle" at the centre of the dish.

The required accuracy is not very high, λ/10, which is 0.6mm at 47GHz, falling to 0.1mm at 240GHz. This should present no difficulty on a metal-working lathe. If a front feed is used then an f/D ratio of 0.5 is recommended; this is the ratio correctly fed with a sectoral horn that tapers in the narrow face only. Initially, a satisfactory feed can be made for experimental work by just radiating from an open guide. Such dishes for the millimetre bands are so small that it is quite good practice to make them oversized and then "underfeed" them. This produces a highly efficient design in the sense that no rf is "wasted" and the best gain is obtained for a given beamwidth. For example, for an f/D ratio of 0.5, the complete dish is turned and the feed is in the plane of the aperture where it is very easy to support.

20.8.3 Lenses

At millimetre wavelengths, techniques similar to optics become practical. Components are much larger than the wavelength and dielectrics exhibit properties which refract the waves in the same way as light is refracted ("bent") in a lens. Thus, not only will a parabolic dish focus microwaves as a concave mirror does light, so a dielectric "lens" will focus millimetre waves. It might be worthwhile for the experimenter to produce a plano-convex lens by turning a disc of a dielectric such as polythene or perspex and trying this as an alternative to a dish or horn!

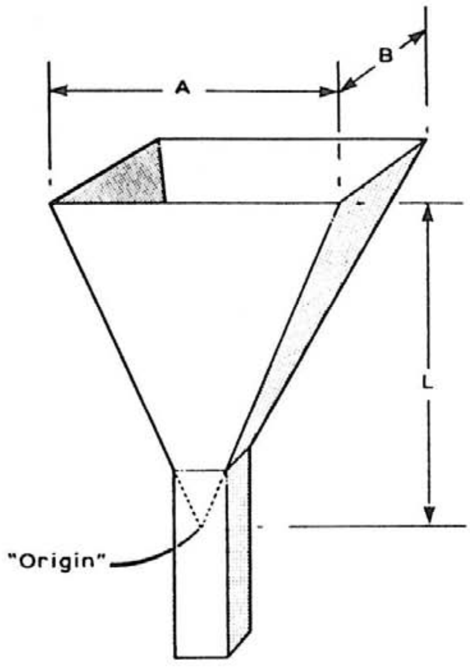


Fig 20.22. Typical horn dimensions for 47 and 76GHz. For 47GHz WG24 is used. 20dB horn: A=28.5, B=22.3, L=33.2; 30dB horn: A=88.6, B=71.5, L=385.7; For 76GHz, WG26 is used. 20dB horn: A=17.6, B=13.8, L=20.4; 30dB horn: A=54.8, B=44.2, L=238. All dimensions in mm. Optimum gain and sectoral horns can be easily designed using the program in Chapter 4, "Microwave antennas"

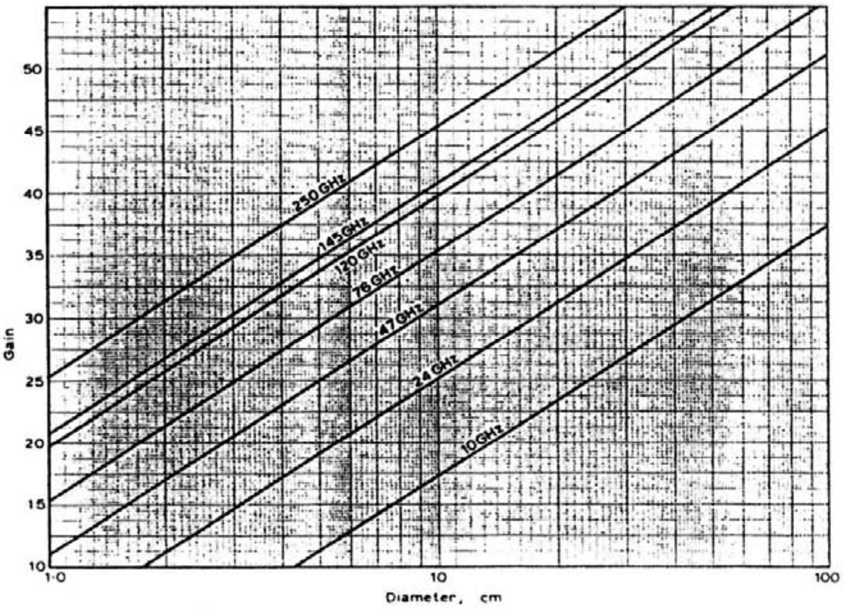


Fig 20.23. Gain of various sized dish antennas

Le cornet RTC

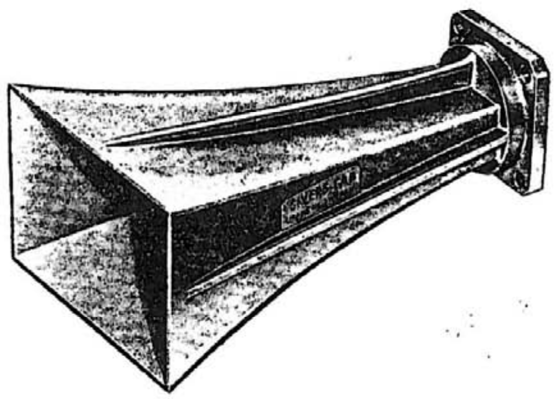
par F4BAY

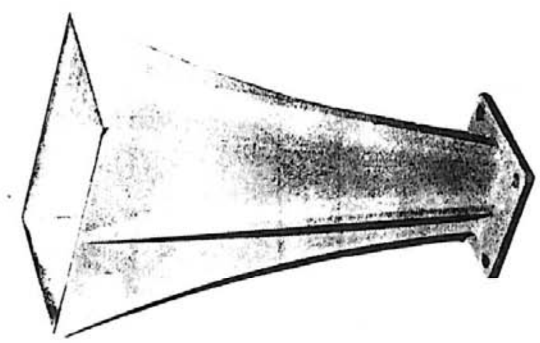
Ce cornet de forme exponentielle sur guide WR90 a été produit par RTC (ACX 01) et par PHILIPS/Sivers Lab (PM7320X). Les deux versions ont des caractéristiques très proches. On les trouve assez souvent dans les brocantes hyper. Ils peuvent être très utiles pour des mesures de gain car la précision de leur réalisation permet de les utiliser comme antenne de référence. Voici le résumé de leurs caractéristiques ainsi qu'une mesure de leur diagramme de rayonnement.

aérien adaptable sur cavités-guides

Data Book RTC

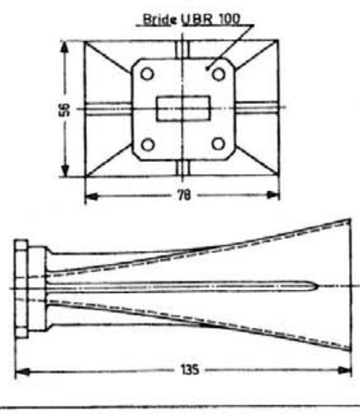
N° d'ordre	Type	Exploitation	Poids (g)	Dimensions hors-tout (cm)	Gain (dB)	Angle d'ouverture	R.O.S.
1	**ACX 01**	D*	280	7,8 x 5,4 x 13,5	16	37° à 8,2 GHz 24° à 12,4 GHz	1,2
2	**ADX 01**	D	150	L = 15 cm	17	15 ° à 10 GHz	1,3





ACX 01

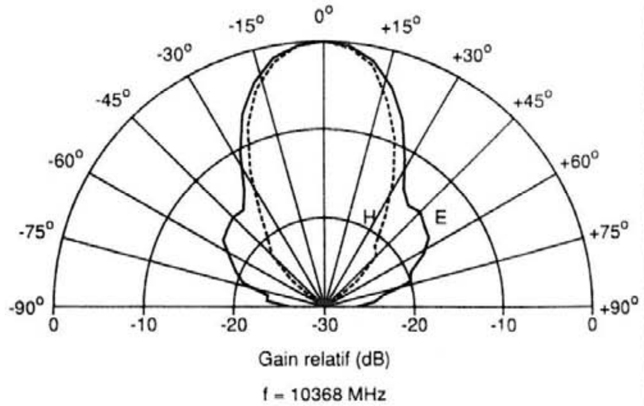
Les cornets sont utilisé pour alimenter les antennes paraboliques ainsi que dans les mesures précises. Le cornet PM 7320X possède un "gain standard" avec des caractéristiques connues dans toute la bande de fréquence. Les paroies ont une forme exponentielle pour assurer une bonne adaptation entre le guide d'ondes et l'espace libre.



Caractéristiques

Type PM 7320X

Gamme de fréquence	8,2 - 12,5 GHz
Guide d'ondes	R100 (WR90, WG16)
Gain au milieu de la bande	16 dB
Précision	0,4 dB
Variation du gain dans la bande de fréquence	± 1,5 dB
Directivité (3 dB)	
plan E	37° à 8,2 GHz 24° à 12,5 GHz
plan H	34° à 8,2 GHz 24° à 12,5 GHz
Niveau du premier lobe secondaire	
plan E	max. = —14 dB
plan H	max. = —20 dB
Dimensions	voir schéma
Poids	160 g



2.2 Antennes Omnidirectionnelles

4.9.2 Slotted-waveguide antennas

This type of antenna [10] is made from rectangular waveguide and consists of a series of resonators (slots) cut into one or both broad faces (see Fig 4.76). If an omnidirectional pattern is essential, reduced-height waveguide is a must: see Fig 4.77(b). The slots or dipoles are required to be parallel with, but alternately offset from, the centre line of the broad face of the guide. This ensures that the phase relationship between adjacent slots is correct. Horizontally polarised radiation is obtained when the slots are vertical. If standard waveguide is used then the pattern shown in Fig 4.77(a) is obtained, having nulls adjacent to the narrow faces. In either case a narrow beam is formed in the vertical plane with the radiation concentrated on the horizon, making this antenna ideally suited to general-coverage beacons. On the lower bands the Alford slot is perhaps more manageable.

Departure from truly circular coverage is mainly dependent on the following factors.

(a) The internal height of the waveguide.

(b) The thickness of the broad wall material.

(c) Whether the slots are machined in one or both broad faces of the guide.

(d) The accuracy and the relative positioning of the resonators.

The resonator length is related to its width. A convenient ratio is when the width is approximately 1/20th of the waveguide wavelength. The length will then be about $0.85 \times \lambda_0$, the free-space wavelength.

Gain is dependent on the *total* number of slots used on the antenna and also on how the power is distributed between them. An array using 16 slots (ie N = 16) is likely to produce a gain in the region of 10 to 12dB.

Reduced-height waveguide

When both broad faces contain slots the pattern will approach optimum when the height is minimum. The height that can be used is perhaps dictated by the ease of feeding the slots. A value of around 0.1λ is recommended as minimum. Due to power being progressively radiated from each slot the ideal situation is departed from along the length of the array. It would be preferable if the power could be introduced to the slots centrally so as to obtain the best symmetrical pattern. See the discussion at the end of the next section which applies generally.

Standard waveguide

In this case, when both broad faces have slots the pattern is bidirectional, producing a four-leaf clover shaped pattern but with the side nulls being very deep and the front less so.

In practice the perfect field pattern is never achieved even in an amateur installation. The tolerances for instance may be as high as 0.2mm (8/1,000in) and still give an acceptable pattern. In the design example given (for 10GHz), the width used is 1.6mm (1/16in). In practice, the use of a 1.6mm end-mill or slotting drill has yielded acceptable results both at 10 and 24GHz, when combined with the somewhat wider tolerances mentioned.

The gain of an antenna using a total of 16 slots (as in the sample calculation) is 10 to 12dB. In order to benefit from a longer array some steps must be taken to ensure that the power arriving at the furthest elements is still sufficient to allow them to contribute in the correct manner. A possible explanation for this requirement is linked to the findings of Blumlein which show that a long structure, when end-fed, radiates power progressively (exponentially). This causes the angle of the radiated wave to shift away from the perpendicular axis of the slots. To avoid this disadvantage centre-feeding the array is suggested. By combining two half-length sections the problem is greatly reduced by introducing equal but opposite angle shifts on each half. One practical way of achieving this may be to construct

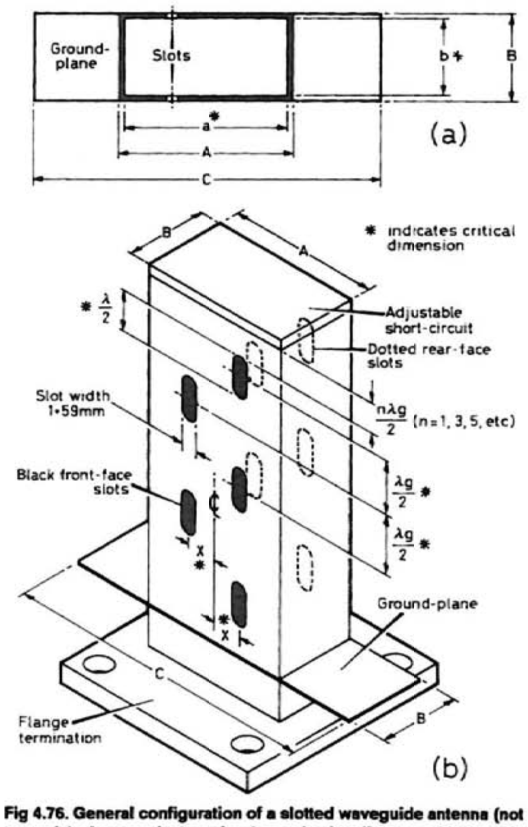


Fig 4.76. General configuration of a slotted waveguide antenna (not to scale). A ground plane is shown in the diagram; this is only needed if the antenna is made from full-height waveguide. If dimension b is 0.1λ or less, the ground plane is omitted but a tapered section (at least 3λ long) from standard-height guide to the reduced section will be required

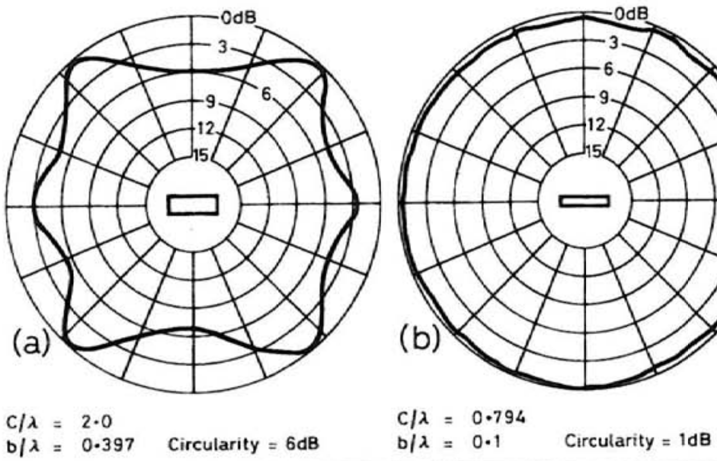


Fig 4.77. Approximate radiation patterns for slotted-waveguide antennas. (a) Full-height waveguide. (b) Reduced-height waveguide

Microwave Handbook RSGB

two practical-length arrays and combine them with a two-way power-splitting device. Then with the slot arrays mounted one up and one down. The resulting array will have both increased gain due to using more better-fed slots and also due to the radiation being maintained on the horizon.

Matching from standard waveguide to reduced-height waveguide is achieved by using a tapered section, the length of which is as long as possible, with three waveguide wavelengths being recommended. An alternative would be to include a matching iris or screws. This will produce the same result but over a much-restricted bandwidth. The remote end of the antenna is closed by means of a sliding short-circuit positioned $\lambda/4$ away from the end of the uppermost resonator. The final position may be adjusted on test for best vswr (minimum return loss). It may be advantageous to fit three or four matching screws, spaced approximately $\lambda_g/8$ apart, near the base of the antenna. A combination of adjustment to these screws and the sliding short should then result in a good match. However, please note a good match is *not* a sign of a good performance. A poorly made array is likely to be capable of a good match! The variation in vswr when an object is moved parallel to the polarisation plane will indicate approximately where the power is being radiated.

Design formulae

N = total number of slots

ie twice the number of slots in one face of the guide, and

$$g = g_1 \times \sin^2(\pi \times x/a)$$

where $g = 1/N$ and x = displacement of slots from centre-line, in millimetres.

L_0 = free-space wavelength
L_g = waveguide wavelength
a = internal dimension of broad face of guide (mm)
b = internal dimension of narrow face of guide (mm)

Note that angular functions are in radians.

$$\text{Then } g_1 = 2.09 \times (L_g/L_0) \times (a/b) \times \cos^2(\pi \times L_0/2 \times L_g)$$

Worked example for 10GHz

L_g (at 10,368MHz) = 37.322mm
L_0 (at 10,368MHz) = 28.911mm
N = 16
a = 22.86mm
b = 3.0mm
Slot width = 1.59mm

$$g_1 = 2.09 \times \left(\frac{37.322}{28.911}\right) \times \left(\frac{22.86}{3}\right) \times \cos^2\left(\pi \times \frac{28.911}{2} \times 37.322\right)$$

$$= 2.47$$

$$\text{Then } 1/16 = g_1 \times \sin^2(\pi \times x/a)$$
$$= 2.47 \times \sin^2(\pi \times x/22.86)$$

$\sin^2(\pi \times x/22.86) = 0.025$ and $\sin(\pi \times x/22.86) = 0.159$

giving x = 1.16mm (slot displacement).

Slot length = $L_0/2$ = 28.911/2 = 14.46mm
Slot spacing = $L_g/2$ = 37.322/2 = 18.66mm
Spacing of top slot from end of antenna = 45mm (min)

The formulae and calculations given are directly applicable to other waveguide sizes, and antennas for other frequencies and bands can be designed along the same principles. Such an antenna can be mounted within a thin plastic or glassfibre tube for weather protection, and it has been found that such housings have little effect on the radiation pattern of the antenna but do cause vswr changes. This may be compensated for experimentally by either resetting the matching screws or perhaps by altering the design a little to return to optimum performance when the radome or housing is present. Thus the simplest 10GHz beacon could consist of a Gunn or dielectric tuned oscillator coupled directly to a stacked, slotted-waveguide antenna, with both items of equipment housed within the one protective tube and the modulated supply voltage being fed to the oscillator via an ordinary coaxial cable of any convenient length. See the "Beacons and repeaters" chapter in Volume 2.

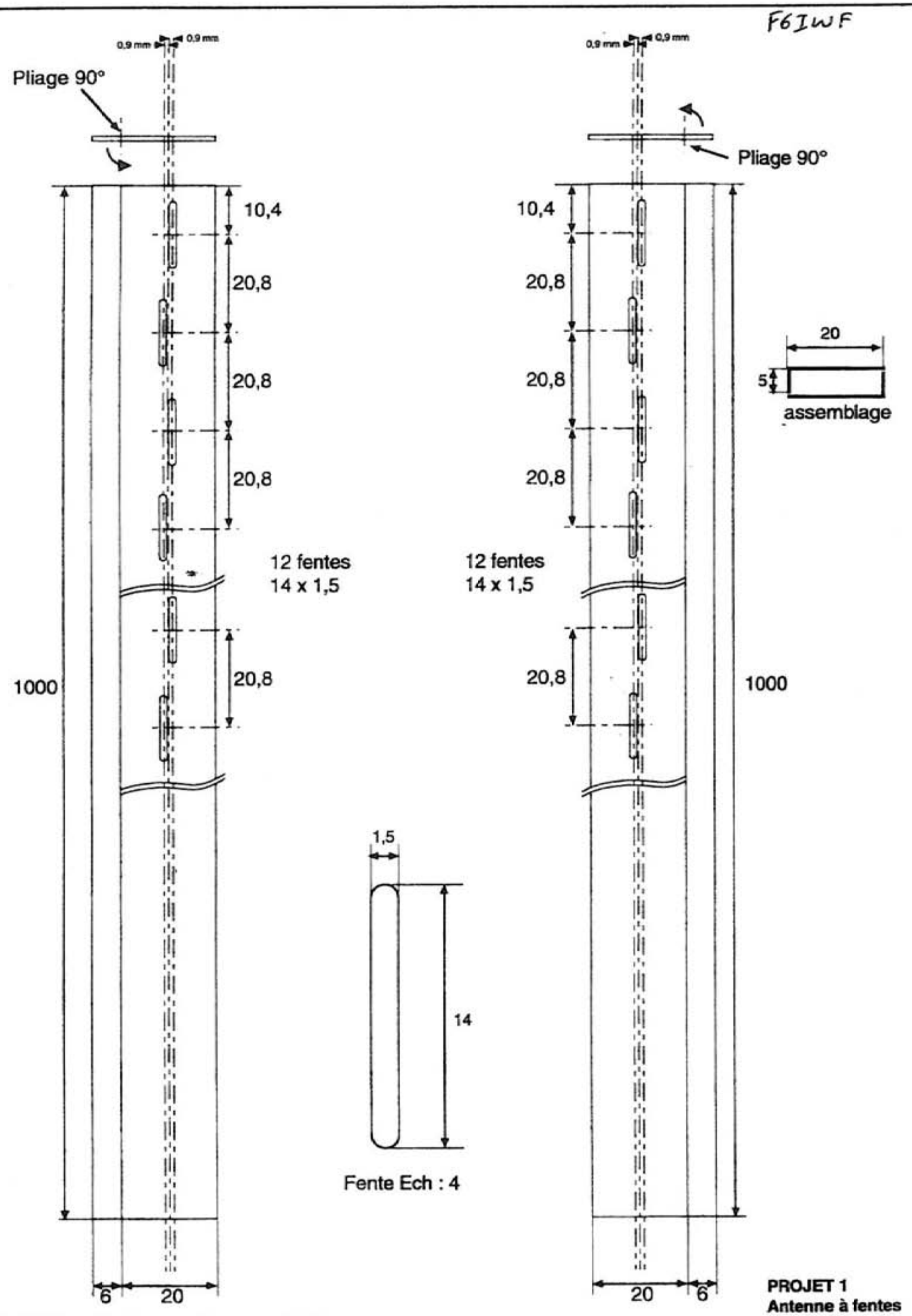
PCB material version

This will behave in exactly the same manner but ought to be easily reproduced once the exact pattern is determined. A single artwork will be needed to allow the slots to be etched on both sides of a thin double-sided board. The negative can be reversed to provide the other side's pattern. The edges may be connected using copper foil soldered along the edges in the same manner as is used to join ground planes together. The width of the broad face will be reduced by the square root of the dielectric constant as it forms a filled waveguide, and thus will have the same cut-off with a narrower broad-face dimension.

4.9.3 Slotted waveguide design program

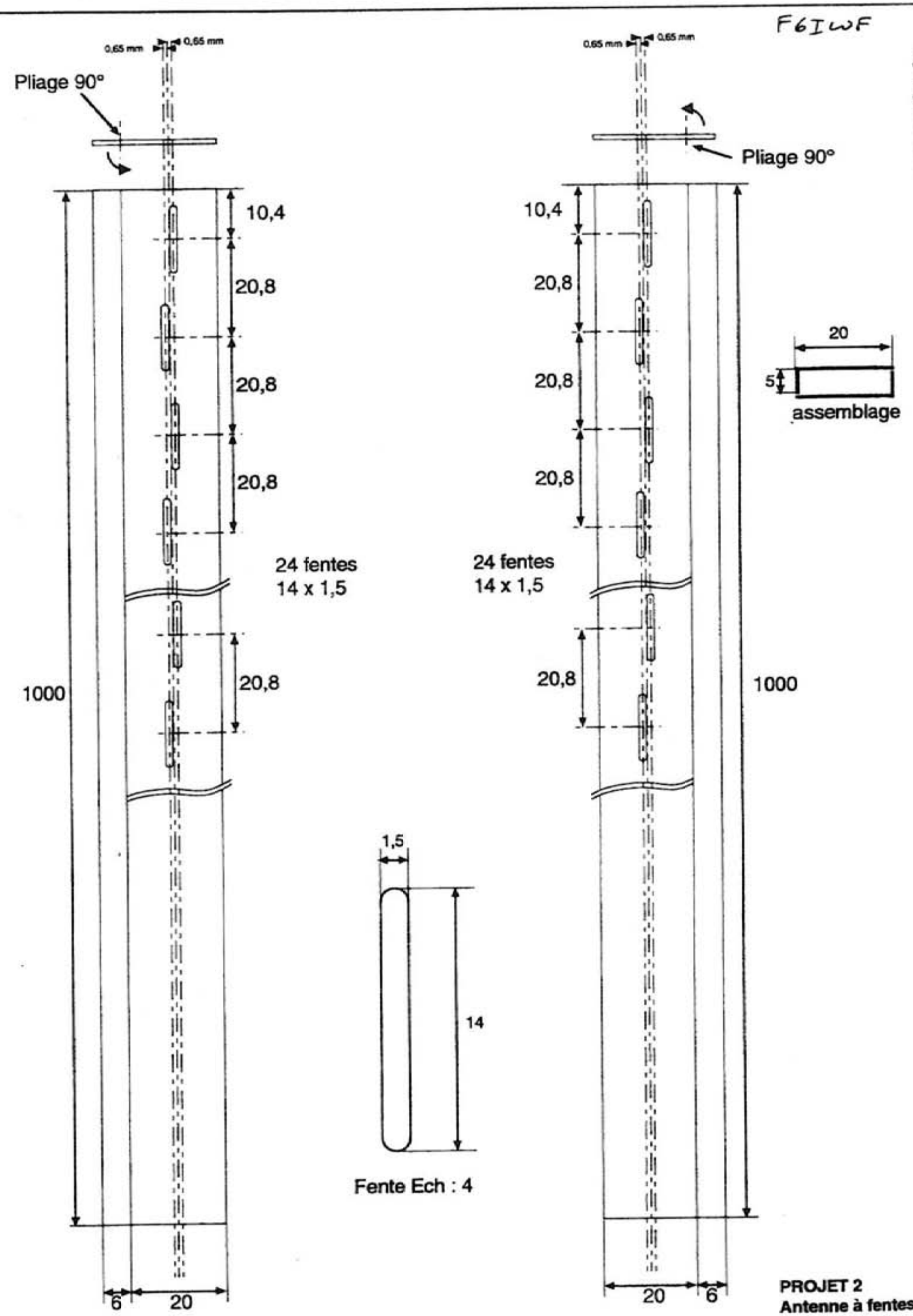
The following program, written in BBC BASIC, enables easy design of slotted-waveguide antennas of the type described in the preceding section and is due to G8AGN.

```
10 REM SLOTTED WG ARRAY DESIGN
20 REM
30 REM C. 1987 B.Chambers G8AGN
40 REM Modified 1987 M.Dixon G3PFR
50 REM
60 @%=&20309:REM set print format to F9.3
100 MODE0
110 PRINT"Slotted waveguide array design program"
120 PRINT"--------------------------------------":PRINT
130 INPUT"Enter centre frequency in GHz ";F
140 RESTORE
150 FOR T=1 TO 6
160 READ WG$,A,B,FL,FH
170 IF F>FL AND F<FH THEN 200
180 NEXT
190 PRINT:PRINT"WAVEGUIDE DATA NOT AVAILABLE FOR THIS FREQUENCY":
    GOTO 310
200 PRINT:PRINT"Recommended waveguide size is WG";WG$
210 PRINT:PRINT"Internal dimensions are :     a = ";A;" ins"
220 PRINT"                                    b = ";B;" ins"
230 PRINT:INPUT"Is this OK  ";P$
240 IF LEFT$(P$,1)="Y" THEN T=6:NEXT:GOTO 320
250 PRINT:INPUT"Which size is to be used ";W$
260 RESTORE
270 FOR T= 1 TO 6
280 READ WG$,A,B,FL,FH
290 IF WG$=W$ THEN T=6:NEXT:GOTO320
300 PRINT:PRINT"WAVEGUIDE DATA NOT AVAILABLE"
310 PRINT:INPUT"Enter a and b in inches":A,B
320 A=25.4*A:B=25.4*B
330 L=300/F:LC=2*A
340 LG=L/SQR(1-L*L/(LC*LC))
350 L2=0.5*L:LG2=0.5*LG
360 PRINT:
    INPUT"Enter value for reduced waveguide dimension b in inches
                    (default value is 0.25 of original b)
          ";b$
380 IF b$="" THEN B=0.25*B:ELSE B=25.4*VAL(b$)
385 VDU11:VDU11:@%=&20409:PRINT"Enter value for reduced waveguide
     dimension b in inches                  (default value is 0.25 of
     original b)                    ?";B/25.4
390 PRINT:INPUT
    "Enter slot width in inches (default value is 0.0625in.) ";w$
395 IF w$="" THEN W=0.0625 ELSE W=VAL(w$)
400 W=25.4*W:W2=0.5*W
405 VDU11:@%=&20409:PRINT"Enter slot width in inches (default value
    is 0.0625in.) ?";W/25.4:@%=&20309
410 PRINT:
    INPUT"Enter desired vertical 3dB beamwidth in degrees ";BW
412 IF BW=0 THEN VDU11:VDU11:GOTO 410
420 NS=102/BW:NL=INT(NS):BWH=102/NL:NH=NL+1:BWL=102/NH
430 @%=&10:PRINT:PRINT;NL;" slots will give a beamwidth of approx.
     ";INT(BWH);" degs."
440 PRINT:PRINT;NH;" slots will give a beamwidth of approx. ";
    INT(BWL);" degs."
450 @%=&20309:PRINT:INPUT"Enter number of slots ";NS
460 PRINT:INPUT"Is antenna to be semi-omni (1) or omni-directional
     (2) ";NF
470 N=NS*NF
480 G=1/N
490 PRINT:PRINT"Normalised slot conductance = ";G
500 AA=COS(PI*L*0.5/LG)
510 BB=G*L*B/(2.09*LG*A*AA*AA)
520 SD=ASN(SQR(BB))*A/PI
530 PRINT:PRINT"Slot displacement = ";SD;" mm"
540 IF SD<W2 THEN PRINT:PRINT"SLOT DISPLACEMENT TOO SMALL. REDUCE
     NUMBER OF SLOTS":GOTO 410
550 PRINT:PRINT"Slot length = ";L2;" mm"
560 PRINT:PRINT"Centre to centre slot spacing = ";LG2;" mm"
570 PRINT:PRINT"Waveguide internal dimensions are a = ";A;" mm"
580 PRINT:PRINT"                                  b = ";B;" mm"
590 PRINT:PRINT"Nominal bandwidth = +/- ";50/N;" %"
800 @%=10:REM Reset print format
4990 REM Waveguide data
5000 DATA 10,2.84,1.34,2.6,3.95
5010 DATA 12,1.872,0.872,3.95,5.85
5020 DATA 14,1.372,0.662,5.85,8.2
5030 DATA 16,0.9,0.4,8.2,12.4
5040 DATA 18,0.622,0.311,12.4,18.0
5050 DATA 20,0.42,0.17,18,26.5
5060 END
```



03/1992 Matiere : laiton Ep : 1mm

PROJET 1
Antenne à fentes
gain 12 dB



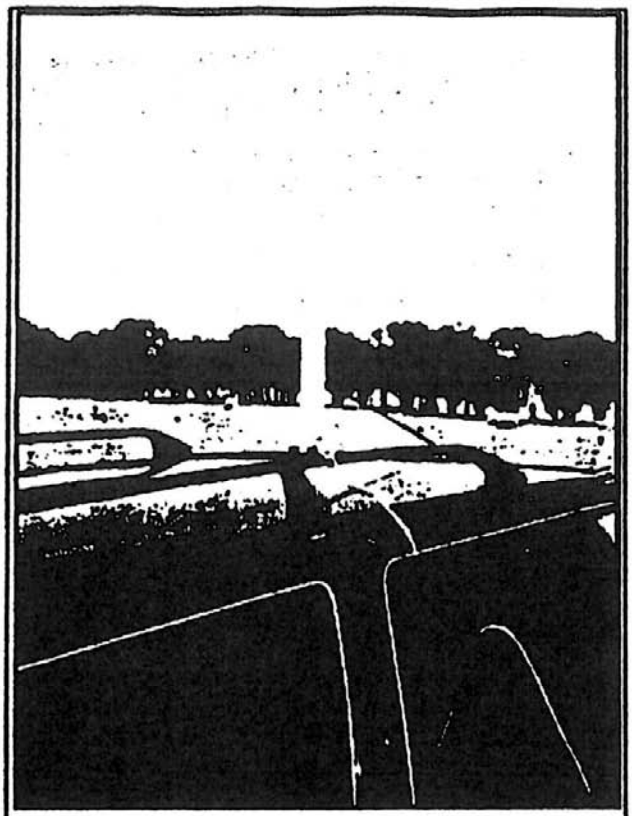
03/1992 Matiere : laiton Ep : 1mm

PROJET 2
Antenne à fentes
gain 15 dB

10 GHz Omnidirectional Antenna

Ken Vickers G3YKI

Microwave Newsletter April 97



There is no shortage of information on how to design slotted waveguide antennas, but to actually make them can become a problem without relatively sophisticated machining facilities, especially when you get to the higher frequencies. I am sure it is possible to accurately position a 1mm wide slot on a piece of copper waveguide on the kitchen table using a ground down hacksaw blade, but I am not prepared to do it 16 times to make an antenna.

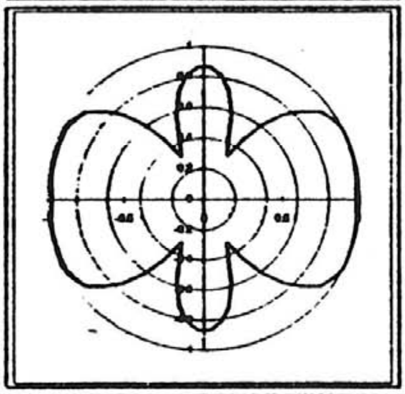
This antenna was made in a few hours and requires no more than a hand drill, saw and file.

So what's the difference?

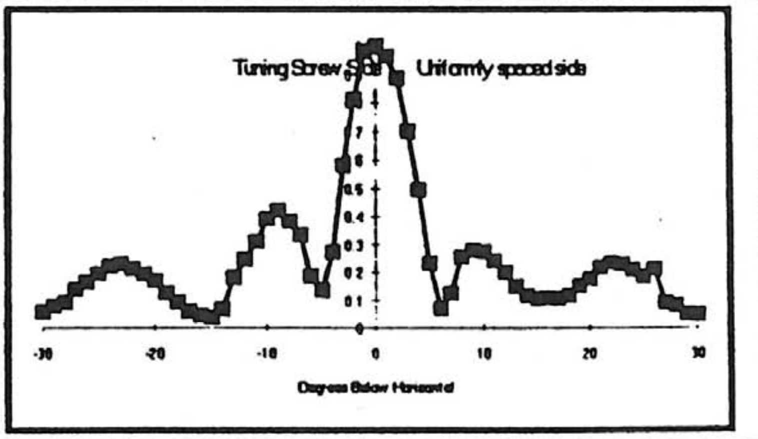
This antenna uses round holes rather than slots. They are much easier to make! A normal slotted waveguide antenna has the slots in the broad face of the waveguide. The broad face has both vertical and horizontal currents, so a vertical slot has to be used if you want to radiate only horizontal polarisation. The short wall carries only horizontal currents so the shape of the holes does not matter much.

What are the Disadvantages?

- The holes are not resonant at 10 GHz, so they do not radiate as readily as resonant slots. The result is a high "Q" sharply tuned antenna.
- The radiating elements on opposite sides of the waveguide are further apart, so the omnidirectionality is not as good.
- The vertical spacing of the elements is greater than one wavelength in free space which leads to less than optimum gain for the length of the antenna, and larger sidelobes in the vertical plane.



Vertical and horizontal Radiation Patterns of a 6 Element Antenna



How to make it

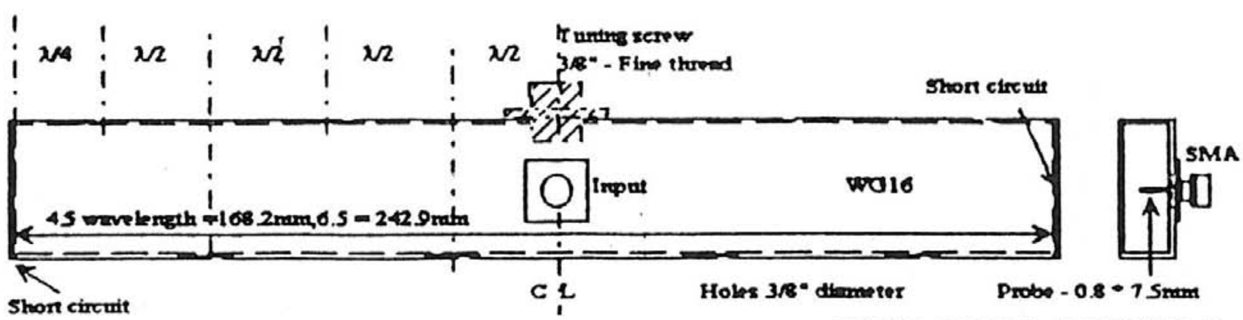
The waveguide must be exactly a multiple of one half guide wavelength long between short circuits at the operating frequency

The holes are 3/8" diameter (largest possible)and spaced one guide wavelength, starting quarter guide wavelength from the short circuit.

Holes at the same height on opposite faces will give a null to the side, to get the side lobes they must be offset by half wavelength.

A tuning screw is required to set the resonant frequency

Antenna is fed at the centre by a small probe in the centre of the broad face.



2.3 AUTRES ANTENNES À FAIBLE GAIN

VHF COMMUNICATIONS 3/99

Bob Platts, G8OZP

Dielectric Antenna for 3cm

In celebration of 50 years of the BATC, this article has been reproduced from the latest edition of CQ-TV. For further information about the BATC, see their advertisement on page-165 of this issue ... Editor

Dielectric antennas provide a simple means of achieving reasonable directional gain in a compact unit. They operate on the principle of refraction, but I shall not bore you with all the theory, its a little heavy and to be honest my middle-aged brain is unable to get around it as well as I could in my student days.

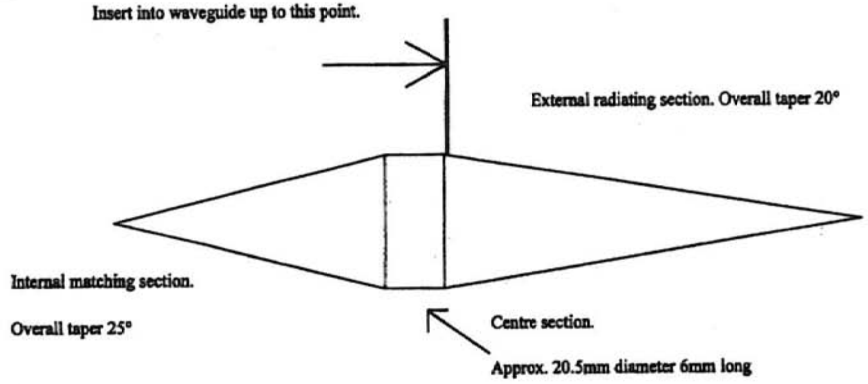
The design provides a gain of app. 20dB, with a match of better than 1.2:1 over the whole 3cm band.

The waveguide is 22mm copper pipe (the standard plumbing variety) and has a transition to WG16. The polarisation is the same as the feeding waveguide.

The material should be Nylon 66, PTFE may be used, it is more difficult to machine but provides improved performance. Nylon 66 is available from good engineering suppliers or RS Components and possibly Farnell.

Machine on a lathe very carefully with a sharp tool. Nylon 66 is naturally slippy. This means that it will not grip very well in the chuck. Also, as it is flexible it can grab, digging the cutting tool into the job, ripping it out of the chuck and throwing it across the workshop. I know from experience. A chuck rotation speed of 600 rpm is recommended, also clear the swarf away regularly whilst machining.

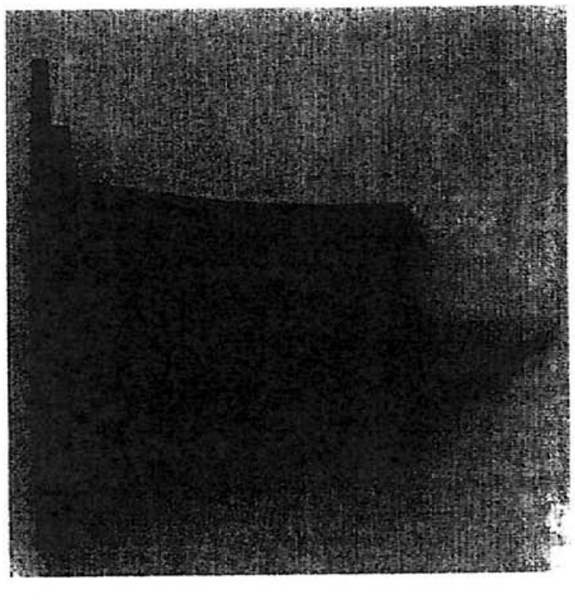
The parallel section should be a tight fit into the 22mm pipe, which will keep moisture out. As there can be a variance in the dimensions of copper pipe it is best to measure the internal diameter accurately before machining. There is no point in trying to glue the unit into the pipe as glues do not stick to Nylon 66.



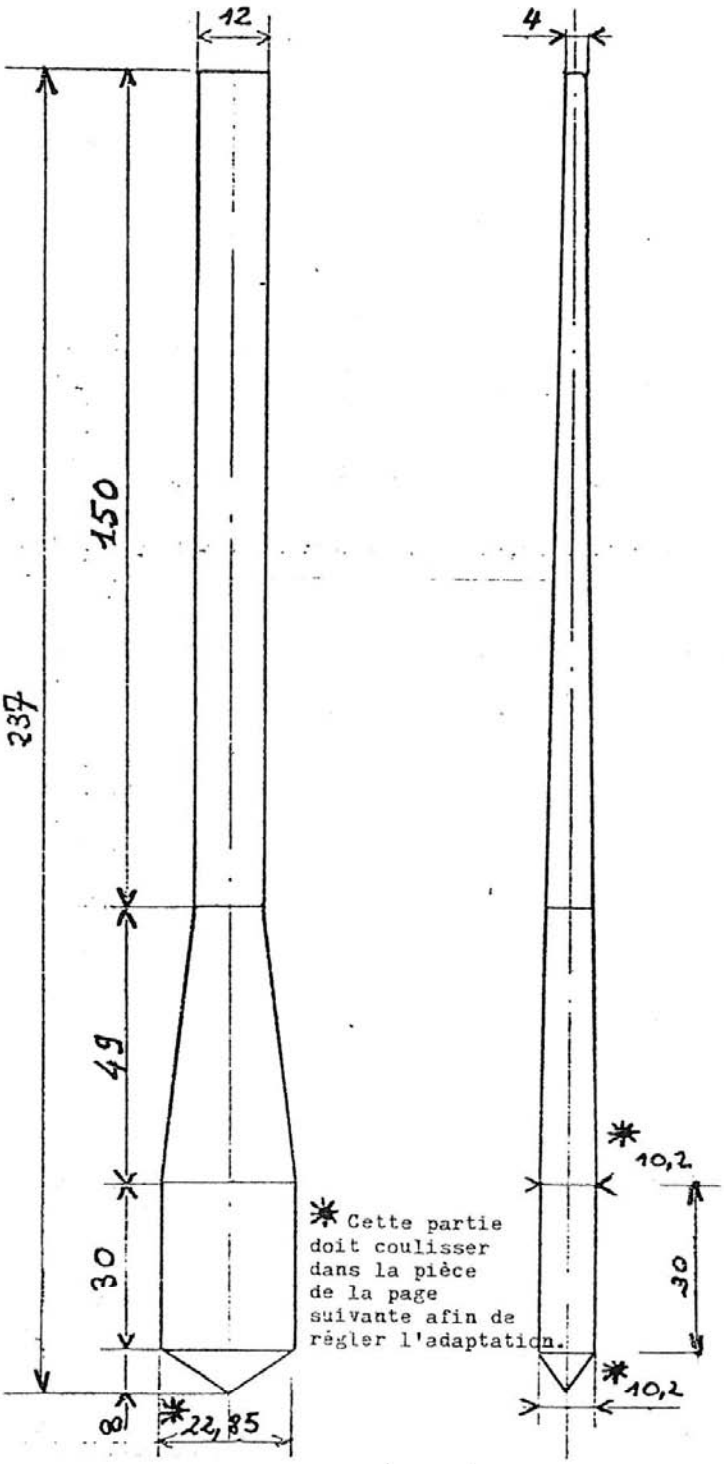
Dielectric Antenna with app. 20dB Gain

To convert the 22mm pipe to the standard WG16 waveguide requires a transition. These are relatively simple to construct.

Approximately 120mm of 22mm copper tube should be annealed for app. half its length, by heating it to dull red and allowing it to cool naturally. Cut a 75 to 100mm long piece of hard wood to a rectangular section of 23mm by 10.75mm. Then, 50mm from one end of this piece of wood shave it down to a section of 6mm square.

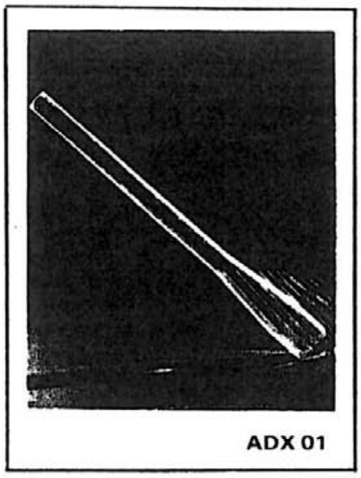


The wooden former is the swaged (aka hammered!) into the annealed end of the pipe. As this is done gently hammer the outside to form the correct size and shape to fit a WG16 flange. Clean the pipe well before soldering into the flange. The other end of the pipe may need trimming back if damaged during swageing.



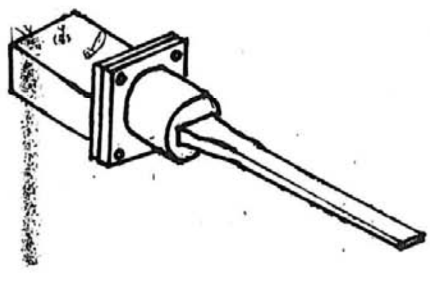
Antenne diélectrique

ancienne fabrication RTC
transmis par F3PJ
Extrait du bulletin du 10 GHz

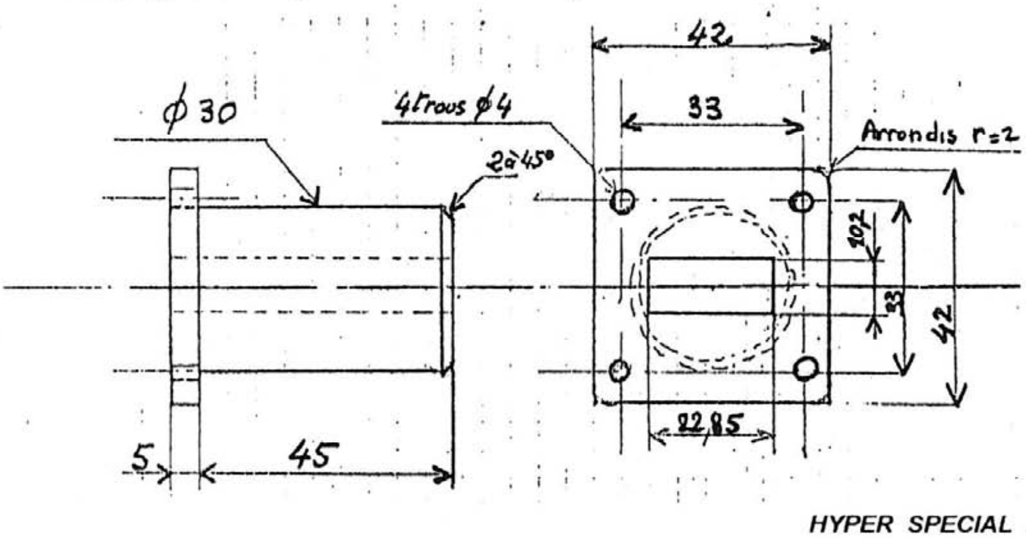


ADX 01

Voir caractéristiques p. 25



* Cette partie doit coulisser dans la pièce de la page suivante afin de régler l'adaptation.



Cette pièce métallique pourrait être remplacée par un morceau de guide d'onde coupé à la longueur.

PCB Antennas for 13, 9, 6 & 3 cm

Dirk Fischer, DH2DAE

Neuer Graben 83, D-44139 Dortmund

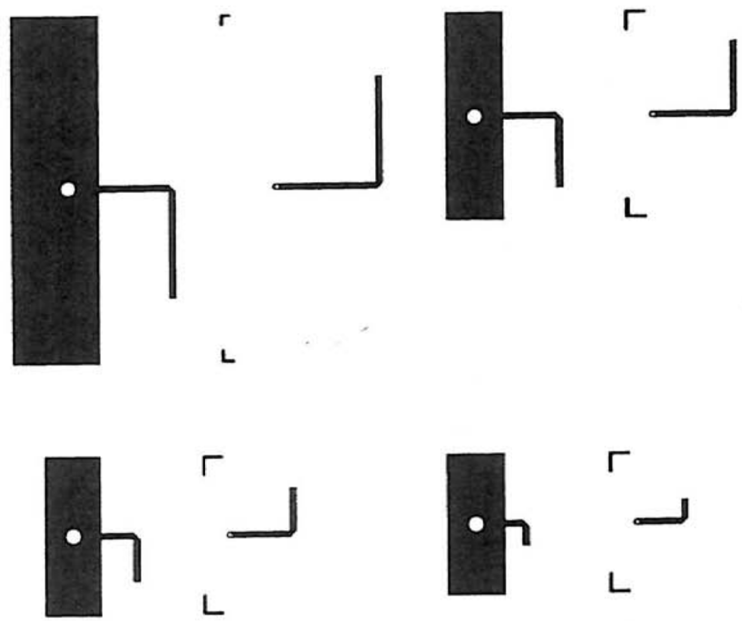
Kurzfassung: Einfache gedruckte Antennen auf TEFLON-Leiterplatte geben Möglichkeiten, Meßaufbauten und einfache Erreger für Spiegel zu realisieren.

Abstract: Simple patch antennas on PTFE-board for the 13, 9, 6 and 3 cm amateur bands provide a facility for simple test setups and measurements.

Beschreibung

Die hier vorgestellten SHF-Antennen wurden in ähnlicher Form für die Bänder 23cm und 13cm in der DUBUS beschrieben [1]. Das Design wurde nun auf Teflonsubstrat angepasst und auf die Bänder 9cm, 6cm und 3cm erweitert. Das Antennenprinzip ist sehr einfach und direkt ersichtlich, für Anwendungen, in denen ein höherer Gewinn oder andere Öffnungswinkel erforderlich sind, können sicher noch Direktoren oder modifizierte Reflektoren vorgesehen werden. Daran wird z.Z. gearbeitet, denkbar wären auch sogenannte "Patch-Antennen" wie sie für den Empfang direktstrahlender Satelliten eingesetzt werden.

Die Antennen sind schmalbandig und lassen sich sehr gut als Mini-Antennen für Versuche im Shack einsetzen. Man kann sie aber auch als Strahler in einem Parabolspiegel verwenden. Der große Vorteil liegt natürlich in dem sehr einfachen Aufbau und der platzsparenden Geometrie der Antennen (s. Foto). Natürlich darf man von einer derartigen Antenne keine Wunder erwarten, ein neues ODX wird sich so sicher nicht erzielen lassen h.i. Wenn es aber nur darum geht, einen Transverter abzugleichen oder einen Oszillator als Testsignal für einen Empfänger bereitzustellen - dann ist diese Ausführung genau richtig. Außerdem benötigt diese Antennenform keinerlei Abgleich!



Patterns for printed antennas

Die Herstellung der Antenne ist sehr einfach, man muß lediglich eine doppelseitige Platine ätzen und diese mit einem geeigneten HF-Anschluß versehen, also N- oder SMA-Norm-Buchsen, evtl geht auch noch die BNC-Norm (Bei 13cm in jedem Fall). Natürlich kann man den Anschluß auch mit einem Stück Semi-Rigid Kabel herstellen.

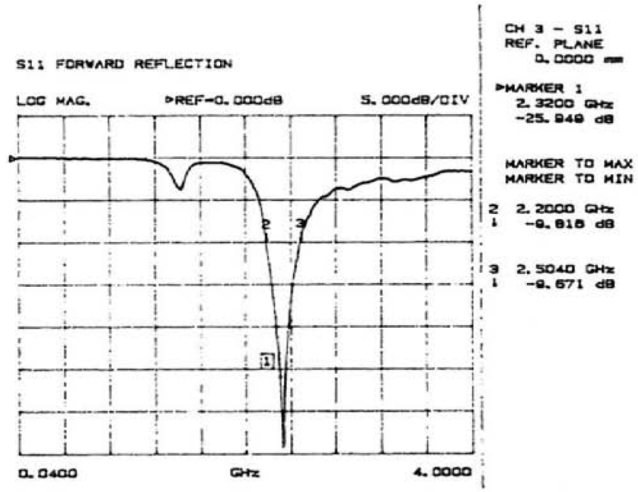


Fig. 1: S11 on 13 cm

Als Platinenmaterial ist Epoxyd durchaus geeignet, der Wirkungsgrad dürfte sich aber bei Teflon gerade bei den höheren Frequenzen erhöhen. Bei Sendeleistungen über 20 Watt muß die Antenne aus Teflonsubstrat bestehen, da die dielektrischen Verluste von Epoxyd dann zu groß werden. Die hier vorgestellten Layouts sind für Teflonsubstrat (er=3,0/0,5mm) optimiert. Um die Antenne vor Witterungseinflüssen zu schützen empfiehlt sich eine Behandlung mit Plastik- oder Klarlack-Spray.

Das Layout der Antennen zeigt Abb. 1. Ein Richtdiagramm konnte (noch) nicht aufgenommen werden, den Verlauf der Anpassung zeigen die Meßdiagramme. Die SSB-Frequenz ist mit einem Marker hervorgehoben, die Antennen sind ausreichend breitbandig, die 10dB-Grenzen sind ebenfalls markiert. Die Rückflußdämpfung liegt auf allen Amateurbändern deutlich unter 10 dB.

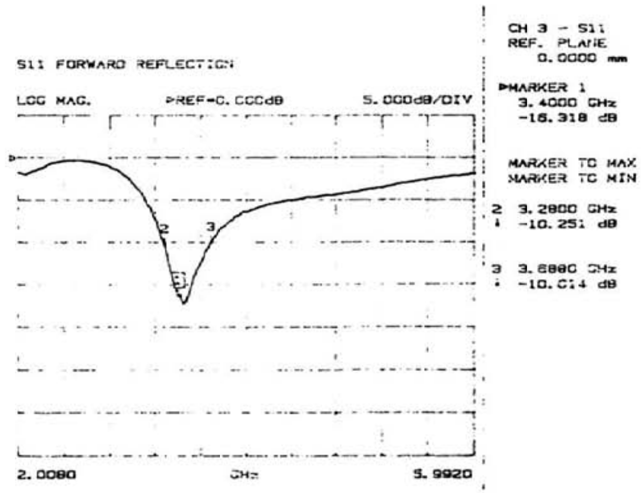


Fig. 2: S11 on 9 cm

Teile

Für Interessenten hält der Verfasser eine begrenzte Anzahl Platinen auf Teflonsubstrat bereit (DM 15.-/Stk.). Außerdem gibt es fertig aufgebaute Antennen mit SMA-Anschluß und Meßprotokoll (DM 30.-/Stk.).

Description

These antennas were described some time ago in DUBUS ([1]) by Peter Riml for 23 and 13 cm. The design has been changed for PTFE substrate and for higher frequencies.

The antennas are small and quite effective. There are useful for measurements and also as feeds for dishes.

The constructiuon is very simple. The only thing to do, is to mount an N-connector or SMA to the PCB. The substrate is PTFE with ε_r – 3.0 and 0.5 mm thickness.

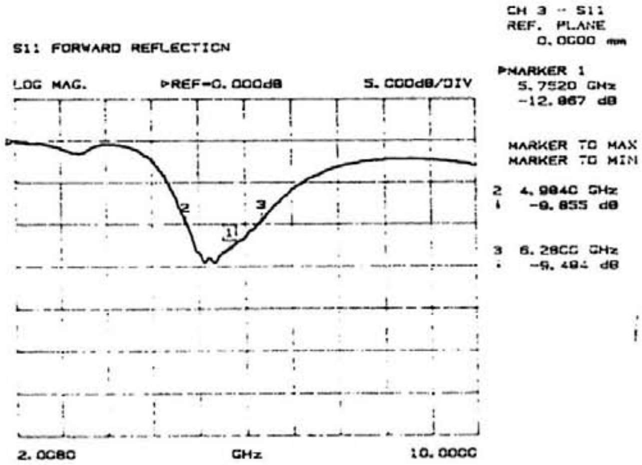


Fig. 3: S11 on 6 cm

Fig. 1 shows the pattern and the subsequent figures the match.

Parts

PCBs are available from the author (DM 15,-/piece). Ready made units are available for DM 30,- with SMA connector and datasheet.

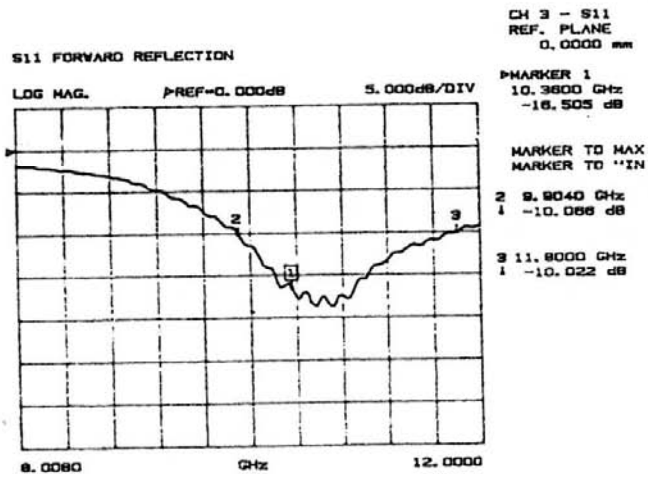


Fig. 4: S11 on 3 cm

References

[1] Peter Riml, OE9PMJ: Gedruckte 2-Element Antenne für das 23cm und 13cm Band, DUBUS 2/86, S. 109

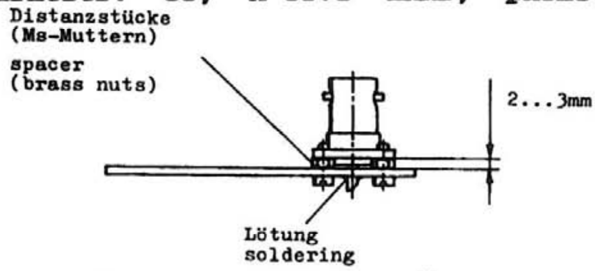
Voir page suivante

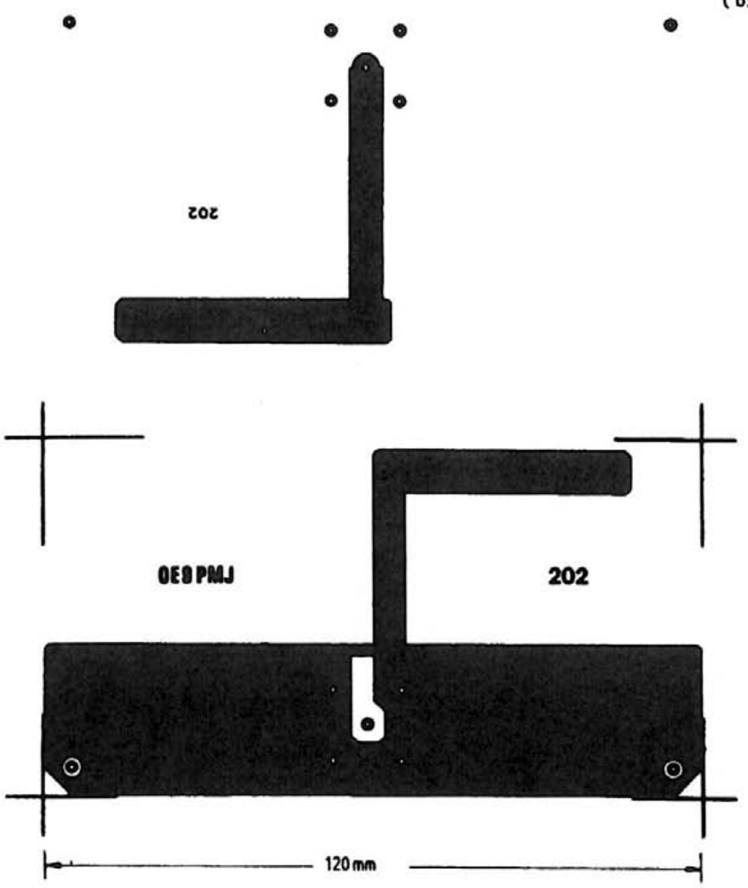
Gedruckte 2-Element Antennen für das 23 und 13cm Band

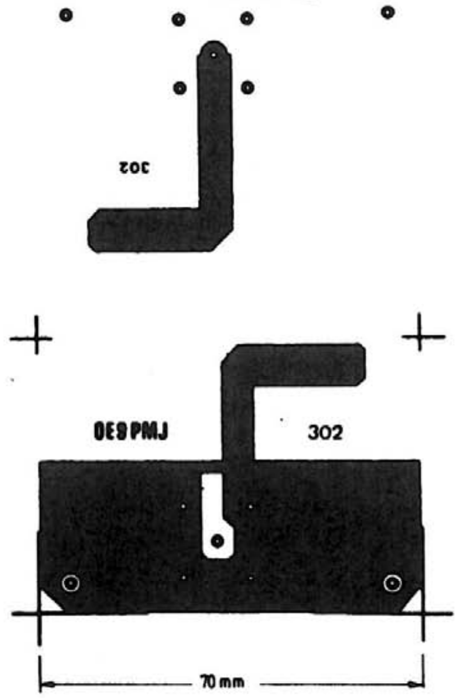
von Peter Riml, OE 9 PMJ

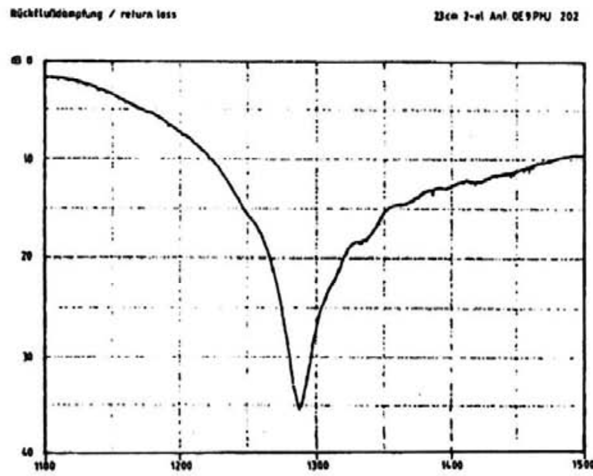
D.: Diese Antennen sind mit einer doppelseitig kaschierten Epoxy Leiterplatte von 1.6mm Dicke mit 5.5 Er hergestellt. Der Gewinn beträgt etwa 5.5dBi (3.5dBd) und die Belastbarkeit ca. 50W (Träger). Der Anschluß kann durch eine BNC-(UG290/U) oder N-Buchse mit UG447-Flansch erfolgen.

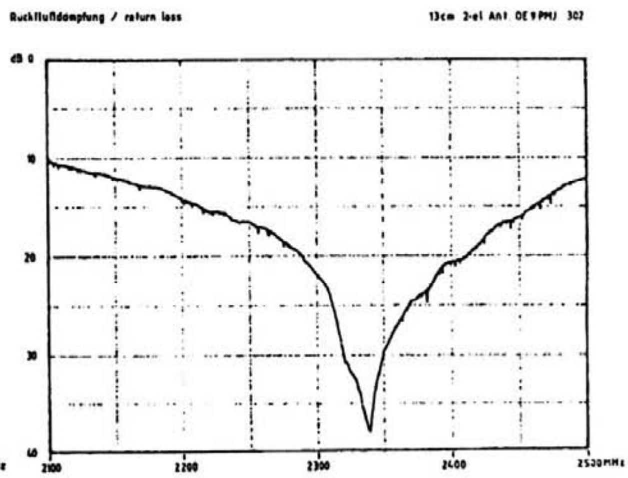
E.: Printed 2-element antennas for 23 and 13 cm bands.
This antennas are made from double clad fibreglass board 1/16" thick and Er 5.5. Its gain is approx. 5.5dBi (3.5dBd) and max load abt 50W permanent. The connection can be obtained using BNC-(UG290/U) or N-sockets with UG447 flange. The pc-boards are available from OE9PMJ, Marktstr. 33, A-6971 HARD, phone: 05574/35330 (13cm DM6 and 23cm DM9).











CHAPITRE 3 : ANTENNES À FORT GAIN

3.1 RÉFLECTEURS

Cassegrain System Evaluation-WA5JAT Extrait de FEEDPOINT

The parabolic reflector available to me had a useable surface diameter of 55.25 inches and an f/D ratio of 0.30 which is difficult to feed efficiently. I wished to increase the "apparent" f/D ratio so that a simpler and more efficient feed could be used. One way would have been to trim the diameter of the reflector but that seemed to be a waste of good reflector surface so I investigated other options. I found that a hyperbolic surface of revolution as a subreflector could be used to increase the effective focal length (f_{eff}) of the system

$$f_{eff} = \frac{(e+1)}{(e-1)} f_p$$

where "e" is the eccentricity of the hyperbola (for you math majors) and "f_p" is the focal length of the parabolic surface.

The hyperbola of revolution shape is defined by the equation

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1 \;\; ; \; b < a$$

where

$$b^2 = a^2(e^2 - 1)$$

or

$$x^2 = a^2 + \frac{y^2}{(e^2 - 1)}$$

where "a" can be chosen to position the feed point.

To double the "apparent" focal length of the parabolic reflector:

$$e = 3 \;\; ; \;\; f_{eff} = \frac{(3+1)}{(3-1)} f_p = 2 f_p$$

and the hyperbolic surface of revolution is defined by

$$x^2 = a^2 + \frac{y^2}{(3^2 - 1)} = a^2 + \frac{y^2}{8}$$

and is placed so that the parabolic focal point (f_p) is coincident with the positive hyperbolic focus ($x = +ae$) and the feed phase center is located at the negative hyperbolic focus ($x = -ae$).

If "a" is chosen so that

$$2ae = f_p$$

then the feed will radiate through a cutout in the parabolic reflector surface and the phase center of the feed will be located at the parabolic reflector surface which minimizes blockage of the reflector surface by the feed.

The next question to be answered was how large in diameter did the hyperbolic reflector need to be? A ray trace layout showed that the subreflector diameter required to fully illuminate the parabolic surface was 28.16 inches. This size subreflector results in a 26% blockage of the projected parabolic surface as shown in Figure 1. This amount of blockage reduces the area to be equivalent to a reflector diameter of 47.8 inches.

It is obvious that the reduced feed radiation angle comes at the expense of capture area and thus reduced antenna efficiency. This has to be traded against the increased illumination efficiency to determine which system gives the greater gain. Also, if the gain is greater with the subreflector, is it worth the fabrication complexity and cost? Would it be better to just illuminate a smaller area of the parabolic reflector? The answers to these questions are still to be determined.

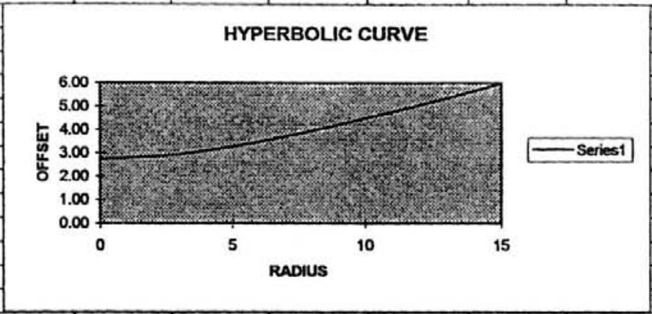
---

[1] Antennas and Radiowave Propagation, Robert E. Collin, McGraw-Hill 1985. ISBN 0-07-11808-1

HYPERBOLIC SURFACE GEOMETRY CALCULATIONS

X=SQRT(a^2+((Y)^2)/8)
a=2.7625

Y	X
0	2.76
1	2.79
2	2.85
3	2.96
4	3.10
5	3.28
6	3.48
7	3.71
8	3.95
9	4.21
10	4.49
11	4.77
12	5.06
13	5.36
14	5.67
15	5.98



Cassegrain System Evaluation-WA5JAT

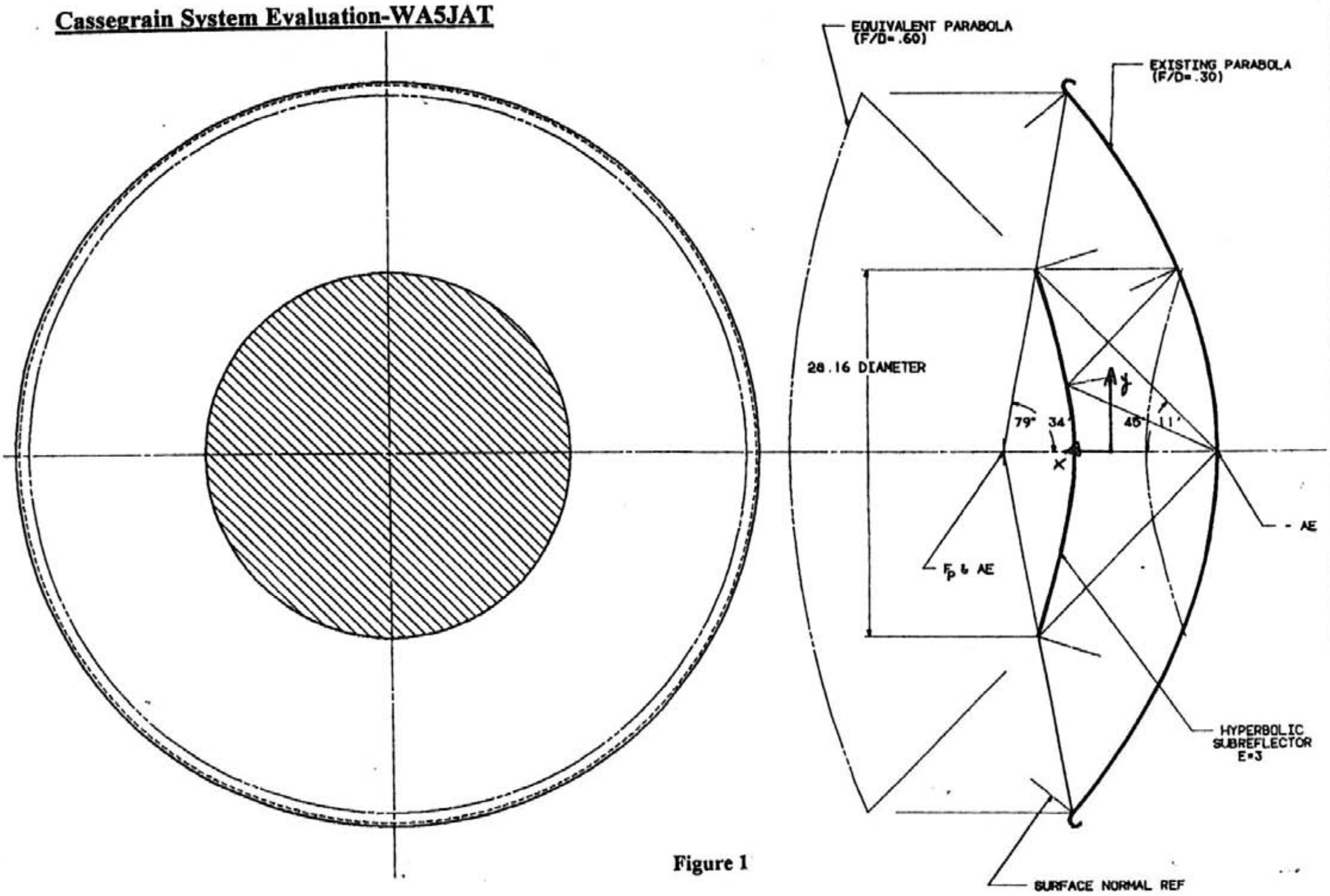
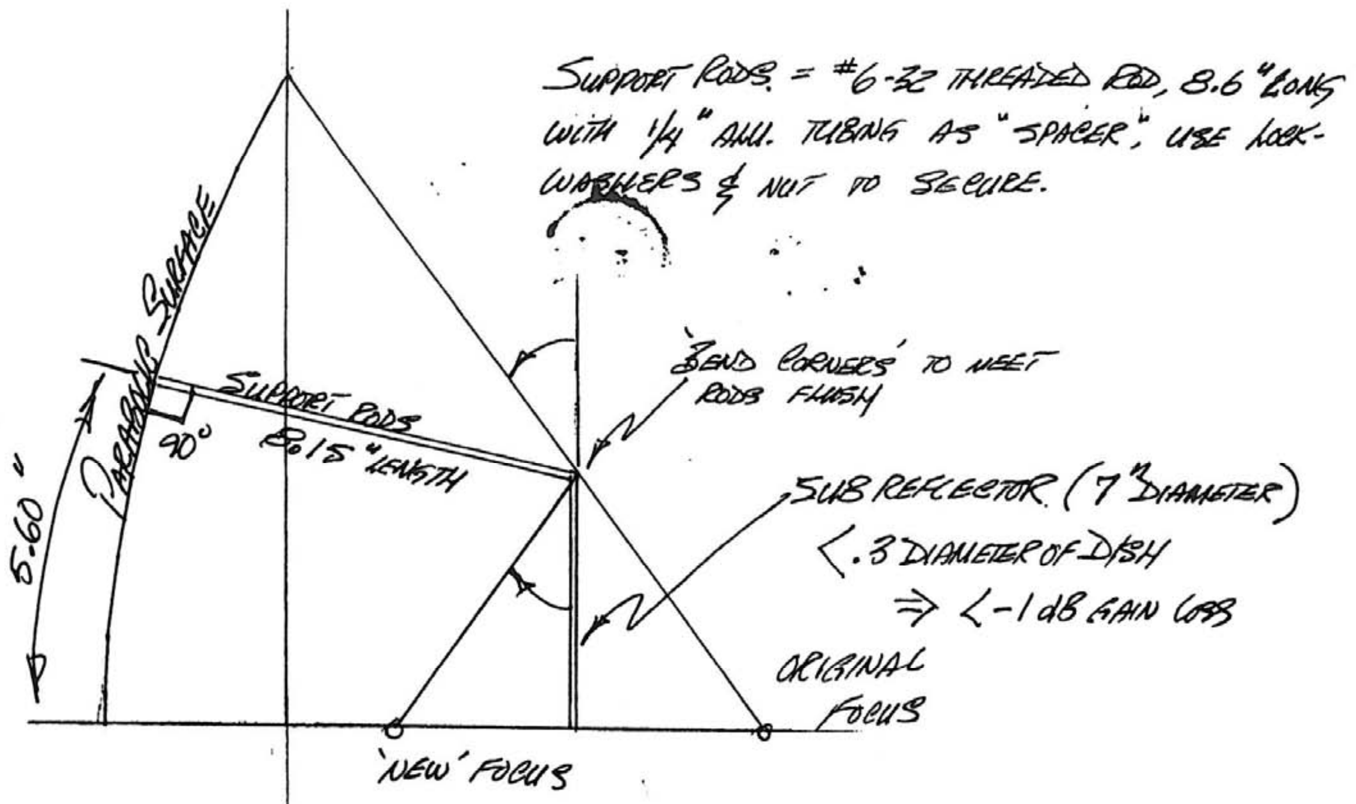


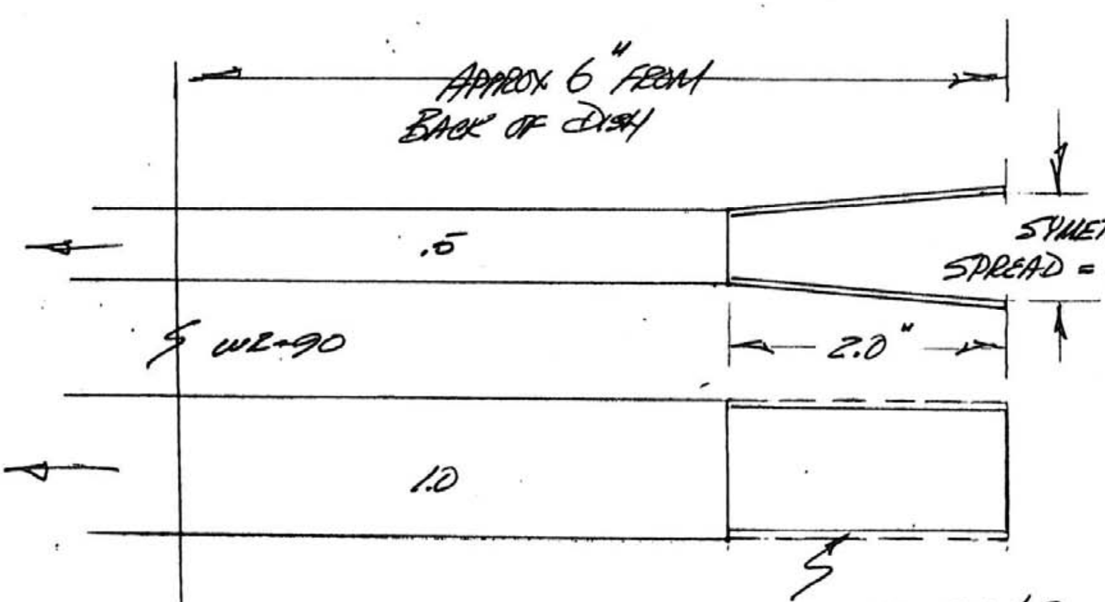
Figure 1

N6CA Dish Subreflector



SIDE VIEW OF DISH

3.5.98 N6CA



- REMOVE TOP & BOTTOM OF GUIDE
- REPLACE TOP & BOTTOM WITH NEW COPPER AFTER SPREADING - SOLDER.

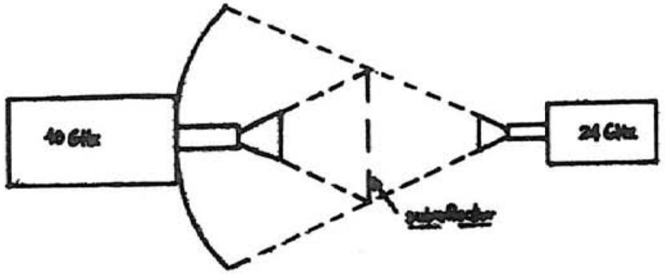
10GHz FEED FOR FLAT SUB-REFLECTOR 23" DISH.

f/d ≅ .49

3.5.98 N6CA

The combined 10/24 GHz feeder design from PAoJGF

When you are working on 24 GHz the beam angle of the dish is always very small and it is sometimes very difficult to aim the dish in the right direction. By using a combination feed for 10 and 24 GHz it is possible to allign the dish first on 10 GHz. The error on 24 GHz allignment will be very small and most probably within the 24 GHz beamwidth.The principle is to use a Cassegrain feed for 10 GHz with a special subreflector. The subreflector will reflect the 10 GHz signal to the dish. On 24 GHz the principle is to illuminate the dish as a prime focus feed. The subreflector is in front of the 24 GHz prime focus feed but due to the special designed patern of holes in the subreflector the 24 GHz signal will pass the subreflector with almost no extra loss.

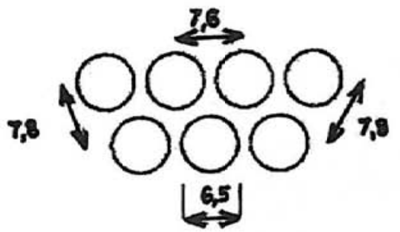


Principle of the combined 10 and 24 GHz feeder. The 10 GHz signal is reflected to the dish and works like a Cassegrain system.

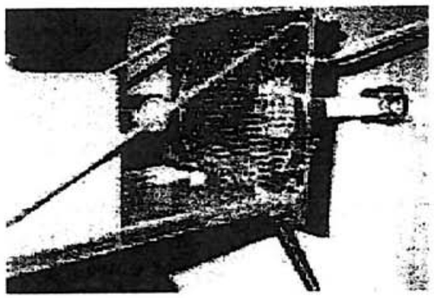
The 24 GHz signal passes the subreflector with very little loss and illuminates the dish as a prime focus feed.

Construction of the subreflector:

The subreflector is made of 2 mm aluminum with an accurate drilled pattern in it. The pattern is made by drilling holes of 6.5 mm with exact distances between the holes. Using a subreflector of 1/5 times the diameter of the dish gives a subreflector diameter of 16 cm with a 80 cm dish. This means that in the subreflector about 800 holes must be drilled with most accurate precision. The subreflector can be mounted in front of the dish but must be alligned very carefully. After the allignment of the total system the gain on 24 GHz is almost the same as a prime focus feed.



This is a picture from the multiband 10/24 GHz feeder made by Jan PAoJGF.



Theoretical explenation how this subreflector works:

The RF signal is an electromagnetic wavefront travelling trough space. The wavefront consists of an H component and a E component. Each of the holes of the subreflector act as a round piece of waveguide. The diameter of the hole must be designed to act as waveguide for 24 GHz but as reflector on 10 GHz. For 10 GHz the hole diameter will behave as a waveguide below its cutt-off frequency. Therefore it will reflect the 10 GHz signal. The cutt-off frequency of this subreflector is arround 13.5 GHz. For 24 GHz the total radiation pattern after passing the subreflector is formed by summing the energy of each individual hole. When the subreflector is good positioned in front of the 24 GHz feed it will not cause extra losses. In this way an ideal multiband feed for 10 and 24 GHz can be realised. The mechanical constraints however can be quite high and will demand very accurate work. Practical results of this design give a performance very close to theoretical maximum values.

Periscope Antenna Systems

ARRL Antenna Book

One problem common to all who use microwaves is that of mounting an antenna at the maximum possible height while trying to minimize feed-line losses. The higher the frequency, the more severe this problem becomes, as feeder losses increase with frequency. Because parabolic dish reflectors are most often used on the higher bands, there is also the difficulty of waterproofing feeds (particularly waveguide feeds). Inaccessibility of the dish is also a problem when changing bands. Unless the tower is climbed every time and the feed changed, there must be a feed for each band mounted on the dish. One way around these problems is to use a periscope antenna system (sometimes called a "flyswatter antenna").

The material in this section was prepared by Bob Atkins, KA1GT, and appeared in *QST* for January and February 1984. Fig 71 shows a schematic representation of a periscope antenna system. A plane reflector is mounted at the top of a rotating tower at an angle of 45°. This reflector can be elliptical with a major to minor axis ratio of 1.41, or rectangular. At the base of the tower is mounted a dish or other type of antenna such as a Yagi, pointing straight up. The advantage of such a system is that the feed antenna can be changed and worked on easily. Additionally, with a correct choice of reflector size, dish size, and dish to reflector spacing, feed losses can be made small, increasing the effective system gain. In fact, for some particular system configurations, the gain of the overall system can be greater than that of the feed antenna alone.

Gain of a Periscope System

Fig 72 shows the relationship between the effective gain of the antenna system and the distance between the reflector and feed antenna for an elliptical reflector. At first sight, it is not at all obvious how the antenna system can have a higher gain than the feed alone. The reason lies in the fact that, depending on the feed to reflector spacing, the reflector may be in the near field (Fresnel) region of the antenna, the far field (Fraunhoffer) region, or the transition region between the two.

In the far field region, the gain is proportional to the reflector area and inversely proportional to the distance between the feed and reflector. In the near field region, seemingly strange things can happen, such as decreasing gain with decreasing feed to reflector separation. The reason for this gain decrease is that, although the reflector is intercepting more of the energy radiated by the feed, it does not all contribute in phase at a distant point, and so the gain decreases.

In practice, rectangular reflectors are more common than elliptical. A rectangular reflector with sides equal in length to the major and minor axes of the ellipse will, in fact, normally give a slight gain increase. In the far field region, the gain will be proportional to the area of the reflector. To use Fig 72 with a rectangular reflector, R^2 may be replaced by A/π, where A is the projected area of the reflector. The antenna pattern depends in a complicated way on the system parameters (spacing and size of the elements), but Table 21 gives an approximation of what to expect. R is the radius of the projected circular area of the elliptical reflector (equal to the minor axis radius), and b is the length of the side of the projected square area of the rectangular reflector (equal to the length of the short side of the rectangle).

For those wishing a rigorous mathematical analysis of this type of antenna system, several references are given in the bibliography at the end of this chapter.

Mechanical Considerations

There are some problems with the physical construction of a periscope antenna system. Since the antenna gain of a microwave system is high and, hence, its beamwidth narrow, the reflector must be accurately aligned. If the reflector does not produce a beam that is horizontal, the useful gain of the system will be reduced. From the geometry of the system, an angular misalignment of the reflector of X degrees in the vertical plane will result in an angular misalignment of 2X degrees in the vertical alignment of the antenna system pattern. Thus, for a dish pointing straight up (the usual case), the reflector must be at an angle of 45° to the vertical and should not fluctuate from factors such as wind loading.

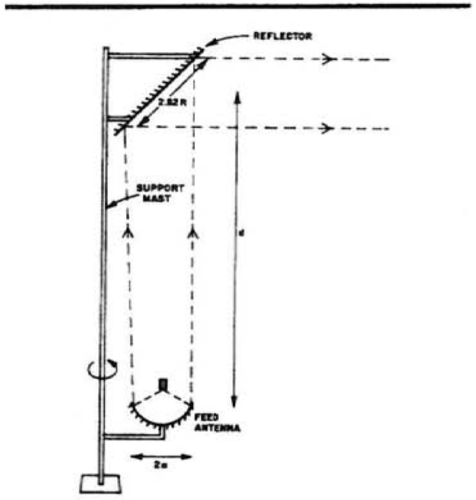


Fig 71—The basic periscope antenna. This design makes it easy to adjust the feed antenna.

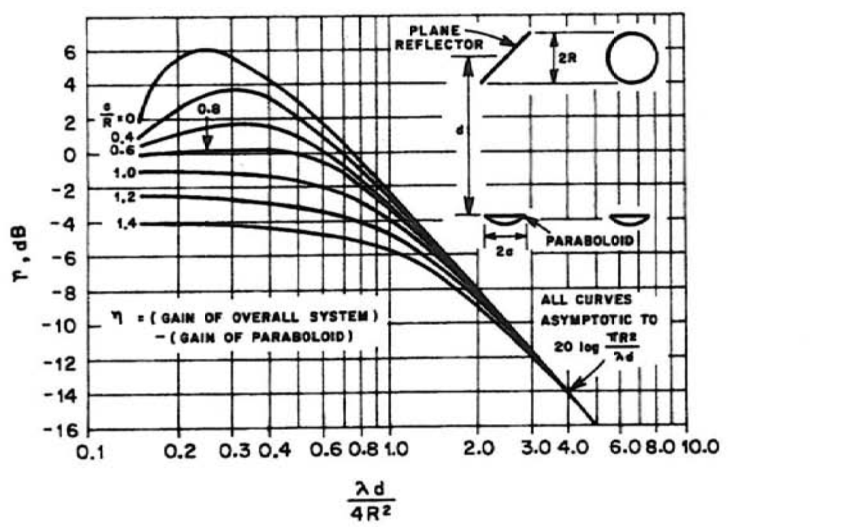


Fig 72—Gain of a periscope antenna using a plane elliptical reflector (after Jasik—see bibliography).

The reflector itself should be flat to better than $^1/_{10}$ λ for the frequency in use. It may be made of mesh, provided that the holes in the mesh are also less than $^1/_{10}$ λ in diameter. A second problem is getting the support mast to rotate about a truly vertical axis. If the mast is not vertical, the resulting beam will swing up and down from the horizontal as the system is rotated, and the effective gain at the horizon will fluctuate. Despite these problems, amateurs have used periscope antennas successfully on the bands through 10 GHz. Periscope antennas are used frequently in commercial service, though usually for point-to-point transmission. Such a commercial system is shown in Fig 73.

Circular polarization is not often used for terrestrial work, but if it is used with a periscope system there is an important point to remember. The circularity sense changes when the signal is reflected. Thus, for right hand circularity with a periscope antenna system, the feed arrangement on the ground should produce left hand circularity. It should also be mentioned that it is possible (though more difficult for amateurs) to construct a periscope antenna system using a parabolically curved reflector. The antenna system can then be regarded as an offset fed parabola. More gain is available from such a system at the added complexity of constructing a parabolically curved reflector, accurate to $^1/_{10}$ λ.

Table 21
Radiation Patterns of Periscope Antenna Systems

	Elliptical Reflector	*Rectangular Reflector*
3-dB beamwidth, degr	60 λ/2R	52 λ/b
6-dB beamwidth, degr	82 λ/2R	68 λ/b
First minimum, degr from axis	73 λ/2R	58 λ/b
First maximum, degr from axis	95 λ/2R	84 λ/b
Second minimum, degr from axis	130 λ/2R	116 λ/b
Second maximum, degr from axis	156 λ/2R	142 λ/b
Third minimum, degr from axis	185 λ/2R	174 λ/b

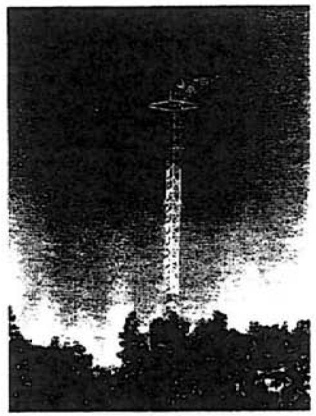


Fig 73—Commercial periscope antennas, such as this one, are often used for point-to-point communication.

CALCUL DES PARAMETRES D'UNE PARABOLE OFFSET

CJ 99

par Julien et Jean-Pierre MORIZET F5OAU

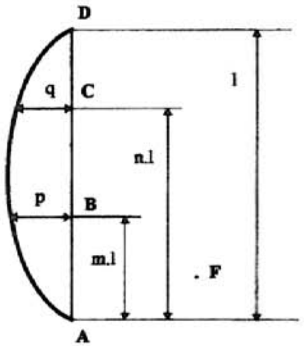
On peut assez facilement récupérer des paraboles de type offset. Toutefois s'il manque la source et son support, il est difficile de retrouver la position du foyer et la distance focale.

Pour y arriver facilement voici un programme écrit en GWBASIC. On aurait pu faire plus moderne avec une feuille de calcul EXCEL ; ce sera pour une prochaine fois.

Pour utiliser ce programme il faut au préalable mesurer certaines dimensions de la parabole.

Tout , d'abord il faut repérer le plan de symétrie de la parabole en se référant à certains indices : trous de fixation, marques du support de la source sur la peinture...

Ensuite dans ce plan de symétrie mesurer la corde et la profondeur de la parabole en deux points B et C au 1/3 et 2/3 de la corde par exemple.



l : longueur de la corde AD

p, q : profondeurs de la parabole aux distances m.l et n.l du bord de la parabole

0<m<n<1

F : foyer

Lancer le programme GWBASIC et entrer les données l, longueur de la corde, p et q profondeurs aux distances m.l et n.l. (m = 0.333 et n = 0.667 si on a mesuré les profondeurs aux 1/3 et 2/3 de la corde). l,p,q sont à exprimer avec la même unité, m et n sont des nombres sans dimension.

Le programme trace la parabole à l'écran et affiche les paramètres :

- angle d'offset (angle axe parabole avec AD, 90° si axe perpendiculaire à AD)

- position du foyer en x et y avec comme repère : A origine, AD axe Oy et Ox perpendiculaire à Oy

- position du foyer donnée par les longueurs FA et FD

- distance focale f

- angle AFD (illumination de la parabole)

Pour vérifier qu'on ne s'est pas trompé dans les mesures et que la parabole n'est pas un patatoïde de révolution, mesurer les profondeurs en 3 points (à l/4, l/2, 3l/4 par exemple) et calculer les paramètres successivement en utilisant les couples de points l/4 et l/2, l/4 et 3l/4, l/2 et 3l/4 ; si on trouve à peu près la même chose ça a de bonnes chances d'être juste.

Le programme marche bien entendu avec les paraboles prim-focus ; cela peut être très utile quand la profondeur au centre de la parabole ne peut être déterminée avec précision.

Nota 1 : On peut aussi trouver la position du foyer par un procédé optique : on dirige la parabole vers le soleil de manière à focaliser la lumière du soleil en une tache ronde la plus petite possible sur un petit morceau de carton par exemple (comme avec une loupe). Il faut à la fois jouer sur l'orientation de la parabole et la position du morceau de carton. Attention ça chauffe et même ça brûle : en faisant la manip avec F5EJZ, nous avons réussi à enflammer du carton épais avec une parabole de 1m de diamètre bien que la parabole de couleur orange n'était pas très réfléchissante.

Nota 2 : La méthode consistant à parler devant la parabole en cherchant la position où l'écho est le plus fort ne donne pas le foyer mais vraisemblablement un point situé à 2f. Par contre l'expérience est très amusante surtout devant une grande parabole (diamètre 2m ou plus)

calculs mathématiques : Jean-Pierre et Julien MORIZET

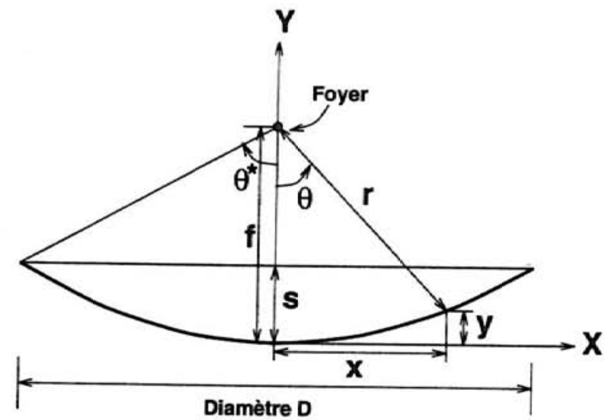
programmation : Julien MORIZET

programme « para4.bas »

```
10 ' Calcul de parabole à partir de 4 points (cas général)
20 ' 31/08/98
30 SCREEN 9
40 ' Faire screen 0 pour revenir au mode initial
41 ' screen 9 sert pour utiliser les instructions graphiques
80 DEFSNG A-Z
85 COL=15:COLOR COL
90 PI=ATN(1)*4
100 CLS
110 GOSUB 2110 'saisie des données
180 IF L<=0 OR P<=0 OR Q<=0 THEN PRINT"l, p et q doivent être positifs":GOTO 2010
185 IF N<=M THEN PRINT "Attention, il faut que n>m":GOTO 2010
186 IF N<=0 OR N>=1 OR M<=0 OR M>=1 THEN PRINT "Il faut 0<m<n<1":GOTO 2010
190 IF Q*M>=P*N OR (1-M)*Q<=(1-N)*P THEN PRINT "Ensemble non convexe":GOTO 2010
200 IF P=Q THEN COL=6:GOSUB 1100:GOSUB 900:GOTO 800
209 'eps=-1 correspond à l'autre parabole
210 'EPS=-1:COL=7:GOSUB 1000:GOSUB 900
220 EPS=+1:COL=6:GOSUB 1000:GOSUB 900
230 GOTO 800
800 COLOR 15:END
900 GOSUB 1040 'calcul de alpha,lambda,mu,f,xf,yf...
905 GOSUB 2200 'affichage des résultats
910 GOSUB 4000 'tracé
920 RETURN
1000 ' p<>q
1010 C=2*L/(P-Q)*(-(N-M)+EPS*SQR((P*N-Q*M)*(Q*(1-M)-P*(1-N))/(P*Q)))
1020 D=L/(P-Q)*(-C*(P*N-M*Q)+L/(P*Q)*(Q*Q*M*(1-M)-P*P*N*(1-N)))
1035 RETURN
1038 '
1040 E=-L
1041 IF C=0 THEN ALPHA=PI/2:GOTO 1045
1042 ALPHA=ATN(2/C)
1043 'IF ALPHA<0 THEN ALPHA=ALPHA+PI
1044 ' ainsi, alpha appartient a ]0,PI[
1045 LAMBDA=(1+C*C/4)^(3/2)/(D-C*E/2)
1050 MU=(C*D/2+E)/(D-C*E/2)
1060 F=ABS(1/(4*LAMBDA))
1070 XXF=-MU/(2*LAMBDA)
1080 YYF=-MU*MU/(4*LAMBDA)+SGN(LAMBDA)*F
1090 XF=1/SQR(C*C/4+1)*(C/2*XXF-YYF)
1091 YF=1/SQR(C*C/4+1)*(XXF+C/2*YYF)
1092 DISTFA=SQR(XF*XF+YF*YF)
1093 DISTFD=SQR(XF*XF+(YF-L)*(YF-L))
```

```
1094 AFBCOS=(XF*XF+(YF-L)*YF)/DISTFA/DISTFD
1095 IF AFBCOS=0 THEN ANGAFB=PI/2:GOTO 1099
1096 ANGAFB=ATN(SGN(AFBCOS)*SQR(1/(AFBCOS*AFBCOS)-1))
1097 IF ANGAFB<0 THEN ANGAFB=ANGAFB+PI
1099 RETURN
1100 ' p=q
1110 C=L/P*(N+M-1)
1120 D=L*L/P*((N+M-1)*(N+M-1)/4-M*N)
1130 RETURN
2000 ' erreurs
2010 END
2100 ' Saisie des données
2110 PRINT TAB(10);"Calcul de parabole à partir de 4 points":PRINT
2120 PRINT"Saisie des données (entrer 0 pour finir)"
2130 INPUT"    l ";L
2135 IF L=0 THEN END
2140 INPUT"    p ";P
2145 IF P=0 THEN END
2146 INPUT"    m ";M
2150 INPUT"    q ";Q
2155 IF Q=0 THEN END
2156 INPUT"    n ";N
2170 PRINT
2180 RETURN
2198 '
2199 ' Affichage des résultats
2200 COLOR COL
2201 PRINT "Angle (degrés)          = ";ALPHA*180/PI
2210 PRINT "Focale                 = ";F
2220 PRINT "Coordonnées du foyer :  x = ";XF
2230 PRINT "                        y = ";YF
2231 PRINT "Distance FA             = ";DISTFA
2232 PRINT "Distance FD             = ";DISTFD
2233 PRINT "Angle AFD               = ";ANGAFB*180/PI
2240 PRINT
2245 RETURN
3998 '
3999 ' tracé
4000 XG=480:YG=150
4004 LINE(XG-150,YG)-(XG+150,YG),8
4005 LINE(XG,YG+50)-(XG,YG-150),8
4060 '
4070 FOR XX=-200 TO 200 STEP .2
4080  YY=(LAMBDA*XX+MU)*XX
4090  X=1/SQR(1+C*C/4)*(C/2*XX-YY)
4100  Y=1/SQR(1+C*C/4)*(XX+C/2*YY)
4110  IF XG+X>=0 AND XG+X<700 AND YG-Y>0 AND YG-Y<500 THEN PSET(XG+X,YG-Y),COL
4120 NEXT XX
4121 XXO=-MU/(2*LAMBDA)
4122 YYO=-MU*MU/(4*LAMBDA)
4123 XO=1/SQR(1+C*C/4)*(C/2*XXO-YYO)
4124 YO=1/SQR(1+C*C/4)*(XXO+C/2*YYO)
4125 LINE(XG+XF,YG-YF)-(XG+XO,YG-YO),COL
4200 PSET(XG,YG),2
4210 PSET(XG,YG-L),2
4220 PSET(XG-P,YG-M*L),2
4230 PSET(XG-Q,YG-N*L),2
4250 PSET(XG+XF,YG-YF),4
4260 PSET(XG,YG-M*L),2
4270 PSET(XG,YG-N*L),2
4490 RETURN
```

Géométrie d'une parabole prime-focus



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

$$r = \frac{2f}{1+\cos\theta}$$

$$x = 2f\tan\frac{\theta}{2}$$

$$f = \frac{D^2}{16s}$$

3.2 LENTILLES

Part 3–Lens antennas and microwave antenna measurements.

By Paul Wade, N1BWT

(From *QEX*, November 1994)

In the previous parts of this series we discussed horn antennas and parabolic dish antennas. We now turn our attention to the third type of practical microwave antennas: lenses. I'll also describe microwave antenna measurement techniques and conclude with a discussion of actual measurement results and a comparison of the three types of antennas.

Lens Antennas

For portable microwave operation, particularly if backpacking is necessary, dishes or large horns may be heavy and bulky to carry. A metal-plate lens antenna is an attractive alternative. Placed in front of a modest-sized horn, the lens provides some additional gain, much like eyeglasses on a near-sighted person. The lens antennas I have built and tested are cheap and easy to construct, light in weight and noncritical to adjust. The *HDL_ANT* computer program makes designing them easy, as well.

There are other forms of microwave lenses—for instance, dielectric lenses and Fresnel lenses—but the metal-plate lens is probably the easiest to build and lightest to carry, so it is the only type I'll describe here.

The metal-lens antenna is constructed of a series of thin metal plates with air between them. The curvature of the edges of the plates forms the lens, and the space between the plates forms a series of waveguides. Fortunately, we can get "air" in a solid form to make construction easier; Styrofoam looks just like air to RF, and it keeps the metal plates accurately spaced. We use aluminum foil for the plates, attaching it to the Styrofoam with spray adhesive and shaping the curvature with a hobby knife on a compass. Designs are limited to those using circles, to ease construction.

Background

These metal-plate lenses were originally described for 10 GHz by KB1VC and me at the 1992 Eastern VHF/UHF Conference, but there is no good reason to limit them to that band.[1] The need for more gain became apparent to us during the 1991 10-GHz Contest. We were atop Burke Mountain in Vermont, on a day as clear as the tourist brochures promise. We could see Mt. Greylock in Massachusetts, where KH6CP was located, but it was too far to work with horn antennas on our Gunnplexers. After K1LPS humped his two-foot dish up the fire tower, we knew that wasn't the best answer for portable work.

Later, we found an article in *VHF Communications* on lens antennas by Angel Vilaseca, HB9SLV, which intrigued us.[2] It described how to design a metal-lens antenna but did not present expected gain or measured results.

We then searched through the references to try to understand how these antennas work, finally discovering that the best work was done before we were born, by Kock.[3] Kock's paper makes it clear how the metal-lens antenna works, and, more importantly, that it *does* work!

Lens Basics

The metal-plate lens works, in principle, like any other lens. A similar optical lens would take a broad beam of light and shape it, by refraction, into a narrower beam.[4] Refraction occurs at the interface of two materials in which light travels at different speeds and changes the direction of travel of the beam of light. If the beam is formed of many rays of light, each one may be bent; the ones at the edge of the beam bend more so they end up parallel to the center rays, which are hardly bent at all. For this to work, each ray must take exactly the same time to travel from its source, at the focal point of the lens, to its destination. Since light travels more slowly in glass, a lens is thicker at the middle, to slow down the rays with a shorter path, and thinner at the edges, to allow the rays with longer paths to catch up, as shown in Fig 1. The needed curvature of the lens to form the beam exactly is an ellipse, but for small bending angles a circle is almost identical to an ellipse, and nearly all optical lenses are ground with spherical curves.

Since light and RF are both electromagnetic waves, we could use glass—or any other dielectric—to make a lens for 10 GHz. For example, a recent article described a dielectric lens made of epoxy resin.[5] But for larger sizes this quickly

[1]Notes appear at the end of this section.

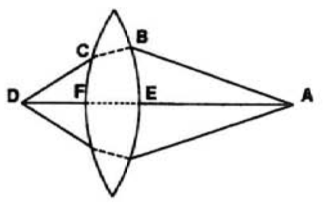


Fig 1—A simple lens. The travel time for each of the rays must be the same, so the time along the line ABCD is the same as that along the line AEFD.

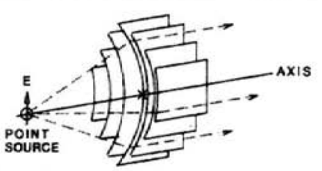


Fig 3—A spherical lens can be formed by a series of spaced plates.

becomes less attractive, and most dielectrics are rather lossy at 10 GHz. Low-loss materials are available but are costly and relatively heavy and difficult to shape.

The Metal-Plate Lens

Since electromagnetic waves travel at different speeds in waveguide and in free space, why not use waveguides of different lengths to form a lens? This has been done and is known as an "eggcrate" lens.[6] However, it is easier to make a group of parallel plates that form wide parallel waveguides, simply shaping the input and output edges of these waveguides to change the path lengths and form the lens surface. This differs from an optical lens in that the phase of the electromagnetic wave travels *faster* in a waveguide than in free space.[7] Thus, the required curvature of a metal lens antenna is the *opposite* of an equivalent optical or dielectric lens—in this case, concave instead of convex. We can still get away with using circular curvatures instead of ellipses as long as we aren't trying to bend the rays too sharply. For that reason, we feed the lens with a small horn, which does part of the beam forming, as shown in Fig 2. Of course, if we want both horizontal and vertical beam shaping, we need a spherical shape, so we must shape the surface described by the edges of the metal plates into a sphere like that of Fig 3.

Lens Design

While the *HDL_ANT* program removes the drudgery from lens design and makes it available to amateurs, a general description of lens design might aid in understanding what is happening and what the computer is telling you.

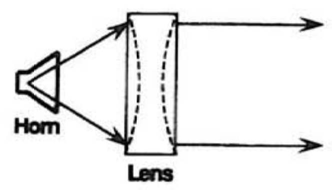


Fig 2—Feeding a lens with a horn lets the horn provide part of the beam shaping.

First, some design objectives are needed: how big a lens is desired, and what are the dimensions of the horn feeding it? Gain is determined by aperture (roughly the diameter for dishes, horns and lenses). A good rule of thumb is that doubling the aperture will increase the gain by 6 dB. For instance, an 8-inch lens in front of a 4-inch horn would add 6 dB to the gain of the horn, and a 16-inch lens would add 12 dB. So, modest gain improvements take modest sizes, but really large gains require huge antennas no matter what kind. However, a 6-dB increase in gain will double the range of a system over a line-of-sight path.

The horn dimensions may be determined by availability, or you may have the design freedom to build the horn as well. The beam width of the horn (which is usually smaller than the physical flare angle of the horn) is used to determine the focal length of the lens. Kraus gives the following approximations for beam width in degrees and dB gain over a dipole:[8]

$$W_{Eplane} = \frac{56}{A_{E\lambda}} \quad \text{(Eq 1)}$$

$$W_{Hplane} = \frac{67}{A_{H\lambda}} \quad \text{(Eq 2)}$$

$$\text{Gain} = 10\log_{10}\left(4.5A_{E\lambda}\,A_{H\lambda}\right) \quad \text{(Eq 3)}$$

where $A_{E\lambda}$ is the aperture dimension in wavelengths in the E-plane, and $A_{H\lambda}$ is the aperture in wavelengths in the H-plane. These approximations are accurate enough to begin designing. From the beam width and desired lens aperture, finding the focal length *f* is a matter of geometry:

$$f = \frac{\text{Lens diameter}}{2\tan\left(\frac{W_{Eplane}}{2}\right)} \quad \text{(Eq 4)}$$

The final and most critical dimension is the spacing of the metal plates. The blue Styrofoam sheets sold as insulation have excellent thickness uniformity, and ³/₄ inch is pretty near optimum for 10 GHz, but the actual dimension should be measured carefully. The thickness determines the index of refraction:

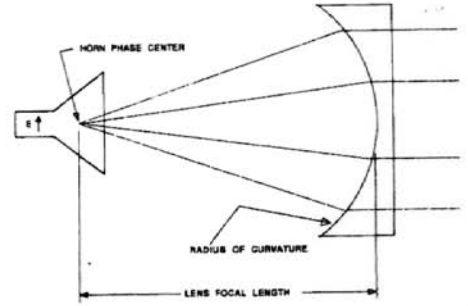


Fig 4—A single-curved lens. The radius of curvature is found using Eq 6, with the radius of the flat side set to infinity.

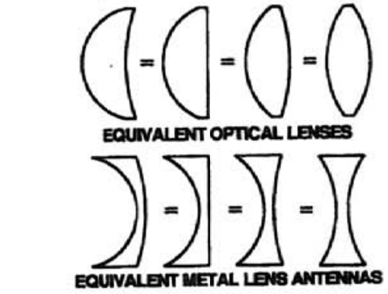


Fig 5—Each of the lenses shown has the same focal length, per Eq 6.

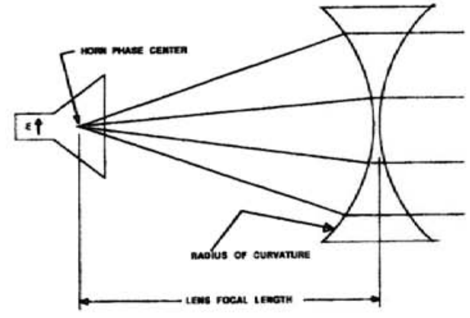


Fig 6—A double-curved lens. *HDL_ANT* provides both single-curved and double-curved lens designs.

$$\text{index} = \sqrt{1-\left(\frac{\lambda_0}{2\times\text{spacing}}\right)^2} \quad \text{Eq 5}$$

which is the ratio of the wavelength in the lens to the wavelength in free space.

Next comes calculation of the lens curvature. The optimum curve is an ellipse, but we know that spherical lenses have been used for optics since Galileo, so a circle is a usable approximation. We can show that the circle is an excellent fit if the focal length is more than twice the lens diameter; photographers will recognize this as an *f*/2 lens. This suggests that the feed horn have a beam width of no more than 28°, or a horn aperture of at least two wavelengths.

The radius of curvature of the two lens surfaces is calculated from the lensmaker's formula (see Note 4):

$$\frac{1}{f} = (\text{index}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad \text{Eq 6}$$

where a negative radius is a concave surface. For the single-curved surface of Fig 4, one radius is set to infinity. All combinations of R1 and R2 that satisfy the formula are equivalent, as shown in Fig 5; the computer program calculates the single-curved and symmetrical double-curved solutions (Fig 6). The radius of curvature calculated above is for the surface, and thus the central plate, which has the full curvature. The rest of the plates must be successively wider and have smaller radii so that the edges of all the plates form a spherical lens surface. This is more geometry, and the program does the calculations for each plate.

The final calculation involves the phase centers of the horn, so that the lens-to-horn distance matches the focal length. This is a difficult calculation involving calculation of Fresnel sines and cosines; KB1VC deserves credit for the programming.[9,10] Without a computer, you would use trial-and-error looking for best gain. What the calculations will show is that many horns, particularly the "optimum" designs, have much different phase centers in the E- and H-planes. The program offers to make a crude compensation for this, but, if possible, the H-plane aperture of the horn should be adjusted slightly to match the phase centers. A few trial runs of the program should enable you to find a good combination. If you already have a horn, either try the compensation or just use the E-plane phase center.

For very large lenses, the size may be reduced by stepping the width of the plates into zones which keep transmission in phase, as shown in Fig 7. The program will suggest a step dimension if it is useful. At 10 GHz, a step is useful only for lenses larger than 2 feet in diameter.

Construction

Construction is straightforward, using metal plates of aluminum foil spaced by Styrofoam, as suggested by HB9SLV (see Note 2). A 2-foot by 8-foot sheet of blue Styrofoam, ³/₄-inch thick, is less than $5 at the local lumberyard and will make several antennas. The aluminum foil is attached to the foam using artist's spray adhesive, available at art supply stores. Spray both surfaces lightly, let them dry for a minute or two, then spread the foil smoothly on the

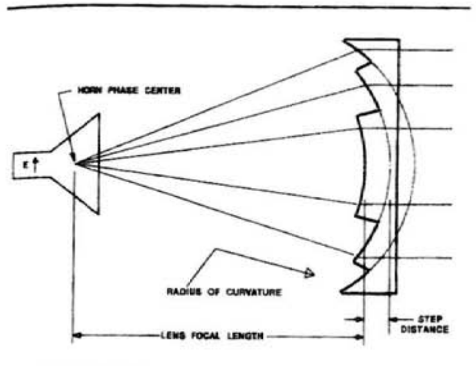


Fig 7—A zoned lens can be used to implement large lenses, reducing the needed thickness.

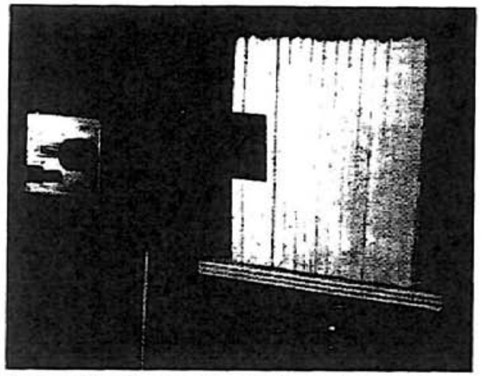


Fig 8—A 300-mm lens placed in front of a Gunnplexer transceiver provides about 10 dB of additional gain over that of the horn alone.

foam. If the adhesive melts the foam, you are using too much.

Next mark the outline of a rectangle for each metal plate on the foil. These will be used later to cut the foam and line up the plates, so they should all be the same size. Then mark the center of each curve and measure off the radius to the center of the circle. Using a compass with a hobby knife attached, place the point at the center of the circle and cut the curve through the foil into the foam. When all the curves are cut, peel off the unwanted foil, leaving the lens plates. Then cut up the rectangles with a razor blade and stack the blocks into a lens. (You did number them, didn't you?) Each rectangle should have foil on one side. If it looks good, glue them up two at a time. The final antenna will be a block of foam—there is no need to shape the foam to the lens curve. Shrink-wrapping the lens with thin plastic makes nice weatherproofing.

A few helpful hints are in order. Sharp knife blades really help in this process, and permanent markers don't smear. Also, if the foam is cut halfway through, it will snap cleanly on the line.

Adjustment

A metal-lens antenna only works in the E-plane. This is parallel to the elements of a dipole or Yagi but perpendicular to the wide dimension of a waveguide. The plates *must* be perpendicular to the wide dimension to provide gain.

The horn should point through the center of the lens, but the focus distance is not as critical as with a dish. Aiming is done by pointing the feed horn; the lens focuses the beam more tightly but does not change the beam direction. Tilting the lens will *not* steer the beam—if you don't believe this, take an optical lens, like a magnifying glass, focus it on something, and tilt it.

We found that the best gain was with the horn slightly closer to the lens than calculated, probably because of edge effects. Making the size of the plates slightly larger than calculated would probably eliminate this effect and make the gain a bit higher; since a wavelength at 10 GHz is about an inch, an inch or two oversize is plenty.

One other interesting effect was found with Gunnplexers: since the transmitter is also the receiver local oscillator, reflected power from the lens adds to the LO power, or subtracts when out-of-phase. This makes the received signal strength vary with every half-inch change in lens-to-horn distance, with very little change in signal strength observed at the other station. So, adjust the spacing for the best received signal. Of course, this effect does not exist on a system with low LO radiation.

Using the *HDL_ANT* Program

The lens section of *HDL_ANT* calculates the dimensions for the plates of a lens. Since all curves are circles that are easily drawn with a compass, templates are not generated. The basic input data is entered interactively, then results are presented in tabular form. If you like the results, they may be saved to a file for printing or further processing; if not, try another run with new data.

All dimensions are in millimeters. There are two reasons for this: the first is that odd fractions lead to errors in measurement, and the second is that one millimeter is a good tolerance for 10-GHz lens dimensions. If all measurements are made to the nearest whole millimeter, good results can be expected. The only exception is in the plate spacing, and that is accurately controlled by the foam thickness.

Results

We have constructed and tested three metal-plate lens antennas to date: a 150-mm single-curved version, and 150-mm and 300-mm double-curved versions. Fig 8 shows the 300-mm lens fed by a WBFM Gunnplexer system, and Listing 1 shows the *HDL_ANT* design of this antenna. All the lenses are designed to be fed with the standard Gunnplexer horn, which has well-matched phase centers, whether by design or by accident. Gain measurements are shown in Table 1. The lenses perform with about 50% efficiency if we consider them as having a round aperture; the corners do not contribute significantly, but we made them square for convenient fabrication and mounting.

We also used the lenses during several contests during 1992, 1993 and 1994. The 300-mm lens increased the range of our WBFM Gunnplexer transceivers by approximately 50%, to over 200 km, enabling contacts over new paths. The equipment was still highly portable due to the light weight of the lens, and they have survived mishaps with only a few harmless dents in the foam.

Further Uses for Metal Lenses

The metal-lens antenna could be useful at other frequencies: for 5.76 GHz a foam thickness of around 35 mm would be good, and at 24 GHz approximately 8-mm-thick foam might work, though it could be lossy at that frequency.

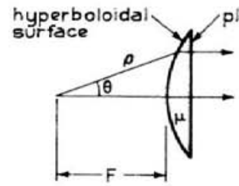
A lens can also be part of a more complex antenna system. For instance, a divergent lens can be used to provide better illumination for some of the very deep dishes that are sometimes available as surplus. A book on optics (such as Note 4) will show how to change the focal points appropriately.

Lens Summary

We have demonstrated that metal-lens antennas may be easily designed and constructed using the *HDL_ANT* computer program and that a book-sized lens, light and rugged enough for backpacking, provides gain enhancement adequate to double the range of a Gunnplexer system.

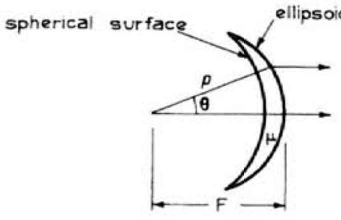
Lentilles diélectriques

μ: Indice de réfraction du matériau diélectrique ($\mu = \sqrt{\epsilon_r}$).



$$\frac{\rho}{F} = \frac{\mu - 1}{\mu \cos\theta - 1}$$

(a) hyperboidal lens



$$\frac{\rho}{F} = \frac{\mu - 1}{\mu - \cos\theta}$$

(b) ellipsoidal lens

Two simple one-surface lenses
a **hyperboidal lens**
b **ellipsoidal lens**

3.3 Sources Monobande pour Paraboles

A PLUMBER'S DELIGHT FEEDHORN FOR 5.7GHz

Microwaves Newsletter

A practical solution to feeding a 1 metre offset dish - designed by Paul, G0HNW

Copper tubing and plumbing fittings can be used at 5.7GHz. They are readily obtainable at plumber's merchants. The outside diameter of the tubing used in my design is 35 millimetres. The matching fittings are measured for inside diameter.

35mm o.d. tubing is just big enough to allow 5.7GHz through. The transition shown in Figure 1 assumes a waveguide wavelength of 17mm.

FIG. 1

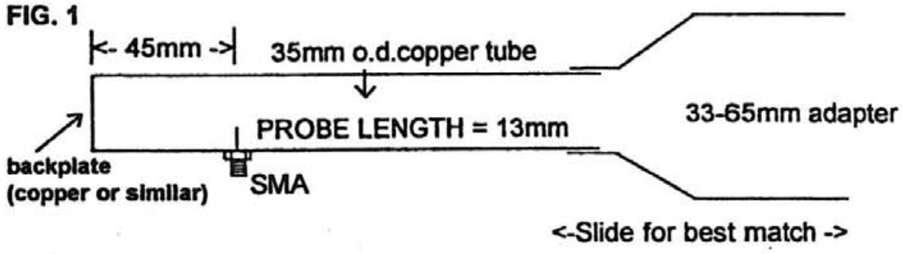


Figure 1 illustrates the main constructional features of the horn feed. The 35-63mm adapter is the largest that is obtainable going directly from 35mm. To use a larger aperture it would be necessary to employ several adapters "in series" and this would make the whole assembly too heavy. The total length of tubing can be any convenient length but the distance from probe to backplate must be as specified.

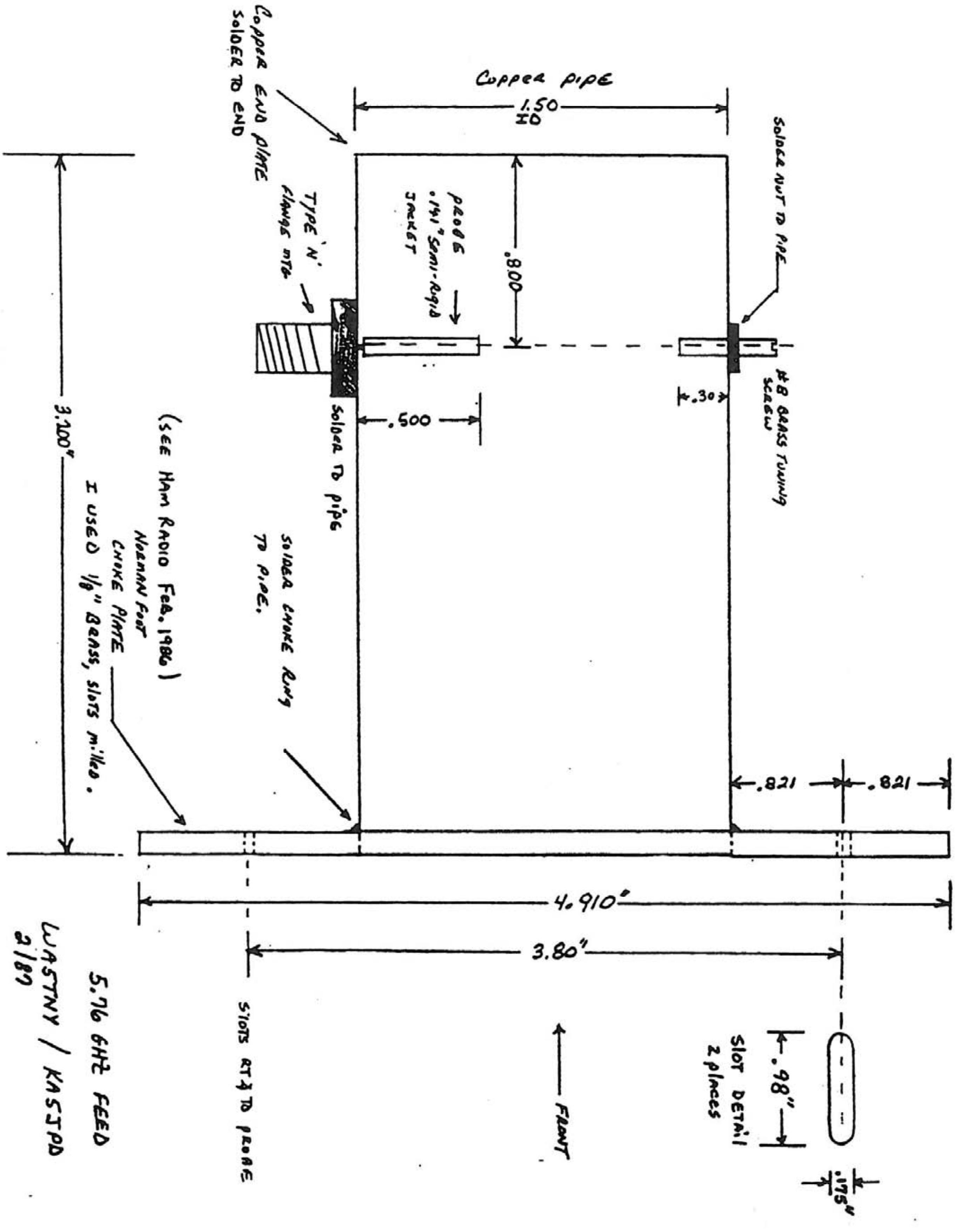
I fabricated a slightly larger horn but it was only marginally better than the 65mm adapter, which is much more robust. If my calculations are correct, 76 mm would produce a scaled version of the popular W2IMU dual mode horn for this band.

Bends of 45 and 90 degrees can be used to go around corners, any polarisation rotation being compensated for by rotating the the transition to produce horizontal radiation. A straight coupler will allow this. When adjustments are completed the assembly should be soldered up, taking care to avoid solder getting inside the feed. "Slotting" one side of the coupler makes an effective socket so that it can be easily removed for transit.

My horn feed produces 4.5dB of Sun noise with a 1 metre diameter offset-fed dish. A triband feed gave only 0.2dB, yes, 0.2dB !

A good match was achieved without the use of matching screws.

(Editor's note: Horn feeds of this type are ideal for dishes with f/D's of around 0.6, which is the case for most ex-Sat TV offset fed types. Many thanks to Paul for this useful article)



Microware Update 91

Penny feed (RSGB)

Microwave Handbook RSGB

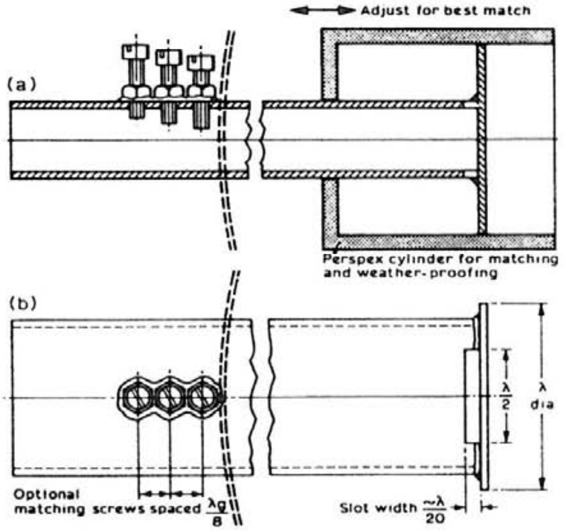


Fig 18.143. Modified Cutler ("Penny") feed (G4ALN)

The feed is made by cutting two appropriately dimensioned grooves in the end of a length of WG16 and soldering on a circular end disc (the "penny"). The length of the slot formed and the diameter of the disc are thought to be not critical within a few percent, and the width of the slots even less so. Signals with standard horizontal polarisation are produced with the broad walls of the waveguide vertical. The feed can be used without any attempt to improve the match – the vswr is typically about 1.5:1. The match may be improved by conventional matching screws fitted behind the dish as shown in the drawing or by means of the Perspex protective and matching sleeve also illustrated there. A professional 610mm (24 inch) dish complete with WG16 feed, designed for 11.1 to 11.2GHz, was acquired. The feed was a version of the feed just described. In the knowledge that this had been designed for use at (nominal) 11,150MHz, on the assumption that a professional designer would not have used this kind of feed had it not been acceptably efficient and in light of reports that this type of feed was not very efficient with certain types of dish, it was decided to make some careful physical measurements of both the dish and feed. The results of these measurements,

Table 18.9. The "Penny" or modified Cutler feed

Measurement:	Professional	G4ALN	Suggested Dimensions
Frequency:	**(11.15GHz)**	**–**	**(10.38GHz)**
Disc diameter	1.25λ (33.36)	1.0λ (28.9)	1.25λ (35.83)
Slot length	0.5λ (13.35)	0.5λ (14.45)	0.5λ (14.34)
Slot width	0.085λ (2.25)	0.05λ (1.45)	0.085λ (2.42)
Scatter pins:			
Diameter	0.08λ (2.1)	None	0.08λ (2.3)
Length	0.1λ (2.8)	None	0.1λ (3.0)

when compared with the original version, are quite interesting and may help to shed some light on the apparent inefficiency of the modified Cutler feed.

First the dish was measured and it "weighed in" with the following characteristics:

Diameter (D)	=	610mm
Depth (C)	=	115mm
Focus (f)	=	202.23mm
f/D ratio	=	0.332

The measurements of C and calculations for f were confirmed by measuring the distance between the detachable feed mounting plate and the *centre of the slots*. Next the feed was examined and a number of interesting points emerged. The feed is illustrated in the dimensioned diagrams (Fig 18.144) and summarised and compared with the original G4ALN dimensions in the following table. Suggested (calculated) dimensions for 10.380GHz are also given (all in mm) in Table 18.9. The most significant differences between the professional feed and G4ALN's version are:

1. The disc is much thicker, about 0.185λ (4.9mm) and this may be significant. "Scaled" for 10.380GHz, this would be 5.26mm.

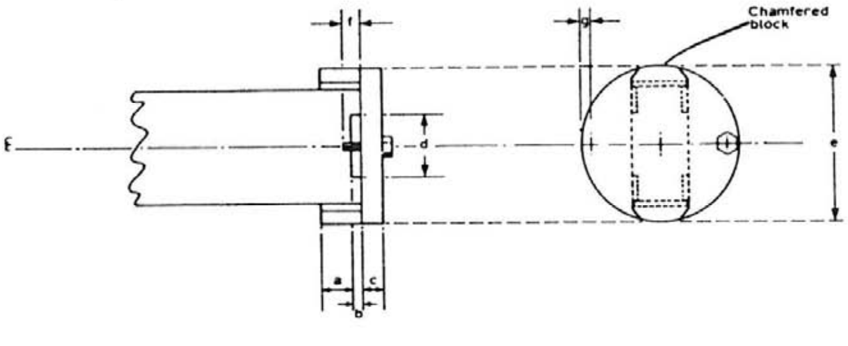


Fig 18.144. Modified "Penny" feed (G3PFR). Dimensions are given in Table 18.9

2. The disc is backed by two chamfered blocks, as shown in the diagrams. It is probable that these, too, have a significant effect on dish illumination.

3. The width of the slots is greater in the professional feed.

4. The presence of two "scatter" pins mounted near the rim of the disc and lying above the midline of the broad face of the guide. Since they were pieces of studding fitted into tapped holes and locked with a lock-nut, they were presumably "tunable" at some stage of assembly.

5. The f/D ratio of the dish is significantly greater than that described in the original text.

Big Dish Feed for 10.3 GHz

By Chuck Steer, WA3IAC
(From *Microwave Update '91*)

This paper describes an easy-to-build dish feed for 10.368 GHz. A feed of this type can be made using a piece of copper water pipe with a piece of brass as the back wall. The feed should be within a proper size for the frequency being used.

Using 0.75-in. ID copper pipe, my initial results were less than desired. This was with a probe about 0.2-in. from the back wall and 0.2-in. long. This type of feed was hard to reproduce with good results. I was able, however, to "tune" for best match by adding a 2-56 × 1-in. screw, 180° from the feed. A typical return loss was −13 to −15 dB.

Recently, I read about a 10-GHz feedhorn built by G4DDK. The odd thing about this feed is that the ID was 1.125-in., the probe was 0.030-in. long, and it was placed about 0.375-in. from the back wall.

Given $TE\,01 = \frac{9034.85}{d\ (\text{inches})}$ and $TE\,11 = \frac{6917.26}{d\ (\text{inches})}$

where d is the ID of the feed, we get:

TE 01 = 7227.88 MHz and
TE 11 = 5533.81 MHz

Given the above calculations, the feed should not work at 10.3 GHz, but rather much lower in frequency. I then wondered if there was not a mistake in the drawings from G4DDK. My first try at duplicating this feed was using pipe with 1.25-in. ID and a probe length of 0.2-in., 0.375-in. from the back wall. My probe was just the center conductor of the 0.141-in. semirigid line, about 3 in. long, with an SMA connector on the other end. This produced a return loss of about −5 dB at 10.3 GHz. The best return loss was at about 12.5 GHz, *higher*, not lower in frequency as calculated. For my next try, I made the probe 0.3 in. long and measured a return loss of −18 dB (1.22:1 SWR). Not bad!

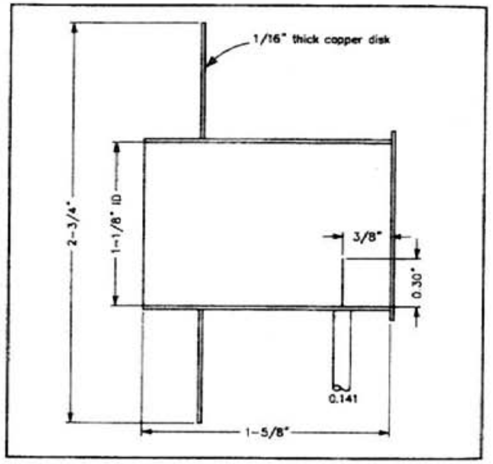


Fig 1—X-band feed for large dish antennas, made from 1.25-in. ID copper pipe.

I have since made three feeds this way and they all worked well. The worst return loss was −15 dB and the best was about −30 dB.

Next came the choke ring. I stayed with the G4DDK feed and made the outside diameter of the choke plate 2.75-in. and the inside diameter to just fit the OD of the copper pipe. The next step is to adjust the choke ring position for best gain. Start with the choke plate about 0.5-in. from the open end of the feed and move it away from the open end.

Alimentation "feed back" (f1DXI)

Alain, F6 BNN ayant mis à ma disposition une parabole de 30 cm de diamètre qui, mesures prises, devait avoir un F/D peu différent de 0,5, le problème consistait à réaliser une source adaptée, c'est-à-dire $\theta = 2 \times 53°$ d'ouverture à − 10 dB . Ceci n'est qu'une évaluation simpliste, mais plus que suffisante pour une station OM. Les résultats obtenus restent remarquablement bons.

Le gain théorique d'un aérien parfait possédant cette surface de capture est :

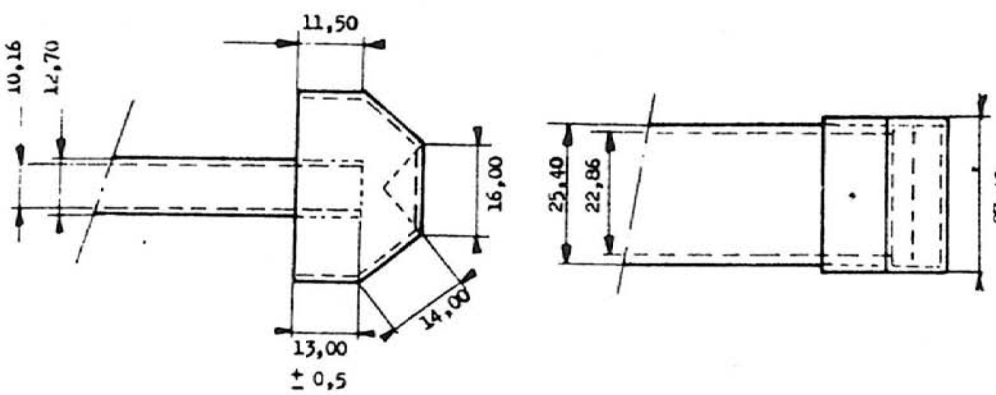
$G_p = \frac{4\pi S}{\lambda^2}$ soit dans notre cas 1.056,2. $G_{dB} = 10 \log_{10} G_p = 30{,}2$ dB

Considérant un rendement de 50 % soit − 3 dB, cette parabole correctement illuminée devait apporter un gain/iso d'environ 27 dB .

A ce propos, il est bon de noter que l'angle d'ouverture de la source à 10 dB est toujours supérieur à l'angle de rayonnement de l'aérien complet à 10 dB.

Théoriquement, l'angle est identique si la source est repoussée à l'infini, ce qui dans la pratique n'offre aucun intérêt.

Lors d'une visite chez William , F6 DLA, j'ai pu prendre les dimensions d'une alimentation feed back alimentant une parabole de F/D ≈ 0,45.



J'ai rapidement réalisé cette pièce en cuivre épaisseur 10/10 et entamé les premières mesures

Extrait du bulletin du 10 GHz

The RCA DSS Dish

The original incentive to use an offset-feed dish was provided by Zack Lau, KH6CP, who pointed out that the 18-inch RCA DSS dishes are available by mail order for about $13.[5] I ordered a dish and a mounting bracket to see if I could figure out how to use one at 10 GHz.[6] When it arrived, it wasn't obvious where the feed point should be, so I took a trip to a local discount store to eyeball the system on display.

Now I had an idea where to put the feed, but not the exact location. The RCA reflector is oval shaped, but Ed, W2TTM, provided the needed insight: the dish aperture should appear circular when viewed on boresight, as shown in Fig 1. Thus the dish must be tilted forward for terrestrial operation. Although the reflector is an oval, the effective antenna aperture is the projected circle, with a diameter equal to the small dimension of the oval, 18 inches for the RCA dish. The tilt angle, feed point location and the rest of the dish geometry can be calculated—see the Appendix for the procedure. Version 2 of the *HDL_ANT* computer program will do these calculations. This program is available from the ARRL BBS (860-594-0306) or via the Internet at **http://www.arrl.org/qexfiles/hdl_ant2.zip** or **ftp://ftp.arrl.org/pub/qex/hdl_ant2.zip**.

The calculations show the focal length of the RCA dish to be 11.1 inches. If the dish were a full parabola rather than just an offset section, the diameter would be about 36 inches, for an *f/D* of 0.30, which would require a feed with a very broad pattern. However, a feed horn need only illuminate the smaller angle of the offset section, a subtended angle of about 77°. This subtended angle is the same as a conventional dish with an *f/D* of 0.7, so a feed horn designed for a 0.7 *f/D* conventional dish should be suitable. Rectangular feed horns have been shown to work well with offset reflectors and are readily designed to illuminate an *f/D* this large.[7] I used G3RPE's graph for rectangular feed horn design and the *HDL_ANT* computer program to design suitable rectangular horns.[8,9] I made two of different lengths from flashing copper. Subsequently, I added an approximation to G3RPE's curves to version 2 of *HDL_ANT* so the program can design feed horns for both offset and conventional dishes as well as generate templates for them.

Since the actual reflector geometry has an *f/D* of 0.30, the focal distance should be quite critical. As explained in Part 2 of my previous *QEX* series, this dimension is the most critical for dish antenna performance—even more critical for reflectors with smaller *f/D*—so the phase center of the feed should be positioned within a quarter-wavelength of the focal point. The RCA dish must be tilted forward to an angle of 66.9° from horizontal for terrestrial operation with the beam on the horizon. In this orientation, the focal point is just below the lower rim of the dish, so the feed horn is out of the beam. To locate the focus accurately, I calculated the distance to both the top and bottom of the rim, tied a knot in a piece of string and taped the string to the rim so the knot was at the focus when the string was pulled taut, as shown in Fig 4. Then I made a sliding plywood holder for the feed horn, taped it in place and adjusted it so that the knot in the string was at the phase center of the horn, about 6 mm inside the mouth of the horn, shown in Fig 5. (For visibility, the string in the photograph is much heavier than the kite string I used so a small knot could locate the focus more accurately.) Materials aren't critical when they aren't in the antenna beam!

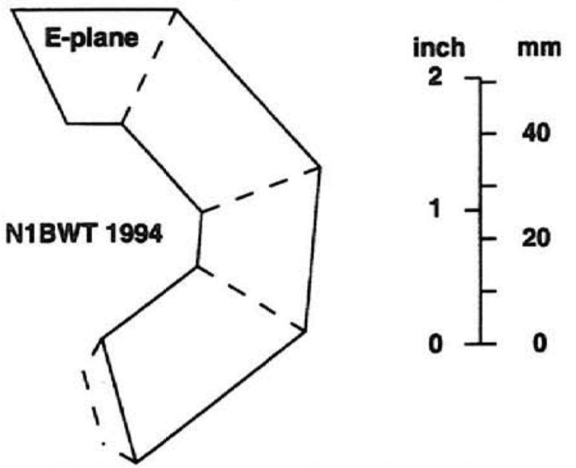


Fig 6—Template for a 10-GHz feed horn that can be used with the RCA DSS offset dish.

Where should the feed horn be aimed? On a conventional dish it is obvious—at the center. However, an offset feed is much closer to one edge of the dish, so that edge will be illuminated with much more energy than the opposite edge. I read an article that did a lengthy analysis of the various aiming strategies and then suggested that small variations have little effect, so aiming at the center of the reflector is close enough.[10]

After all this analysis, it was time to see if the offset dish really works. We (W1RIL, WB1FKF, N1BAQ, and N1BWT) set up an antenna range and made the measurements shown in Table 1. The RCA dish with a simple rectangular feed horn measured 63% efficiency at 10 GHz, significantly higher than we've *ever* measured with an 18-inch conventional dish. Varying the focal distance showed that the calculations were correct and that this dimension is critical. Fig 6 is a template produced by the *HDL_ANT* program for the rectangular feed horn that gave the highest efficiency, and Fig 7 is a photograph of the feed horn I made with the template.

The higher efficiency of the offset-feed dish is mainly due to reduced blockage by the feed and supporting structure. Fig 8 is a photograph of a conventional dish while measuring sun noise, so that the shadow of the feed demonstrates the actual area blocked—neither light nor RF energy from the sun is reaching the reflector. Fig 9 is a photograph of the RCA offset dish peaked on the sun to measure sun noise; note that the shadow of the feed is only a tiny area at the bottom edge. Remember that these feed horns provide a tapered illumination, so the energy illuminating the center of the reflector is typically 10 dB stronger than at the edge. Thus, central blockage in a conventional dish is *ten times* worse than the same area blocked at the edge of an offset dish, and the photographs clearly illustrate how much more blocked area there is in a conventional axial-feed dish.

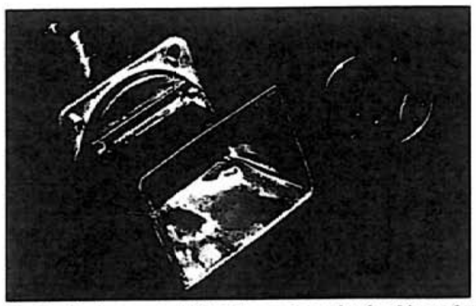


Fig 7—Photograph of 10 GHz rectangular feed horn for RCA DSS offset dish made using template in Figure 6.

Preparing to Receive Phase 3D's 10.4-GHz Downlink: A Project Study Report

Here's a project to keep you busy while awaiting Phase 3D's ascent. The dishes described are compact and easy to disguise.

By Josef Maier, OE3JIS

Editor's Note: This article also appears in the AMSAT-NA Journal *(Sep / Oct, 1998). Thanks to AMSAT-NA for permission to reprint it here.*

This project was carried out in my preparation for my ground station to receive 3-cm downlink signals from the Phase 3D satellite. I was curious enough about new X-band technology to identify components that are already available on the market for Phase 3D use. These components are relatively small in size and are so compact that in my case, I was able to install the components in an existing transceiver.

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Layout Basics

According to various AMSAT publications and previous studies, we can expect the Phase 3D frequencies shown in Table 1 for Mode X. Note that below 1 GHz, transmission and reception of space microwave signals are disturbed by cosmic-noise signals and above 15 MHz through absorption from atmospheric water vapor, water content and oxygen. However, the 10.4-GHz band is relatively free from these effects. Also, a lot of experience in the 11-12 GHz range exists from European satellite television technology for similar bands and also for the necessary equipment.

Microwave Antennas

The reception of 10.4 GHz signals requires high-gain antenna dishes, which usually must be home constructed. The following dish-construction options are available:

A) Parabolic dishes with central reception/transmission feeds.

B) Parabolic dishes with offset reception/transmission feeds

C) Dishes with indirect feed constructions (ie, Cassegrain, Gregorian and other backfire systems)

For amateur reception purposes, the first two (A and B) options are most interesting, and these are the ones that I have realized, tested and report in this article. Fig 1 shows the approximate relationship between power gain, dish diameter (Option A) and 3-dB beamwidth in degrees for 10.4 GHz.

Bigger dishes yield higher gains and narrower beamwidths, so they require more-precise directional control to track a satellite's position. Therefore the dish should be as small as possible for a good signal reception. In addition, smaller dishes have lesser wind loads. (See Table 2.)

Table 1—Preliminary Phase 3D 10-GHz Specifications

Downlink Frequencies
Analog: 10,451.025 MHz to 10,451.275 MHz with center at 10,451.150 MHz
Digital: 10,451.450 MHz to 10,451.750 MHz

Satellite Transponder
PEP transponder: 50 W
Satellite antenna gain: 20 dBi
Satellite EIRP: 37 dBWi
PEP per QSO: 24 dBWi
Path loss: 207 dB
Ground station EIRP: −183 dBWi

Ground Station Options
Station 1: 60 cm (2ft) dish
Gain: 33 dBi
Signal Power/QSO: −150 dBWi
Noise Temp 150K: 1.5 dB NF
Noise Power in SSB: −173 dBW
Signal-to-Noise Ratio: 23 dB
Station 2: 30 cm (1 ft) dish
Gain: 27 dBi
Signal Power/QSO: −156 dBWi
Noise Power in SSB: −173 dBwi
Signal-to-Noise Ratio: 17 dB

Meanwhile an offset dish uses a section of the parabolic shape that is not symmetric about the centerline. Fig 2 shows the center cross-section view of such a dish. This construction has several advantages:

- No feed shadow on the dish
- No reduction in gain
- Easier to construct and t adjust the exact focus point
- Flexibility for future installation of a second feed for other bands.

The offset of the focal point is less critical for adequate performance. This makes it possible to place a second feed (for another band) on the

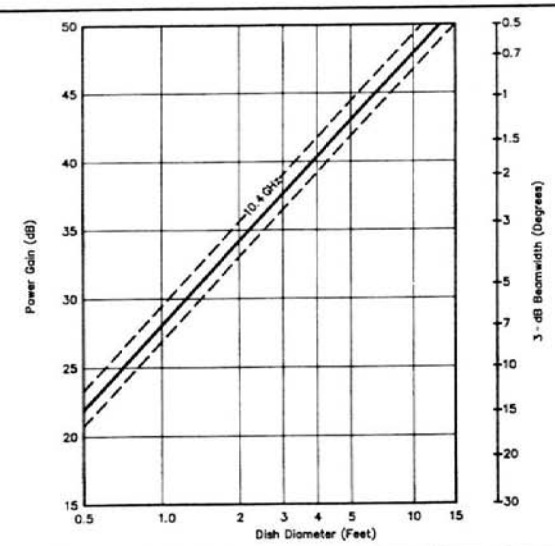


Fig 1—Relation between gain, dish diameter and 3-dB beamwidth (in degrees) for 10.4 GHz.

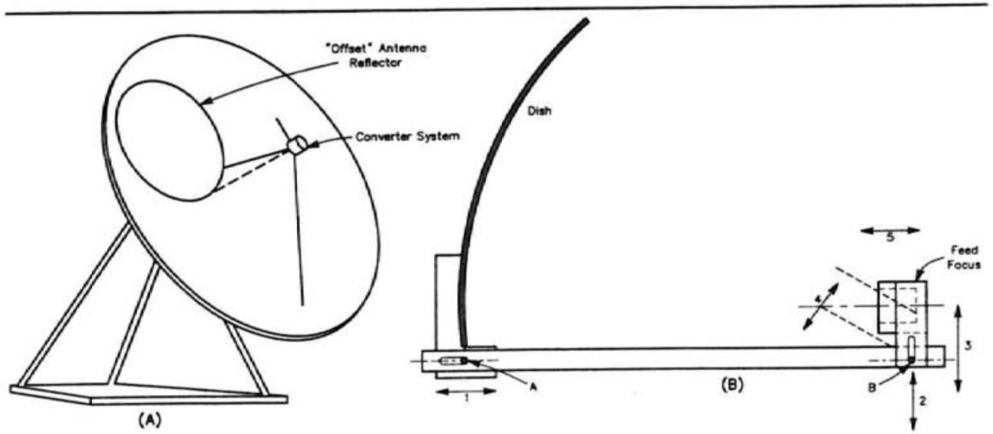


Fig 2—A shows the derivation of an offset-feed dish from a center-fed dish. B shows how an offset-feed may be adjusted. Arrows labeled 1 through 5 indicate possible focal point adjustments. Joints A and B swivel in the plane of the drawing.

same dish. In addition, small surface irregularities (holes or bolt heads) have no noticeable effect on the efficiency of the dish. The relation of focal length and dish diameter is essential for the feed construction. The feed must have a beamwidth that illuminates the dish from edge to edge, typically at the –10-dB points. If the beamwidth is too narrow, not all of the dish area is illuminated.

There are dishes made of metal-mesh constructions suitable for the frequency in use. For the 10.4-GHz band, there is no advantage for such dishes. For my experiments, I used industrially prefabricated aluminum dishes that are relatively inexpensive and available on the market.

Remarks about Microwave Transmission Lines

In the microwave bands, energy transport is done on the surface of conductors in thin layers. This is well known as the *skin effect* of metal conductors. Coax cables have extremely high losses in microwave bands; that is the reason why waveguides are used. The cross section of this guide can be rectangular, round or other shapes. The section surface is essential for the way that energy propagates down the waveguide. These different kinds of propagation are referred to as *modes*. A mode describes a pattern in which the field strength varies across the transmission line. In a well-designed line, only one mode exists; it is called the *dominant* mode. If a cross-sectional dimension of the waveguide is inappropriate (usually larger than the λ/2), a variety of propagation patterns occur—making performance unpredictable. The waveguide should also be a good conductor with a high surface quality. For maximum performance, gold-plated constructions are used. For example, steel waveguide losses (in decibels) in the 10-GHz region are 2.5 times the losses in copper waveguide. (For copper waveguide with 1-dB loss, a similar steel waveguide would have 2.5 dB loss.—*Ed.*) This in a waveguide 25.4 ×12.7 mm in external, rectangular dimensions (Waveguide Nu. 16 dimension). As shown in Table 3, you can also use copper pipes as waveguides.

To couple a signal from a waveguide to a downlink signal converter a *waveguide transition* is necessary. With this item, the signal is transferred to a coax cable and connector from the converter. Such transitions require some research using test procedures in a microwave laboratory and precision manufacturing. Fig 3 shows a waveguide transition for 10.4 GHz.

Downconverter

During my experiments, I used the 10-GHz super-low-noise MKU 10 OSCAR opt. 01 that downconverts signals from 10.451 GHz to 432 MHz. The gain is more than 30 dB and my test results show 42 dB. Its noise figure is 1.15 dB at 18°C. The MKU 10 downconverter is small (30×56×74 mm) and weighs only 95 grams. Power consumption is 220 mA, from 12-15 V dc. Fig 4 shows the circuit diagram of this downconverter that was designed by Michael Kühne, DB6NT. It is available at Kühne Electronic, BRD.[1] (In the United States this downconverter is available from SSB Electronics and Downeast Microwave.—*Ed.*)[2,3]

[1]Notes appear on page 49.

I used a 70-cm portion of an all-mode Kenwood TR-851 to receive the downconverted signal and with an ICOM IC-R7000 for backup. The converter case is not completely weatherproof. Later, I plan to place the MKU 10 in an airtight, soldered metal box for the outdoor installation. This weatherproofing is necessary to overcome the danger of corrosion from condensation, which I have experienced in earlier S-band installations.

10.451150-GHz Test Beacon

Unfortunately, Phase 3D is now on the ground and not in orbit. Therefore, a test beacon is necessary to test how well the assembly works. I ordered the MKU 10 from Kühne Electronics with several modifications (Fig 5). The power was reduced to the minimum level of 10 mW, and the oscillator crystal was trimmed to 10.41150 GHz. That frequency resides in the middle of Phase 3D's 10.4-GHz analog band. The size of the beacon is 111×55×30 mm, and its weight is 160 g. Laboratory test results concluded:

- Output power 10 mW
- Spurious and harmonics less than 40 dB
- DC current 220 mA, 12 to 15 V

Even at this reduced power level, a simulation of the expected Phase-3D signal at ground level is not possible because of the closeness between the transmitter and receiver. Calculations show that the beacon is much too strong, but there is a good possibility to control the function of the installation, and I have an S-band beacon for future tests.

Feedhorn

Fig 6 shows a cross-section drawing of the feed. The beamwidth of the feed is 140° at the –10-dB points—sufficient for the offset-dish solution I have identified. This feed was tested in the laboratory, and its losses are very low. The material is aluminum and the resonant monopole is gold-plated brass. Such feeds can be readily bought on the market.[4]

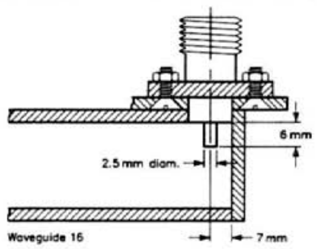


Fig 3—Cross-section view of a waveguide transition.

Table 2—Estimated Dish Wind Loads

Dish Diam.	Projected Surface Area (m²)	Max. Force (Newtons, wind at 100 kph)
30 cm	0.072	85 N
60 cm	0.28	335 N
90 cm	0.64	770 N

Table 3—Properties of Copper Pipe used as Waveguide

OD (mm)	Wall Thickness (mm)	F1 Min (Cutoff, MHz)	F2 Max (Atten. Freq. MHz)
15	0.5	12,557	16,404
22	0.6	8452	11,041—3-cm guide
28	0.6	6560	8569

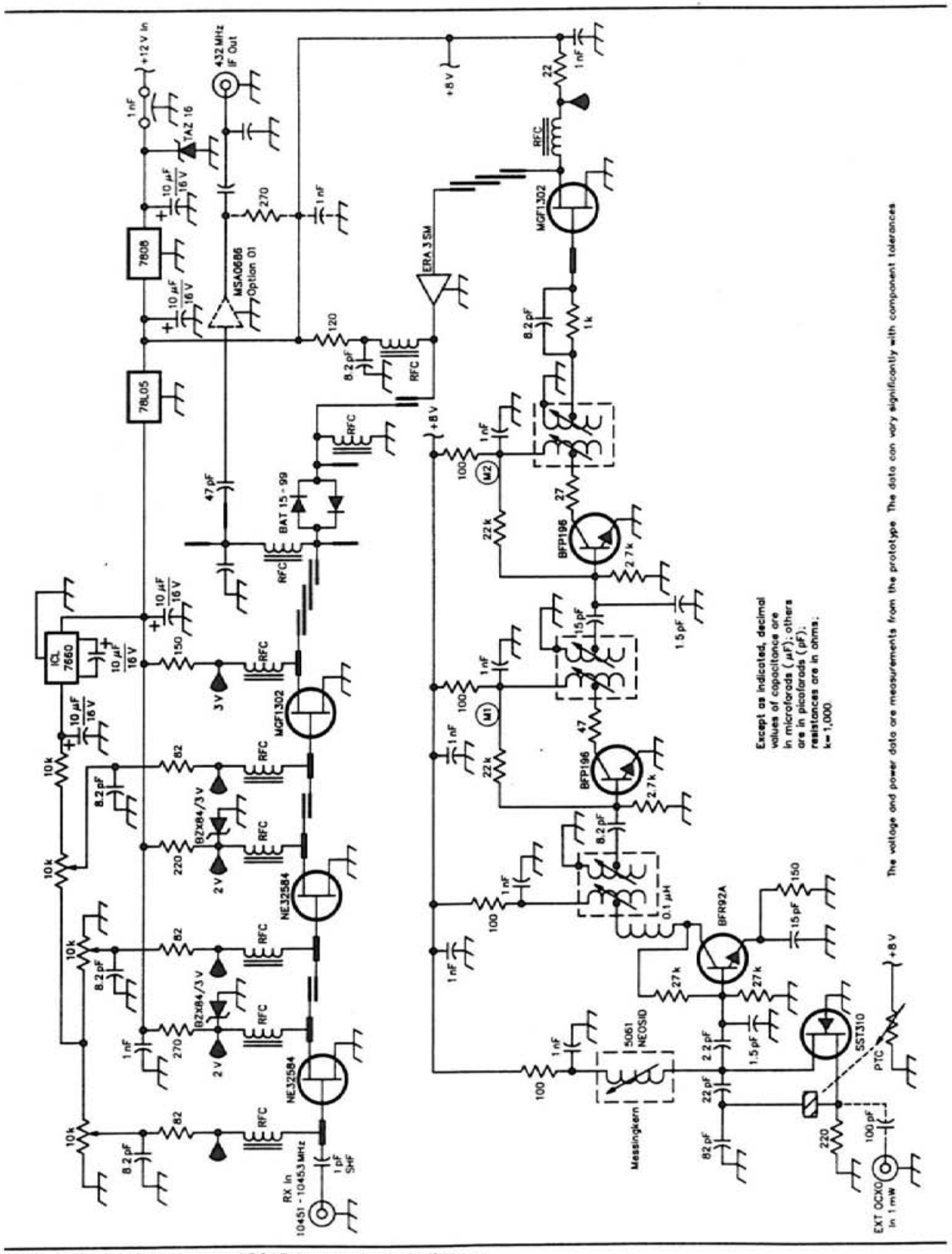


Fig 4—Downconverter MKU 10 OSCAR (option 1) circuit diagram.

Option A: Dish with Central Feed

I can buy this dish ready-made from Eisch Electronics (see Note 2). The dish is constructed by PROCOM-Denmark.[5] Table 4 shows its specifications.

At 10.4 GHz, the SWR is about 1.6:1 (see Fig 7). Meanwhile, Fig 8 shows the dish from the front side, with the reflector soldered to the central waveguide. Fig 9 is a view from the backside with the waveguide transition, converter and the other test arrangements. The waveguide and the transition are gold plated.

Option B: Offset-Dish Construction

This dish type is characterized by its elliptical circumference shape (Fig 10). The outside dimensions are 40 cm and 36 cm. The manufacturer is unknown to me, but it is a dish for digital satellite television that was inexpensively purchased. The feed (see the earlier description) is fixed with clamps, and the whole feed position can be adjusted in many ways (See Fig 2).

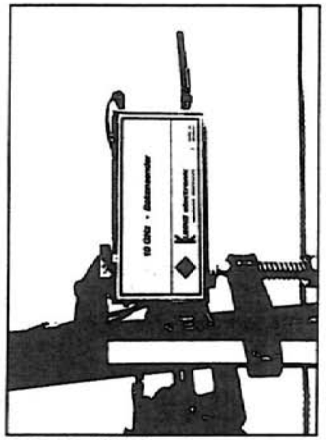


Fig 5—The MKU 10 test beacon.

Table 4—Procom Dish Specifications

Technical Data	
Diameter	48 cm
Gain	27 dBd
F/D	0.4
Beamwidth	6°

Testing These Dishes

First, I must state that these dishes were not made with exact scientific methods. I started the beacon and after a warm-up period of five minutes, and I heard a roaring S9+ signal on the all-mode Kenwood TR-851E at 432.150MHz. The high noise level was because of the high gain (42 dB) of the converter (at about S7) and was to be expected. The signal strength was so high, however, that the S-meter indicator was pinned. This first trial shows only that the system works on both dish types. Of course, the distance of five meters is too small and there were some wall reflections. The next step was an area-field test over a distance of 1 km and those tests confirmed that both the dishes work. Even this test showed strong S9+ beacon-signal readings. By moving the antennas up and down and left and right, I could make some adjustments of the offset-antenna feed.

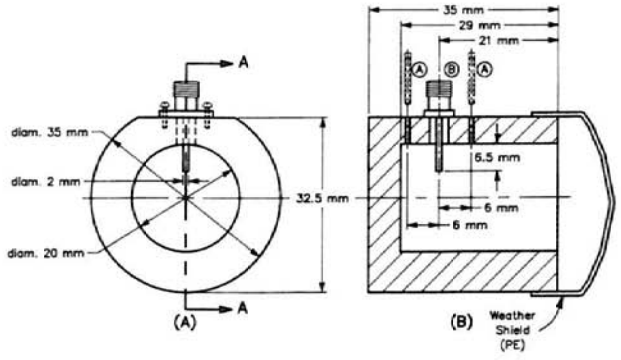


Fig 6—Cross section of 10.4-GHz feed. A is an end view; B is a cross section through AA. Circles A indicate M2 (metric) trim screws. Circle B indicates the SMA connector.

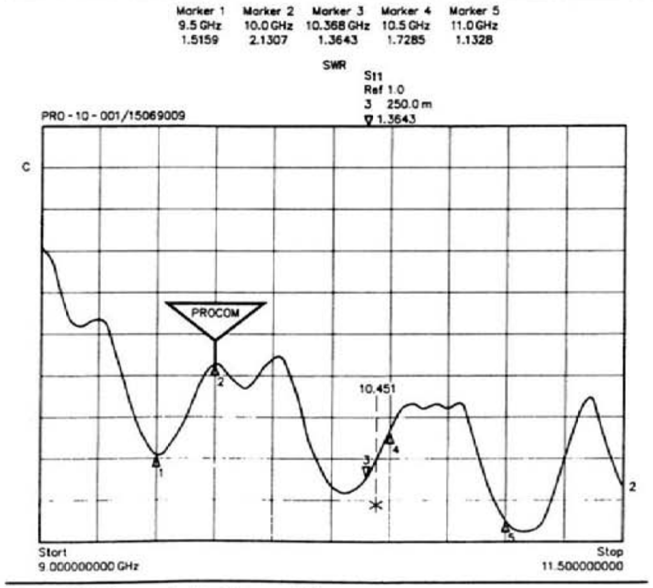


Fig 7—SWR diagram for the Procom dish.

Fig 8—Center-fed Procom dish front view.

The field tests had been repeated with an ICOM IC-R7000 as indicator. The noise readings were reduced to S1.5, and the signal indications were S9 to S9+. There was a difference of S7.5 to S8 between the noise and the USB signal. As I mentioned before, the beacon was too strong for the simulation of the Phase 3D predicted values.

For my case, tests have shown that the dish (Option 1) of the downconverter with its high gain has too much reserve and would be not necessary. The noise level is no big problem for me because I use an NF digital filter that rejects the noise to a great extent. I am very much delighted at the clear signal strength of the converter and the good reception S/N value.

Both types of antennas have a clearly defined polarization direction from the feed side. It was interesting to observe the effect of changing the polarization direction 90° relative to the beacon. In most test cases, the readings on the ICOM IC-R7000 S-meter changed by two S units. If the space signal comes down with circular polarization, a good S/N reserve will help a lot.

I intend to install the offset dish on the vertical rotating boom of my rig with an separate TV-dish rotator. I think I am ready for the Phase 3D X band. Hopefully, this satellite will soon be in orbit!

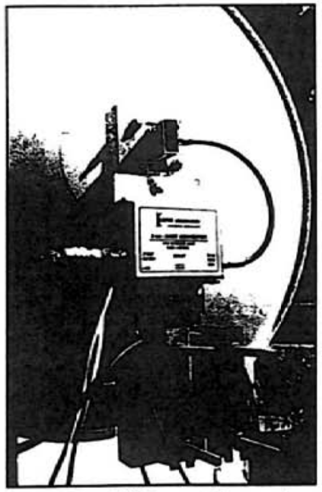


Fig 9—Center-fed Procom dish rear view.

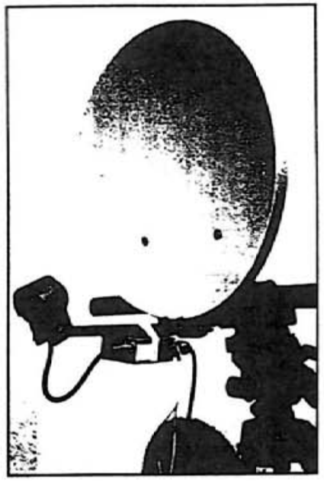


Fig 10—Offset-feed dish view.

Notes

[1] Kühne Electronics, Birkenweg 15, D-95119 NAILA/Hölle BRD, Germany; tel 09288/8232, fax 09288/1768; **kuhne.db6nt@hof.baynet.de**.

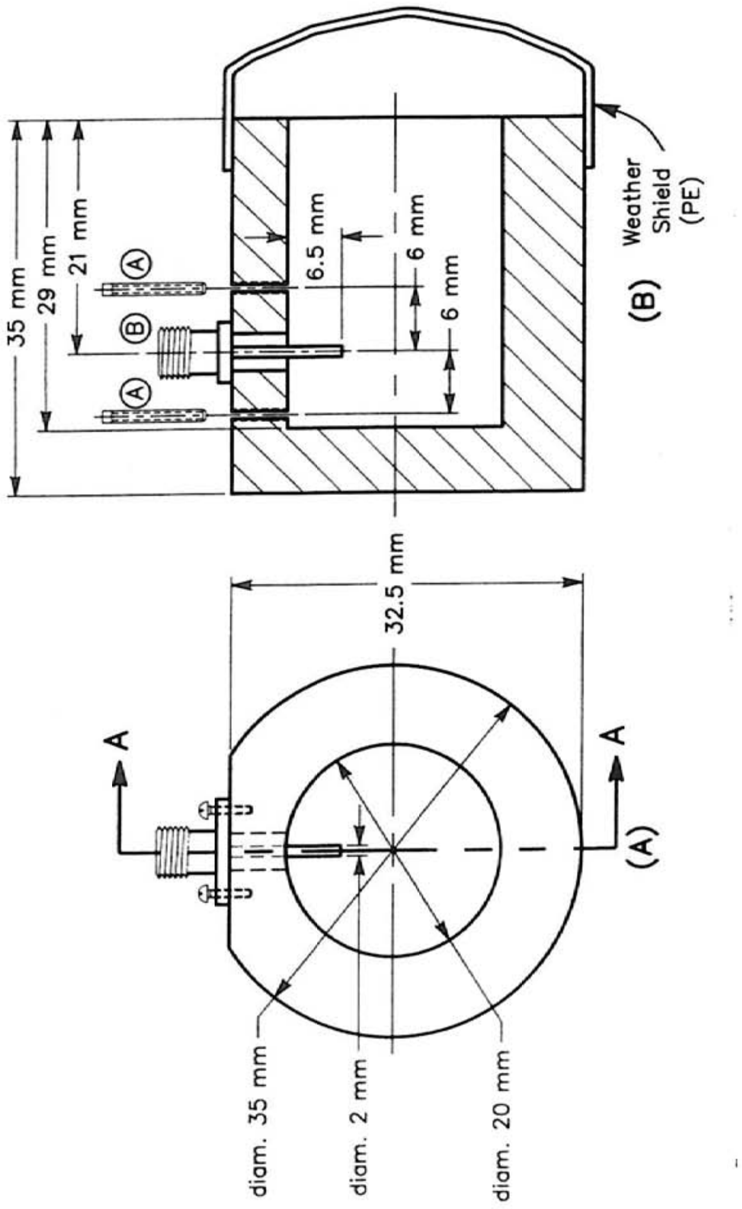
[2] SSB Electronic, 124 Cherrywood Dr, Mountaintop, PA 18707; tel 570-868-5643; **http://www.ssbusa.com**.

[3] Down East Microwave Inc, 954 Rt 519, Frenchtown, NJ 08825 USA; tel 908-996-3584, fax 908-996-3702; **http://www.downeastmicrowave.com/**.

[4] Eisch Electronic, Abt-Ulllrich-Str.16, 89079 ULM-Gögglingen BRD, Germany; tel:07305 23208, fax 07305 23306.

[5] Procom A/S, Vinkelvaenget 21-29-DK-3330 Gorlose, Denmark; tel (++45)42 27 84 84; fax (++45)42 27 85 48.

Josef Maier, OE1/OE3JIS, is married and has two sons. With an Austrian engineering degree, he has worked in several companies as a designer, project engineer and work planner. Josef is now retired. He was first licensed (CEPT 1) in 1987. Josef is very active on satellites (over 7000 QSOs—including 230 countries—on analog satellites) and holds several satellite awards. He is a member of ÖVSV, AMSAT-UK, ARRL, ISWL and a life member of AMSAT-NA.



MODIFYING THE RCA DSS DISH FOR 10 GHZ

BY KEN SCHOFIELD - W1RIL

The 18" offset RCA dish made for digital satellite system (DSS) reception is an excellent candidate for modification to Amateur Radio 10 Ghz use. It is compact, light, has the advantage of an offset feed (no feed blockage) and is readily changed to 10 Ghz operation. N1BWT (now W1GHZ) used this dish with a tailored homemade horn feed 1 whereas I am using the original RCA horn with modifications.

The first RCA feed I modified in 1996 was done by removing the LNA board at the rear of the horn and placing a short across the opening. The raised rib inside the horn was removed using a milling cutter and an SMA connector was mounted on the side of the horn at the appropriate spot. A saddle fitted to the curvature of the horn under the SMA made a flat mounting surface for the connector. Both were secured to the side of the horn with 2-56 machine screws the innards of which were finished flush with the inside horn surface. For added insurance of a good joint, silver bearing epoxy was used between the saddle and horn and SMA and saddle on final assembly. The trick of using a ball bearing and magnet to locate the "sweet spot" for tuning was used and a 2-56 hole was drilled and tapped in the horn wall to accept the tuning screw and locking nut. Oddly enough this lined up with the previously removed rib - obviously RCA knew more about this than I did!!

The following equipment setup was used for tuning the horn for

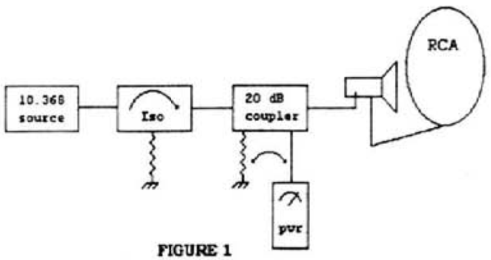


FIGURE 1

best return loss which was measured at 15.4 dB. (VSWR 1.4:1) At the time this return loss was deemed acceptable - 97% of the power was getting to the load. The dish tested well at the NEWS meeting at Enfield, CT on July 12, 1997. Sun noise was 1.4 dB and dish efficiency 65%. It also gave a good account of itself in the 10 Ghz contest in 1997.

During the Fall-Winter of 97/98 it was decided to put an LNA and an amplifier as close to the feed as possible. With this in mind a 4 watt solid state amplifier and a 1 dB noise figure LNA. of KH6CP (now W1VT) design2 along with an SMA relay were mounted around and CLOSE to the horn assembly feed. The key word here is CLOSE! An immediate improvement on receive was noticed. I could now hear the antenna picking up noise from trees, ground etc. Even in the confines of my basement, covering the horn with my hand dropped the received noise level by a perceptible amount. A gallant effort was made to improve the return loss but despite my best efforts it remained in the 15 to 16 dB region. Interestingly enough it was found that putting the plastic cover on the horn caused a 0.5 to 0.6 dB reduction in the return loss. I would, however, expect this trade off to be more acceptable than a feed full of rain water!

MODIFYING THE FEED.

Step by step details on the modification of the feed is as follows:

1. Remove nut/bolt assembly from dish strut and remove feed. Retain hardware.
2. Remove two screws - one on each side at base of horn flare. Retain hardware.
3. Carefully separate and remove plastic housing. Spread at flared area and carefully remove each section. Small ears at the mounting end hold them together along with a larger tab at the backside of the horn. The tabs can be disengaged by pressing and or lifting the opposite section of the plastic housing.
4. Remove eight Philips screws with intragal washers securing an aluminum plate to the back of the feed. Remove the plate. This plate and hardware will not be reused.
5. Working in a static free area - remove eight Philips screws/ washers holding metal casting and metal plate covering the printed circuit board. This casting and hardware will also not be reused.
6. Clip the metal tab connecting the pc board to the F connector and carefully remove the pc board. Wrap the board in aluminum foil to prevent damage from static and put aside for future use. There are some excellent gaAsfets and other surface mount parts available on the board .
7. At the back of the white plastic cover locate 4 retaining ears. These are about 5/8 inch long and hold the cover to the horn. Using a pair of medium size diagonal cutters gently grip and bend the plastic at each of these protrusions outward. Put pressure on one to get it started over the metal rim and push with your thumb and fingers around the others to pop the cover off. Retain the cover and rubber gasket. If you were unlucky and destroyed the cover during removal a suitable substitute is readily available - see later text on testing.
8. Looking inside the horn, locate the metal protruding rib. Remove this rib using a milling cutter - file - small Dremel grinding wheel - drill - or whatever method best works for you. I found it easier using a 1/2 inch mill end cutter and making very small cuts.

1 Wade, P., N1BWT, " More on Parabolic Dish Antennas" QEX Dec. 1995/ARRL UHF Microwave Projects Manual VOL 2
1 Lau, Z., KH6CP, "The Quest for 1 dB on 10 Ghz" QEX Dec. 1992

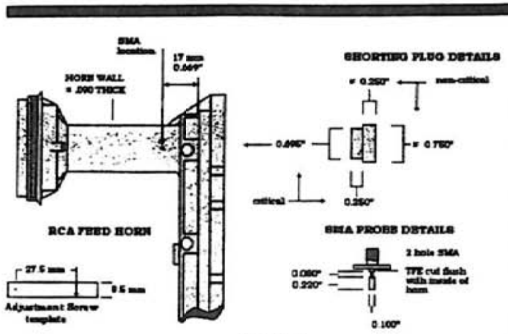


FIGURE 2

MODIFYING THE RCA DSS DISH
PART B

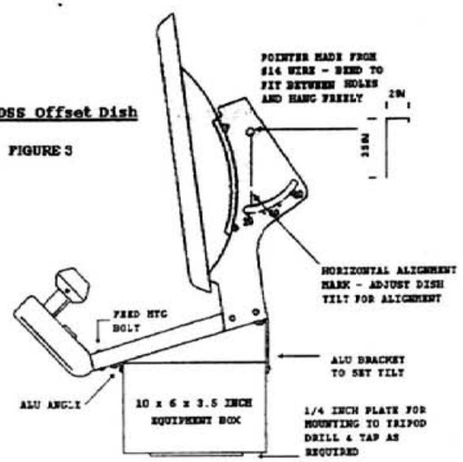
1. Fabricate the shorting plug for the rear of the horn using 3/4 inch or slightly larger aluminum rod stock. Cut to the dimensions shown in the drawing. Note the two critical dimensions - the 0.697 inch insert diameter and the 0.250 inch insert length. The rod can be cut to 0.700 initially and then finished to 0.697 to get a tight pressed fit into the rear of the horn.1
2. Accurately locate and mark with a scribe or prick punch the location for the SMA connector. See figure 2 for dimensions.
3. Using the adjusting screw template as shown in figure 2 - align the SMA location on the template to that on the horn and wrap the paper around the horn with the arrow pointed toward the flared open end. The arrow will indicate the point at which a hole will be drilled and tapped for the 2-56 matching adjustment screw. Note that this falls in line with the previously removed rib - if it doesn't you went the wrong way around the horn.
4. Fabricate the SMA probe per the drawing. You can make this adjustable if you like by using brass tubing - sliding it up and down on the 0.080 inch post. Gently dimple one side with a prick punch to cause the tubing to bind on the post. Once the proper placement is made, solder in place.
5. Drill and tap the necessary holes for the SMA and adjustment screw. File a flat area under the SMA connector. The horn wall is approximately 0.090 inch thick. Don't remove any more wall material than is necessary so as not to weaken the 2-56 mounting area for the SMA connector.
6. Mount the SMA connector using conductive epoxy under the connector flange and around the edges. The mounting screws should be finished flush with the inside wall of the horn.
7. Put a nut on a 1/2 inch brass 2-56 machine screw and insert into the adjusting screw hole. When adjusted this screw will protrude into the horn approximately 5.5 mm.
8. Insert and press into place the shorting plug at the rear of the horn. This should fit tightly and the shoulder should be flush against the rear of the horn.
9. Drill and cut away the necessary material on the gray plastic covers for access to the SMA and adjustment screw when the covers are in place.
10. Re-assemble the gray covers on the horn. Use previously saved hardware.
11. Re-assemble the horn on the dish. Use previously saved hardware.

TESTING THE MODIFIED FEED:

Set up to measure return loss and adjust the matching adjustment screw for minimum reflected power. Adjust the probe length also at this time if you chose to use the adjustable type. Replace the gasket and white cover removed in step 7. If it broke on removal replace it with the plastic frosting container found in a package of Pillsbury Cinnamon Rolls. Use tape around the bottom edge to hold it on. It is a perfect replacement and has the added advantage of being able to be taken off easily. The RTL changes the same using either cover, -0.5 to -0.6 dB. Another advantage - undoubtedly the most important - ***the cinnamon rolls are delicious!!***

RCA DSS Offset Dish

FIGURE 3



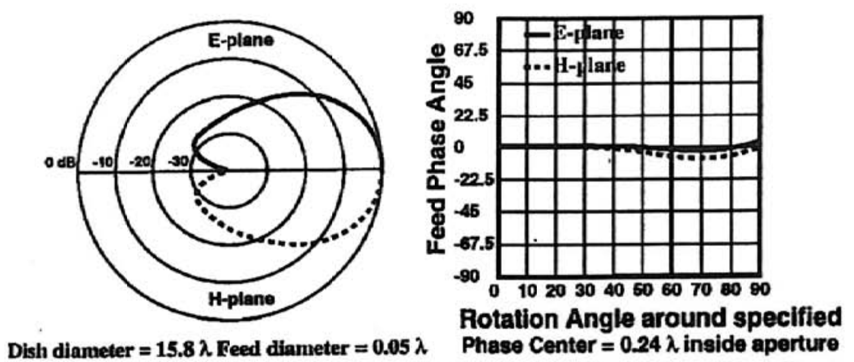
SETTING UP THE OFFSET DISH:

Getting the correct tilt angle on the dish so it is looking at the horizon is quite simple. Fabricate a piece of #14 wire and hang between the two holes behind the dish - see figure 3. Tilt the dish to the position where the pointer lines up with the alignment mark (22.6 degrees) on the frame. I used an aluminum bracket to set the tilt angle - others have used a wooden wedge. You can use whichever method works the best for your circumstances. Figure 3 also shows the equipment box under the dish. This mounts to the top of the tripod with a 1/4-20 bolt arrangement similar to that found on many tripods. The newly added amplifier, LNA and SMA relay (not shown in the drawing) are located at the feed. The amplifier is below and in line with the horn and the LNA and relay are on the side of the horn housing. The total length of the UT-141 feedline is less than 1.5 inches.

Paul, W1GHZ was kind enough to model the dimensions of the RCA feed using Physical Optics Techniques. The results are shown in Figure 4 and give an overall picture of the feeds possible performance.

1 Realizing that everyone does not have access to a lathe, I will make this plug available to any NEWS member who needs one.

RCA DSS corrugated horn, 1.95"aperture, 58 deg flare, by P.O.



Dish diameter = 15.8 λ Feed diameter = 0.05 λ

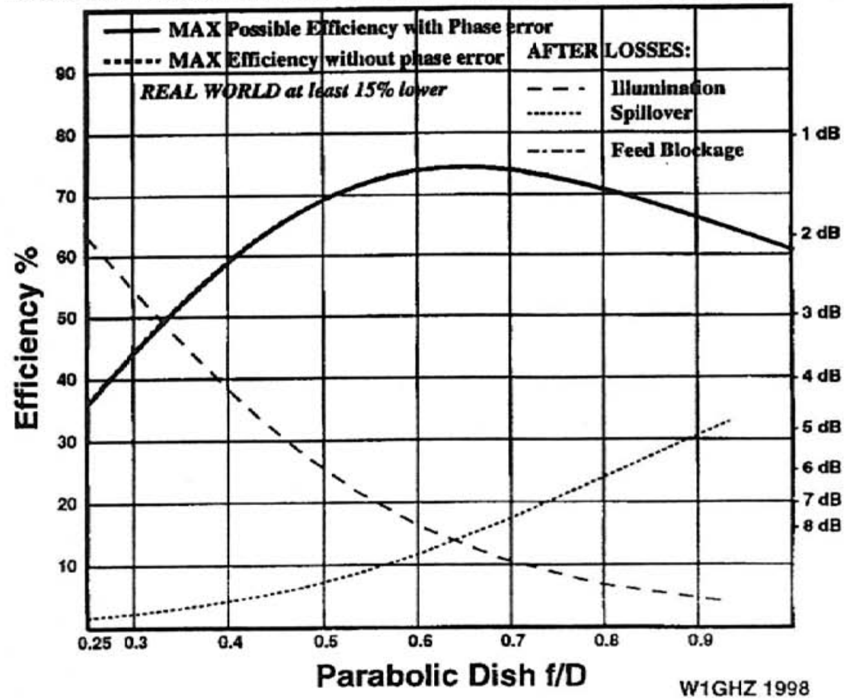


FIGURE 4

6. Clavin Feed

The Clavin feed is a cavity antenna fed by a resonant slot, with probes that excite a second waveguide mode to broaden the pattern in the H-plane to match the E-plane.[16] Radiation patterns approximate our desired feed pattern, Fig 3, while maintaining a good phase center. Fig 10 is a sketch of one I made from a 1-inch copper plumbing pipe cap. It is best for deep dishes with *f/D* in the 0.35 to 0.4 range. The resonant slot makes it more narrowband than the others (not a problem for amateur use), and the smaller size would have less feed blockage than the "Chaparral" or Kumar feeds, so it might provide better performance on smaller dishes.

A scalar feed is one that has no inherent polarization; the word "scalar" means that the electric field distribution is independent of the axis in which you look at the distribution. The result is that scalar horns have equal beamwidths and sidelobes in both azimuth and elevation. This can't be achieved with a standard flared horn, so scalar horns are usually preferred for dish feeds. The symmetry also makes them suitable for both linear and circular polarization. The W2IMU dual-mode horn and the "Chaparral" and Kumar feeds below are scalar feeds.

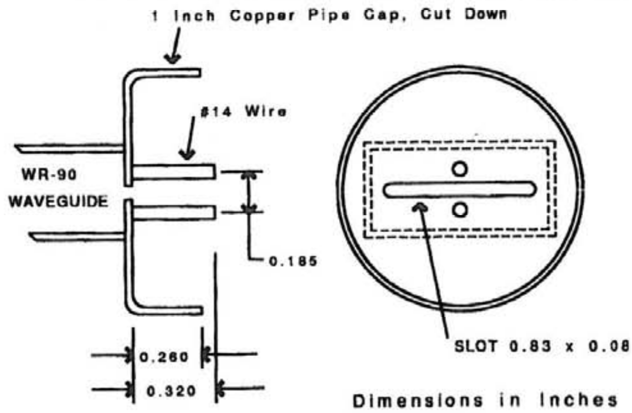


Fig 10—A Clavin feed for 10 GHz, made from a 1-inch copper pipe cap.

Source 10 GHz

Ein Nachteil dieses Systems sowie auch mehrerer nachfolgend beschriebener Ausführungen ist, daß damit der Parabolspiegel nicht ganz ausgeleuchtet wird. Dies ergibt sich schon aus der typischen Abstrahlcharakteristik des Dipols mit Reflektor.

Ein weiteres Modell eines Strahlereinsatzes, bei dem eine etwas bessere Ausleuchtung des Spiegels zu erwarten ist, zeigt Abb. 91, und zwar einen sogenannten *Häubchenstrahler* für das 10-GHz-Band. Aus der Schnittzeichnung ist zu erkennen, daß ein rechteckiges Häubchen, welches an den Seiten geschlossen ist, direkt vor der Öffnung des Hohlleiters montiert ist. Um das Stehwellenverhältnis zu verbessern, ist auch hier wieder der Hohlleiter zu seiner Öffnung hin etwas verjüngt. Von Vorteil bei diesem Strahler wäre es, das Häubchen auf dem Hohlleiter verschiebbar anzuordnen.

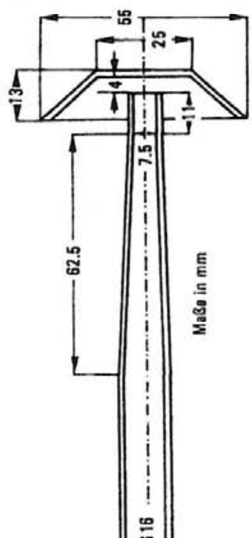


Abb. 91. Häubchenstrahler für das 10-GHz-Band

Mit einem Stehwellen-Indikator, wie er in einem späteren Abschnitt noch beschrieben wird, kann man dann auf bestes SWR abgleichen. Die praktische Ausführung dieses Strahlers ist in Abb. 92 vorgestellt. In Abb. 93 ist ein Häubchenstrahler, eingesetzt in einen Parabolspiegel zu sehen.

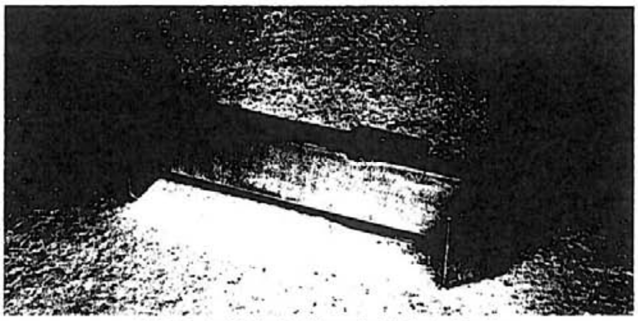


Abb. 92. Praktische Ausführung des Häubchen-Strahlers

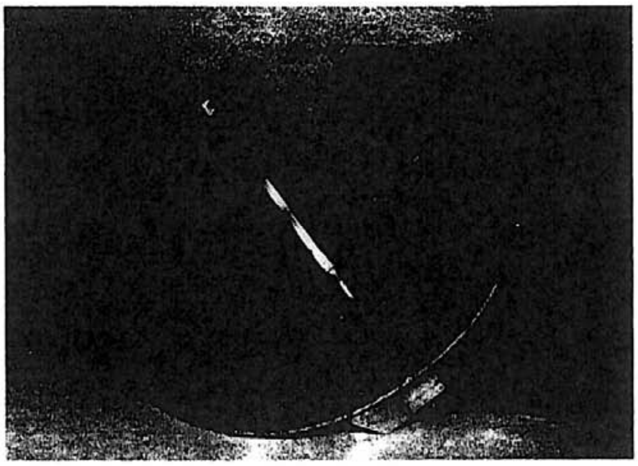
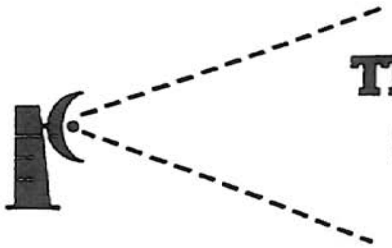


Abb. 93. Häubchenstrahler im Parabolspiegel

Extrait de DL6MH Antenna Manual



THE CHAPARALL SCALAR FEED HORN

Microwave Newsletter Jun 97

.... SOME INITIAL EXPERIENCES AND IDEAS FROM PETER, G3PHO

IN THE BEGINNING ....

The writer has recently started using a four foot diameter dish which had been acquired several years ago. Lying dormant in the garage, it had become the target for one of the XYL's regular "when are you going to tidy out the garage" campaigns and so it was decided to actually use it rather than lose it!

DECISIONS, DECISIONS ...

In previous years, a 60cm offset fed dish of 0.6f/D, with a dual mode feedhorn (1), had given a good account of itself in the 10GHz cumulatives. Would the 4 foot dish (0.4f/D) be much, if any, better? Although it was twice the diameter of the 60cm dish, and therefore theoretically 6dB gain up on it (equivalent to adding a 1 watt PA to a 250mW), other factors come into the end results. For a succint account of how feeds of different kinds actually perform, the reader is highly recommended to look at the article "Secrets of Parabolic Dish Antennas" by Paul Wade, N1BWT. (2)

These factors include the relative effectiveness/efficiency of the two dish feeds and the losses incurred by using a primary focus (direct) feedhorn on the larger dish. The 60cm, being offset fed, does not have such losses entering into to the equation. The four foot dish was brand new and came complete with a matching scalar feedhorn (the "Chaparall"), a mounting kit (four aluminium feed sup[port arms) and a recessed aluminium boss at the feed point to hold the feedhorn in place, so it was assumed that the feed and dish were optimised for maximum results.

THEORETICAL STUFF ...

The Chaparall horn is basically a series of concentric cavities centred around a circular waveguide feed. The cavity rings modify the radiation pattern of the waveguide to produce almost equal beamwidths and sidelobes in both azimuth and elevation, a desirable state of affairs that the more common rectangular horns cannot achieve. Chaparall horns are highly recommended for dishes having f/Ds in the region of 0.35 to 0.45. For high f/Ds such as the offset fed SAT-TV type, the dual mode horn (see ref. above) is more appropriate.

"IN FOR A PENNY, IN FOR A POUND"....

The writer's Chaparall appeared to be an X-band one and possibly was designed for use a little higher than our 10GHz amateur band, so here was another possible source of loss of efficiency coming into the equation! However there is nothing lost in trying so it was decided to use the horn on 10GHz, without modification. The rear of the horn assembly has circular waveguide output, some 20mm in diameter. To connect this to a length of WG16 flexiguide linking it to the 10GHz transverter, a circular-to-rectangular WG16 transition was rather crudely fashioned from the detachable, cast-aluminium spacer that was screwed to the rear of the horn. The 20mm hole in the spacer was flared out to approximate a WG16 aperture by using a round file on the transverter side of the spacer, leaving the other end round to match up with the horn. Other forms of transition could be used, that by G8AGN for example (3).

A short, WG16 right angle bend and 36 inches of flexiguide connect the horn to the 10GHz transverter. The whole assembly, dish and transverter, is mounted on a small, 2 inch diameter mast for portable use. At the transverter output flange is a matching section in waveguide. This "ATU" has three screws spaced 5mm apart down the centre line of the broad face of the WG16 and has been found an essential item when changing from one antenna to another. It's alright to adjust your transverter for sub 2dB noise figures at a microwave "round table" meeting but the situation can change markedly when the antenna and its waveguide feeder are added. Matching screws allow you to adjust for a similar situation to that seen at the roundtable.

RESULTS..........

The Chaparall horn described here appears to provide an excellent match to the writer's equipment, so much so that there is no real improvement to be made when adjusting the screws after changing from the dual mode horn feed to the Chaparall scalar horn. The writer's garden was far too short to set up any meaningful antenna test range, so the next best thing was to try the new antenna in a contest, the May 1997 10GHz Trophy event. At first, it was intended to have the two dishes side by side, for an "instant swap-over," in order to assess their relative performance but it was found impossible to do a quick enough changeover. The results obtained during the Trophy Contest, using the four foot dish from a site on the Yorkshire Wolds (IO93PW), definitely seemed to be better than those obtained from the same site in 1996 when the 60cm offset dish was used. Conditions during the contest were poor and yet the four foot dish and 600mW transverter worked a number of stations well over 300km with relative ease. The May 1997 10GHz Cumulative was the next test of the antenna. From a North York Moors location (IO94KF) another batch of+300km contacts was worked, again on a poor day for North-South propagation. In fact the score for the day was by far the best the writer has ever achieved from that area.

ROLL YOUR OWN? ....

Looking at the Chaparall feedhorn in question, it appears to the writer that it would not be difficult to copy the design, using almost "kitchen table" techniques! For what they are worth, detailed dimensions of the horn are provided herewith. It is suggested that the horn is made from copper, brass or even aluminium tube of various diameters. The writer has not investigated the sources of such tubing however.....the dimensions are given here in the hope that someone may "have a go" and make their own Chaparall feed. A homebrew design could allow for a round-to-rectangular waveguide transition by extending the centre feed tube through the rear of the assembly and flaring the end to take a standard WG16 flange, on the lines of the G8AGN transition mentioned earlier.

DIMENSIONS ....

Please refer to the diagram, Figure 1, when considering these dimensions. Note also that RING D is in fact a feed pipe and is not, of course, blanked off like the other rings. A plastic rain cover is stuck over this central tube. The rings and central tube (RING D) are fixed to a copper or brass disk, RING D passing through a 22mm i.d. hole in the centre of the disk and the remaining rings being accurately cut to the correct depth before cementing or soldering onto the disk. Try to avoid too much solder getting into each cavity thus formed. Perhaps it would be enough to secure the rings at four points each to the backing disk, provided there is a close fit between disk and rings to start with. Other constructors may wish to make each ring out of sheet brass or copper, rather than attempt to find suitable tubing.

Note also that the circular waveguide, Ring D, protrudes above the plane of the other three rings by some 5.5mm. This is to allow for fine adjustment of the radiation pattern of the horn. The home constructor could easily make this adjustable. The writer's commercial version is fixed however, since it has been matched to the dish upon which it it used.

	INTERNAL DIAMETER	WALL THICKNESS	CAVITY DEPTH
RING A	56 mm	1 mm	7.5 mm
RING B	45 mm	1 mm	7.5 mm
RING C	30 mm	1.5 mm	7.5 mm
RING D	20 mm	1 mm	see below

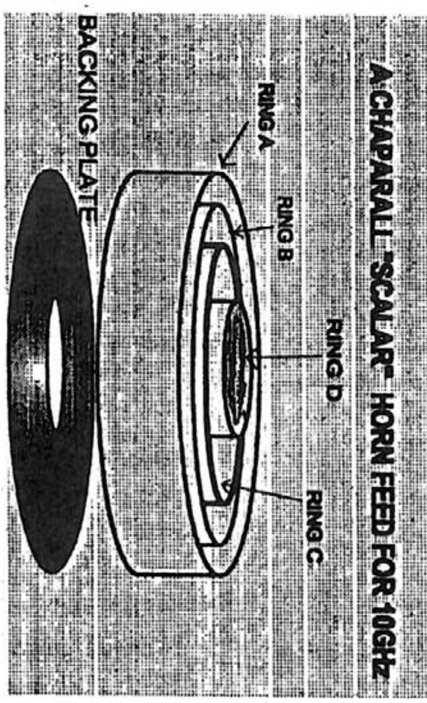
NOTES:

1. All dimensions shown are in millimetres.

2. The centre pipe projects 13mm through the backplate (i.e. 5.5 mm beyond the other rings) and should be made adjustable.

3. The depth of all the three cavities formed by rings A, B and C is 7.5 millimetres.

FIG. 1

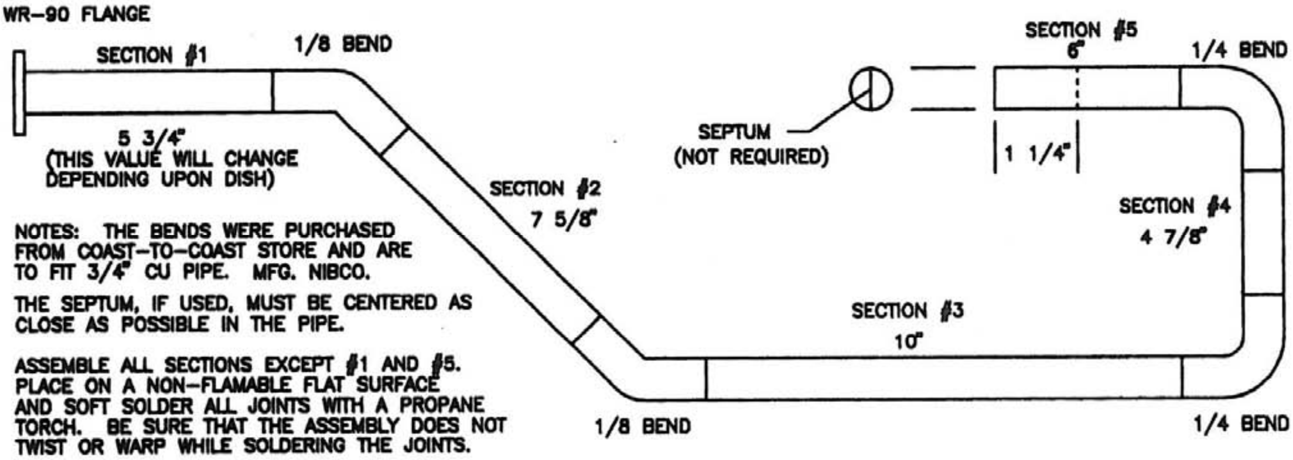


Is anyone using or building such a feed? Comments and suggestions to the Microwave Newsletter please!

REFERENCES: 1. Dual Mode Horn for 10GHz (Microwave Newsletter, April 1995]

2. [Microwave Update 1994]

3. Forming Tool for Circular pipe to WG16 transition [RSGB Microwave Manual Vol.3 p.18.6]



NOTES: THE BENDS WERE PURCHASED FROM COAST-TO-COAST STORE AND ARE TO FIT 3/4" CU PIPE. MFG. NIBCO.

THE SEPTUM, IF USED, MUST BE CENTERED AS CLOSE AS POSSIBLE IN THE PIPE.

ASSEMBLE ALL SECTIONS EXCEPT #1 AND #5. PLACE ON A NON-FLAMABLE FLAT SURFACE AND SOFT SOLDER ALL JOINTS WITH A PROPANE TORCH. BE SURE THAT THE ASSEMBLY DOES NOT TWIST OR WARP WHILE SOLDERING THE JOINTS.

#1 & #5 WILL BE SOLDERED AFTER TESTING. IF THE TESTS SHOW THAT THE POLARIZATION ROTATION IS NOT GREATER THAN ABOUT 6 DEG. THEN #1 AND #5 CAN BE SOLDERED AS IS. OTHERWISE #1 & #5 MUST BE HELD IN POSITION AND THE STRUCTURE ROTATED UNTIL THE POLARIZATION IS AT ZERO DEGREES.

USING NIBCO BENDS PRODUCED ABOUT SIX DEGREES ROTATION. USING EPC BENDS PRODUCED ABOUT 18 DEGREES ROTATION. THESE ARE THE ONLY BENDS TESTED.

extrait de la Newsletter SBMS

WA6EXV
Chuck Swedblom
P.O. Box 605
Ridgecrest, CA 93556-0605

CIRCULAR WAVEGUIDE SHEPHERDS CROOK

Date 9-9-97		Sheet 1

Application of Circular Waveguide With an 11-GHz TVRO Feed

The circular waveguide (3/4-inch copper type M) shepherd's crook feed described by WA6EXV in the San Bernardino Microwave Society's December 1993 newsletter was utilized in conjunction with a "Chaparral" brand 11-GHz TVRO Super- feed described by N1BWT. This feed system, with a 30-inch diameter, 0.375 F/D ratio, aluminum dish has been successfully used and has resulted in 2.8 dB of sun noise. This combination is being explored by the Long Island based TEN-X Group.

By Bruce Wood, N2LIV

(From *The 22nd Eastern VHF/UHF Conference*)

Crook

A sketch of the shepherd's crook feed is provided in Figure 1 with a listing of the pipe lengths utilized to construct it for this dish size, F/D ratio, and 11.25-inch focal length. These section lengths may be adjusted for various other size dishes. "NIBCO" brand pipe fittings were used for the elbows and couplings. The pipe lengths indicated includes the length of pipe recessed within the fittings.

Launcher

Several styles of SMA to round waveguide launchers were constructed as shown in Figure 1. The basic dimensions followed WA6EXV's design. Thread-in SMA connectors were used, Amphenol #901-9027. To gain more thread depth 1/2of a coupler sleeve was soldered on, or a small brass block constructed. The simplest method of launcher construction provided a rear wall for the waveguide and sufficient additional thread depth utilizing a 3/4 inch "NIBCO" pipe end cap. The NIBCO pipe end cap technique is unpopular in some areas because of so called slightly unpredictable results. When soldering the end cap, make sure the pipe and cap is super cleaned, coated with liquid rosin flux, and be sure the solder "wicks" all the way to the bottom of the end cap. Failure to do this could result in a "microwave choke joint" that could make tune up more difficult.

Feed

The "Chaparral" brand Model #11-0148 feed horn was connected directly to the circular shepherd's crook feed by cutting off the existing waveguide flange on the Chaparral feed horn and enlarging with a lathe the existing remaining 3/4" hole section to 7/8". This will allow the 3/4" copper pipe to be mounted directly within the feed to a depth of approximately 1/2". Anti oxidant grease was applied to help prevent corrosion between the copper and aluminum and the feed horn was finally epoxied in place.

Dish Mounting

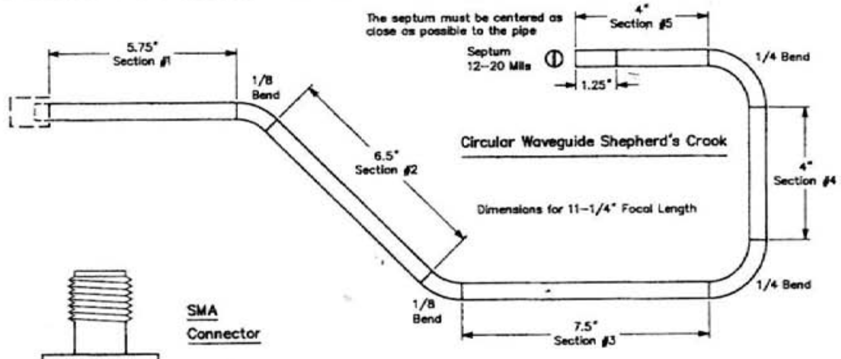
The shepherd's crook was secured to the aluminum dish's center mounting plate with ordinary plumbing fittings. I originally planned to use a simple 3/4-inch pipe coupling thru the dish's center plate but was concerned about the difficulty of soldering copper pipe fittings to the aluminum plate, possible galvanic corrosion in the salt air here on Long Island, and structural strength. I then located sweat to threaded screw type fittings which were also much stronger than a simple pipe coupling fitting and required no soldering. NIBCO brand fittings were used to construct the center dish feed-thru that will allow adjustment of the focal length and polarity. A pair of 3/4-inch copper male and female adapters part #C604 & #C603, respectively, were reamed out to 7/8-inch ID to allow the shepherd's crook to pass through them.

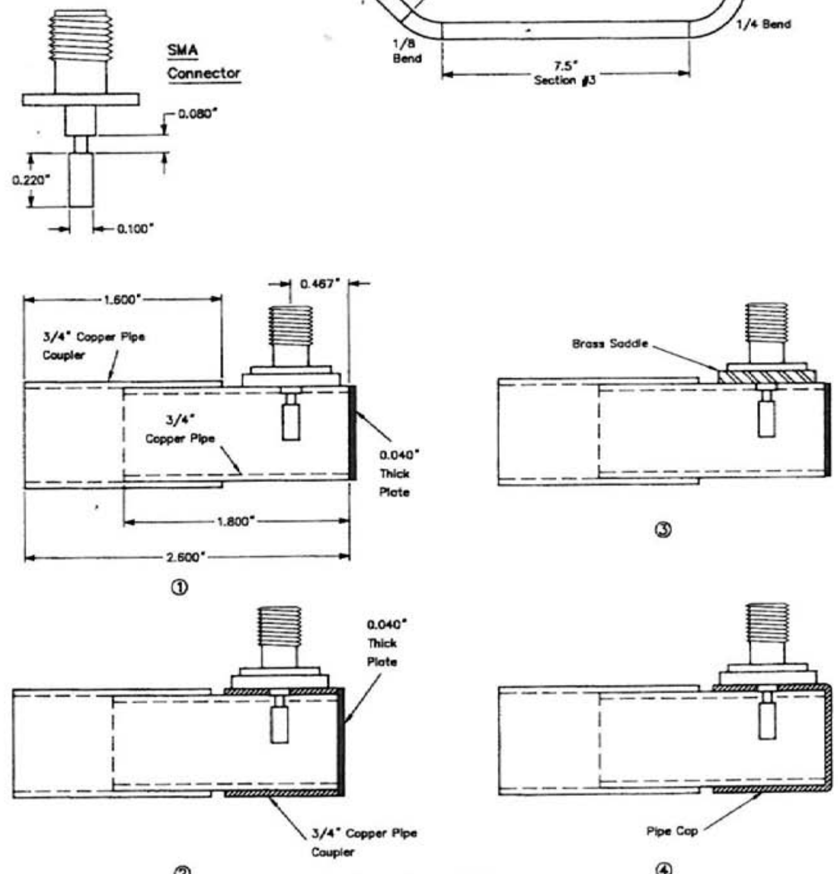
Two adjustable reamers from MSC Model 02239069 and 02239077 with a large tap handle were used to cut the hole. Approximately one hour was required to perform this operation. Screw the male threaded adapter pipe into the female before placing both into the vise, and performing the reaming operation. This supports the male adapter properly. The adapter becomes quite thin after the reaming. Be sure to insert a piece of 3/4-inch pipe before applying a wrench to the male adapter. The 3/4-inch pipe will keep it from deforming during the tightening operation. If a 3/4-inch to 1-inch NIBCO threaded pipe adapter is used, the amount of reaming required is drastically reduced to approximately 10 minutes). In addition, the resulting couplings are much stronger. The slight disadvantage is that a large hole is required in the center of the dish. If a lathe is available this is a second option. The rear male adapter was slotted in four places and a stainless steel hose clamp was used to apply sufficient compressive forces as to not deform the shepherd's crook and to also secure the feed in place after adjustment of the focal length and polarity. Large washers may be used to take up any slop.

Results

The dish has a theoretical gain of 33.6 dBd and a 2.43 degree beam width. While on the antenna test range the polarity, focal length and coax to waveguide adapter (for phase and polarization rotation within the crook) were adjusted for maximum signal strength. Measurements on the antenna range were curtailed due to rain. Subsequent sun noise measurements resulted in 2.8 dB of sun noise, when using a 2.2 dB NF sun noise measurement instrumentation.

A Return Loss of better than 20 dB was obtained by launcher probe adjustment.





Circular Waveguide to SMA Launchers

A Simple Dual-Mode (IMU) Feed Antenna for 10.368 GHz

By Richard H. Turrin, W2IMU

(From *Microwave Update '91*)

The small-aperture dual-mode reflector-feed antenna can be simply constructed from readily available copper water pipe plumbing fittings, as shown by the cross-sectional drawing. The circular waveguide section is standard ¾-in. Type-M copper water pipe which will support only the dominant TE11 mode. The tapered section is a ¾- to 1½-in. fitting reducer. This part may be constructed differently by different manufacturers. Try to find a fitting reducer with abrupt corners at both ends of the taper. Some parts are made with a well-rounded corner at the large end. While this part is satisfactory, it requires a slightly different positional length of the 1½-in. copper pipe coupling, for proper mode phasing.

While the correct flare angle of the conically tapered section should be 30°, the copper fitting reducer will have a flare angle of about 40°. The ⅛-in. soft copper tubing ring fitted inside the fitting reducer compensates for the difference in taper angle.

A simple, inexpensive, efficient and very low SWR coupling may be made from a standard ¾-in. coupling, which is slotted axially (six slots about ½-in. long), so that a hose clamp may be used as a securing device.

Form the soft copper ring to fit snugly inside the fitting reducer, and sweat it in place first. Clear all burrs from the inside of the pipe ends and sweat the parts together as per Fig 1, with a minimum of solder and paste. Wash the assembly thoroughly with a detergent, to remove all traces of soldering paste, and if desired, spray all surfaces with clear Krylon to help preserve the bright copper finish.

This feed antenna will have a −10 dB beamwidth of −44 degrees, with very low (less than −30 dB) side and rear radiation. The E- and H-plane main radiation patterns are virtually identical, as in the original dual-mode design. The resulting main radiation is circularly symmetric and will support any polarization.

This feed antenna is ideally suited to a rear-fed cassegrainian antenna reflector system, where the hyperbolic subreflector is designed to match the main reflector f/D ratio.

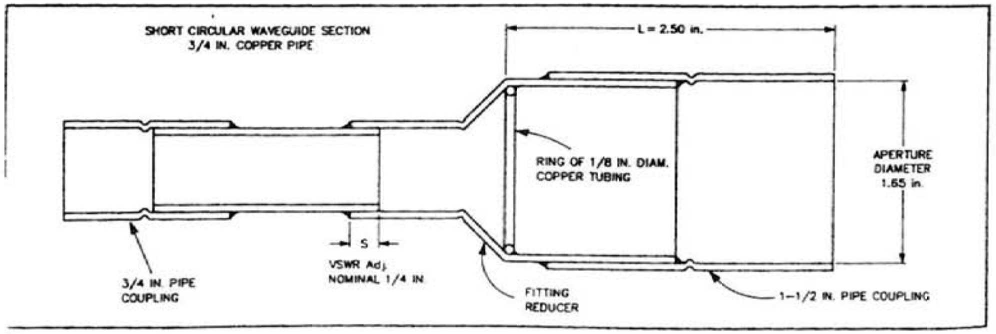


Fig 1

10-GHz IMU Feedhorn Update

By Kent Britain, WA5VJB

I have had excellent results with Dick Turrin's dual-mode feedhorn. I now use the simple dual-mode feed on several antennas, including the source antenna for the Central States VHF Society's 10-GHz antenna range.

In Texas, the local source for ¾-in. to 1½-in. adapters is Nibco. They use a different technique for molding the adapters with much less taper in the transition. It was very nice of them to transition over ½ at 10 GHz, so the ⅛-in. ring that Dick added in his horn was unnecessary.

Watch that taper! If the reducer transitions over about ½ to ¾ in., you can use the coupler as is.

The horn can get a bit heavy. One trick is to cut back the 1.5-in. coupler. Not only do you shave off a little weight, but some plumbing companies make the coupler long enough to let you build two antennas from that $3 coupler.

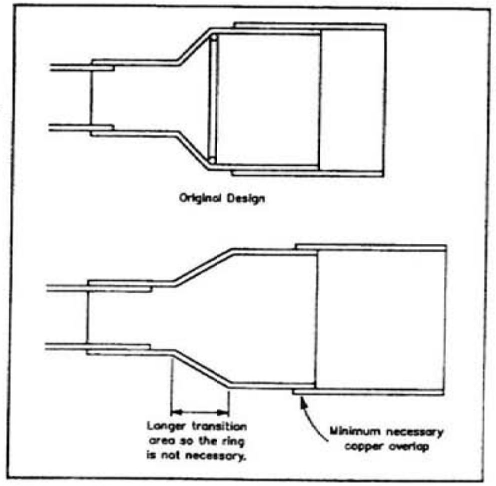


Fig 1—Details of the 10-GHz dual-mode feed-horn.

Feeding a 12 inch SHF Dish on 10 GHz

Zack Lau, W1VT

Description

For a 0.6 f/D dish, a popular choice is the W2IMU feed. It offers good illumination efficiency, low sidelobes, and a relatively small blockage. My design uses is made out of 3/4 and 1 1/2 inch water pipe joined by a conical adapter bent out of a piece of 50 mil copper sheet (bending this was a challenge). After bending, the adapter was filed and sanded to mate with the tubing sections.The 0.911 inch length of 3/4 inch tubing (0.808 ideal) has a 265 mil probe (50 mil diameter, long center conductor of SMA connector) 398 mils from the back wall. Interestingly enough, cutting a circle in half generates the required 30 degree taper for the conical section. The length of the 1.48 inch ID section is 1.548 inches. I measured a return loss of 21 dB.

Source of the 12 inch 0.6 f/D dishes: http://www.shfmicro.com/ SHF Microwave Parts Company Alan, WA9GKA prutz@shfmicro.com 7102 W. 500 S. La Porte, IN 46530

Beschreibung

Um einen Parabolspiegel mit einem F/D von 0,6 auszuleuchten, eignet sich das W2IMU Horn sehr gut. Es hat einen guten Wirkungsgrad, niedrige Nebenzipfel und eine kleine Fläche.

Mein Design besteht aus zwei Kupferrohren mit 0,75" und 1,5" mm Durchmesser, die durch einen konischen Adapter, der aus 1 mm dickem Kupferblech gebogen wird, verbunden ist. Das 0,75" Rohr (20,4 mm Innendurchmesser) ist 23,1 mm lang. Die Viertelwellen-Sonde besteht aus dem 1,27mm dickem Innenleiter einer SMA-Buchse und ist 6,75 mm lang. Der Kurzschluß auf der Rückseite befindet sich 10,1 mm dahinter.

Für den konischen Teil aus Blech braucht man nur einen Halbkreis ausschneiden, wie es in Abb. 1 gezeigt wird. Das 1,5" Rohr (37,6mm Innendurchmesser) hat eine Länge von 39,3 mm.

Die Rückflußdämpfung des Horns wurde mit 21 dB gemessen.

References

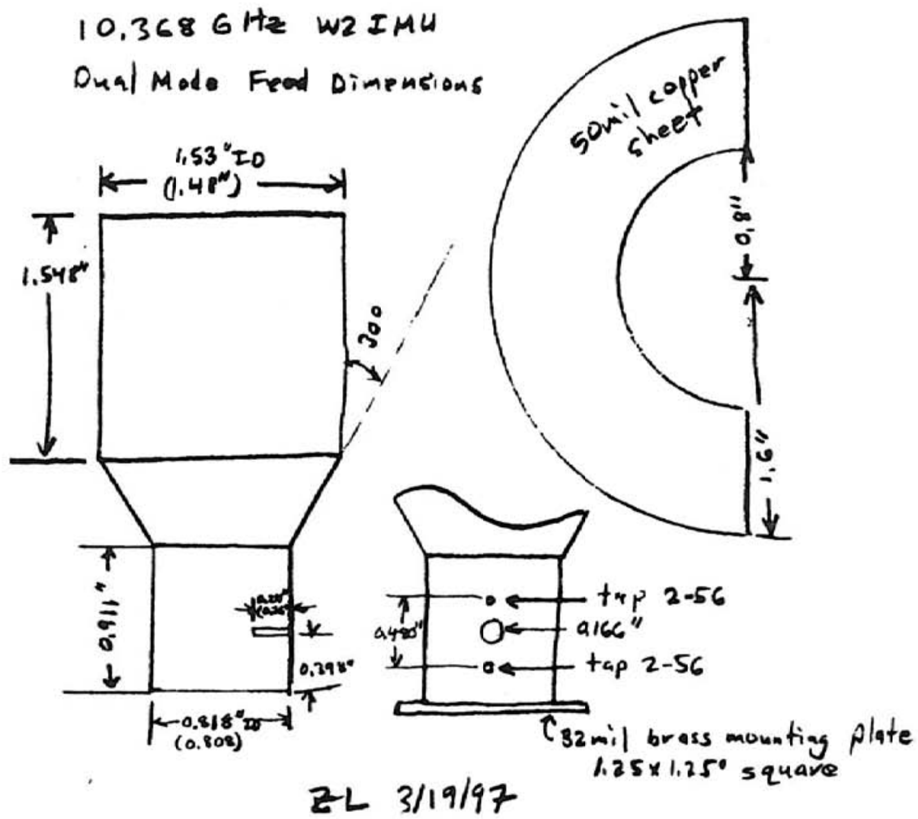
[1] Dick Turrin, W2IMU, "Parabolic Reflector Antennas and Feeds," The ARRL UHF/Microwave Experimenter's Manual, ARRL, 1990. Page 9-31 has the dimensions I used.

[2] Dick Turrin, W2IMU, "A Simple Dual-Mode (IMU) Feed Antenna for 10368 MHz,"

[3] Proceedings of Microwave Update '91, ARRL, 1991, p. 309. Also included in the Proceeding VII International EME Conference Washington DC August 15, 16, 17, 18, 1996. Get them from Willie Mank 7620 Bensville Rd., Waldorf, MD 20603. $US 12.00 +shipping ($3.00 in the US)

Dick*s design using standard pipe fittings that I couldn*t find at the local hardware stores.

Fig. 1: Mechanical Data



Calculations for the W2IMU Dual-Mode Feedhorn

Paul Wade W1GHZ (ex-N1BWT) ©1998
wade@tiac.net

Extrait de μW Newsletter Dec 98 / Janv 99

Simple cylindrical feedhorns for dishes, like the "coffee-can" type, usually have radiation patterns with poor front-to-back ratio. The backward radiation misses the reflector, resulting in a decrease in efficiency and thus gain. An example of the radiation pattern of a coffee-can feed is shown in Figure 1, as well as the calculated dish efficiency this feed would produce with reflectors of various f/D ratios. The unwanted backward radiation is a result of currents in the rim of the horn. A number of techniques to improve this front-to-back ratio have been described; one of the more elegant is the W2IMU dual-mode feedhorn.

Dual-mode horn operation

The dual-mode horn eliminates undesired currents in the rim of the horn which produce sidelobes and backlobes. In the words of Dick Turrin, W2IMU[1], "The basic notion involved is to excite a circular aperture with both the TE_{11} and TM_{11} modes with their relative phases and amplitudes adjusted to cancel the electric field at the aperture boundary."

I used the NEC2 computer program[2] to calculate the radiation pattern for several versions of the dual-mode feedhorn, starting with an input file model of the antenna originally developed by PA3AEF. Then I calculated the potential dish performance provided by the calculated feed patterns using software I developed[3]. The pattern shown in Figure 2 is very clean, with low side and back lobe levels. The calculated efficiency is best for a reflector f/D around 0.5 to 0.6. This version[4], with an output diameter of 1.31λ, is popularly known as the W2IMU feed, and has been used from 432 MHz to 24 GHz with good results on both conventional and offset dishes.

The original Turrin article[1] also described a larger version with an output diameter of 1.86λ. The graph for this larger version in Figure 3 shows that the f/D for best efficiency is about 0.8, a better match for some offset dishes. We could further optimize by choosing the appropriate output diameter for the f/D of our reflector, then calculating the other dimensions for a dual-mode feed.

We have found that DSS offset-fed dishes work well at 10 GHz. These dishes require a feed pattern equivalent to the feed for a conventional dish with an f/D of about 0.7. The appropriate aperture for this f/D is close to 1.5 inches, so I picked up a copper plumbing adapter which flares out from ¾ inch pipe, the input waveguide, to 1½ inch pipe – it looks like a dual-mode feed. To see how well it would work as a dual-mode feed, I measured the dimensions and used NEC2 to calculate the radiation pattern. The result, shown in Figure 4, is terrible; large sidelobes result in poor spillover efficiency, and phase errors make the total efficiency low.

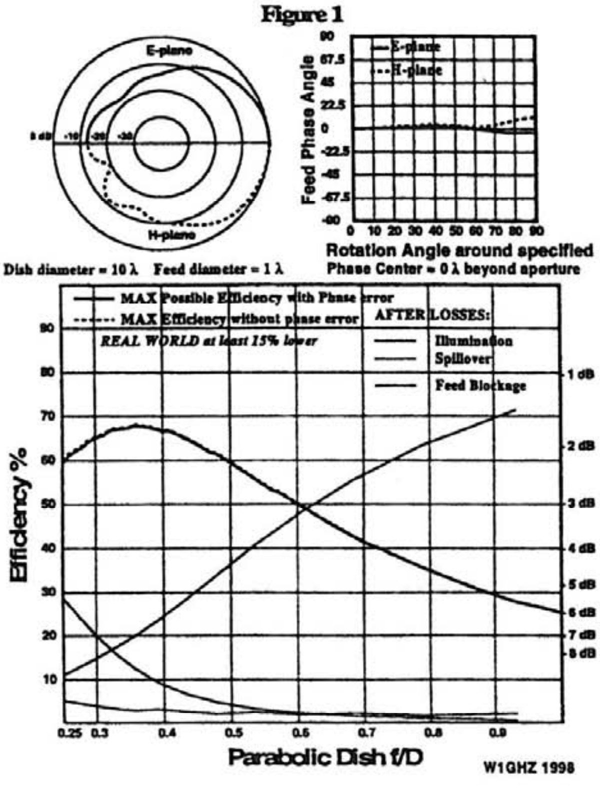
From the example in Figure 4, we can infer that the dual-mode feed must be dimensioned properly to work well.

Dual-mode horn calculations

A sketch of the W2IMU dual-mode feed is shown in Figure 5. The input circular waveguide flares out to a larger output section. Only the TE_{11} mode will propagate in the smaller input waveguide, but both the

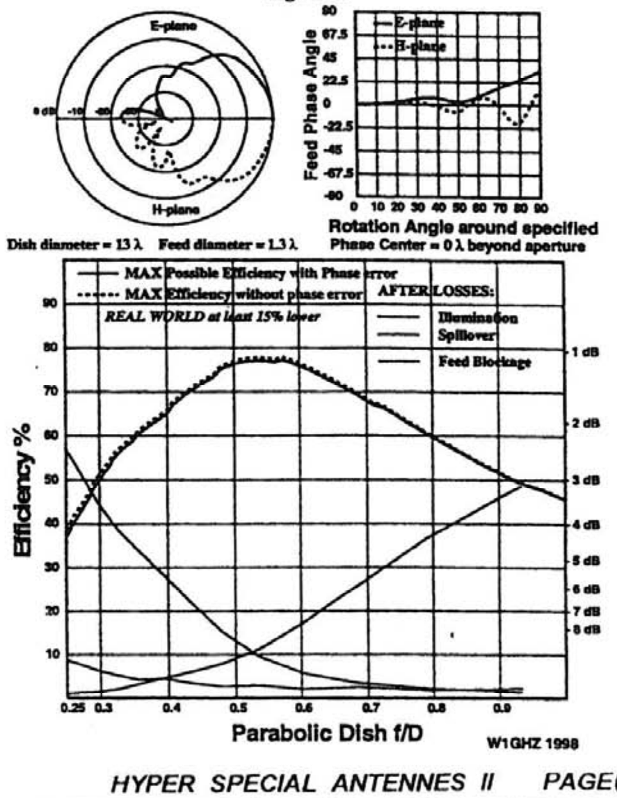
Coffee can feed 0.76λ diameter, by NEC2

Figure 1



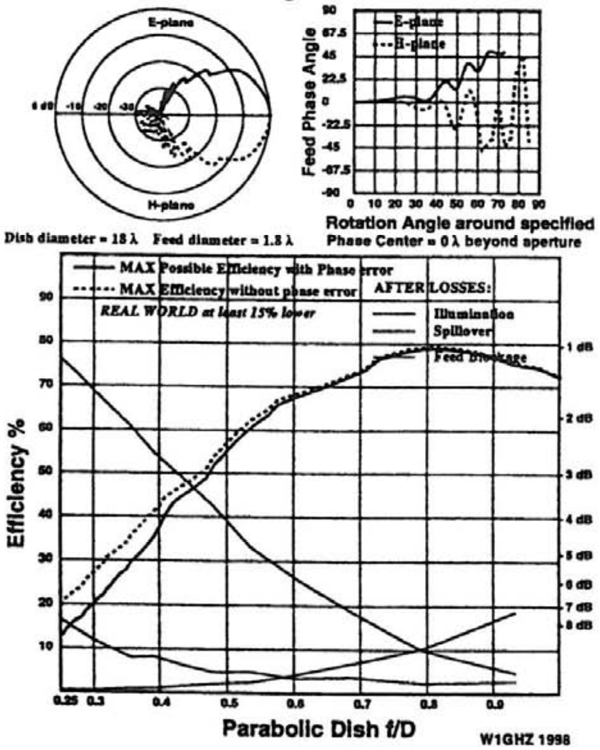
W2IMU dual-mode feedhorn, 1.31λ diameter, by NEC2

Figure 2



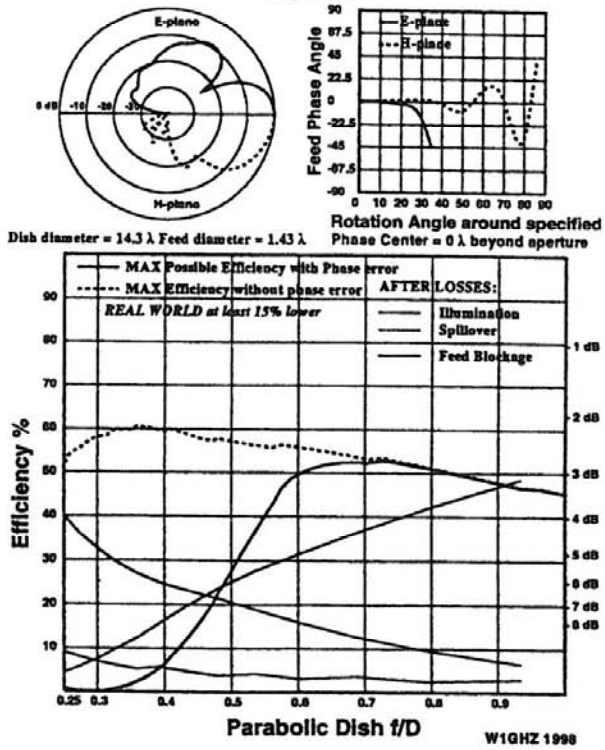
Large W2IMU dual-mode feed, 1.88λ diameter, by NEC2

Figure 3



W2IMU feed - bad imitation, by NEC2

Figure 4



TE_{11} and TM_{11} modes can propagate in larger output waveguide. Our goal is for the relative phases and amplitudes of the TE_{11} and TM_{11} modes to cancel the electric field at the aperture boundary.

The length of the output section controls the relative phase of the two modes, while the flare angle controls the relative amplitude of the two modes. To achieve cancellation of current in the rim of the horn and thus minimize lobes, we must find the right combination of flare angle and output phasing section length.

The transition between the input waveguide diameter, A in Figure 5, and the output section diameter, B, generates the TM_{11} mode; the flare angle adjusts the amplitude of the two modes. We can easily calculate[5] the flare angle:

$$Flare\_halfangle = \frac{44.6\,\lambda}{B}$$

Since different waveguide modes travel at different phase velocities, we can calculate a length, C, for the output phasing section that will result in mode cancellation. At the flare end of the phasing section, the TM_{11} mode is 90° out of phase with the TE_{11} mode. Then the phasing section should have a length C which results in the two modes being shifted by an additional 270°, or ¾λ. We can calculate the desired length as:

$$C = \frac{0.75}{\frac{1}{\lambda_g} - \frac{1}{\lambda_g'}}$$

where λ_g is the guide wavelength for the TE_{11} mode and λ_g' is the guide wavelength for the TM_{11} mode. But first we must calculate the guide wavelengths for the two modes:

$$\lambda_g = \frac{\lambda}{\sqrt{1 - \left(\frac{\lambda}{\lambda_C}\right)^2}}$$

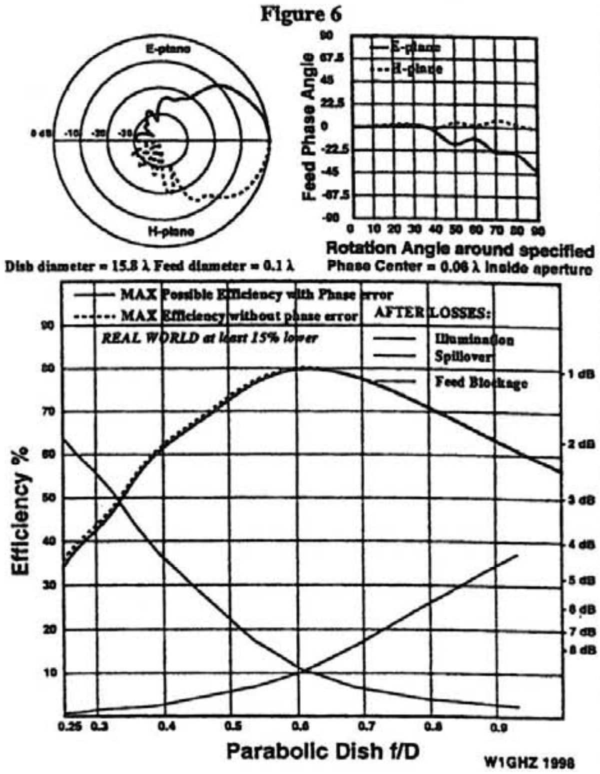
where λ_C is the cutoff wavelength for the mode for which we are calculating λ_g. In the output phasing section with diameter B, the cutoff wavelength for the TE_{11} mode $\lambda_C = 1.706 \cdot B$, while the cutoff wavelength for the TM_{11} mode $\lambda_C' = 0.82 \cdot B$.

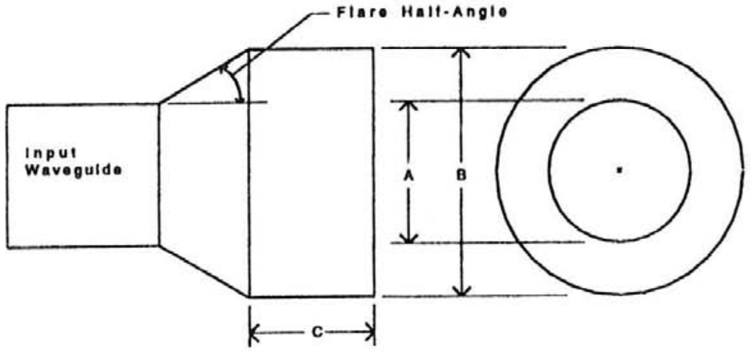
Thus, with a bit of arithmetic we can calculate the optimum dimensions for any desired aperture diameter. For a quick estimate of the optimum aperture diameter for any f/D, try: $B_\lambda \cong 2.35 \cdot f/D$. As the diameter gets larger, the length of the larger output phasing section also increases to maintain the phasing relationship between the two modes.

The consequences of not achieving the proper phasing are clearly illustrated in Figure 4. Using the above equations, we find that the length of the larger pipe should be 2.72 inches rather than the 1.24

G3PHO 10 GHz dual-mode feedhorn, by NEC2

Figure 6





W2IMU DUAL-MODE HORN

Figure 5

inch length of the fitting alone. Also, the flare half-angle should be 29.1°, while the angle in the plumbing fitting is 39°, so the fitting needs serious modification to become a dual-mode feed.

From the cutoff wavelength equation above for λ_C', the minimum aperture diameter which will propagate the TM_{11} mode is 1.22λ; if the diameter is any smaller, it can only be a single-mode feed. On the other hand, if the aperture diameter is too large, then additional modes may be generated. The cutoff wavelength for the next higher mode, the TE_{12} mode, is $\lambda_C = 0.589 \cdot B$. Thus the maximum aperture diameter without additional modes is 1.7λ. Since one of Dick's original examples had an aperture diameter of 1.86λ, this limit may apparently be stretched a bit without performance degradation.

These calculations might seem daunting at first glance, but only require a couple of minutes on a hand calculator. As an alternative, I have included the calculations in version 3 of my HDL_ANT computer program – download it from *www.qsl.net/n1bwt*.

Dual-mode feed examples

As examples of actual dual mode feeds, we can examine three versions which have been published in Britain. I modeled both using NEC2 in order to evaluate their performance.

The first example is a 10 GHz version described by G3PHO[6] using British plumbing fittings. The plot in Figure 6 shows a clean pattern and good dish efficiency for an f/D around 0.6, a bit smaller than the DSS dishes require, but very usable. Peter has done a good job with this version.

The second example is the 5.7 GHz "plumbers delight" by G0HNW[7]. Paul states that the aperture with the available plumbing is a bit small for an offset dish, and the plot in Figure 7, bears this out, showing best efficiency for an f/D of about 0.4. In fact, the aperture diameter is 1.21λ, which is smaller than the cutoff wavelength for the TM_{11} mode, so it is unlikely that this feed supports dual-mode operation. Further evidence is the radiation pattern with several significant sidelobes, including one rather large one. I suspect that it is behaving more like a simple coffee-can feed. Despite the sidelobes and lack of dual-mode operation, it would be quite a good feed for f/D in the 0.45 to 0.5 range. For good illumination of an offset reflector, the aperture diameter should be around 1.5λ, or about 3 inches.

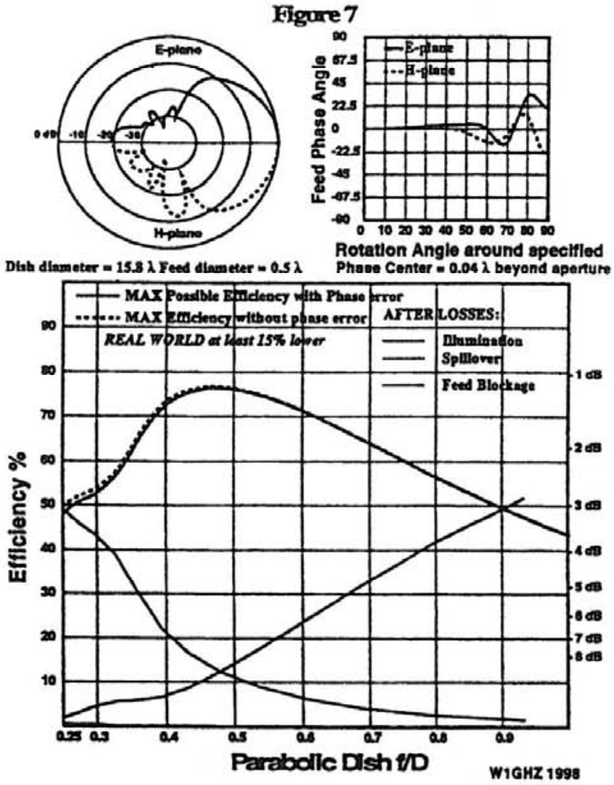
Although this version is not optimized for an offset dish, Paul reports a significant improvement compared a triband feed. Since the triband feed gives best results with very deep dishes, we would expect poor performance when feeding an offset dish. Also, the triband feed has been shown to be rather lossy at 5.7 GHz, further reducing efficiency. Almost anything is better than a triband feed for an offset dish at 5.7 GHz.

The third example is a 24 GHz version by G8ACE. The plumbing fitting used in this version provides an aperture of 22mm, or1.75λ, which is about right for an offset dish. The input waveguide is 10mm pipe, and there are apparently no plumbing reducers from 22mm to 10mm. Instead, a reducer to an intermediate size of 15mm is used, so that there are two flare sections with a length of 15mm waveguide between them. This combination makes it difficult to predict how the two modes will end up, but I was able to calculate the radiation pattern using NEC2. The results are shown in Figure 8. The E-plane pattern has large sidelobes and a null at about 30° off-axis, suggesting that modes do not have the desired relationship at the aperture.

Rapid changes in amplitude, like the null in the E-plane pattern, are usually accompanied by rapid phase changes. This is clearly illustrated in Figure 8 – the feed phase plot in the upper right exhibits a large change in phase around 30° off-axis. The effect on dish efficiency is evident in the lower graph, showing significant phase error at the larger illumination angles required for small f/D.

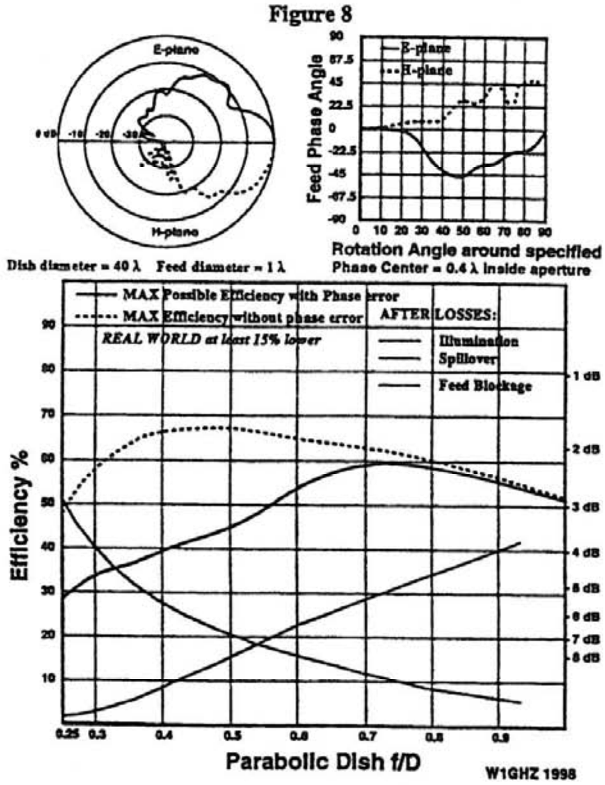
G0HNW Plumbers Delight for 5760 MHz, by NEC2

Figure 7



G8ACE dual mode feed for 24 GHz, by NEC2

Figure 8



We can deduce from this last example that a single flare section offers much better mode control. At 24 GHz, dimensions are small enough so that it should be easy to fabricate a short conical section. My HDL_ANT program will prepare a paper template for any desired flare dimensions.

Conclusion

The W2IMU dual-mode feed can provide excellent performance for both offset and conventional parabolic dishes. Dimensions are somewhat critical, but optimum dimensions may be calculated for a range of f/D, and performance can be analyzed using the NEC2 program.

References

For more information, see the *W1GHZ Microwave Antenna Book – Online* at *www.qsl.net/n1bwt.*

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7. P. Widger, G0HNW, "Plumber's Delight for 5.76 GHz," *RSGB Microwave Newsletter,* May 1998.
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Dual-Mode Feedhorn for 24 GHz

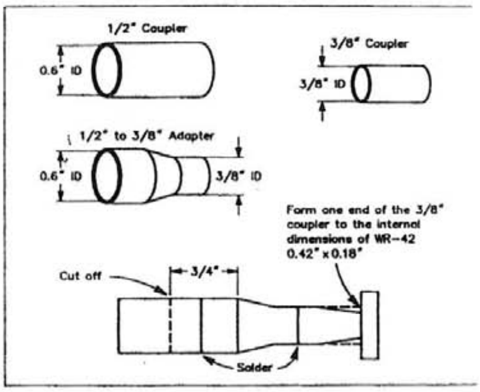
By Kent Britain, WA5VJB

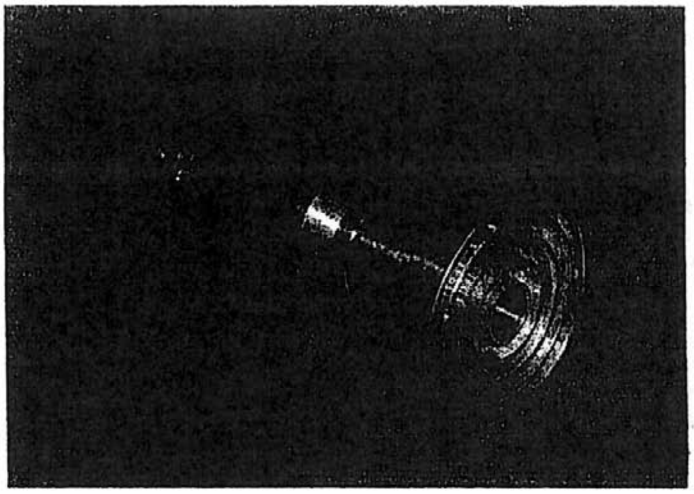
(From *Microwave Update '91*)

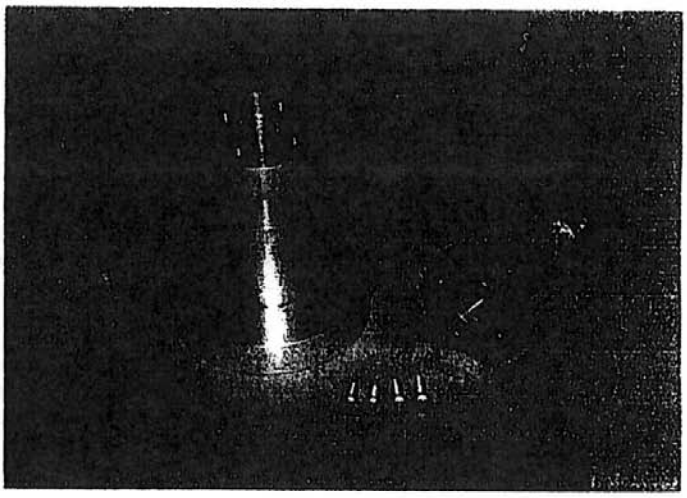
I really like Dick Turrin's (W2IMU) latest Dual-Mode Feedhorn for 10 GHz, built from plumbing fittings. A little math and a trip to a plumbing supply house (Boy, has that sales clerk learned to stop asking me questions!) and I came up with a 24-GHz version of Dick's very popular 1296-MHz EME dish feed.

The end of the 3/8-in. coupling can be formed to the same size as a WR-42 flange. Soldering is a bit tricky, since all three are butt joints. I held the entire assembly in a long clamp, soldering everything at once with a torch on a low flame. The end was cut off with a pipe cutter after it cooled off.

Testing went well. Gain was a little over 12 dBi and the 10 dB-down points (suggested dish illumination at the edges) were ±45°. The E and H beamwidths were within 5°, and no sidelobes were noted. At the 1991 Central States VHF Society antenna contest, I fed a 12-in. 0.42 f/D dish with this feed. Performance was very close to theoretical gain.







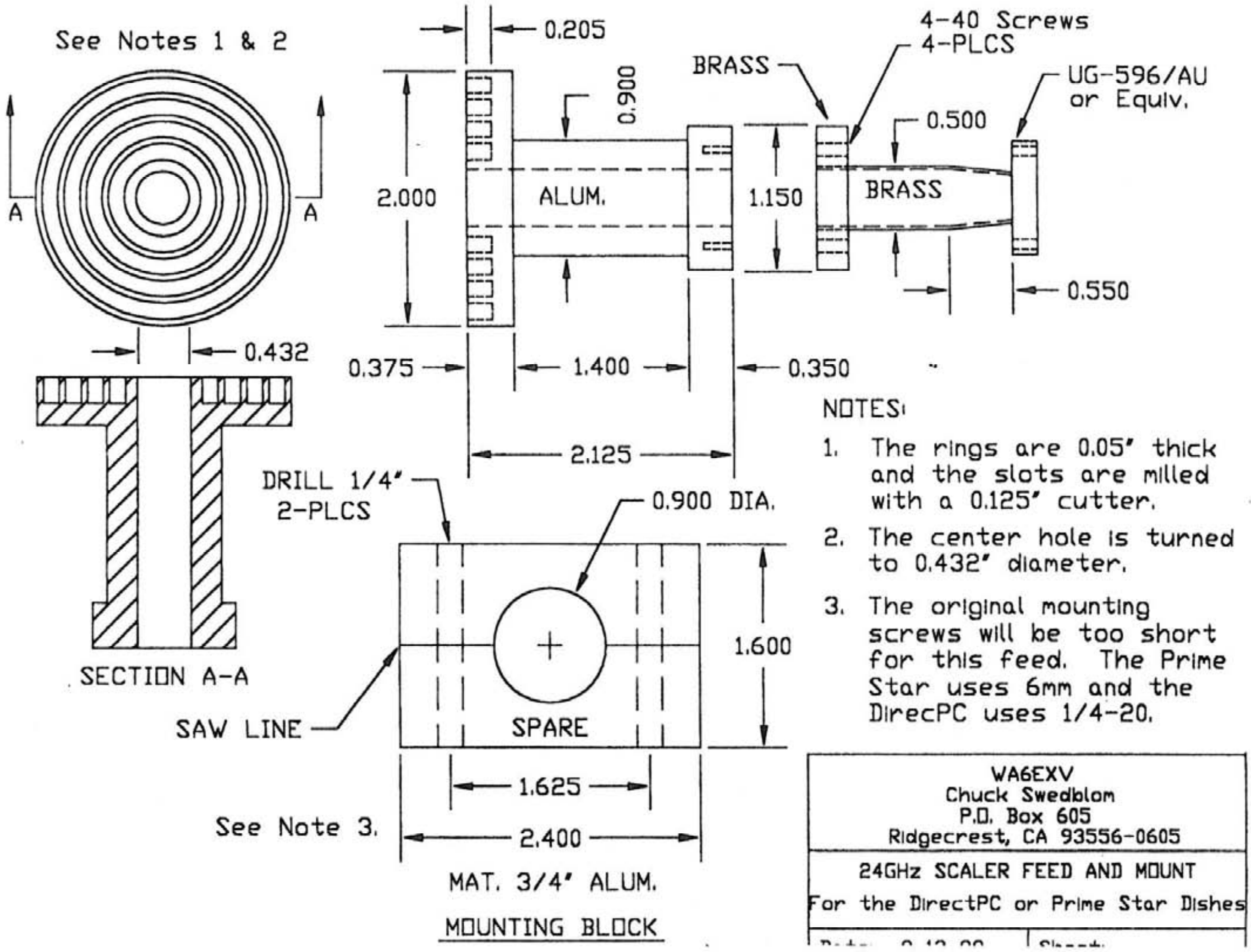
24 GHz SCALER FEED AND MOUNT

For the DirectPC or Prime Star Dishes

Chuck Swedblom, WA6EXV
chuckswed@juno.com

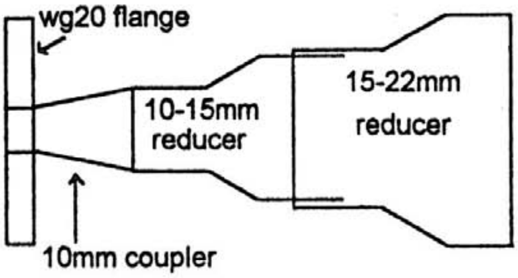
The existing feed on the two dishes provided a measured efficiency of 60% at 10.368 GHz. I decieded to explore the possibility of using the dishes at 24 GHz and built this feed to fit in place of the original one. Since my antenna range is too short (92'), WA6QYR and I located two sites about a half mile apart on two sides of a small canyon to conduct these test using an antenna of known gain. The results of these tests showed that the DirectPC antenna had an efficency of 59% using this feed at 24.125 GHz. The original tests on the Prime Star dish did not perform this good, but the Prime Star dish was used and had been installed here in Ridgecrest for two years or more, whereas the DirectPC dish was brand new. Also there is some doubt in my mind that the Prime Star tests may be flawed. Further tests of the Prime Star will be conducted in the near future.

I built the Scaler Feed as shown, since I have the tools and enjoy turning and milling metal. I have also built the scaler section using 1/16" G10 or FR4 PCB material and thin hobby brass strips to form the rings with equal results. In this case the 1/2" brass tubing (circular waveguide) would extend through the center of the scaler and would have to be long enough to allow for mounting, a total of about 3.5". Also the mounting technique has to be modified such that the center of the feed will be at the same location as the present one. I used a brass strap soldered to the 1/2" circular waveguide and bent such that the alignment was correct and then drilled two 1/4" holes in the strap to bolt it to the mounting arm of the dish.



Extrait de µW Newsletter Avril 98

A DUAL MODE HORN FOR 24GHz - John, G8ACE



This horn was made up from the details in the ARRL UHF/Microwave Projects handbook (p.10-26), metric components being substituted for the imperial sizes of the original design. Whilst the original horn functions well, it was found that adding a further reducer, sized 15-22mm, increased the gain available from an Amstrad style offset dish. Construction is straight forward. The 10mm coupler is re-shaped at one end into a taper to fit into the WG20 flange. The taper is extended right through the flange with the help of a short section of WG20 to maintain the internal profile.The 10-15mm reducer is butt soldered to the 10mm coupler and finally the 15-22mm reducer slides over the 10-15mm reducer. The VSWR can be adjusted by sliding the second reducer back and forth over the first.

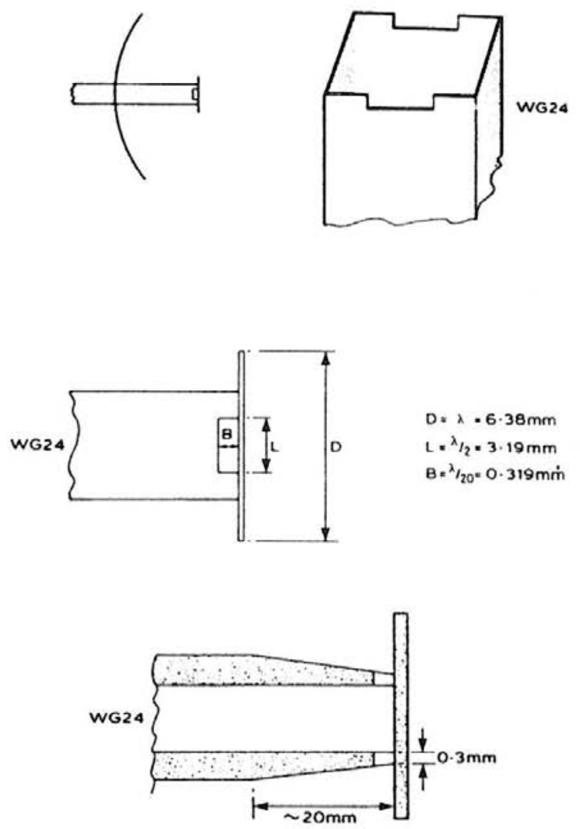


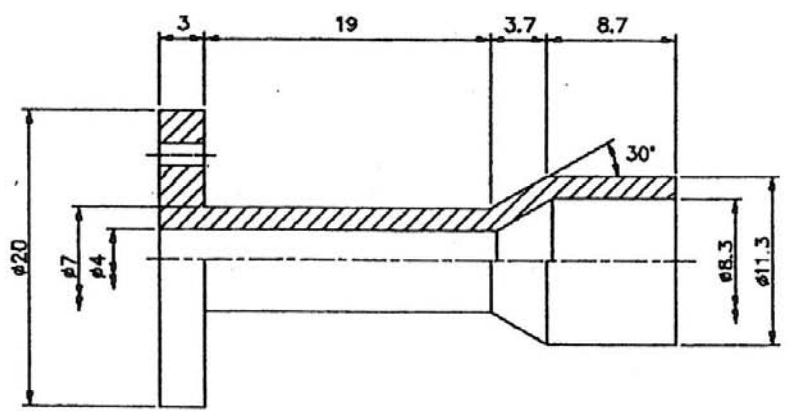
Fig 20.34. Dish feed for 47GHz (HB9MIN)

The antenna used was a 70cm dish (lamp-shade) with an f/D ratio of 0.3, measured gain of 40dB and fed with a scaled-down version of the "penny feed", shown in Fig 20.34. Great accuracy is needed in the construction of the feed and it may be more practical to use a large horn. The pointing accuracy needed for such a dish is better than 0.5°!

ANTENNAS pW newsletter Avril 99

G7MRF and G4CBW decided to use 10" dishes with an f/d of 0.37, with a 60mm diameter "splash plate" feed. This is fed by approx. 100 mm of K&S 3/16" round tube (4 mm ID) with a circular flange used to connect to the transverter. To aid alignment of the waveguide to the transverter, a length of K&S 5/32" tube (fits inside 3/16" tube) was cut to just under the 100mm and a collar of 3/16" tube soldered to it to act as a stop, to prevent hitting the pcb down the 4mm hole in the transverter. This then allowed the dish waveguide feed to be positioned accurately before tightening the flange screws on the transverter.

Figure 3 - W2IMU feedhorn for 47GHz



G0IVA decided to use one of the ex-BSB Channel Master 35 cm offset fed dishes (f/d approx. 0.7). A W2IMU dual mode feedhorn was calculated for 47.088 GHz. The waveguide feed to the horn actually calculates to be approx. 4.5 mm. This value agrees with standard circular waveguide sizes recommended for 47 GHz. However since the 4.0 mm hole has been used on the transverter successfully, the waveguide feed to the horn was left at 4.0 mm. G7MRF turned the horn up out of a solid piece of brass, as it seemed too small to try making up from bits of tubing. This was mounted via its flange directly on the 47 GHz transverter body. An aluminium plate was made up that acted as a cover for one half of the transverter and a mounting plate for the 12 GHz LO. This whole assembly was then positioned to place the horn at the dish focal point, with some adjustment available for fine-tuning.

3.4 Sources Multibandes pour Paraboles

Dual-Band Feedhorn for the DSS Offset Dish

5760 and 10368 MHz

By Paul Wade, N1BWT

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(From *Microwave Update '97*)

I recently completed a new transverter for 5760 MHz in a fairly small package. It fits on top of my 10 GHz transverter next to the wedge that supports the RCA DSS offset dish. I designed a 5760 MHz feed horn for the dish using my *HDLANT21* computer program (**http://www.arrl.org/qexfiles**), built one, and modified the transverter slightly to allow for quick changing of the feed horns with two wingnuts. Now I had a package, shown in Figure 1, for a compact two-band rover station.

I was wondering if it was possible to make a good dual-band feed when Dick, K2RIW, mentioned that WR-112 waveguide covers both 5760 MHz and 10368 MHz; even though the handbooks don't list it as usable for 5760, the cutoff frequency is slightly lower so it still works.

The next problem was designing a feed horn to cover both bands with decent illumination for the dish. A few trial calculations showed that a 10 GHz horn providing –10 dB edge illumination taper would provide a –3 dB edge illumination at 5760 MHz—most of the energy would miss the dish! On the other hand, a horn designed for 5760 would have a much narrower beam at 10 GHz, so the outer portions of the dish would receive very little illumination energy; only the performance of a much smaller dish would result. After some fiddling of the numbers, I found a compromise which might have the same loss of efficiency at both frequencies.

The final design, using the *HDLANT21* template shown in Figure 2, has an illumination taper of roughly –16 dB at 10.368 GHz, so it is somewhat under-illuminated, and roughly –5 dB at 5760 MHz, somewhat over-illuminated. I adjusted the horn length to match the phase centers at 10.368 GHz, since it is most critical at the higher frequency.

The next problem was getting a good VSWR at both frequencies. The surplus WR-112 waveguide-to-coax transitions I had weren't very good at 5760 MHz, so tuning was required. I put a small ball bearing inside the waveguide and moved it around with a magnet on the outside until I located a spot which improved the VSWR at 5760 MHz without making the 10368 MHz VSWR too much worse. Then I marked the spot, drilled and tapped the waveguide, and put in a tuning screw. Next I adjusted the screw for best VSWR at 5760 MHz, then put the BB back in and looked for a spot that improved both frequencies. A second screw was added here, then both screws adjusted for a compromise with reasonable VSWR at both frequencies. The final tuning had a VSWR under 1.6 at both 5760 MHz and 10368 MHz, but it is *not* a broadband match.

Figure 1—Dual-band rover system for 5760 and 10368 MHz.

Dual-band Feed Horns for 2304/3456 MHz and 5760/10,368 MHz

By Al Ward, WB5LUA

(From *1997 Central States VHF Conference Proceedings*)

Background

Numerous articles have been written by WA9HUV, VE4MA, N1BWT and others on the proper illumination of a parabolic reflector. Joel Harrison has documented most of these works.[1] The proper illumination of a parabolic reflector with a given F/d (focal length to diameter ratio) requires the careful balance of both the E and H plane beamwidths of the feed horn. The problem on the microwave frequencies is one of putting several feed horns for individual frequencies at the same focal point—a nearly impossible task. Attempting to put multiple feeds at the focal point of the dish generally compromises performance on all bands. The satellite industry has had reasonable success by putting a 12 GHz feed in the middle of a 4 GHz feed. This is most likely due to the significantly smaller diameter of the 12 GHz feed versus the 4 GHz feed. With the relatively closer spacing of the 2304, 3456, 5760, 10,368 MHz bands this technique becomes difficult. Multiple feeds that are slightly offset are one way of obtaining multiband operation but there are some disadvantages, such as pointing offsets for each band. In order to get around the offset pointing problem I began work on in-line feeds, which will be the subject of this article. Any multiband feed will have compromises but I believe the techniques described herein will still result in a high performance antenna system.

Early Experiments on 2304 and 3456 MHz

I first experimented with inline multiband feeds back

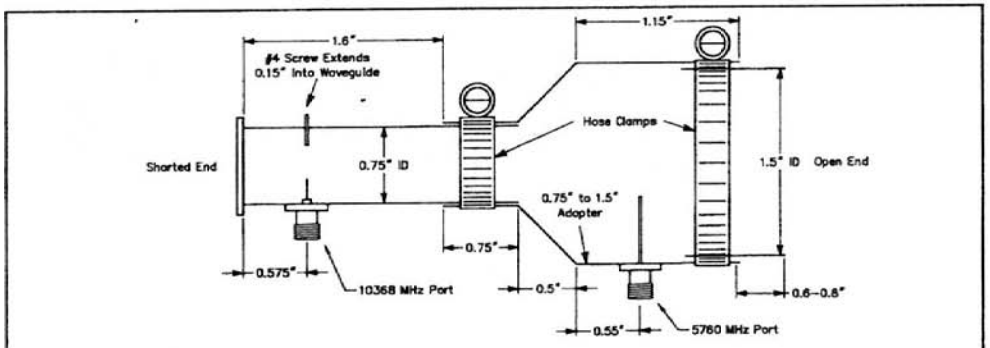


Fig 1—WB5LUA dual 5760 and 10,368 MHz feed horn.

Notes

1) 10,368 MHz probe is made from the center conductor of an SMA connector or 0.141" semi-rigid cable. 0.07" of the Teflon dielectric extends into waveguide. Length of pin above dielectric is 0.3" Tuning screw is diametrically opposite probe and is adjustable.
2) 5760 MHz probe is 0.6 to 0.7" in length and can be made from tubing 0.07 to 0.1" in diameter.
3) Tuning of both frequencies can be accomplished by tuning either probe length or waveguide length.
4) Isolation:
10,368 MHz signal@5760 MHz port = –19 dB
5760 MHz signal@10,368 MHz port = –45 dB
5) Return loss < 23 dB at both ports

Does it work? YES!

I completed it just in time for sun noise measurements at the July 1997 N.E.W.S. meeting, and tested it there on 10368 MHz. The DSS dish with a single-band horn feed has an efficiency better than 60%, while the dual-band feed is around 50%; the gain difference works out to about 1.2 dB.

The next day, I set up a sun noise measurement at 5760 MHz, with similar results: the DSS dish with a single-band horn feed has an efficiency of about 60%, while the dual-band feed is around 50%; the gain difference works out to about 1 dB on this band.

Summary

An RCA DSS dish with this dual-band feed horn provides two band performance only 1 dB down from a single band feed horn on each band. I've never seen a multiband feed with performance this good. This compact antenna is ideal for rover operations.

Questions

Q — Is a tri-band feed horn possible?

A — Not with ordinary waveguide, which cover a frequency range of less than 2 to 1 between cutoff and an upper frequency where other modes can propagate. Ridged waveguide can cover a wider range, but the horn design involves even more compromises.

Q — Is a dual-band horn possible for lower bands?

A — Yes, with a larger offset dish. A dish should be at least 10 λ in diameter for good performance, so the 18 inch RCA dish isn't big enough below 5760 MHz.

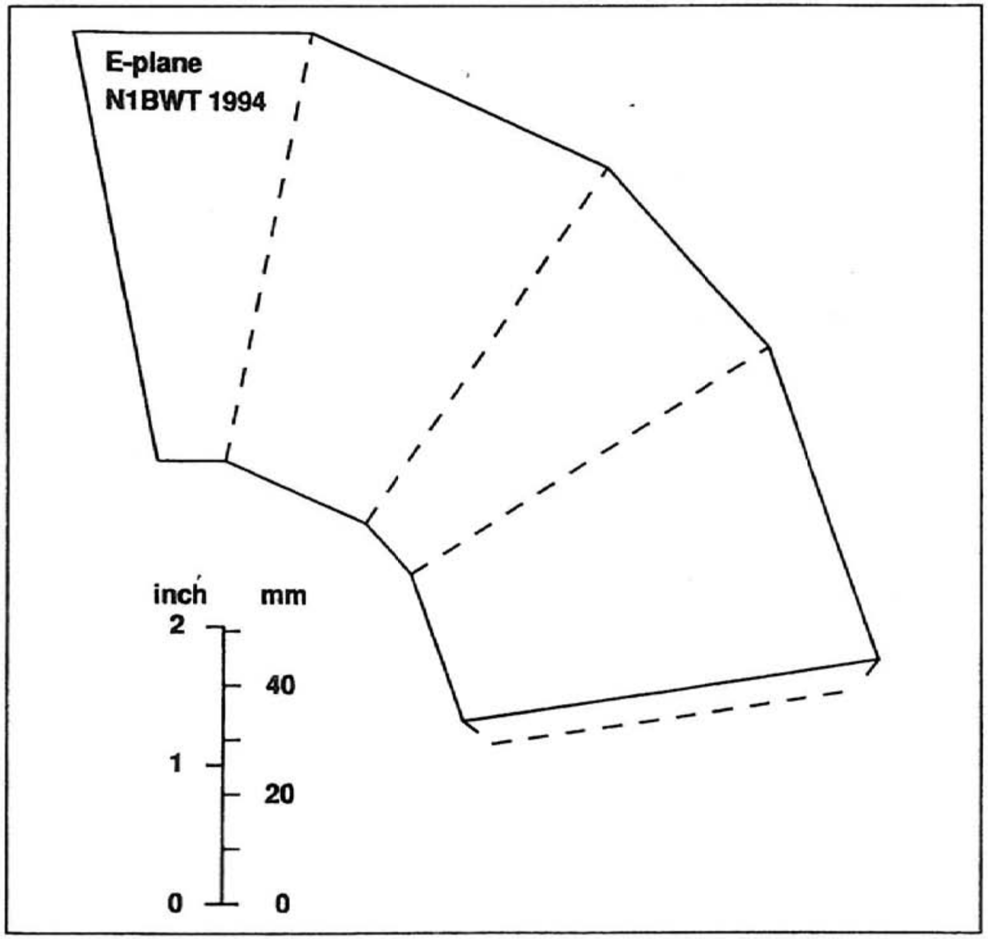


Figure 2—Dual-band feed horn template for RCA DSS offset dish; 5760 and 10368 MHz, WR-112 waveguide. Phase center is about 5 mm inside horn.

in 1989 when I wanted a 2304 and 3456 feed that could be placed at the focal point of the dish and not require an offset in pointing between bands. I got the idea for the inline feed after analyzing the single band dual mode W2IMU feed, which has been used successfully on 1296, 2304 and 10,368 MHz, primarily for EME. The W2IMU feed has two different diameter circular waveguide sections which are designed to equalize the resultant E and H-plane beamwidths. The equal E and H-plane beamwidths with the appropriate taper contribute to a well illuminated high gain antenna. My thought was, what about feeding the larger outer section on the next lower amateur band? I decided to apply this concept to a dual band feed horn for 2304 and 3456 MHz. I used a standard 4 inch coffee can for 2304 MHz followed by a standard soup can for 3456 MHz. The results were very encouraging. This feed has been duplicated by several people over the years including K2DH, AA5C and W5ZN with good results. The construction of this feed and performance on a 32 inch dish is covered in detail in Joel Harrison's article.

Adding 5760 MHZ to Make a Three-Band Feed

I wanted to add 5760 to the original 2304/3456 MHz feed so I decided what would be easier than to just add a 1.5 inch diameter copper pipe to the end of the 3456 MHz can. The results were mixed. Yes, the horn worked but as I found out, the gain was considerably lower than theoretical. This was probably due to the fact that with the large aperture of the multiband feed at 5760 MHz, the feed was under-illuminating the dish.

Separate Dual Band Feed

I decided that the optimum combination would be to just duplicate the 2304/3456 feed for 5760 and 10,368 MHz. The result actually looks very similar to a W2IMU feed for 10,368 MHz. The resultant feed horn, shown in Figure 1, worked very well on 5760 MHz and was only slightly lower than expected on 10,368 MHz. The feed was tried on several dishes with varying F/d ratios and diameters. The resultant antennas were tested during a recent North Texas Microwave Society antenna workshop hosted by Kent Britain, WA5VJB. The results are documented in Table 1.

Test Results

Starting at 5760 MHz, the dual band feed worked very well, producing gains within a dB or two of theoretical 55% numbers when installed on 48 and 55 inch solid dishes and 55 and 72 inch perforated dishes. The new dual band 5760/10,368 MHz feed actually had 6 dB greater gain on 5760 MHz than did the original three band feed as measured on the same 55 inch dish.

On 10,368 MHz, the numbers were down a little but the 72 inch perforated dish, which was the only dish rated for 12 GHz, was still measuring 40.7 dBi. I did not optimize the actual position of the feed. The feeds were placed with the focal point slightly in the mouth of the feed.

The dual 2304/3456 MHz feeds were tested in the same dishes but were slightly offset as only the dual 5760/10,368 MHz feed was at the focal point. As the results show, the gain numbers were somewhat lower than expected but the antenna range was only about 125 ft long and it could be that the larger dishes were underilluminated for the tests.

Construction

The length of both circular waveguide sections was made variable in order to improve the tunability of the feed horn. The monopoles can be preset as shown in Figure 1 and final tuning if needed can be accomplished by tuning the length of the waveguides. The resultant isolation between bands is very good and allows each band to be individually tuned. See Figures 2 and 3. The very good isolation also minimizes the additional isolation required in order to keep from destroying the front-end of the receiver for the other band. I believe part of the increased success of the 5760/10,368 MHz feed horn in regards to low frequency to high frequency isolation may, in part, be due to the smoother transition from the small section to the large section. Secondly it could be due to the 5760 MHz port having a poorer return loss at 10,368 MHz. Be aware that there are several different types of 0.75" to 1.5" transitions available and all may tune slightly differently.

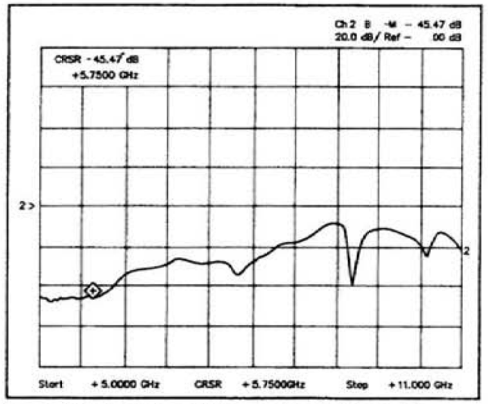


Fig 2—WB5LUA dual 5760 and 10,368 MHz feed horn —5760 MHz port to 10,368 MHz port isolation.

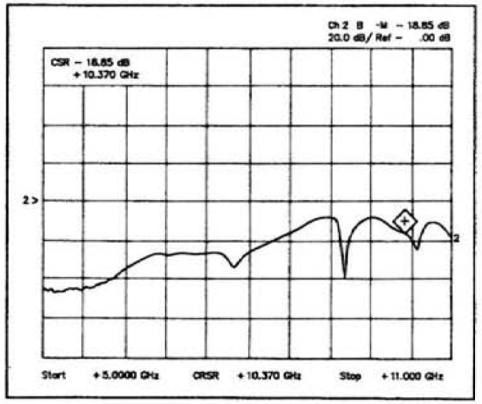


Fig 3—WB5LUA dual 5760 and 10,368 MHz feed horn—10,368 MHz port to 5760 MHz port isolation.

Table 1
1997 NTMS Antenna Gain Measuring Party
Conducted by WA5VJB on March 23, 1997
Compiled by WB5LUA
Antenna range may have been too short for larger dishes, as gain numbers appear compressed.

Band (MHz)	*Call*	*Design*	*Gain (dBi)*	*Theoretical 55% Gain (dBi)*
1296	KA5BOU	15 el Yagi	16	
2304	WB5LUA	72" perf dish with coffee can feed	27	30
	AA5C	6' 40 el Yagi	20.4	
	WB5LUA	55" solid dish with coffee can feed	24.4	27
	WA5VJB	Reference horn	13.5	
3456	WB5LUA	72" solid dish with dual 2304/3456 feed	27.9	34
	WB5LUA	48" solid dish with offset soup can feed	25.7	30
	WB5LUA	55" solid dish with dual 2304/3456 feed	23.9	31
	WB5LUA	DEM loop Yagi	19.5	
	WA5VJB	Reference horn	16.9	
5760	WB5LUA	72" perf dish with dual 5760/10,368 feed	37.0	38
	WB5LUA	48" solid dish with 1.5" diam copper feed	33.5	34
	WB5LUA	55" perf dish with dual 5760/10,368 feed	33.0	35
	WB5LUA	55" solid dish with dual 5760/10,368 feed	32.5	35
	W5ZN	39" solid dish with scalar feed	31.3	32
	WA5TKU	30" solid dish with 1.5" diam copper feed	27.5	30
	AA5C	24" solid dish with dual 5760/10,368 feed	27.5	28
	WB5LUA	55" solid dish with old WB5LUA 3-can feed	27.0	35
	WB5LUA	12"x18" horn	21.0	
	WA5VJB	Reference horn	15.5	
10,368	WB5LUA	72" perf dish with dual 5760/10,368 feed	40.7	43
	WB5LUA	55" solid dish with dual 5760/10,368 feed	38.7	41
	WB5LUA	55" perf dish with dual 5760/10,368 feed	37.7	41
	WA5TKU	30" solid dish with 1.5" diam feed	33.7	36
	AA5C	24" solid dish with dual 5760/10,368 feed	33.2	34
	W5ZN	24" solid dish with WR90 to scalar feed	32.5	34
	WB5LUA	18" fiberglass dish with WR90 feed	28.7	31
	WA5VJB	Reference horn	17.7	

Conclusion

I am very encouraged by the initial results of the multiband feeds. I now have one dish for 2304, 3456, 5760 and 10,368 MHz. The 5760 and 10,368 MHz feed is at the focal point with the 2304/3456 MHz feed slightly offset. End result is that if 5760 MHz is peaked on a particular station then 10,368 MHz is also peaked. Same is true of 2304 and 3456 MHz. Good luck. Feedback is greatly appreciated.

Note
[1] "Horns for the Holidays", *1997 Proceedings of the Central States VHF Society Conference*, p 53-63.

Microwave Update 98

W5ZN Dual Band 10 GHz / 24 GHz Feedhorn

by
Joel Harrison, W5ZN

Recent articles by Al Ward and I have previewed dual band feedhorn designs for 2.3 and 3.4 GHz as well as 5.7 and 10 GHz[1]. Our recent design work on 24 GHz equipment naturally prompted the next logical dual band design step – a 10 GHz / 24 GHz dual band feed.

Why a Dual Band Feed for 10/24 GHz?

If you have experienced operating on 24 GHz you know (if you haven't, you need to know) that antenna alignment with the other station is extremely critical, not only in azimuth but elevation as well. Even with a one foot dish, the beamwidth is so narrow that communication at distances of only 30 miles is difficult without the ability to properly aim the antenna before attempting communication. While antenna alignment is critical at 10 GHz, it provides a wider beamwidth to work with to accomplish accuracy for 24 GHz work.

The Design

While in Germany on business last year, I had a discussion with Erhard Seibt, DC4RH, about 24 GHz activity and distance achievement. Erhard told me of a design which is used regularly in Germany to reduce the complications associated with antenna alignment.

The design was a basic 10 GHz feedhorn made from a length of ¾" copper pipe with a WR-42 waveguide flange soldered to the pipe as the closed end. During my construction attempts, I experienced difficulty maintaining a clean non-soldered area on the flange waveguide opening while ensuring sufficient uniform contact with the end of the ¾" pipe. In addition, I was unable to obtain an acceptable return loss (SWR) on 24 GHz.

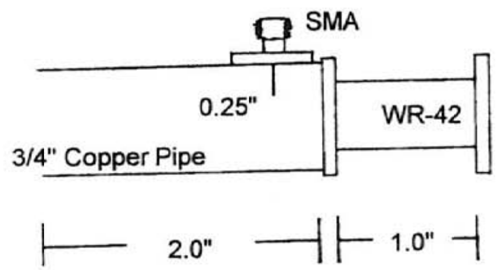
My modified design uses the basic10 GHz feedhorn idea utilizing a length of ¾" copper pipe, with modifications to the 24 GHz section. Rather than attempt to maintain a clean entrance area on the waveguide flange opening, I used an approximate one inch length of WR-42 waveguide with a flange on each end. This provides easier attachment to the ¾" copper pipe while maintaining an ideal flange entrance area. Also, the short length of WR-42 waveguide can be used for tuning by inserting a tuning screw if needed.

Construction Tips

- Construct the 10 GHz Waveguide section first by soldering the SMA connector and probe to the ¾" copper pipe.
- Next, solder a WR-42 waveguide flange to a 1" length of WR-42.
- Wrap a moist paper towel around the SMA connector, secure in place, then solder the flange to the copper pipe. The moist towel allows removal of heat in the connector area to prevent desoldering of the SMA connector while soldering the flange. Likewise, use vice grips to lightly clamp the WR-42 waveguide at the flange. This will provide support during the soldering process as well as prevent desoldering of the WR-42 waveguide section from the flange.
- Solder a flange to the other end of the WR-42.
- Check return loss. If necessary, tuning screws can be used on both the 10 GHz and 24 GHz sections.

I have obtained repeatable results in constructing this design of feedhorn. Return loss on 10 GHz has been >20 dB and > 16 dB on 24 GHz. I have used a tuning screw on 10 GHz, but it has not been necessary on 24 GHz. After cleanup, you can paint the feedhorn your favorite color.

Good luck on 24 GHz!



References:
1. Horns for the Holiday's, Joel Harrison, W5ZN, 31st Central States VHF Society Proceedings, 1997, Hot Springs, Arkansas and Microwave Update '97 Proceedings, Sandusky, Ohio.
2. Dual Band 5.7 / 10 GHz Feedhorn, Al Ward, W5LUA, 31st Central States VHF Society Proceedings, 1997, Hot Springs, Arkansas and Microwave Update '97, Sandusky, Ohio.